THE
2026-27

Radiology UPDATE

A 20-hour Comprehensive and Clinically Relevant Review of Key Imaging Topics Across Multiple Subspecialties of Radiology.

American Educational Institute, Inc.

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David R. Victor, JD
CEO

Dear Registrant:

Advancements in imaging technology, evolving diagnostic criteria, and the integration of artificial intelligence continue to reshape the field of radiology. Staying clinically current is essential to providing accurate diagnoses and optimizing patient outcomes. ***The 2026-27 Radiology Update*** is designed to provide you with the latest insights and evidence-based approaches in diagnostic imaging.

This comprehensive 20-hour course features expert-led lectures spanning a broad range of imaging subspecialties, including neuroradiology, nuclear medicine, breast imaging, pediatric radiology, cardiothoracic imaging, abdominal imaging, and healthcare leadership. Presentations cover topics ranging from adult brain tumors, neurodegenerative disorders, and intracranial infections to theranostics in oncology, cardiac MR and CT case reviews, pediatric trauma imaging, and advanced breast imaging techniques. Additional lectures explore the future of radiology practice, imaging report standardization, physician employment contracts, healthcare reimbursement, and the role of behavioral economics in clinical decision-making, providing participants with a well-rounded update on both clinical and professional aspects of modern radiology.

To help you assess your level of comprehension, we have included brief self-evaluation quizzes within this syllabus. These tests are included in this syllabus and are identified by the black edges of the pages on which they are featured.

Your feedback is invaluable in shaping future iterations of this program. Please take a moment to complete the evaluation questions provided for each lecture. Additionally, we encourage you to engage with our expert faculty—your inquiries and insights contribute to a dynamic learning experience.

We also invite you to take advantage of the collaborative nature of this course. The diversity of participants provides an opportunity to exchange knowledge and perspectives with fellow radiologists and imaging specialists.

Thank you for your participation. I hope you find ***The 2026-27 Radiology Update*** both educational and rewarding.

Cordially,
American Educational Institute, Inc

David R. Victor, Esq.
CEO

TABLE OF CONTENTS

- COURSE OBJECTIVES
- DISCLOSURES
- PRESENTATIONS

Adult Brain Tumors ***Joshua P. Nickerson MD, FACR***

Joshua P. Nickerson MD, FACR - Biography 7

Presentation Outline 8

Self Evaluation 15

Overview of Theranostics in Oncology ***Don C. Yoo, MD, FACR***

Don C. Yoo, MD, FACR - Biography 16

Presentation Outline 17

Self Evaluation 27

Imaging of the Biliary System ***Robert M. Marks, MD***

Robert M. Marks, MD - Biography 28

Presentation Outline 29

Self Evaluation 42

The Future of Radiology Practice ***Andrew Moriarity, MD, MBA***

Andrew Moriarity, MD, MBA - Biography 43

Presentation Outline 44

Self Evaluation 50

Intracranial Infections ***Joshua P. Nickerson MD, FACR***

Presentation Outline 51

Self Evaluation 57

Emergency Nuclear Medicine Cases ***Don C. Yoo, MD, FACR***

Presentation Outline 58

Self Evaluation 74

Pediatric Trauma Imaging ***Summer Kaplan, MD***

Summer Kaplan, MD - Biography 75

Presentation Outline 76

Self Evaluation 82

Physician Employment Contracts: Avoiding the Mistakes That Cost Careers ***David M. Yousem, MD, MBA***

David M. Yousem, MD, MBA - Biography 83

Presentation Outline 84

Self Evaluation 91

Neurodegenerative Disorders ***Joshua P. Nickerson MD, FACR***

Presentation Outline 92

Self Evaluation 98

Nuclear Medicine for Infection and Inflammation ***Don C. Yoo, MD, FACR***

Presentation Outline 99

Self Evaluation 112

TABLE OF CONTENTS

Standardizing Imaging Reports ***Andrew Moriarity, MD, MBA***

Presentation Outline 113

Self Evaluation 125

Understanding the RBRVS System: How Physicians Are Valued and Paid ***David M. Yousem, MD, MBA***

Presentation Outline 126

Self Evaluation 136

Facial Trauma Imaging: Fracture Patterns, Complications, and High-Risk Findings ***David M. Yousem, MD, MBA***

Presentation Outline 137

Self Evaluation 151

Importance of Patient Preparation for PET/CT ***Don C. Yoo, MD, FACR***

Presentation Outline 152

Self Evaluation 168

Cardiac MR and CT Case Reviews ***Anil K. Attili, MD***

Anil K. Attili, MD - Biography 169

Presentation Outline 170

Self Evaluation 187

Breast Biopsy Techniques ***Gary J. Whitman, MD***

Gary J. Whitman, MD - Biography 191

Presentation Outline 192

Self Evaluation 216

Inflammatory Demyelinating Lesions: MRI Patterns, Diagnostic Criteria, and Key Mimics ***David M. Yousem, MD, MBA***

Presentation Outline 217

Self Evaluation 229

Thoracic Imaging: Case Review ***Anil Kumar Attili, MD***

Presentation Outline 230

Self Evaluation 249

Axillary Staging and Breast Localization ***Gary J. Whitman, MD***

Presentation Outline 251

Self Evaluation 280

Behavioral Economics and Clinical Decision-Making ***Andrew Moriarity, MD, MBA***

Presentation Outline 281

Self Evaluation 291

COURSE OBJECTIVES

After completing ***The 2026-27 Radiology Update*** you should have acquired the knowledge that will better enable you to better:

- Develop a structured imaging approach to **adult brain tumors** that integrates lesion location, morphology, and advanced imaging techniques to refine differential diagnosis and management.
- Understand the principles, clinical applications, and future directions of **theranostics in the diagnosis and treatment of oncologic disease.**
- Understand **biliary system** abnormalities and diseases, and relevant imaging methods.
- Examine how healthcare payment policy and market forces are shaping **radiology practice ownership and governance.**
- Recognize key imaging features of **intracranial infections** to differentiate bacterial, viral, fungal, and parasitic etiologies and guide timely management.
- Recognize **key nuclear medicine studies** used in emergency settings and apply accurate interpretation strategies to support time-sensitive clinical decision-making.
- Enhance knowledge of **pediatric trauma imaging**, including appropriate CT protocols, radiation safety, and the identification of critical findings in head, spine, chest, and abdominal trauma.
- Identify key provisions in **physician employment contracts** and apply strategies to avoid common legal, financial, and professional pitfalls.
- Identify key imaging features of **major neurodegenerative disorders** to improve diagnostic accuracy and guide clinical management.
- Understand the role of conventional nuclear medicine and PET/CT in the evaluation of **infection and inflammatory disease.**
- Implement **standardized terminology and reporting frameworks** to improve clarity, consistency, and clinical impact of imaging interpretations.Understand the structure of the **Resource-Based Relative Value Scale (RBRVS) system** and how RVUs, geography, and conversion factors determine physician reimbursement.
- Apply a systematic imaging approach to accurately identify **facial fractures**, associated complications, and injuries requiring urgent intervention.
- Understand evidence-based **patient preparation strategies** for FDG PET/CT to optimize image quality, diagnostic accuracy, and clinical interpretation.
- Appreciate the utility and findings of **MR and CT imaging** in the evaluation of common cardiac conditions.
- Compare ultrasound-guided and stereotactic **breast biopsy techniques** and apply principles of imaging-pathology concordance to clinical practice.
- Apply contemporary MRI criteria and imaging features to accurately differentiate **multiple sclerosis and related demyelinating disorders** from common mimics.
- Understand the evaluation, disease distribution, imaging patterns, and diagnosis of parenchymal lung diseases. Integrate **axillary imaging findings and localization techniques** to guide staging and surgical management of breast cancer.
- Analyze how **cognitive biases** influence clinical and financial decision-making and apply strategies to improve judgment under uncertainty.

All learning objectives above address IOM/ACGME core competencies.

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Radiology UPDATE

FACULTY DISCLOSURES

The individuals listed below have control over the content of ***The 2026-27 Radiology Update***. None of them have a financial relationship with an ineligible company.

David R. Victor, Esq., CEO, American Educational Institute
Billy J. Allen, president, American Educational Institute
Michael P. Zintsmaster, MD, clinical content director
Stephen Zintsmaster, MD, peer reviewer
Anil K. Attili, MD, faculty member
Summer L. Kaplan, MD, faculty member
Robert M. Marks, MD, faculty member
Joshua P. Nickerson MD, FACR, faculty member
Andrew Moriarity, MD, MBA, faculty member
Gary J. Whitman, MD, faculty member

The following faculty members of ***The 2026-27 Radiology Update*** have a financial relationship with an ineligible company:

David M. Yousem, MD, MBA, faculty member, consultant for TrueLearn, Elsevier & Medicolegal Expert Witness

Don C. Yoo, MD, FACR, faculty member, consultant for Invicro/Perceptive

All lectures presented by speaker with relevant financial relationships have been peer reviewed. All speakers with finance relationships have attested that clinical recommendations they make are evidence-based and free of commercial bias.

All relevant financial relationships have been mitigated prior to the start of this activity in accordance with the ACCME standards.

FACULTY

Joshua P. Nickerson MD, FACR

Joshua P. Nickerson MD, FACR is a Professor of Radiology at Oregon Health & Science University, where he serves as Vice Chair for Academic Affairs. He is a former Division Chief of Neuroradiology, Residency Program Director, and Vice Chair of Education. An active leader in radiology education, Dr. Nickerson contributes to multiple national organizations, including the American Board of Radiology and the American Society of Neuroradiology. He is a dedicated educator and international speaker, with scholarly work focused on brain tumor imaging, advanced MRI techniques, infectious disease, and curriculum development.

You may contact Dr. Nickerson with any questions or comments at nickerjo@ohsu.edu.

Adult Brain Tumors
Joshua P. Nickerson MD, FACR

Adult Brain Tumors

Joshua P Nickerson, MD FACR
Professor and Vice Chair for Academic Affairs
Department of Radiology
Oregon Health & Science University

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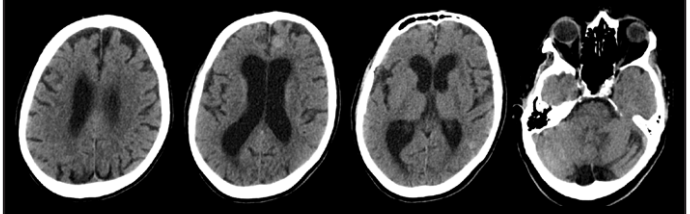
Adult Brain Tumors

- Tumor imaging protocols
- Approach to a new intracranial mass
- Recent changes to the WHO nomenclature
- Advanced imaging options
- Illustrative cases



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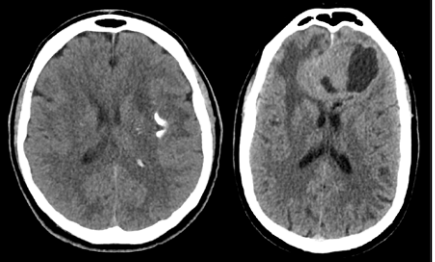
Tumor Imaging via CT



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Tumor Imaging via CT

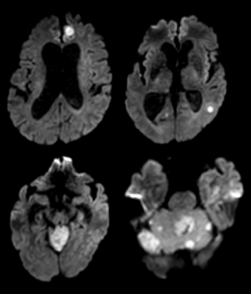
- Mineralization
- Vasogenic edema
- Intratumoral hemorrhage
- Underlying calvarium



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Tumor Imaging via MRI

- Gadolinium-enhanced MRI of the brain
- Improved tissue contrast
- T1 and T2 characteristics and enhancement pattern
- Standard sequences: T1, T2, T2 FLAIR, GRE or SWI, DWI, T1-post gadolinium
- Gradient vs TSE post-contrast imaging?



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Approach to the New Mass

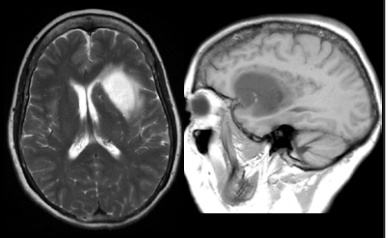
- **Question #1**: Where is it?
  - Intra- vs Extra-axial
  - Intraventricular?
- Solitary vs Multiple
- Solid vs Cystic/Necrotic
- Emergent features?
  - Hydrocephalus
  - Herniation



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Approach to the New Mass

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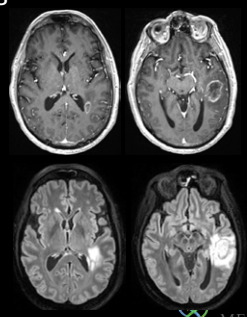


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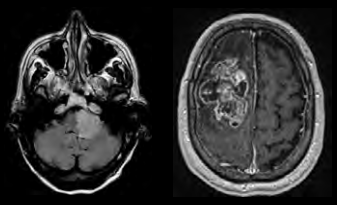


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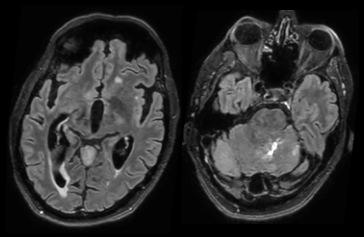


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Approach to the New Mass

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Approach to the New Mass

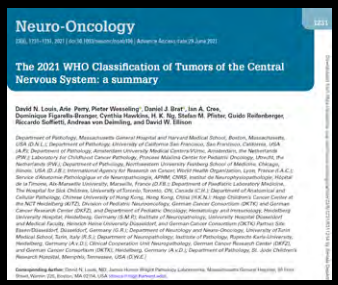
Most Common Differentials

Extra-Axial Meningioma Dural metastasis Lymphoma Solitary fibrous tumor	**Solitary** Astrocytoma Oligodendroglioma Lymphoma *Metastasis*	**Solid** Astrocytoma (G1-3) Oligodendroglioma Lymphoma Metastasis
Intra-Axial Metastasis Astrocytoma Oligodendroglioma Lymphoma	**Multiple** Metastasis Lymphoma	**Cystic/Necrotic** Glioblastoma Metastasis Hemangioblastoma Lymphoma in AIDS

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The WHO and Tumor Nomenclature


Neuro-Oncology

The 2021 WHO Classification of Tumors of the Central Nervous System: a summary

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The WHO and Tumor Nomenclature

- Taxonomy Changes
  - Molecular grouping
- Nomenclature Changes
  - Simplification
  - Locations dropped
- Grading Changes
  - Arabic numerals
- Specific Changes
  - Gliomas, Glioneuronal Tumors and Neuronal
  - Choroid Plexus Tumors
  - Medulloblastomas
  - Embryonal Tumors
  - Pineal Tumors
  - Meningiomas
  - Mesenchymal Tumors
  - Nerve Tumors
  - Lymphomas
  - Sellar Tumors
  - Metastatic Tumors

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The WHO and Tumor Nomenclature

- Molecular changes incorporated
- This is NOT universal
  - Some types rarely diagnosed with molecular approach
- Some types grouped by markers ie: IDH or H3 status
- This is likely an intermediary hybrid
- Type and subtype replace “entity

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The WHO and Tumor Nomenclature

- Locational names (ie chordoid glioma of the third ventricle) modified to drop location unless of clinical utility
- Modifiers such as "anaplastic" have been removed

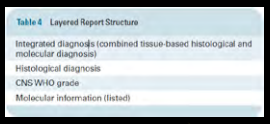


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The WHO and Tumor Nomenclature

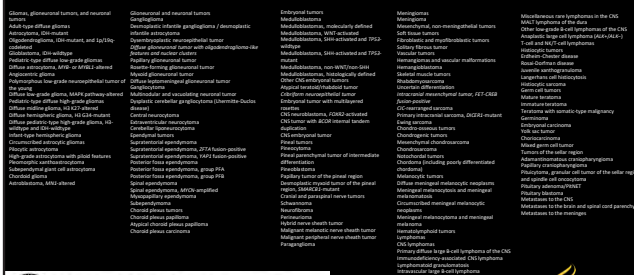
- Roman numerals are OUT!
- Arabic numerals provide for less chance of error
- Grading within types
  - IDH-mutant astrocytoma grades 2-4 (No more "anaplastic")
  - Meningiomas grade
- WHO grade no longer restricted to histological grade
- NOS or NEC (not elsewhere classified)



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The WHO and Tumor Nomenclature



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Advanced Imaging Options

- Diffusion including DTI
- Functional MRI
- MR Perfusion
- PET MR
- APT Imaging
- MR Spectroscopy

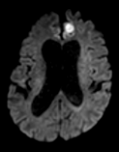


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Diffusion Imaging

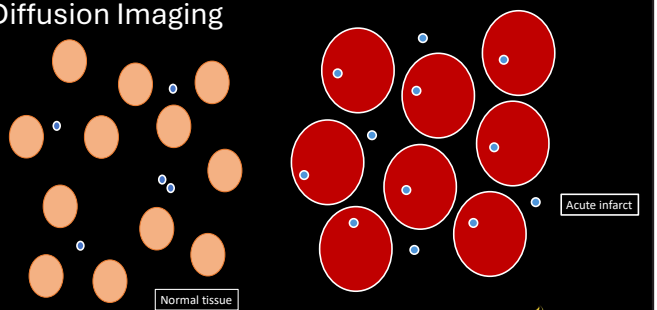
- Based on ease of water diffusion
- States that result in cell swelling make free diffusion more difficult= RESTRICTED
- Images are T2 weighted and prone to "shine through"
- ADC values (apparent diffusion coefficient) are quantifiable sum of vectors also acquired



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Diffusion Imaging

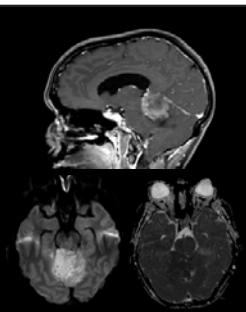


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Diffusion Imaging

In tumor imaging, restricted diffusion has been found to correspond to densely cellular tumor, often higher grade

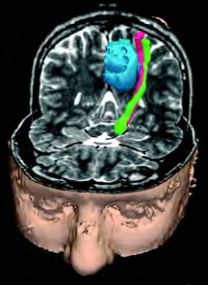


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Diffusion Tensor Imaging

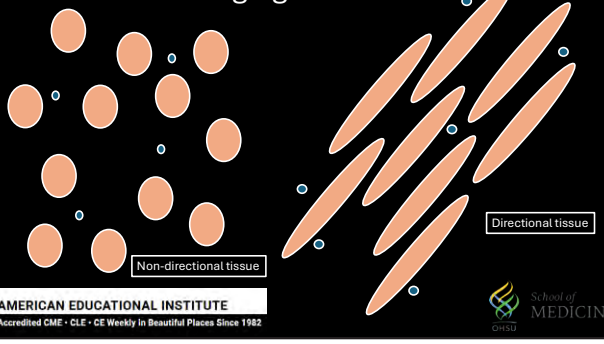
- DTI data allows for generation of estimates of white matter fiber pathways
- Used to evaluate effect of tumor on adjacent brain
  - Disruption
  - Infiltration
  - Displacement



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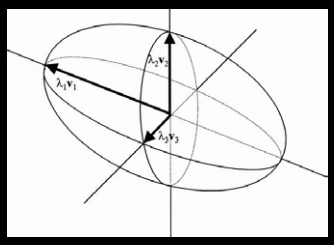
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Diffusion Tensor Imaging



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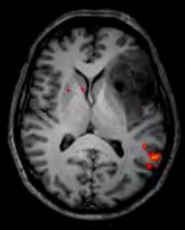
Diffusion Tensor Imaging



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Functional MRI

- Task-based (usually) study evaluating changes in blood flow in real time
- Most often BOLD technique
- Can be combined with DTI



Sentence Completion Task

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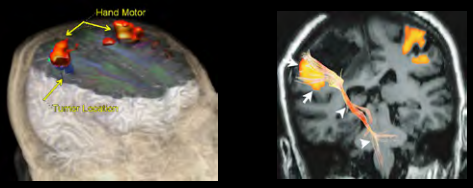
Functional MRI

- Limitations
  - Requires patient cooperation
  - Very motion sensitive
  - Somewhat age-dependent
  - Neurovascular uncoupling
  - Qualitative information
- Most common task paradigms:
  - Hand motor
  - Foot motor
  - Tongue motor
  - Word generation
  - Sentence completion
  - Rhyming
  - Passive listening
  - Object naming

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Functional MRI

Combination of activation clusters with tractography seeding may guide operative approach



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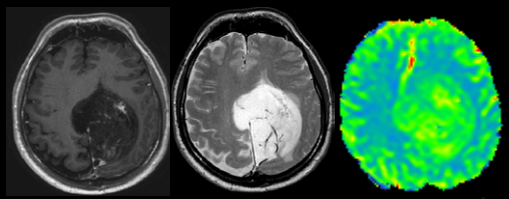
MR Perfusion Imaging

- Most common technique is DSC
- Image acquisition during gadolinium administration
- EPI technique, T2-weighted
- Injection at 3-5mL/sec
- Inflow causes decrease in T2* effects and subsequent recovery as the contrast washes out
- Generate rCBV, MTT, TTP. CBF is tricky…

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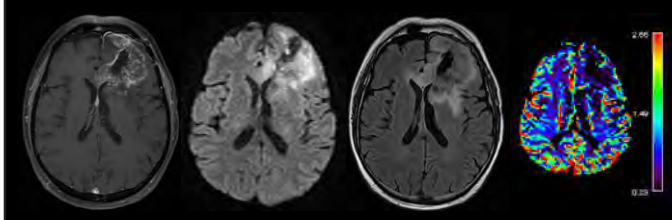
MR Perfusion Imaging

- Tumor Imaging
  - Most useful in the setting of tumor vs radiation necrosis
  - Also assess questionable tumor grade



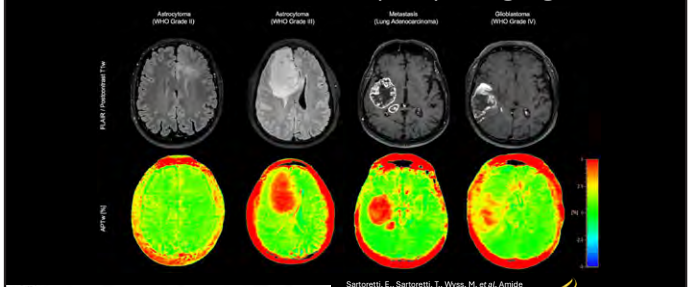
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MR Perfusion Imaging



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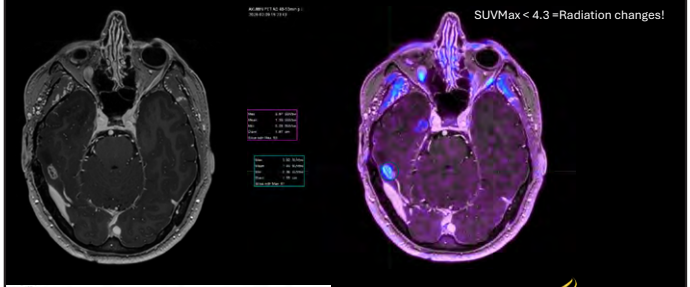
MR Amide Proton Transfer (APT) Imaging



Sartoretti, E., Sartoretti, T., Wyss, M. *et al.* Amide proton transfer weighted (APTw) imaging based radiomics allows for the differentiation of gliomas from metastases. *Sci Rep* **11**, 5506 (2021). https://doi.org/10.1038/s41598-021-85168-8

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MR/PET



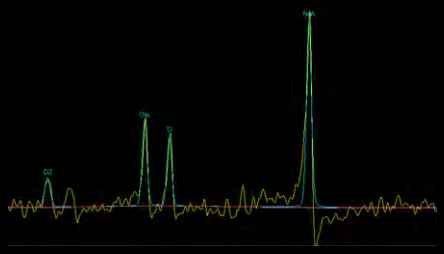
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MR Spectroscopy

- Generates metabolite maps within a selected voxel (sample area)
- Originally MRS focused on phosphorus spectroscopy, but now H^1 is the rule
- Typical peaks in normal brain include:
  - Myoinositol
  - Choline
  - Creatine
  - N-acetyl aspartate
  - Lipids

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MR Spectroscopy



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MR Spectroscopy

- NAA- marker of axonal density
- Cr- relatively stable (but not always!)
- Cho- marker of cellular turnover
- Lactate- marker of anaerobic metabolism
- Ala- may be elevated in meningiomas
- Lipids- often elevated in metastases or MS

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MR Spectroscopy

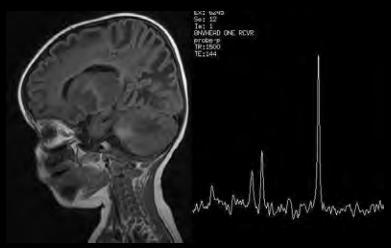
- In 2004 CMS stated that there was not adequate evidence that MRS was reasonable and necessary for brain tumor diagnosis
- Practically speaking- a limited problem solving tool at best
- Numerous artifacts and limitations
- Findings typically nonspecific
- May have greater utility at high field strength (7T+)

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MR Spectroscopy

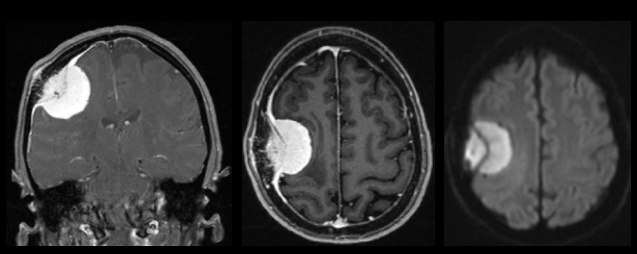
"One of the few diseases to which spectroscopy has made a contribution."

-Anne Osborn, MD

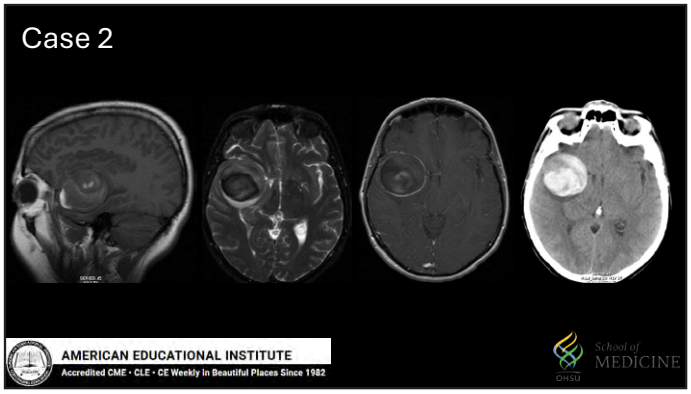


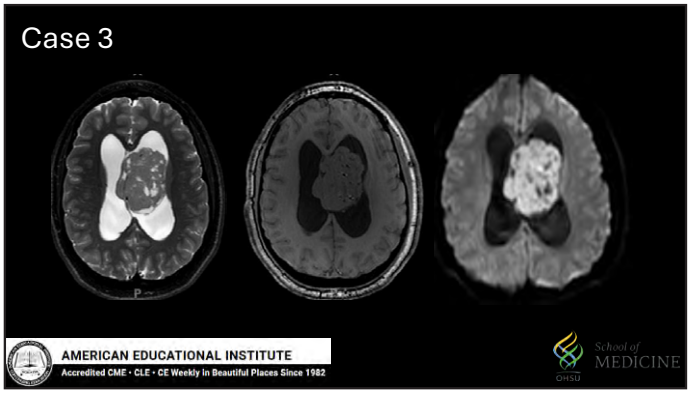
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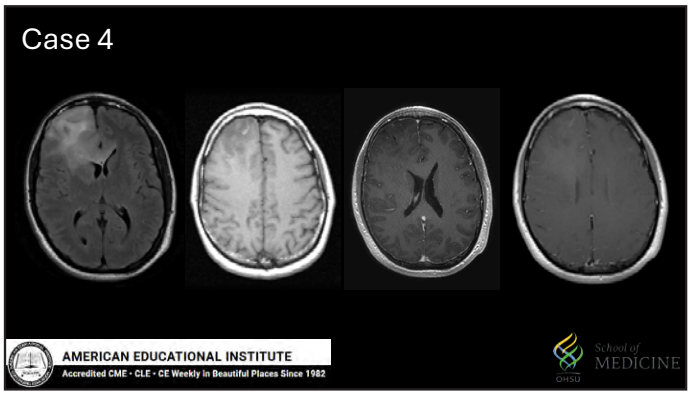
Case 1

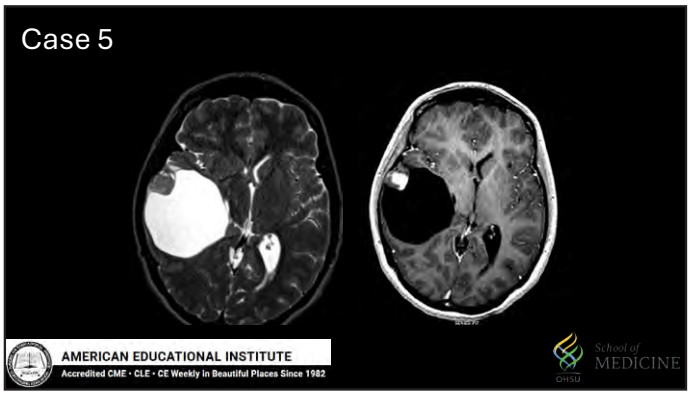


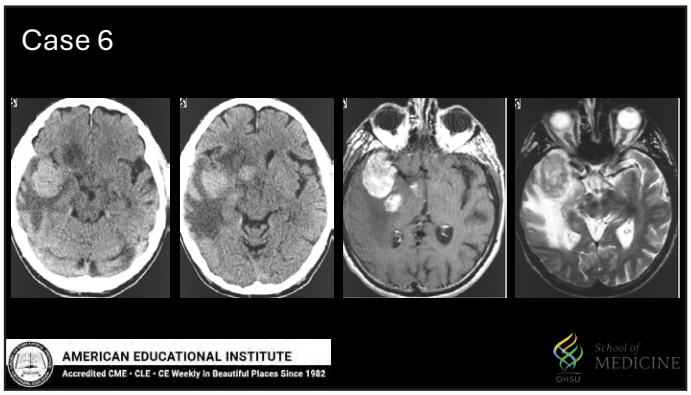
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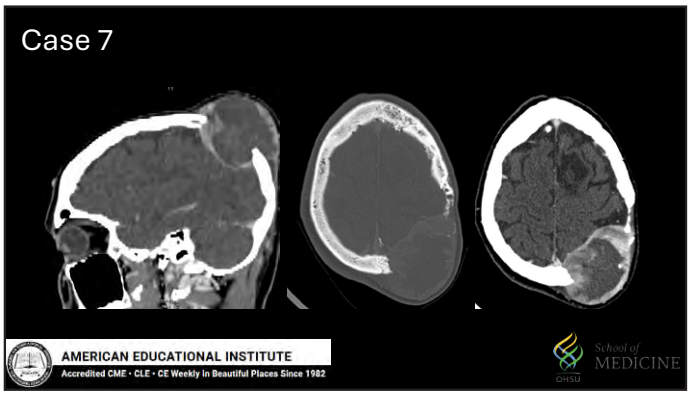

Case 2
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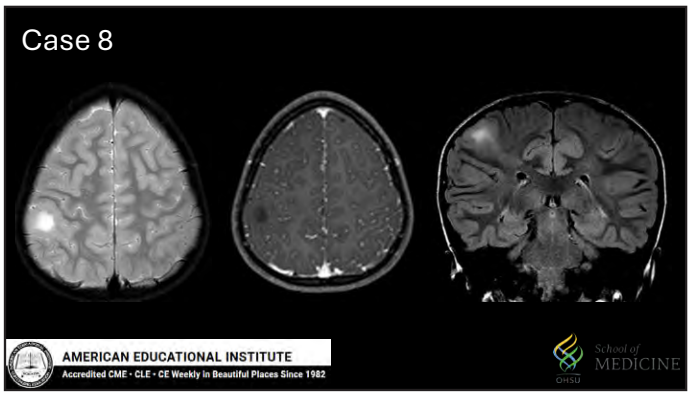

Case 3
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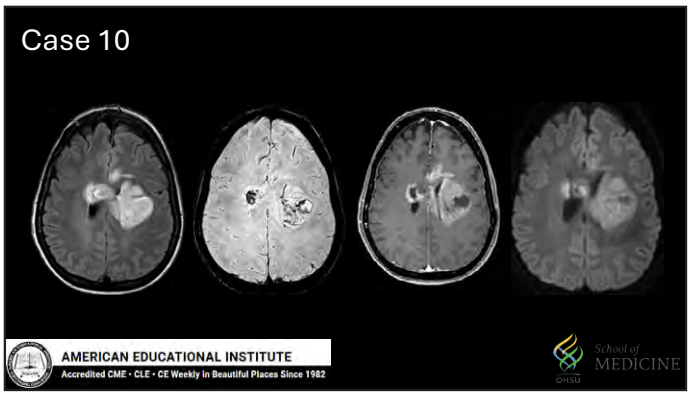

Case 4
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Thank You
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SELF EVALUATION

Adult Brain Tumors

1. T/F - Restricted diffusion within a brain tumor generally suggests a densely cellular, often higher-grade tumor.

2. According to the updated WHO classification, which adult-type diffuse glioma is defined by IDH-wildtype status?

a. Astrocytoma
b. Oligodendroglioma
c. Glioblastoma
d. Pilocytic astrocytoma

3. T/F - The WHO tumor grading system continues to use Roman numerals (I–IV) to classify CNS tumors.

4. Which advanced MRI technique is most useful for distinguishing recurrent tumor from radiation necrosis?

a. Functional MRI
b. Diffusion Tensor Imaging
c. MR Perfusion Imaging
d. MR Spectroscopy

5. When evaluating a newly discovered intracranial mass, which of the following is one of the first questions that should be answered?

a. What is the molecular subtype?
b. Where is the lesion located (intra- vs. extra-axial)?
c. What is the patient's Karnofsky score?
d. What chemotherapy regimen should be used?

Answer Key: 1. T, 2. C, 3. F, 4. C, 5. B

FACULTY

Don C. Yoo, MD, FACR

Don C. Yoo, MD, FACR is a Professor of Diagnostic Imaging and Clinician Educator at The Warren Alpert Medical School of Brown University, and Director of Nuclear Medicine at Rhode Island and The Miriam Hospitals. He also serves as Director of Medical Student Radiology Education at Brown. Trained at SUNY Brooklyn, with residency at Brown and fellowship in nuclear medicine in Boston, Dr. Yoo is a nationally recognized leader in nuclear medicine and molecular imaging. He has held leadership roles with the American College of Radiology and RSNA, and is an active educator and speaker at national meetings and academic institutions.

You may contact Dr. Yoo with any questions or comments at don_yoo@brown.edu.

Overview of Theranostics in Oncology
Don C. Yoo, MD, FACR

Overview of Theranostics in Oncology

Don C. Yoo, MD, FACR
Professor of Radiology, Clinician Educator
The Warren Alpert Medical School of Brown University
Director of Medical Student Radiology Education
Director of Nuclear Medicine, Rhode Island and The Miriam Hospitals



BROWNHealth UNIVERSITY
BROWN Alpert Medical School

Objectives

1. "Theranostics" review the evolution of oncologic radiopharmaceuticals used in neuroendocrine and prostate cancer
2. Discuss the economic impact of recently approved diagnostic oncologic PET tracers and therapies
3. Discuss why the Nuclear Regulatory Commission (NRC) is considering whether or not to allow new limited scope Authorized User (AU) pathway for certain therapeutic and theranostic radiopharmaceuticals
4. New Innovations and future directions in Theranostics

Disclosures

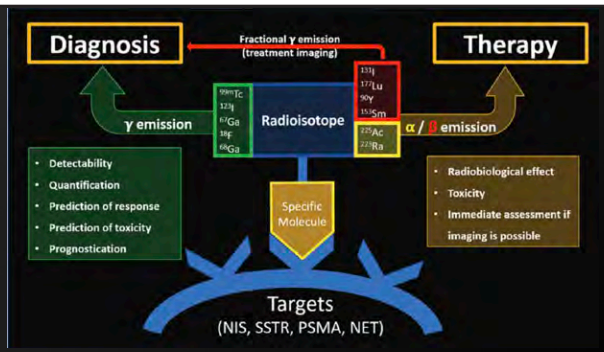
Consultant – Invicro (Perceptive)

Introduction - Theranostics

Theranostics - combination of therapy and diagnostic imaging.

Theranostics relatively new term – 1998
-first used by John Funkhouser – PharmaNetics
-combine diagnosis, treatment, and follow-up of disease

Thera – Therapy (B emitter Lu-177) or Alpha emitter (Ac-225)
nostics- Diagnostics (Ga68-DOTATATE, Ga68-PSMA)

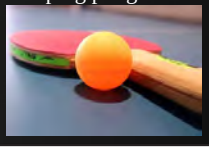


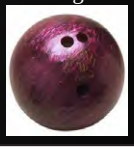
Marin, J. F. G. *et al.* Theranostics in Nuclear Medicine: Emerging and Re-emerging Integrated Imaging and Therapies in the Era of Precision Oncology. *Radiographics* 40, 1715–1740 (2020).

Comparing masses Beta and Alpha Particle

Mass of beta particle is 1/2,000th of alpha particle

Ping pong ball = 3 grams
Bowling ball= 6 kg or 6,000 grams
Mass of ping pong ball is 1/2,000th of bowling ball!





Courtesy of
Dr. Phillip Kuo

Mechanism of action - Alpha particle vs Beta particle

Alpha shorter range compared to beta
(100 microns instead of mm, 1mm is 1000 microns)

Alpha also can't kill deep in tumor so repeated doses required



First Radioactive Therapy/Theranostic- Radioiodine

March 31, 1941- Saul Hertz delivered the first therapeutic dose of radioiodine for hyperthyroidism


Local Researchist Discovers Cure for Goitre Through A-Bomb By-Product

BY SHIRLEY E. GIBLEY

In 1936, the field of radioactive isotopes and their possible uses to extend and test medical theories and biochemical processes was just coming to the forefront of medical research. In that same year, Dr. Saul Hertz, of Brookline, attended a Harvard Medical School conference and was particularly inspired by a speech delivered by Dr. Karl T. Compton, in which the President of Massachusetts Institute of Technology made a plea for medical men to become interested in the application of the newer physical methods which were then becoming available through technological studies.

Thus was born the germ of an idea with which Dr. Hertz has worked, studied and experimented, and which today has resulted in his revolutionary discovery of a new treatment for Graves' dise- case (popularly referred to as pop-eyed goitre) through the application of radio- active iodine.

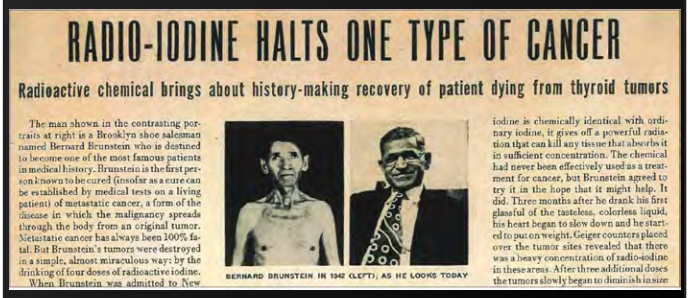
(Continued on Page 11)

DR. SAUL HERTZ
Commander (MC) USNR

UN Commission In Report on

Hertz B. A tribute to Dr. Saul Hertz: The discovery of the medical uses of radioiodine. World J Nucl Medicine. 2019;18(1):8–12.

Extension to Cancer


RADIO-IODINE HALTS ONE TYPE OF CANCER

Radioactive chemical brings about history-making recovery of patient dying from thyroid tumors

The man shown in the contrasting portraits at right is a Brooklyn shoe salesman named Bernard Brunstein who is destined to become one of the most famous patients in medical history. Brunstein is the first person known to be cured (insofar as a cure can be established by medical tests on a living patient) of metastatic cancer, a form of the disease in which the malignancy spreads through the body from an original tumor. Metastatic cancer has always been 100% fatal. But Brunstein's tumors were destroyed in a simple, almost miraculous way: by the drinking of four doses of radioactive iodine.

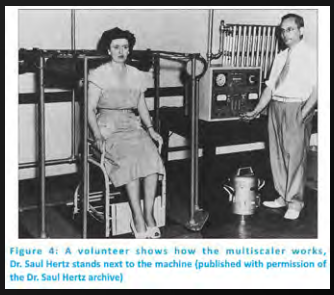
When Brunstein was admitted to New

BERNARD BRUNSTEIN IN 1942 (LEFT), AS HE LOOKS TODAY

iodine is chemically identical with ordinary iodine, it gives off a powerful radiation that can kill any tissue that absorbs it in sufficient concentration. The chemical had never been effectively used as a treatment for cancer, but Brunstein agreed to try it in the hope that it might help. It did. Three months after he drank his first glassful of the tasteless, colorless liquid, his heart began to slow down and he started to put on weight. Geiger counters placed over the tumor sites revealed that there was a heavy concentration of radio-iodine in these areas. After three additional doses the tumors slowly began to diminish in size

Hertz B. A tribute to Dr. Saul Hertz: The discovery of the medical uses of radioiodine. World J Nucl Medicine. 2019;18(1):8–12.

Dx testing came later
Development of equipment to measure uptake


Figure 4: A volunteer shows how the multiscaler works, Dr. Saul Hertz stands next to the machine (published with permission of the Dr. Saul Hertz archive)

Hertz B. A tribute to Dr. Saul Hertz: The discovery of the medical uses of radioiodine. World J Nucl Medicine. 2019;18(1):8–12.

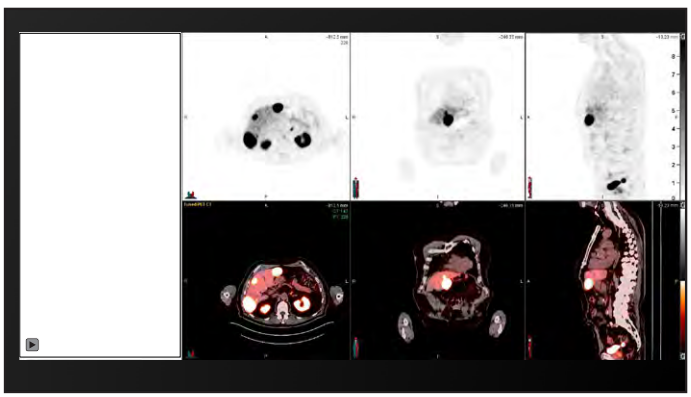
Saul Hertz - Theranostics

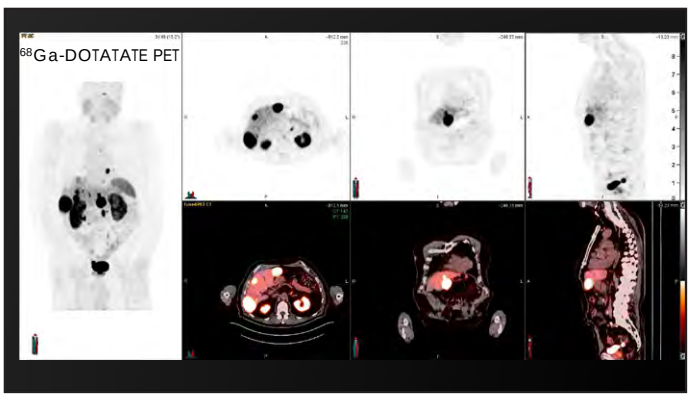
" …with the rapid development of the field of Nuclear Physics and its application to the problems of medical research and treatment, it might be desirable for the hospital to build up a new class of specialists. I suppose an appropriate name for them might be 'Atomizers', 'isotopers' or 'Atomic Specialists'."

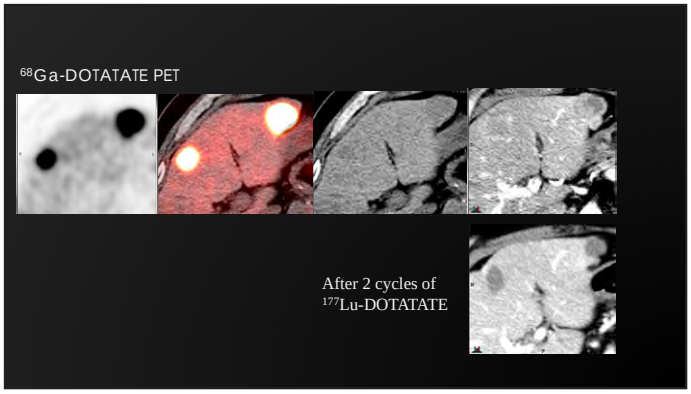
Hertz B. A tribute to Dr. Saul Hertz: The discovery of the medical uses of radioiodine. World J Nucl Medicine. 2019;18(1):8–12.

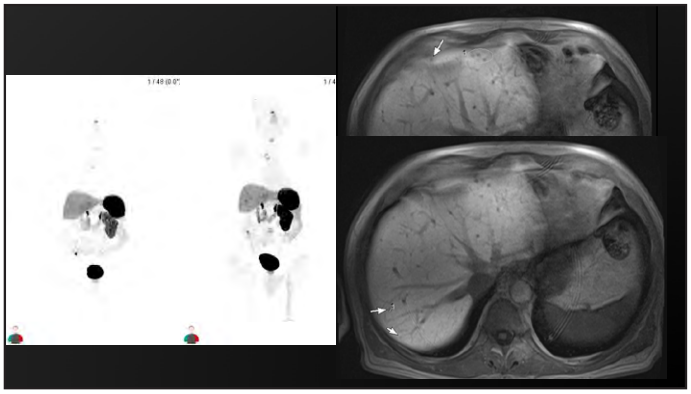
History of FDA Approval of Oncologic and Therapeutic PET Tracers Used in Neuroendocrine Tumors 2016 - 2025

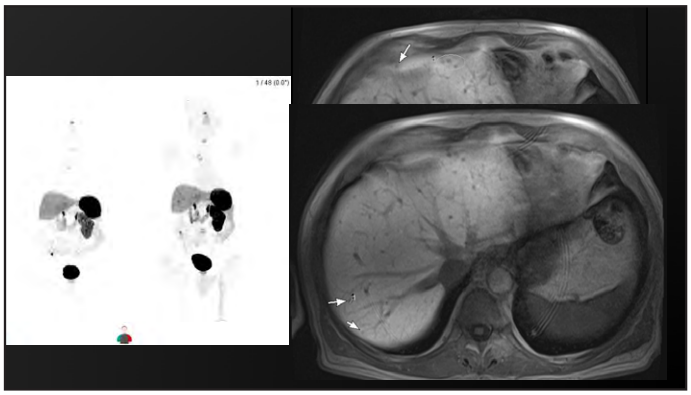
Tracer	Year	Indication
68Ga DOTATATE	2016	Neuroendocrine Tumor
177Lu DOTATATE	2018	Treatment Somatostatin receptor-positive (GEP-NETs) in Adults
64Cu DOTATATE	2020	Neuroendocrine Tumor
177Lu DOTATATE	2024	Treatment Somatostatin receptor-positive (GEP-NETs) in Children >12 year







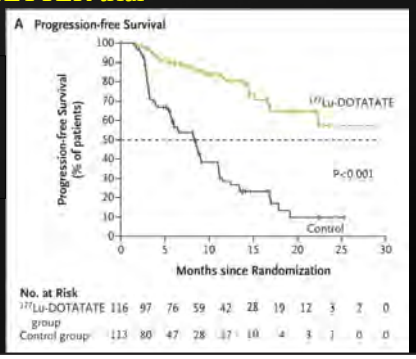






NETTER trial

^{177}Lu-DOTATATE 200 mCi (4 iv infusions/ 8 weeks) + octreotide long-acting repeatable [LAR]
vs.
octreotide LAR alone



Strosberg J et al. N Engl J Med 2017;376:125-135.

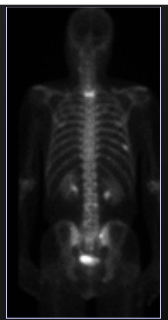
USA Prostate Cancer Statistics Estimates 2025

Prostate Cancer	US
Incidence	313,780 (#1 Men)
Death rate	35,770 (#2 Men) 5-year survival for mCRPC is 15%

American Cancer Society's publication, Cancer Facts & Figures 2025

History of FDA Approval of Oncologic PET Tracers Used in Prostate Cancer and NM Therapies 2012 - 2025

Tracer	Year	Indication
11C Choline	2012	Recurrent prostate cancer (Mayo Clinic)
Radium-223 chloride (Xofigo)	2013	Treatment Prostate cancer bone metastases
18F Fluciclovine (Axumin)	2016	Recurrent prostate cancer
68Ga PSMA-11 (Illuccix)	2020	Initial Staging and Recurrent prostate cancer (UCLA and USCF)
18F-DCFPyL, PSMA (Pylarify)	2021	Initial Staging and Recurrent prostate cancer
177Lu-vipivotide tetraxetan (Pluvicto)	2022	TX PSMA-positive mCRPC (AR pathway inhib and taxane chemo)
68Ga PSMA-11 (Illuccix)	2022	Initial Staging and Recurrent prostate cancer
18F Flotufolastat (Posluma)	2023	Initial Staging and Recurrent prostate cancer
177Lu-vipivotide tetraxetan (Pluvicto)	2025	TX PSMA-positive mCRPC (AR pathway inhib without taxane chemo)

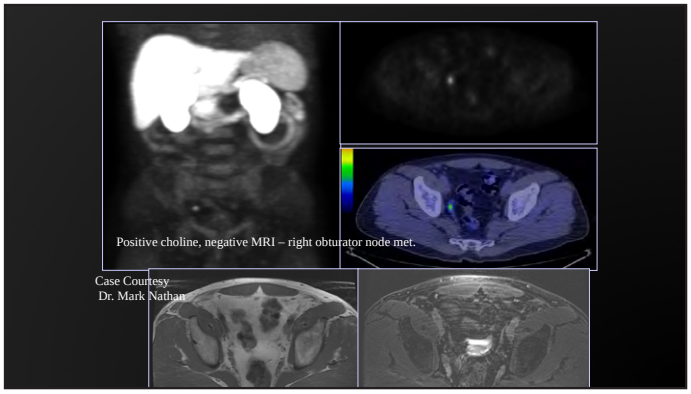


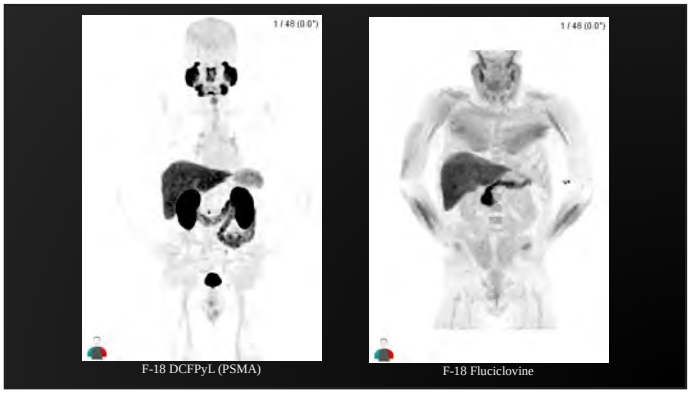
Posterior bone scan shows limited bone metastatic disease.

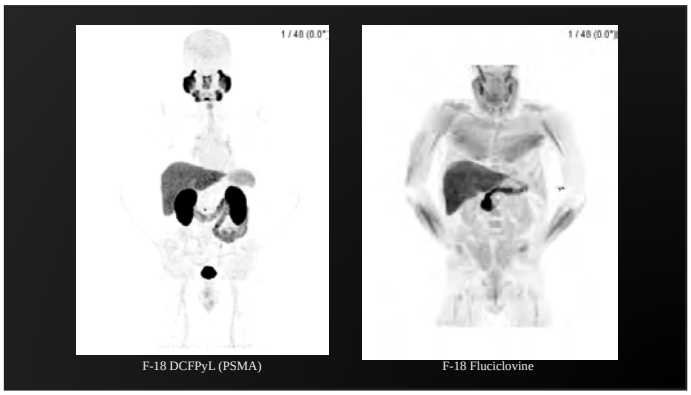


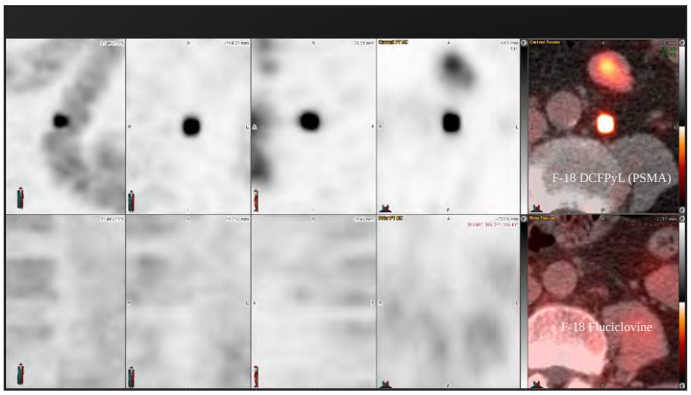
Posterior MIP choline PET, extensive bone metastatic disease.

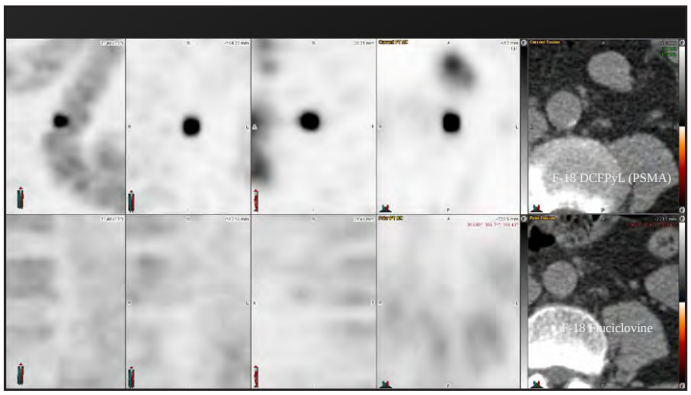
Case Courtesy of Dr. Mark Nathan

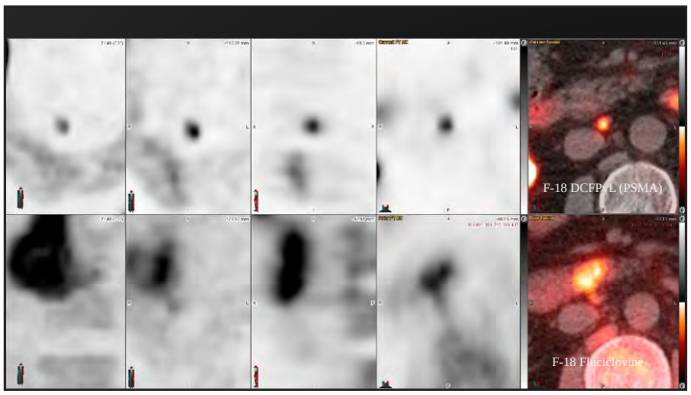

Positive choline, negative MRI – right obturator node met.
Case Courtesy
Dr. Mark Nathan

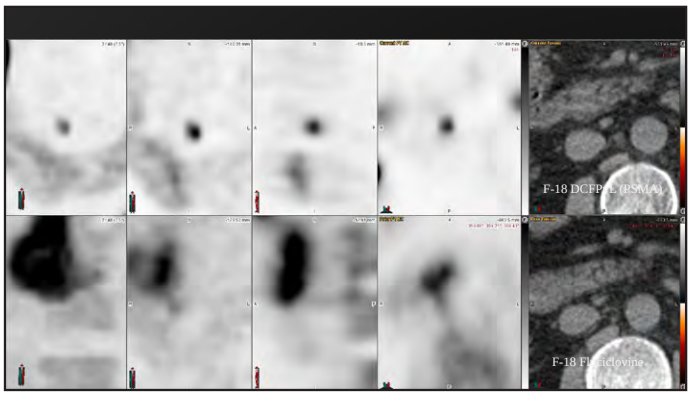

F-18 DCFPyL (PSMA)
F-18 Fluciclovine

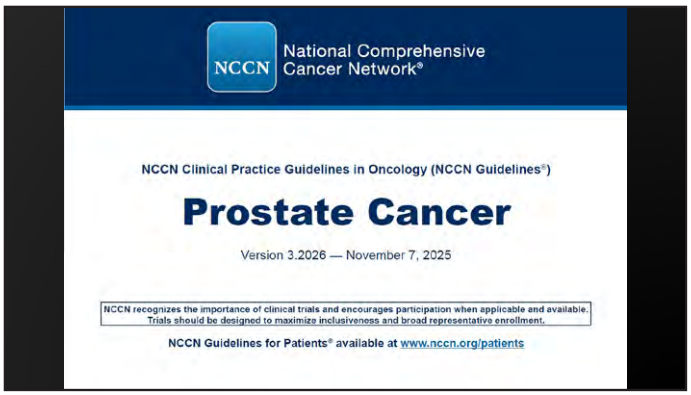

F-18 DCFPyL (PSMA)
F-18 Fluciclovine


F-18 DCFPyL (PSMA)
F-18 Fluciclovine


F-18 DCFPyL (PSMA)
F-18 Fluciclovine


F-18 DCFPyL (PSMA)
F-18 Fluciclovine


F-18 DCFPyL (PSMA)
F-18 Fluciclovine

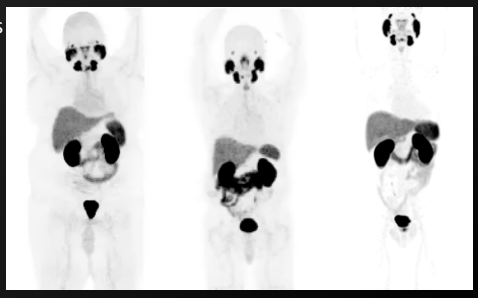

NCCN
National Comprehensive Cancer Network®
NCCN Clinical Practice Guidelines in Oncology (NCCN Guidelines®)
Prostate Cancer
Version 3.2026 — November 7, 2025
NCCN recognizes the importance of clinical trials and encourages participation when applicable and available. Trials should be designed to maximize inclusiveness and broad representative enrollment.
NCCN Guidelines for Patients® available at www.nccn.org/patients

NCCN recommends FDA-approved PSMA agents

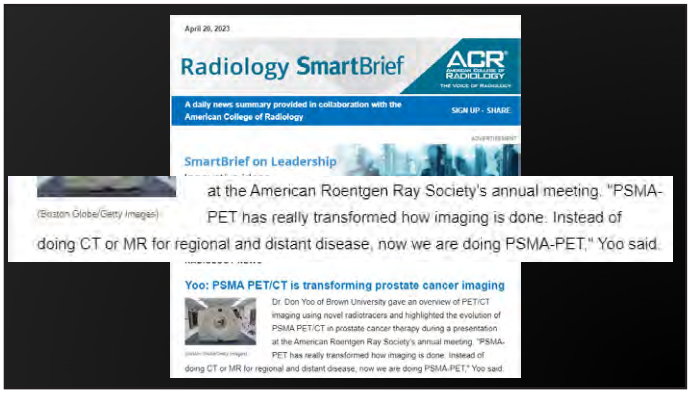
^{18}F-DCFPyL (Pylarify)

^{68}Ga-PSMA-11 (Illuccix)

^{18}F-Flotufolastat (rh-PSMA-7.3) (Posluma)



^{18}F-DCFPyL ^{68}Ga-PSMA-11 ^{18}F-Flotufolastat



Prostate Cancer Imaging

Local (primary disease)
- -MRI
- -TRUS

Regional (pelvis)
- -CT
- -MRI

Distant
- -CT
- -MRI
- -Bone Scan

Prostate Cancer Imaging

Local (primary disease)
- -MRI
- -TRUS

Regional (pelvis)
- -CT
- -MRI

Distant
- -CT
- -MRI
- -Bone Scan

PSMA PET/CT

NCCN 2025

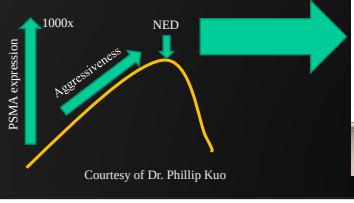
"Because of increased sensitivity and specificity of PSMA-PET tracers for detecting micrometastatic disease compared to CT, MRI, and bone scan at both staging and BCR, PSMA-PET/CT or PSMA PET/MR can serve as a more effective front line imaging tool for these patients."

NCCN 2025

"Because of increased sensitivity and specificity of PSMA-PET tracers for detecting micrometastatic disease compared to CT, MRI, and bone scan at both staging and BCR, PSMA-PET/CT or PSMA PET/MR can serve as a **more effective** front line imaging tool for these patients."

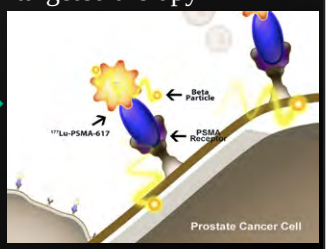
Theranostics combining PET and RLT

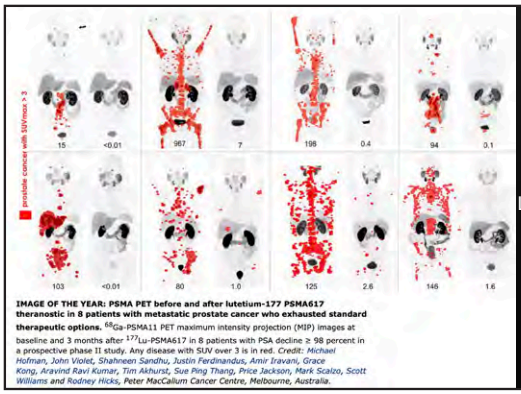
<u>PSMA-PET</u>
Assess expression level of PSMA on tumors throughout whole body



Courtesy of Dr. Phillip Kuo

Treatment with PSMA-targeted therapy





2018 SNMMI Image of the Year Ga-68 PSMA-11 Imaging for Lu-177 PSMA-617

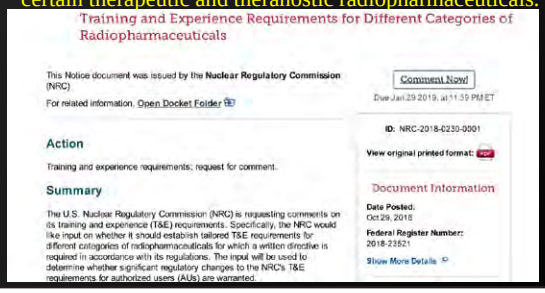
2018 - NRC considering changing key elements of 10 CFR 35.390 T & E requirements for AU

Whether it should establish category-specific T & E requirements

What specialty board certificates should be recognized for AU-eligibility (other than ABR, ABNM)

Whether there is a shortage in the number of AUs such that patient access to the agents is diminished

2018 - NRC considering changing key elements of 10 CFR 35.390 T & E requirements for AU to allow limited scope AU pathway for certain therapeutic and theranostic radiopharmaceuticals.



Training and Experience Requirements for Different Categories of Radiopharmaceuticals

This Notice document was issued by the **Nuclear Regulatory Commission** (NRC)

For related information, Open Docket Folder

Comment Now!

Due Jan 29 2019, at 11:59 PM ET

Action

Training and experience requirements; request for comment.

Summary

The U.S. Nuclear Regulatory Commission (NRC) is requesting comments on its training and experience (T&E) requirements. Specifically, the NRC would like input on whether it should establish tailored T&E requirements for different categories of radiopharmaceuticals for which a written directive is required in accordance with its regulations. The input will be used to determine whether significant regulatory changes to the NRC's T&E requirements for authorized users (AUs) are warranted.

ID: NRC-2018-0230-0001

View original printed format:

Document Information

Date Posted: Oct 29, 2018

Federal Register Number: 2018-23621

Show More Details



ORIGINAL ARTICLE CLINICAL PRACTICE MANAGEMENT

Training and Education Requirements for Authorized Users of Therapeutic Radiopharmaceuticals: Changes Under Consideration for 10CFR35.390 and Their Potential Impact

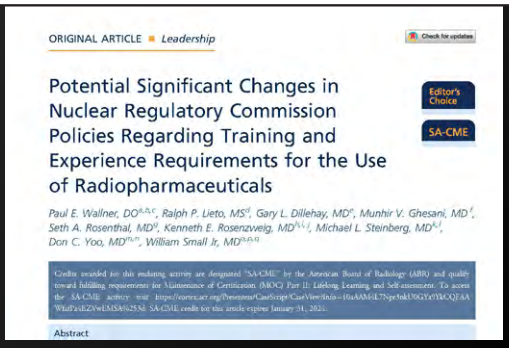
Paul E. Wallner, DO, Ralph P. Lieto, MS, Gary L. Dillehay, MD, Munhir V. Ghesani, MD, Seth A. Rosenthal, MD, Kenneth E. Rosenzweig, MD, Michael L. Steinberg, MD, Don C. Yoo, MD

Abstract

The US Nuclear Regulatory Commission (NRC) and 38 Agreement States have the regulatory authority to promulgate and enforce regulations related to the use of radioisotopes for medical purposes. Elements of these regulations include training and experience (T&E) requirements for individuals authorized to use the agents. These regulations are specified in 10CFR35.390. At this time, the NRC is considering significant revisions to the T&E requirements. This article describes current regulations and concerns related to the proposed changes and details the ACR organizational response.

Key Words: NRC; training and experience requirements for radiopharmaceuticals; Radiopharmaceutical administration regulations; Radiopharmaceutical approved users

J Am Coll Radiol 2019;16:1572-1576. Copyright © 2019 American College of Radiology



ORIGINAL ARTICLE *Leadership*

Potential Significant Changes in Nuclear Regulatory Commission Policies Regarding Training and Experience Requirements for the Use of Radiopharmaceuticals

Editor's Choice

SA-CME

Paul E. Wallner, DO, Ralph P. Lieto, MS, Gary L. Dillehay, MD, Munhir V. Ghesani, MD, Seth A. Rosenthal, MD, Kenneth E. Rosenzweig, MD, Michael L. Steinberg, MD, Don C. Yoo, MD, William Small Jr, MD

Abstract

J Am Coll Radiol. 2021 Feb;18(2):312-317.

New Pipeline - Redesigned ABR (2017) 16 month Pathway Combined Training and Dual Certification – Radiology and Nuclear Medicine

More than 200 residents have been enrolled in the ABR 16-month pathway leading to specialty certification in diagnostic radiology (DR) and subspecialty certification in nuclear radiology (NR)

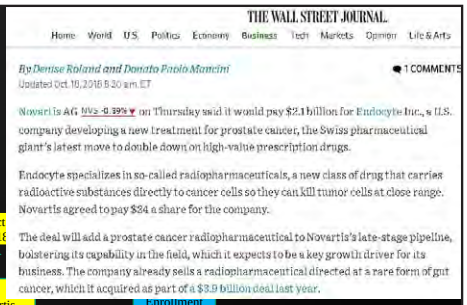
56 participating DR residencies and 1 Integrated IR residency
-Many residencies have enrolled more than one resident

NRC ruling on AU 2/2022

NRC will maintain current authorized user (AU) training and experience (T&E) requirements

Huge win for the ACR and allies!

VISION Trial



THE WALL STREET JOURNAL.

Home World U.S. Politics Economy Business Tech Markets Opinion Life & Arts

By Denise Roland and Donato Paolo Mancini

1 COMMENTS

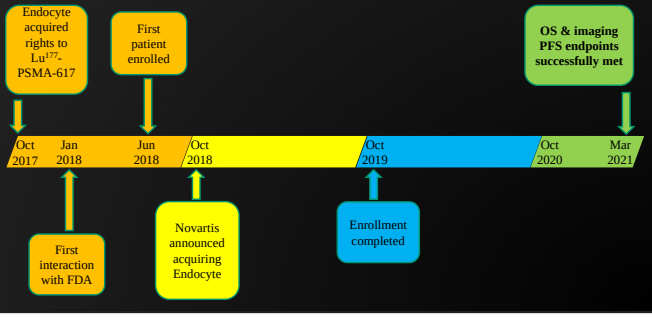
Updated Oct. 10, 2016 8:20 a.m. ET

Novartis AG NVS -0.39% on Thursday said it would pay $2.1 billion for Endocyte Inc., a U.S. company developing a new treatment for prostate cancer, the Swiss pharmaceutical giant's latest move to double down on high-value prescription drugs.

Endocyte specializes in so-called radiopharmaceuticals, a new class of drug that carries radioactive substances directly to cancer cells so they can kill tumor cells at close range. Novartis agreed to pay $34 a share for the company.

The deal will add a prostate cancer radiopharmaceutical to Novartis's late-stage pipeline, bolstering its capability in the field, which it expects to be a key growth driver for its business. The company already sells a radiopharmaceutical directed at a rare form of gut cancer, which it acquired as part of a $3.9 billion deal last year.

VISION Trial Timeline- 3.5 yrs



VISION Trial Phase 3

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Lutetium-177–PSMA-617 for Metastatic Castration-Resistant Prostate Cancer

O. Sartor, J. de Bono, K.N. Chi, K. Fizazi, K. Herrmann, K. Rahbar, S.T. Tagawa, L.T. Nordquist, N. Vaishampayan, G. El-Haddad, C.H. Park, T.M. Beer, A. Armour, W.J. Pérez-Contreras, M. DeSilvio, E. Kpamegan, G. Gericke, R.A. Messmann, M.J. Morris, and B.J. Krause, for the VISION Investigators*

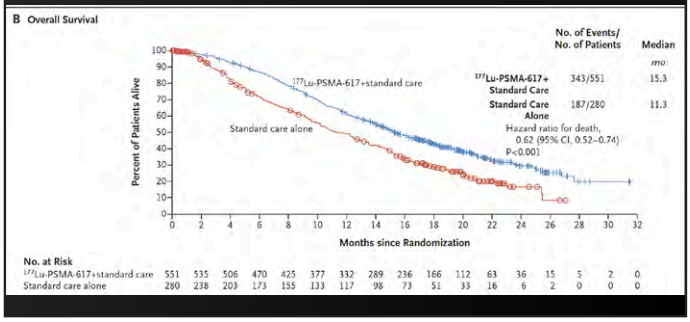
ABSTRACT

BACKGROUND

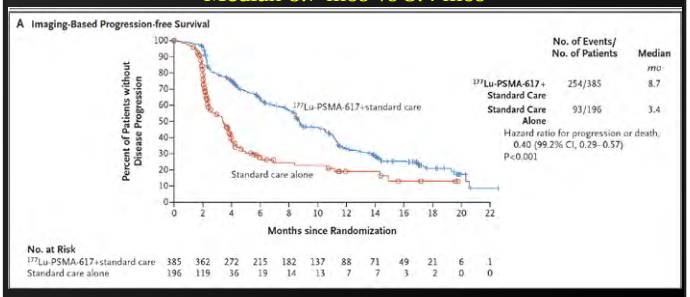
Metastatic castration-resistant prostate cancer remains fatal despite recent advances. Prostate-specific membrane antigen (PSMA) is highly expressed in metastatic castration-resistant prostate cancer. Lutetium-177 (^{177}Lu)–PSMA-617 is a radioligand therapy that delivers beta-particle radiation to PSMA-expressing cells and the surrounding microenvironment.

Sartor, O. *et al.* Lutetium-177–PSMA-617 for Metastatic Castration-Resistant Prostate Cancer. *New Engl J Med* (2021) doi:10.1056/nejmoa2107322.

Overall Survival- HR 0.62 (p<0.001)
Median OS 15.3 vs 11.3 months



Imaging-Based PFS- HR 0.40 (p<0.001)
Median 8.7 mos vs 3.4 mos



Sartor, O. *et al.* Lutetium-177–PSMA-617 for Metastatic Castration-Resistant Prostate Cancer. *New Engl J Med* (2021) doi:10.1056/nejmoa2107322.

Event	^{177}Lu-PSMA-617 plus Standard Care (N=529)		Standard Care Alone (N=205)	
	All Grades	Grade ≥3	All Grades	Grade ≥3
	number of patients (percent)			
Any adverse event	519 (98.1)	279 (52.7)	170 (82.9)	78 (38.0)
Adverse event that occurred in >12% of patients				
Fatigue	228 (43.1)	31 (5.9)	47 (22.9)	3 (1.5)
Dry mouth	205 (38.8)	0	1 (0.5)	0
Nausea	187 (35.3)	7 (1.3)	34 (16.6)	1 (0.5)
Anemia	168 (31.8)	68 (12.9)	27 (13.2)	10 (4.9)
Back pain	124 (23.4)	17 (3.2)	30 (14.6)	7 (3.4)
Arthralgia	118 (22.3)	6 (1.1)	26 (12.7)	1 (0.5)
Decreased appetite	112 (21.2)	10 (1.9)	30 (14.6)	1 (0.5)
Constipation	107 (20.2)	6 (1.1)	23 (11.2)	1 (0.5)
Diarrhea	100 (18.9)	4 (0.8)	6 (2.9)	1 (0.5)
Vomiting	100 (18.9)	5 (0.9)	13 (6.3)	1 (0.5)
Thrombocytopenia	91 (17.2)	42 (7.9)	9 (4.4)	2 (1.0)
Lymphopenia	75 (14.2)	41 (7.8)	8 (3.9)	1 (0.5)
Leukopenia	66 (12.5)	13 (2.5)	4 (2.0)	1 (0.5)



Sartor O et al, NEJM June 23, 2021; DOI: 10.1056/NEJMoa2107322

FDA approves Pluvicto for metastatic castration-resistant prostate cancer

On March 23, 2022, the Food and Drug Administration approved Pluvicto (lutetium Lu 177 vipivotide tetraxetan, Advanced Accelerator Applications USA, Inc., a Novartis company) for the treatment of adult patients with prostate-specific membrane antigen (PSMA)-positive metastatic castration-resistant prostate cancer (mCRPC) who have been treated with androgen receptor (AR) pathway inhibition and taxane-based chemotherapy.

On the same day, the FDA approved Locametz (gallium Ga 68 gozetotide), a radioactive diagnostic agent for positron emission tomography (PET) of PSMA-positive lesions, including selection of patients with metastatic prostate cancer for whom lutetium Lu 177 vipivotide tetraxetan PSMA-directed therapy is indicated. Locametz is the first radioactive diagnostic agent approved for patient selection in the use of a radioligand therapeutic agent.

Patients with previously treated mCRPC should be selected for treatment with Pluvicto using Locametz or another approved PSMA-11 imaging agent based on PSMA expression in tumors. PSMA-positive mCRPC was defined as having at least one tumor lesion with gallium Ga 68 gozetotide uptake greater than normal liver. Patients were excluded from enrollment if any lesions exceeding certain size criteria in the short axis had uptake less than or equal to uptake in normal liver (See full prescribing information, section 14).

FDA approval on March 23, 2022

Both Lu-177 PSMA-617 and Ga68-PSMA-11

FDA Approval Parallels the VISION Clinical Trial Protocol Failed ARPI and Taxane-based chemo

HIGHLIGHTS OF PRESCRIBING INFORMATION
These highlights do not include all the information needed to use PLUVICTO safely and effectively. See full prescribing information for PLUVICTO.

PLUVICTO™ (lutetium Lu 177 vipivotide tetraxetan) injection, for intravenous use
Initial U.S. Approval: 2022

INDICATIONS AND USAGE

PLUVICTO is a radioligand therapeutic agent indicated for the treatment of adult patients with prostate-specific membrane antigen (PSMA)-positive metastatic castration-resistant prostate cancer (mCRPC) who have been treated with androgen receptor (AR) pathway inhibition and taxane-based chemotherapy. (1)

DOSAGE AND ADMINISTRATION

- Select patients for treatment using LOCAMETZ® or an approved PSMA-11 imaging agent based on PSMA expression in tumors. (2.2)
- Recommended Dosage: Administer 7.4 GBq (200 mCi) every 6 weeks for up to 6 doses. (2.3)
- Dose interruption, reduction, or permanent discontinuation may be required due to adverse reactions. (2.4)

DOSAGE FORMS AND STRENGTHS

Injection: 1,000 MBq/mL (27 mCi/mL) in a single-dose vial. (3)

CONTRAINDICATIONS

None. (4)

WARNINGS AND PRECAUTIONS

- Risk From Radiation Exposure: Minimize radiation exposure during and after treatment with PLUVICTO consistent with institutional good radiation safety practices and patient treatment procedures. Ensure patients increase oral fluid intake and advise patients to void as often as possible to reduce bladder radiation. (5.1)
- Myelosuppression: Perform complete blood counts. Withhold, reduce dose, or permanently discontinue PLUVICTO and clinically treat based on severity. (2.4, 5.2)
- Renal Toxicity: Advise patients to remain well hydrated and to urinate frequently. Perform kidney function laboratory tests. Withhold, reduce dose, or permanently discontinue PLUVICTO based on severity. (2.4, 5.3)
- Embryo-Fetal Toxicity: Can cause fetal harm. Advise male patients with female partners of reproductive potential to use effective contraception. (5.4, 8.1, 8.3)
- Infertility: PLUVICTO may cause temporary or permanent infertility. (5.5, 8.3)

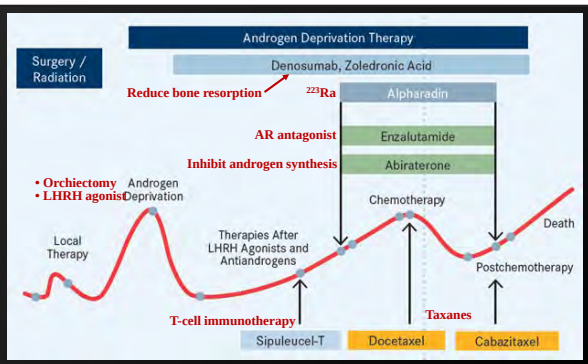
ADVERSE REACTIONS

Most common adverse reactions (≥ 20%) are fatigue, dry mouth, nausea, anemia, decreased appetite, and constipation. (6.1)
Most common laboratory abnormalities (≥ 30%) are decreased lymphocytes, decreased hemoglobin, decreased leukocytes, decreased platelets, decreased calcium, and decreased sodium. (6.1)

To report SUSPECTED ADVERSE REACTIONS, contact Novartis Pharmaceuticals Corporation at 1-888-669-6682 or FDA at 1-800-FDA-1088 or www.fda.gov/medwatch.

See 17 for PATIENT COUNSELING INFORMATION.

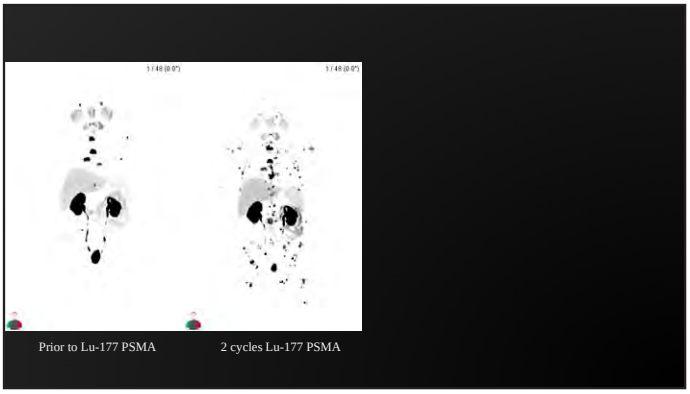
Revised: 3/2022

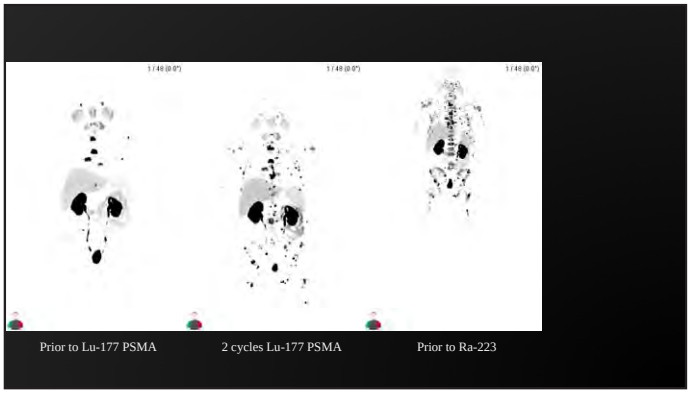


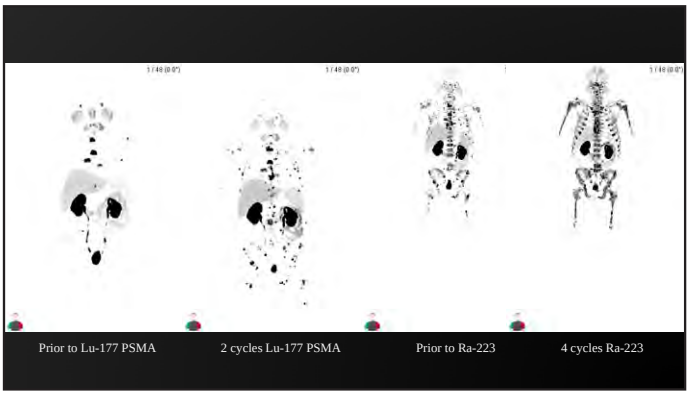
https://scotdir.com/wp-content/uploads/2016/2/prostate-cancer-treatment_1.jpeg



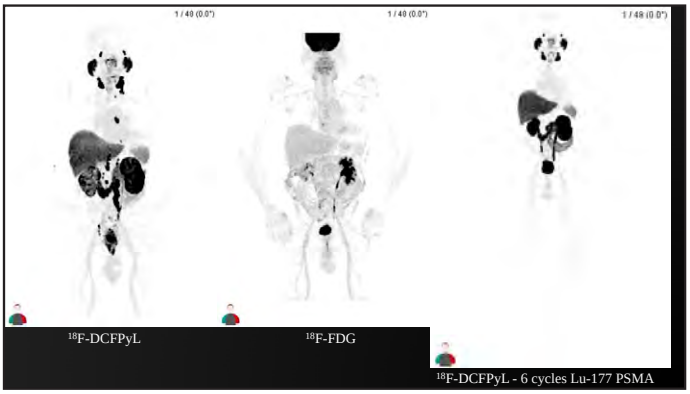
Prior to Lu-177 PSMA











[^{177}Lu]Lu-PSMA-Radioligand Therapy Efficacy Outcomes in Taxane-Naïve Versus Taxane-Treated Patients with Metastatic Castration-Resistant Prostate Cancer: A Systematic Review and Metaanalysis

Swayamjeet Satapathy[1], Ranjit K. Sahoo[2], and Chandrasekhar Bal[1]

Evaluate the impact of prior taxane chemotherapy on response and survival outcomes in mCRPC patients after [177Lu]Lu-PSMA-RLT

-taxane-naive patients had significantly better odds of biochemical response

-taxane-naive status was also a predictor of significantly better progression-free survival

Satapathy S, Sahoo RK, Bal C. J Nucl Med. 2023 Aug;64(8):1266-1271.


ARTICLE IN PRESS

ESMO

ANNALS OF ONCOLOGY

ORIGINAL ARTICLE

Final overall survival and safety analyses of the phase III PSMAfore trial of [^{177}Lu]Lu-PSMA-617 versus change of androgen receptor pathway inhibitor in taxane-naive patients with metastatic castration-resistant prostate cancer

K. Fizazi[1,*], K. N. Chi[2], N. D. Shore[3], K. Herrmann[4,5], J. S. de Bono[6], D. Castellano[7], J. M. Piulats[8], A. Fléchon[9], X. X. Wei[10], H. Mahammedi[11], G. Roubaud[12], M. Fleming[13], T. Haas[14], S. Ghebremariam[15], T. N. Kreisl[15], S. Rajagopalan[16], O. Sartor[16] & M. J. Morris[17], for the PSMAfore Investigators[†]

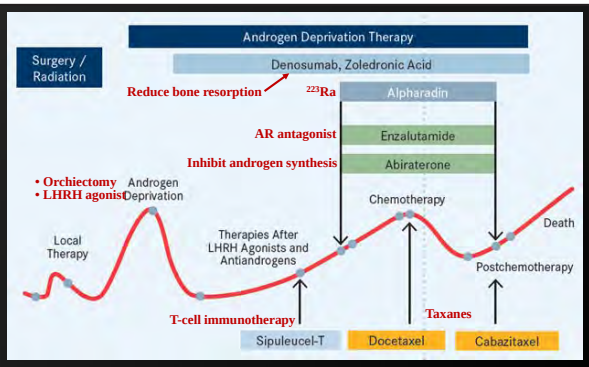
[1]Institut Gustave Roussy and Centre Oscar Lambret, Université Paris-Saclay, Villejuif, France; [2]BC Cancer, Vancouver, Canada; [3]START Carolinas Research Center, AUC Urology Specialists, Myrtle Beach, USA; [4]Department of Nuclear Medicine, University of Duisburg-Essen, German Cancer Consortium (DKTK)-University Hospital Essen, Essen; [5]National Center for Tumor Diseases (NCT), NCT West, Essen, Germany; [6]The Institute of Cancer Research and The Royal Marsden Hospital, London, UK; [7]Medical Oncology Department, Hospital Universitario 12 de Octubre, i+12 Research Institute, Madrid; [8]Catalan Institute of Oncology, Barcelona, Spain; [9]Centre Léon-Bérard, Lyon, France; [10]Dana-Farber Cancer Institute, Boston, USA; [11]Centre Jean Perrin, Clermont-Ferrand; [12]Institut Bergonié, Bordeaux, France; [13]Virginia Oncology Associates, Norfolk, USA; [14]Novartis Pharma AG, Basel, Switzerland; [15]Novartis Pharmaceuticals Corporation, East Hanover; [16]Tulane University Medical School, New Orleans; [17]Genitourinary Oncology Service, Memorial Sloan Kettering Cancer Center, New York, USA

Available online XXX 8/2025

FDA expands Pluvicto's metastatic castration-resistant prostate cancer indication

On March 28, 2025, the Food and Drug Administration expanded the indication for lutetium Lu 177 vipivotide tetraxetan (Pluvicto, Novartis Pharmaceuticals Corporation) to include adults with prostate-specific membrane antigen (PSMA)-positive metastatic castration-resistant prostate cancer (mCRPC) who have been treated with androgen receptor pathway inhibitor (ARPI) therapy and are considered appropriate to delay taxane-based chemotherapy.

Patients with previously treated mCRPC should be selected for Pluvicto using Locametz (active ingredient gallium Ga 68 gozetotide) or another approved PSMA positron emission tomography (PET) product based on PSMA expression in tumors.



https://scotdir.com/wp-content/uploads/2016/2/prostate-cancer-treatment_1.jpeg

How many patients could benefit from Theranostics for prostate cancer?

How many patients could benefit from Theranostics for prostate cancer?

~310,000 new Prostate cancer per year

Diagnostic:
^{18}F-DCFPyL (Plarify)
^{68}Ga-PSMA-11(Illuccix)
^{18}F-18F Flotufolastat (Posluma)

~180,000 (high risk and BCR)

Therapy: ^{177}Lu-PSMA
~40,000 x 6 cycles = 240,000 cycles

* Cheng et al. Nat Rev Clin Oncol 18, 801–822 (2021).

What is the costs for these treatments?

What is the costs for these treatments?

Diagnostic Radiopharmaceutical costs
180,000 studies x $3000 = $540 million

Therapy Radiopharmaceutical costs
-240,000 cycles x $40,000 = $9.6 Billion

New Innovations and
Future Directions in Theranostics

FAPI PET
Fibroblast Activation Protein Inhibitor

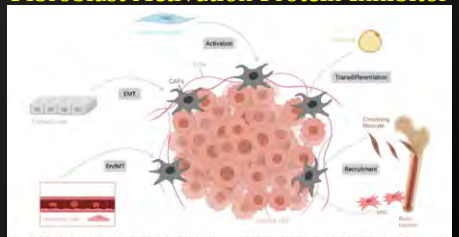


Figure 2. Origins of CAFs. CAFs represent a very heterogenous population deriving from several different cell origins such as normal resident tissue fibroblasts, fibrocytes, mesenchymal cells, epithelial and endothelial cells as well as adipocytes, pericytes and smooth muscle cells. The transformation to CAFs occurs in concordance with distinct mechanisms including activation, transdifferentiation, mesenchymal transition and recruitment. Adapted with permission from ref. [33].

Dendl K, Koerber SA, Kratochwil C, et al. FAP and FAPI-PET/CT in Malignant and Non-Malignant Diseases: A Perfect Symbiosis? *Cancers*. 2021;13:4946.

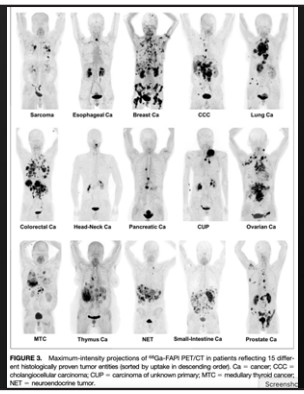


FIGURE 3. Maximum-intensity projections of ^{68}Ga-FAPI PET/CT in patients reflecting 15 different histologically proven tumor entities (sorted by uptake in descending order). Ca = cancer; CCC = cholangiocellular carcinoma; CUP = carcinoma of unknown primary; MTC = medullary thyroid cancer; NET = neuroendocrine tumor.

POTENTIAL TO IMAGE A WIDE VARIETY OF TUMOR TYPES AND LIKEWISE BROAD THERANOSTIC POTENTIAL

Kratochwil, C. *et al.* 68Ga-FAPI PET/CT: Tracer Uptake in 28 Different Kinds of Cancer. *J Nucl Med* **60**, 801–805 (2019).

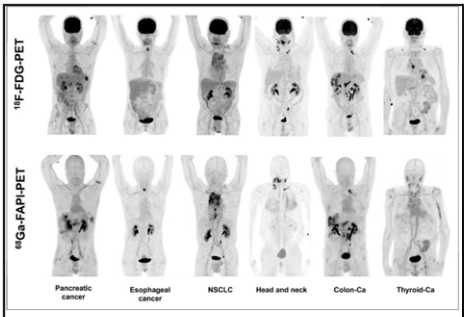
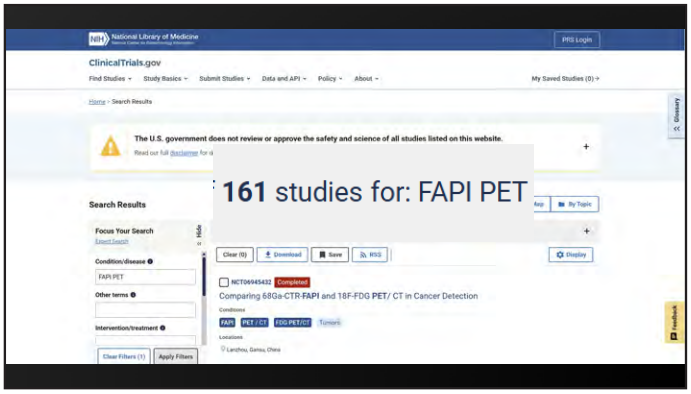


FIGURE 3. Intraindividual comparison of 6 patients with 6 different tumor entities undergoing ^{18}F-FDG PET and ^{68}Ga-FAPI PET imaging within less than 9 d. Five of 6 patients present similar strong tumor uptake with ^{18}F-FDG and ^{68}Ga-FAPI, and 3 of 6 could benefit from lower background in liver or pharyngeal mucosa. In contrast, iodine-negative thyroid cancer patient presented only minor ^{68}Ga-FAPI tracer uptake compared with ^{18}F-FDG. Ca = cancer; NSCLC = non–small cell lung cancer.

How does FAPI-PET compare to FDG-PET?

- 5/6 had similar high uptake
- Potential benefit of less background in liver and pharyngeal mucosa
- 1/6 FDG>> FAPI (radioiodine-negative thyroid CA)

Giesel FL, Kratochwil C, Lindner T, et al. 68Ga-FAPI PET/CT: Biodistribution and Preliminary Dosimetry Estimate of 2 DOTA-Containing FAP-Targeting Agents in Patients with Various Cancers. *J Nucl Med*. 2019;60:386-392.



FAPI-PET

For which tumors and clinical scenarios should FAPI-PET replace FDG
- How to use for response (assessing tumor stroma rather than tumor cells)

Optimal use of FAPI-PET for theranostics
- Patient eligibility for therapy
- Best analyses for prognostic information

Will targeting tumor stroma for RLT be effective?
- Beta particles can kill nearby tumor cells but what about alpha particles
- Will altering the tumor stroma be beneficial for combination therapies

Theranostics of tomorrow: current clinical trials of novel therapeutic and diagnostic radiopharmaceuticals

SIEMENS Healthineers Theranostics

170+

Novel therapeutic radiopharmaceuticals[1]
Isotopes and clinical trial phase

90+

Novel imaging component of theranostics[1]
Isotopes and clinical trial phase

60+ Of these therapeutic radiopharmaceuticals are based on I-131 and Ac-225, which need High energy collimation for imaging.
50+ of the Imaging components for PET imaging are Ga-68 based, which requires special consideration

Courtesy of John Hubbard

[1] Based on internal analysis. Data on file.
[2] Kim YS, Brechbiel MW. An overview of targeted alpha therapy. *Tumour Biol*. 2012;33(3):573-90. doi:10.1007/s13277-011-0286-y.

74

Unrestricted © Siemens Healthineers, 2023 MI-5870

Market overview
Anticipated global molecular imaging growth

SIEMENS Healthineers Theranostics

The global nuclear medicine radiopharmaceutical market is expected to grow 18% per year from 2020–2031.[1]

$33B in 2031[1]

Projected global nuclear medicine radiopharmaceutical market

The radiotherapeutics market is expected to grow by 32% per year from 2020–2031.[1]

In 2031 the radiotherapeutics market is expected to make up 75% of the global nuclear medicine radiopharmaceutical market

~$25B[1]

Courtesy of John Hubbard

[1] Goethals, P. and Zimmermann, R., 2021. Clinical Radiopharmaceuticals Report & Directory. NUCLEAR MEDICINE Report & Directory (PART 2) 8th. Edition. [online] MEDraysintell, p.29. Available at: <http://www.medraysintell.com> [Accessed 27 February 2022].

Accreditation "Theranostics"

SELF EVALUATION

Overview of Theranostics in Oncology

1. T/F - Theranostics combines diagnostic imaging and targeted therapy using related radiopharmaceuticals directed at the same biological target.

2. Which therapeutic radiopharmaceutical is FDA-approved for treatment of somatostatin receptor-positive gastroenteropancreatic neuroendocrine tumors (GEP-NETs)?

a. Ga-68 DOTATATE
b. Lu-177 DOTATATE (Lutathera)
c. F-18 DCFPyL
d. Radium-223

3. According to the lecture, which imaging modality is recommended by the NCCN as a more effective front-line tool than CT, MRI, and bone scan for detecting micrometastatic prostate cancer?

a. FDG PET/CT
b. Bone scintigraphy
c. PSMA PET/CT
d. Ultrasound

4. T/F - Alpha particles have a shorter tissue range but higher mass than beta particles.

5. In the VISION trial, Lu-177 PSMA-617 therapy demonstrated which of the following benefits in metastatic castration-resistant prostate cancer?

a. No improvement in survival
b. Improved overall survival and progression-free survival
c. Improved imaging response only
d. Benefit only in patients with localized disease

Answer Key: 1. T, 2. B, 3. C, 4. T, 5. B

FACULTY

Robert M. Marks, MD

Robert M. Marks, MD is a board-certified diagnostic radiologist and a professor of radiology at the University of San Diego. His clinical expertise is in body imaging of the abdomen and pelvis. His research interests include liver imaging including hepatocellular carcinoma diagnosis and surveillance. Prior to joining UC San Diego Health, he served as chief of abdominal imaging and program director of the body imaging fellowship at Naval Medical Center San Diego.

Dr. Marks previously served as a US Navy flight surgeon through two deployments.

He completed fellowship training in body imaging at Naval Medical Center San Diego and residency training in radiology at Naval Medical Center Portsmouth.

He is a member of the Society of Abdominal Radiology, American Roentgen Ray Society, Radiological Society of North America, and American College of Radiology. He has been a manuscript reviewer for multiple journals including *Abdominal Radiology,* the *American Journal of Roentgenology*, and *Radiographics*.

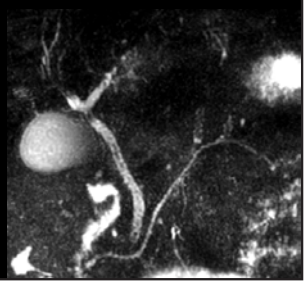
You may contact Dr. Marks with any questions or comments by email at rmarks@health.ucsd.edu.

Imaging of the Biliary System
Robert M. Marks, MD

Imaging of the Biliary System

Robert Marks, MD, FSAR
Clinical Professor of Radiology
UC San Diego Health

UC San Diego
SCHOOL OF MEDICINE
Department of Radiology



Disclosures

- Guerbet LLC

Objectives

- Describe Imaging Methods of the Biliary System
- Explain Normal and Variant Anatomy of the Biliary System
- Understand Disease Processes of the Biliary System

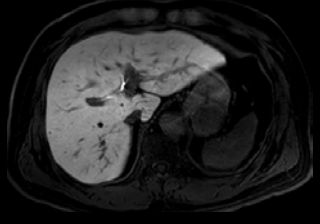
Methods of Evaluation of the Bile Ducts

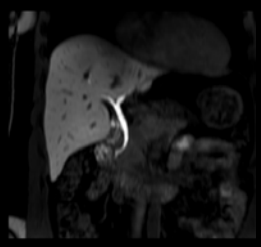
- Ultrasound is considered first line - cost and availability, no radiation
- MR and CT can be more effective than ERCP
  - Can see the entire system
  - Lower complications
- Percutaneous transhepatic cholangiography - also allows access to biliary tree for drainage or stent placement
- Nuclear Medicine - IDA (Tc99m-iminodiacetic acid)
- ERCP

MR Contrast Agents

- Eovist (Gadoxetate dimeglumine) 0.025 mmol/kg
  - 50% Hepatobiliary clearance
  - Image 20 minutes after injection
- Multihance (Gadobenate dimeglumine) 0.05 mmol/kg
  - 5% Hepatobiliary clearance
  - Image 45-60 minutes after injection

Hepatobiliary Phase

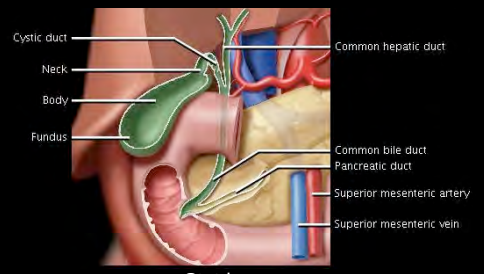




Anatomy of the Bile Ducts

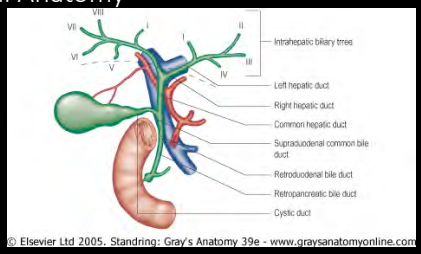
- Progressively larger branches from peripheral to central
- Eventually forming right and left hepatic ducts
- Right and left ducts form the common hepatic duct
- When cystic duct from GB meets the CHD, it becomes the common bile duct (CHD and CBD are extrahepatic)
- Ends at the sphincter of Oddi as the ampulla of Vater
- CBD and pancreatic duct share a common orifice in 60%

Anatomy of the Extrahepatic Bile Ducts



Statdx

Normal Anatomy



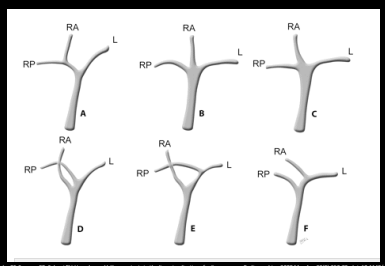
© Elsevier Ltd 2005. Standring: Gray's Anatomy 39e - www.graysanatomyonline.com

Catalano OA, Singh AH, Uppot RN, Hahn PF, Ferrone CR, Sahani DV. Vascular and biliary variants in the liver: implications for liver surgery. Radiographics. 2008 Mar-Apr;28(2):359-78. doi: 10.1148/rg.28207

Variant Anatomy

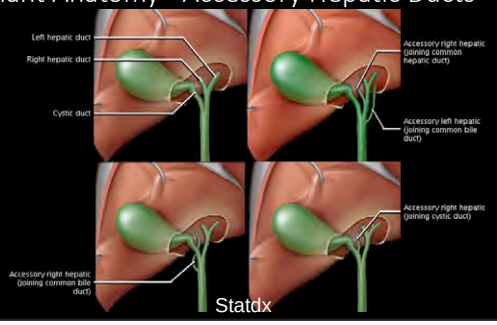
- Important to recognize as there may be implications at hepatic surgery or cholecystectomy
  - Classic anatomy only occurs in < 60%
- Crossover variant - right posterior duct drains into left hepatic duct (13-19%)
- Triple confluence - R anterior, R posterior and left hepatic ducts come together at same point (11%)
- Low insertion of the cystic duct
- Cystic duct inserts on medial rather than lateral side

Variant Anatomy



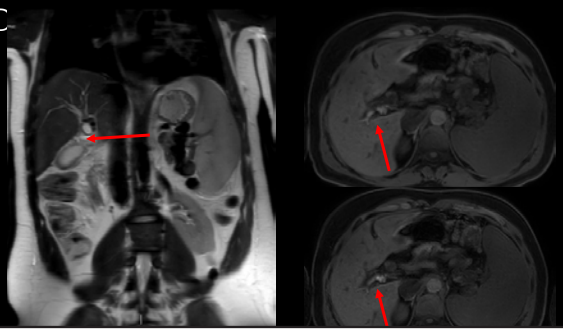
Catalano OA, Singh AH, Uppot RN, Hahn PF, Ferrone CR, Sahani DV. Vascular and biliary variants in the liver: implications for liver surgery. Radiographics. 2008 Mar-Apr;28(2):359-78. doi: 10.1148/rg.28207

Variant Anatomy - Accessory Hepatic Ducts

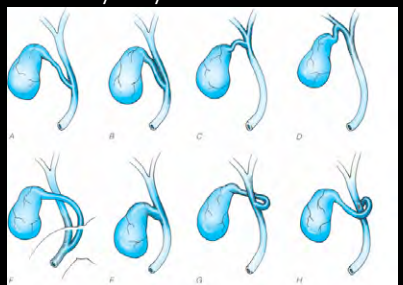


Statdx

Variant Anatomy – Cholecystohepatic D



Variant Anatomy - Cystic Duct



Sureka, Binit & Bansal, Kalpana & Patidar, Yashwant & Arora, Ankur. (2016). Magnetic resonance cholangiographic evaluation of intrahepatic and extrahepatic bile duct variations. Indian Journal of Radiology and Imaging. 26. 22. 10.4103/0971-3026.178283.

Case 1
Fetal Ultrasound

Case 1
Fetal Ultrasound



Case 1
Neonatal Ultrasound



Case 1
MRCP



Choledochal Cysts

- Congenital cystic dilation of the bile ducts
- Can be extrahepatic, intrahepatic or both
- Etiology unknown and likely multifactorial
  - High association with anomalous insertion of pancreatic duct and reflux of pancreatic enzymes
- More common in Asian population
- Leads to biliary stasis, stone formation, cholangitis and cholangiocarcinoma (2-18%)

Choledochal Cysts
Todani Classification

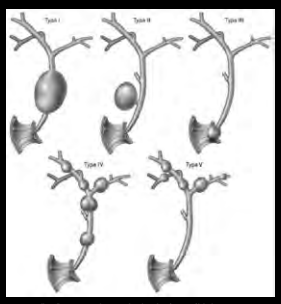
Type I – Fusiform dilation of CBD

Type II – CBD diverticulum

Type III – Choledochocele

Type IV – Multifocal intrahepatic and extrahepatic dilations

Type V – Intrahepatic dilations (Caroli Disease)



Bell D, Abusseiriy K, Vadera S, et al. Todani classification of bile duct cysts. Reference article, Radiopaedia.org (Accessed on 17 Jan 2025) https://doi.org/10.53347/rID-12081

Choledochal Cysts
Type I

- Type I is the most common type (75-95% of cases)
- Usually diagnosed in early childhood
- Can involve entire CBD
- Bile duct measuring > 10 mm in child
- Usually surgically excised with choledochojejunostomy



Choledochal Cysts
Type II

- True diverticulum
- Rare
- Excised



Choledochal Cysts Type III

- Choledochocele
- Dilation of intraduodenal duct
- May be lined by either duodenal or bile epithelium
- May obstruct duodenum
- May not be resected



Choledochal Cysts Type IV

- Type IVa – multifocal intra- and extrahepatic ducts
- Type IVb – Multifocal extrahepatic and/or cystic duct
- Resected with reconstruction



Choledochal Cysts Type V

- AKA Caroli disease
- Multifocal dilation of intrahepatic ducts
- Part of the spectrum of fibropolycystic liver disease rather than a true choledochal cyst disease
- "Central dot sign" – portal radical at center or periphery of dilated duct



Choledochal Cysts Type V

- Complicated by stasis, stone formation, cholangitis
- Treatment is supportive (antibitotics, stone removal) but may require transplant



Dilated Ducts

- Obstructed ducts may not be enlarged
- Enlarged ducts may not be obstructed

Dilated Ducts

- Obstructed ducts may not be enlarged
- Enlarged ducts may not be obstructed
- Laboratory Evidence of Obstruction - Elevated alk phos and direct bilirubin

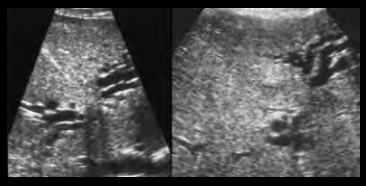
Dilated Ducts

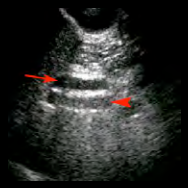
- Obstruction without dilation - may be early
- Dilation without obstruction - Ducts normal up to 6 mm.
  - Can be enlarged in the elderly because of elastic tissue degeneration (add 1 mm for every 10 years) and in patients status post cholecystectomy
- Bile ducts can also appear larger on conventional cholangiography from distention and magnification

Dilated Ducts

- Normal intrahepatic ducts should not exceed 40% of the diameter of the adjacent portal vein or 2 mm
- On ultrasound may have a "double barrel" appearance
- CT/MRI will show tubular structures parallel to and on one side of the portal veins
- Normal CBD and CHD < 6-7 mm
- Benign disease is the cause of 75% of obstructive jaundice in adults

Double barrel - intrahepatic bile duct dilation



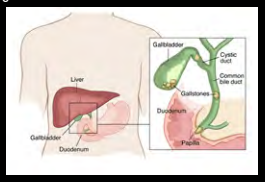


Dilated Ducts

- Differential
  - Stone
  - Biliary Stricture
  - Inflammation
  - Neoplasm

Bile Duct Stones

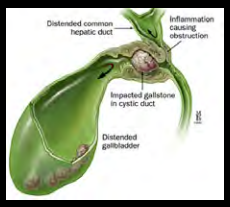
- Choledocholithiasis - accounts for 20% of adult obstructive jaundice
- Ultrasound sensitivity for the detection of bile duct stones ranges from 20-80%
- Unenhanced CT - 70-80% sensitivity for detection of CBD stones
- MRCP sensitivity up to 99% sensitive



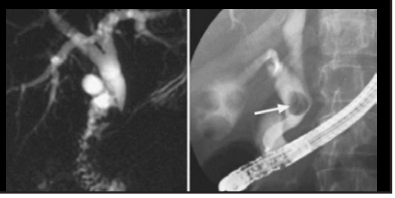
https://www.surgeon.melbourne/choledocholithiasis-bile-duct-stones/

Mirizzi Syndrome

- Gallstone in the cystic duct obstructing the common hepatic duct



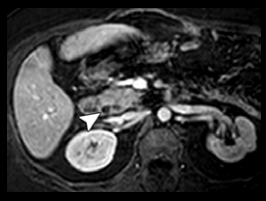
https://www.instagram.com/dr.mina.tavakol.radiologist/p/CbsjcWQsZv9/?img_index=1



Strictures

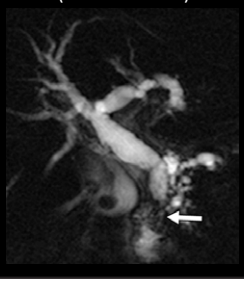
- Benign - smooth, concentric, short segment

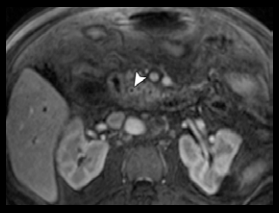




Strictures

- Malignant - abrupt, irregular, long segment (enhancement)





Benign Strictures

- 40-45% of obstructing jaundice in the adult
- Can lead to recurrent cholangitis, stone formation, cirrhosis and end-stage liver disease
- Multiple causes:
  - Trauma/surgery/interventional procedure
    - Iatrogenic up to (80%)
  - Prior stone passage, Cholangitis, Pancreatitis, Radiation therapy
- Minimal wall enhancement may be present

Benign Strictures

Appearance

- Type
- Iatrogenic: Stricture involves CHD, CBD
- Chronic pancreatitis: Intrapancreatic CBD
- PSC: "Beaded appearance" usually intra- and extra-hepatic, isolated to intrahepatic in 20%, rarely isolated extrahepatic
- IgG4-related disease: Intrapancreatic CBD, possibly intrahepatic mimicking PSC
- Recurrent pyogenic: Segmental/lobar intrahepatic dilation (favors left lateral and right posterior), pigment stones, extrahepatic strictures
- HIV cholangiopathy: Sclerosing cholangitis with papillary stenosis, long segment

Benign Strictures

- Preferred treatments: Endoscopic balloon dilation with/without drainage and/or stenting
- Surgical options include choledochojejunostomy and hepaticojejunostomy

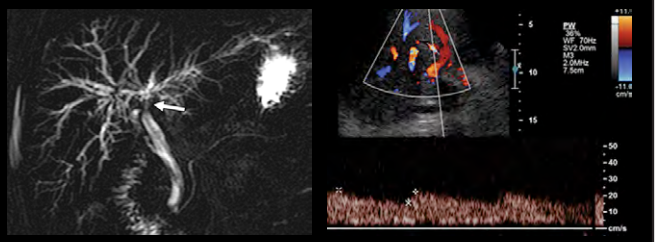
Iatrogenic Strictures

- Estimated incidence of benign biliary strictures occurring after cholecystectomy is <1%
- Incidence is reported as higher in laparoscopic versus open
- Ligation of the cystic duct too close to CBD or inadvertent ligation of the CBD/CHD are most common causes

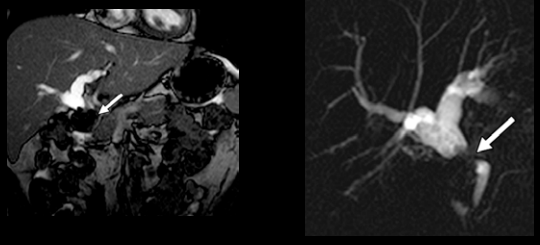
Iatrogenic Strictures

- Orthotopic liver transplant is increasingly identified as source of benign strictures - occurring in up to 30%
- Strictures can occur in early (<30 days) or late (>30 days) posttransplant period
- May be anastamotic or nonanastamotic
  - Anastamotic - usually from fibrosis
    - Anastamosis is usually extrahepatic
  - Nonanstamotic - usually from hepatic artery stenosis/thrombosis
    - May also result from recurrence of disease (PSC)
    - Usually intrahepatic

Iatrogenic Strictures – Post Transplant



Iatrogenic Strictures – Post Cholecystectomy



Malignant Strictures

- Cholangiocarcinoma
- HCC
- Pancreatic adenocarcinoma
- Direct invasion by adjacent tumors (gastric carcinoma)

Case 2

35-year-old male with RUQ pain

Which of the following is the MOST LIKELY diagnosis?

1. Sclerosing Cholangitis
2. Ascending Cholangitis
3. Caroli Disease
4. Cholangiocarcinoma



Primary Sclerosing Cholangitis

- Autoimmune disease characterized by inflammation and fibrosis
- More common in males
- Associated with inflammatory bowel disease (UC) in 50-70% of cases
- Diagnosis requires typical imaging characteristics, appropriate labs and clinical history and lack of other causes of cholangitis

Primary Sclerosing Cholangitis

- Alternating foci of dilation and stricture ("beaded" appearance), also may see webs and diverticuli
- Both intra- and extrahepatic ducts
  - Most severely affected are the main right and left ducts
- Isolated intrahepatic ducts may be involved in 20%
  - Isolated extrahepatic duct involvement rare
- Fibrosis predominately affects the periphery and results in lobular liver contour and marked enlargement of caudate
- The development of a focal high-grade "dominant" stricture may herald the development of cholangiocarcinoma

Primary Sclerosing Cholangitis

- Course is highly variable
- Can progress to biliary cirrhosis (50%) and cholangiocarcinoma (7%)
- Medical therapy includes ursodiol (ursodeoxycholic acid) and steroids
- Majority will require liver transplant from cirrhosis

Primary Sclerosing Cholangitis



Primary Sclerosing Cholangitis



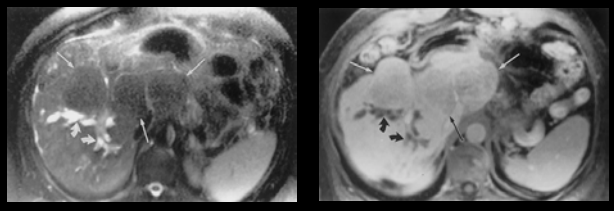
Primary Sclerosing Cholangitis



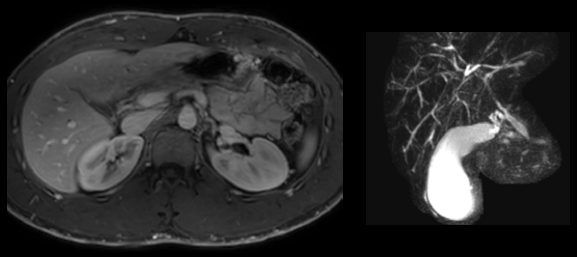
Primary Sclerosing Cholangitis



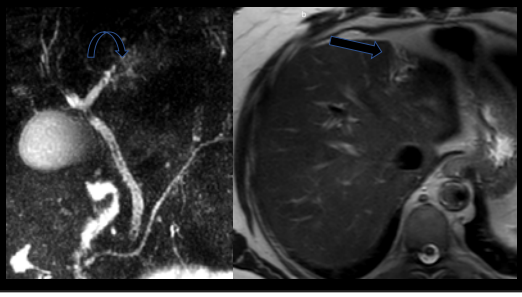
Cirrhosis in Primary Sclerosing Cholangitis



Primary Sclerosing Cholangitis



Primary Sclerosing Cholangitis



IgG4-related Cholangitis

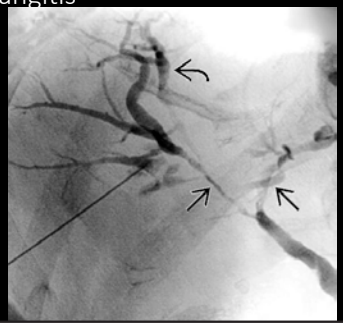
IgG4-related Cholangitis

- Distinct disease that primarily affects the pancreas (autoimmune)
- Affects other organs, including the bile ducts, gallbladder, kidneys and thyroid
- Characterized by lymphocytic infiltration, obliterative phlebitis and variable fibrosis in the affected organ
- Laboratory findings include elevated serum IgG4 and serum autoantibodies (ANA, RF)
- IgG4-related sclerosing cholangitis is present in up to 88% of patients with autoimmune pancreatitis

IgG4-related Cholangitis

- Thickening, stenosis and wall enhancement will be seen in the bile ducts
- Most commonly causes stricture of the common bile duct, although milder intrahepatic strictures can occur
- Because of similar imaging findings, differentiation from PSC can be difficult
- Usually demonstrates a dramatic response to corticosteroid therapy
- Disease recurrence is common

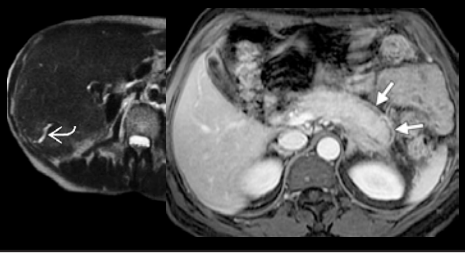
IgG4 Cholangitis



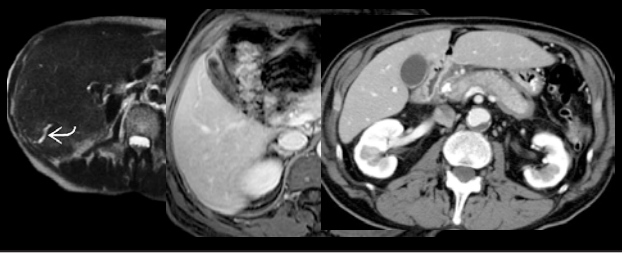
IgG4 Cholangitis



IgG4 Cholangitis



IgG4 Cholangitis



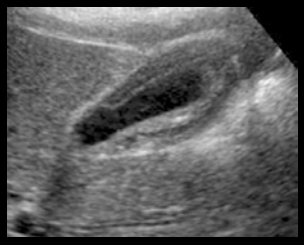
IgG4 Cholangitis





IgG4 Cholangitis





Ascending Cholangitis

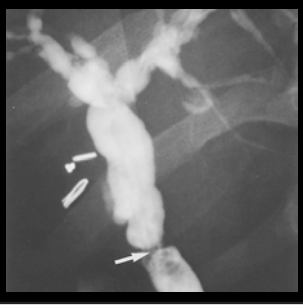
Ascending Cholangitis

- Bacterial infection of an obstructed biliary system
- Obstruction is usually from a stricture, stone or papillary stenosis
- Clinical diagnosis: Charcot triad - pain, fever, jaundice

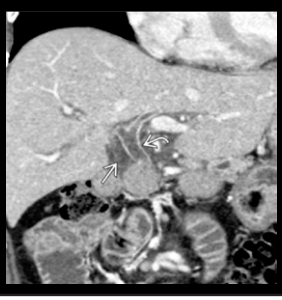
Ascending Cholangitis

- On CT:
  - Hyperenhancement of the duct wall
  - Fluid or edema around the duct
  - Increased density of the bile fluid
- Other modalities show similar findings
- Liver abscess and sepsis can result from increased pressure in the biliary system leading to necrosis and rupture of the duct wall

Ascending Cholangitis



Ascending Cholangitis



Recurrent Pyogenic Cholangitis

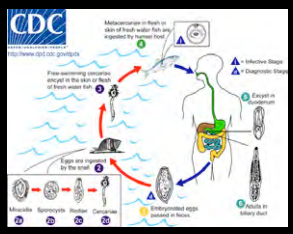
Recurrent Pyogenic Cholangitis

- Chronic parasitic infection endemic in southeast Asia
- Recurrent attacks of right upper quadrant pain, recurrent fevers and jaundice
- Usual parasite is *Clonorchis sinensis* and/or *Ascaris lumbricoides*
- Uncommon in the U.S., third most common cause of acute abdomen in Hong Kong

Chlonorchis sinensis



https://en.wikipedia.org/wiki/Clonorchis_sinensis



https://www.cdc.gov/dpdx/clonorchiasis/index.html

Recurrent Pyogenic Cholangitis

- Characterized by multifocal strictures and dilatations with intra- and extrahepatic biliary pigment stones
- May also see pneumobilia
- May be confined to the left lobe (often lateral segment)
- Disproportionate dilation of the extrahepatic ducts unrelated to stricture or stone
- Complications include hepatic abscess (20%) and cholangiocarcinoma (5%)

Recurrent Pyogenic Cholangitis



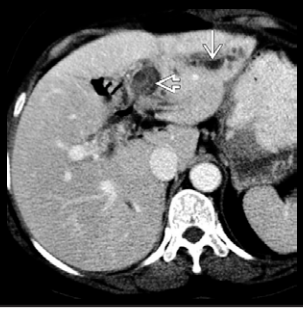
Statdx

Recurrent Pyogenic Cholangitis





Recurrent Pyogenic Cholangitis



Recurrent Pyogenic Cholangitis

- Treatment options are multiple and include:
  - Endoscopic sphincterotomy
  - Surgery - biliary drainage, left lobectomy
  - I.R. - Percutaneous biliary drainage of affected segments, basket removal of pigment stones, balloon dilation of strictures
  - Medication - Praziquantel
- Goal is to clear the ducts of stones, eliminate bile stasis and prevent acute attacks of cholangitis

AIDS-related Cholangiopathy

AIDS-related Cholangiopathy

- Infectious cholangitis related to opportunistic infections
- Usually in patients with CD4 count <100 cells/mm3, incidence is now greatly decreased with HAART
- Causative organisms usually *Cryptosporidium* or CMV

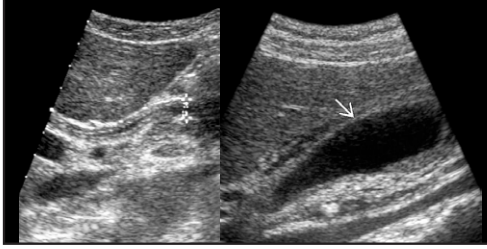
AIDS-related Cholangiopathy



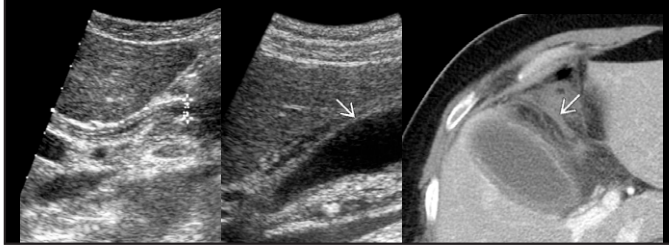
AIDS-related Cholangiopathy



AIDS-related Cholangiopathy



AIDS-related Cholangiopathy



AIDS-related Cholangiopathy

- Poor prognosis secondary to advanced AIDS presentation
- Sphincterotomy may provide some relief but does not alter the course of intrahepatic disease
- anti-CMV therapy is not effective

Chemotherapy Induced Cholangitis

Chemotherapy Induced Cholangitis

- Secondary to hepatic artery infused chemotherapeutic agents in the setting of metastatic disease to the liver
- Chemotherapeutic agents include floxuridine, 5-fluorouracil and bevacizumab
- Produces an inflammatory fibrosing process around the portal triads
- May be secondary to direct effect or ischemia from thrombosis of the hepatic arteries
- Stricture of the bifurcation of the common hepatic duct most common

Chemotherapy Induced Cholangitis



Cholangiocarcinoma

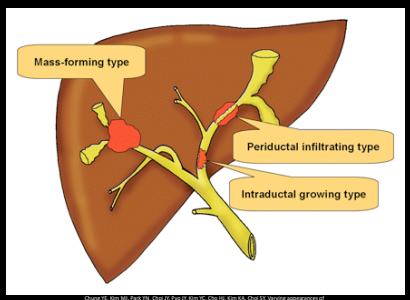
Cholangiocarcinoma

- Malignancy arising from the bile ducts
- 10-20% of primary hepatic neoplasms
- Usually arises in the setting of pre-existing diseases:
  - stones, PSC, recurrent pyogenic cholangitis, Caroli disease
- Up to 70% located in the hilum (Klatskin tumor) but may occur anywhere along the course of the bile ducts
- Poor prognosis - median survival of 7 months and 5 year survival rate of 0-10%

Cholangiocarcinoma

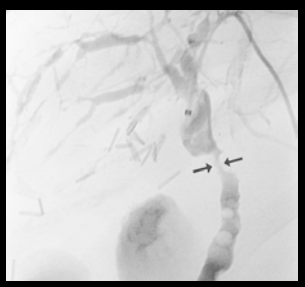
- Up to 70% located in the hilum (Klatskin tumor) but may occur anywhere along the course of the bile ducts
  - Distal CBD: 30-50%
  - CHD: 14-35%
  - Confluence: 10-25%
- Contains large central core of fibrous tissue

Cholangiocarcinoma

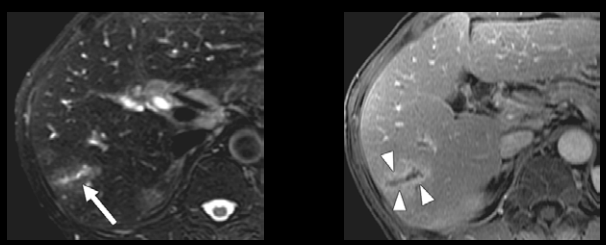


Chung YE, Kim MJ, Park YN, Choi JY, Pyo JY, Kim YC, Cho HJ, Kim KA, Choi SY. Varying appearances of cholangiocarcinoma: radiologic-pathologic correlation. Radiographics. 2009 May-Jun;29(3):683-700. doi: 10.1148/rg.293085729. PMID: 19448110

Cholangiocarcinoma



Cholangiocarcinoma - Periductal Type



Chung YE, Kim MJ, Park YN, Choi JY, Pyo JY, Kim YC, Cho HJ, Kim KA, Choi SY. Varying appearances of cholangiocarcinoma: radiologic-pathologic correlation. Radiographics. 2009 May-Jun;29(3):683-700. doi: 10.1148/rg.293085729. PMID: 19448110

Cholangiocarcinoma - Intraductal Type

- May present as:
  - Marked dilation of the bile duct with solitary or multifocal papillary masses
  - Upstream and downstream ductal dilatation
    - Duct dilation is on the basis of mucin production, similar to IPMN in the pancreas

SELF EVALUATION

Imaging of the Biliary System

1. What is the most common choledochal cyst?

a. Type I
b. Type II
c. Type III
d. Type IVa
e. Type IVb

2. Which of the following is correct regarding Primary Sclerosing Cholangitis?

a. Liver transplant is curative
b. Does not involve the extrahepatic bile ducts
c. Does not increase the risk of developing cholangiocarcinoma
d. Has a higher association with Crohn's disease than with ulcerative colitis

3. T/F - Recurrent pyogenic cholangitis is associated with intra and extra-hepatic biliary pigment stones.

4. Which of the following is true regarding biliary dilation and obstruction?

a. Results in elevated CEA and bilirubin
b. A CBD measurement > 8 mm always represents an obstruction.
c. An abnormally dilated intrahepatic bile duct is diagnosed only when it is greater in size than the adjacent portal vein.
d. Most causes of biliary obstruction are benign.

5. T/F - Cases of AIDS related cholangiopathy are rising

Answer Key: 1. A, 2. A, 3. T, 4. D, 5. F

Andrew Moriarity, MD, MBA

Andrew Moriarity, MD, MBA is a board-certified diagnostic radiologist specializing in abdominal and oncologic imaging and serves as President of Advanced Radiology Services, one of the nation's largest physician-owned radiology practices. He previously held leadership roles in clinical operations and quality, guiding organizational growth, subspecialization, and initiatives in peer learning and multi-specialty collaboration. He is an Associate Professor at Michigan State University College of Human Medicine and core residency faculty focused on quality and safety. Dr. Moriarity trained at Henry Ford Hospital, where he served as Chief Resident, and completed fellowship training at UCLA. He also earned an MBA with High Distinction from the University of Michigan Ross School of Business. A national leader in radiology policy and economics, he has served in multiple roles with the American College of Radiology and contributes to advancing patient-centered, data-driven care.

You may contact Dr. Moriarity with any questions or comments at andy.moriarity@gmail.com.

The Future of Radiology Practice
Andrew Moriarity, MD, MBA

The Future of Radiology Practice

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President, Advanced Radiology Services, PC
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College of Human Medicine
MICHIGAN STATE UNIVERSITY

Advanced Radiology Services PC

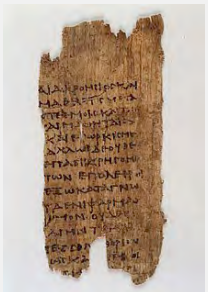
Objectives

- Review important milestones of healthcare payment
- Examine how payment policy informs practice governance
- Discuss recent trends in practice governance and ownership

Healthcare payment milestones







en.wikipedia.org/wiki/Code_of_Hammurabi
en.wikipedia.org/wiki/Hippocratic_Oath



en.wikipedia.org/wiki/Social_Security_Act





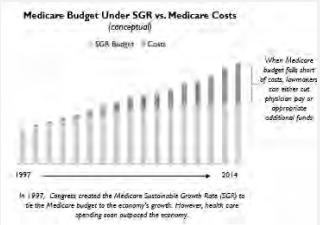
en.wikipedia.org/wiki/Social_Security_Act
ssa.gov/history/ibjom.html





ssa.gov/history/ibjom.html
axios.com/amas-doctor-panel-still-operates-behind-closed-doors-1513306018-b298fdf1-b01e-4905-bebc-ea5ba1d64408.html

The SGR and Fix

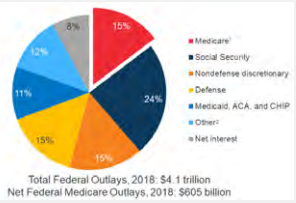


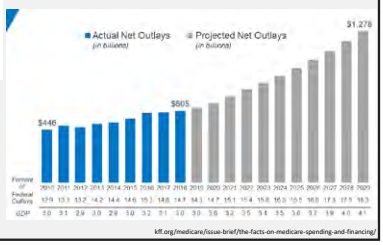


nationaljournal.com/media/media/2014/07/21/Paying-Doc-Fix.PNG
healthaffairs.org/do/10.1377/hblog20161012.057043/full

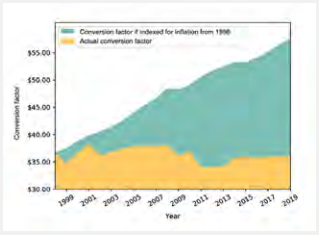
Healthcare payment policy impact on practice governance trends

MACRA 2015	CMS 2020 Final Rule	CMS 2025 Final Rule
2,398 pages	2,100 pages	3,088 pages

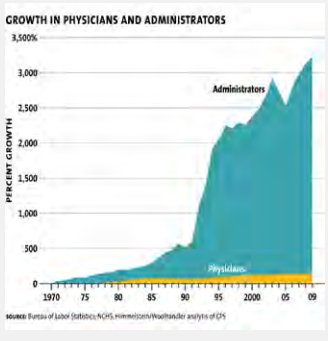




kff.org/medicare/issue-brief/the-facts-on-medicare-spending-and-financing/



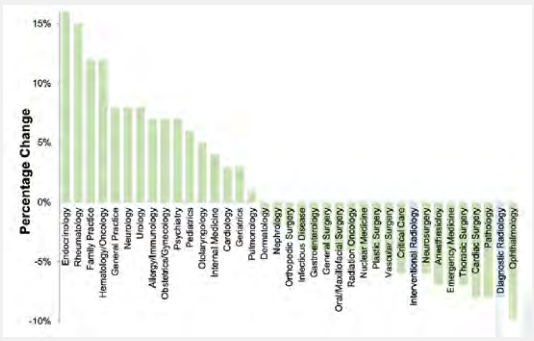
Medicare conversion factor annual statutory vs. actual percentage increases			
Year	Statutory update	Conversion factor	Actual change over previous year
2016	+0.5%	$35.8043	-0.34%
2017	+0.5%	$35.8887	+0.24%
2018	+0.5%	$35.9996	+0.31%
2019	+0.25%	$36.0391	+0.11%



bulletin.facs.org/2019/09/medicare-physician-payment-on-the-decline-its-not-your-imagination/
milkenreview.org/articles/priced-out



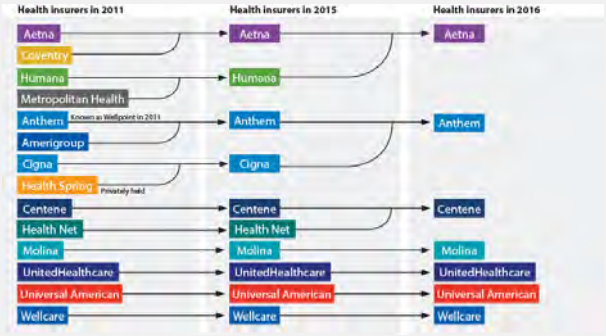
bulletin.facs.org/2019/09/medicare-physician-payment-on-the-decline-its-not-your-imagination/
i2.wp.com/financialsamurai.com/wp-content/uploads/2021/04/inflation-2021-boom.png?fit=1456,9999



doi.org/10.3174/ajnr.A6619



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coventrybuidingsociety.blogspot.com/2019/09/coventry-bought-by-aetna.html

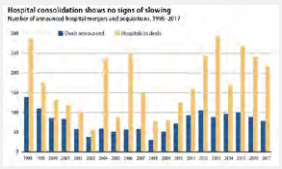


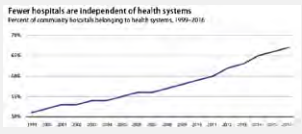
4sighthealth.com/after-the-breakups-big-payers-find-vertical-love-in-new-faces/

Consolidation

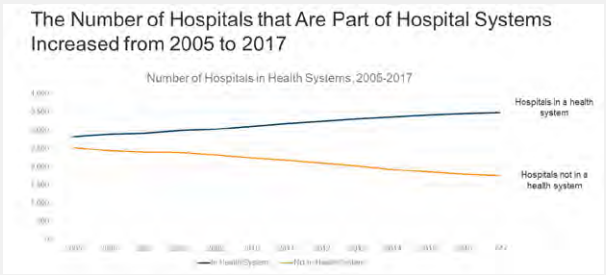
- Horizontal hospital consolidation
- Horizontal physician consolidation
- Vertical consolidation
- Consolidation vs Medicare





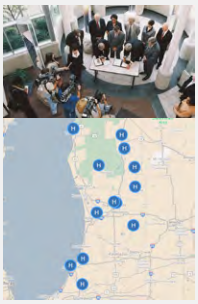


americanprogress.org/issues/healthcare/reports/2018/12/05/461780/provider-consolidation-drives-health-care-costs/



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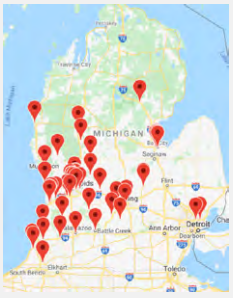
Consolidation





history.spectrumhealth.org

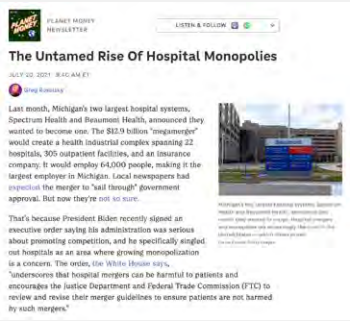
Consolidation





history.spectrumhealth.org

Consolidation


The Untamed Rise Of Hospital Monopolies

Last month, Michigan's two largest hospital systems, Spectrum Health and Beaumont Health, announced they wanted to become one. The $12.9 billion "megamerger" would create a health industrial complex spanning 22 hospitals, 305 outpatient facilities, and an insurance company. It would employ 64,000 people, making it the largest employer in Michigan. Local newspapers had expected the merger to "sail through" government approval. But now they're not so sure.

That's because President Biden recently signed an executive order saying his administration was serious about promoting competition, and he specifically singled out hospitals as an area where growing monopolization is a concern. The order, the White House says, "underscores that hospital mergers can be harmful to patients and encourages the Justice Department and Federal Trade Commission (FTC) to review and revise their merger guidelines to ensure patients are not harmed by such mergers."

https://www.npr.org/sections/money/2021/07/20/1017631111/the-untamed-rise-of-hospital-monopolies


BHSH System Announces Name: Corewell Health™

GRAND RAPIDS, Mich. and SOUTHFIELD, Mich., Oct. 11, 2022 – BHSH System, the new health system formed in February 2022 by Beaumont Health and Spectrum Health, announced its new name today, Corewell Health™, signaling its bold commitment to health and wellness.

Beaumont + Spectrum Health

Together, we are now

Corewell Health™


Research Letter

February 18, 2020

Private Equity Acquisitions of Physician Medical Groups Across Specialties, 2013-2016

- Anesthesiology (19.4%)
- Multispecialty (19.4%)
- Emergency medicine (12.1%)
- Family practice (11.0%)
- Dermatology (9.9%

- 2015-16: Increased activity in cardiology, ophthalmology, radiology, & obstetrics/gynecology


Table 1. Characteristics of Physician Medical Groups Acquired 2013-2016 (N = 355)

Characteristic	Total
Acquired by private equity group	
No. of practices	355
No. of sites	1426
No. of physicians[a]	5714
Physicians per practice, mean (SD) [median]	16.3 (26.3) [7]
Sites per practice, mean (SD) [median]	4.0 (7.8) [1]
Physicians per site, mean (SD) [median]	6.2 (12.7) [2]
Practice accepts new patients, No. (%)	289 (81.4)
Practice accepts Medicare, No. (%)	296 (83.4)
Practice accepts Medicaid, No. (%)	214 (60.3)
Location of practice by US region, No. (%)[b]	
South	184 (43.9)
Midwest	90 (21.5)
Northeast	69 (16.5)
West	76 (18.1)

doi:10.1001/jama.2019.21844

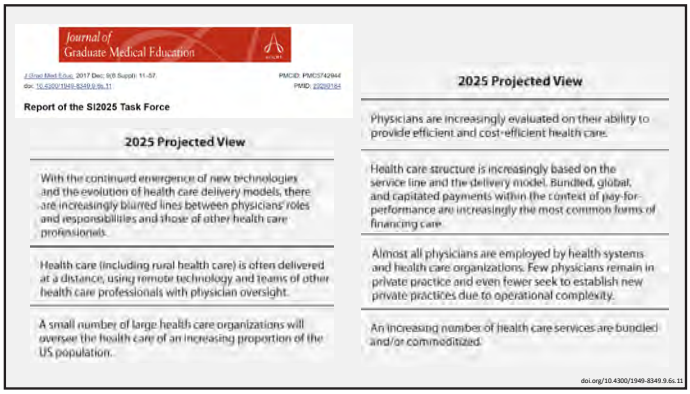

Research Letter

February 18, 2020

Private Equity Acquisitions of Physician Medical Groups Across Specialties, 2013-2016

- "Private equity firms expect greater than 20% annual returns, and these financial incentives may conflict with the need for longer-term investments in practice stability, physician recruitment, quality, and safety."
- "There may be additional pressures to increase revenue streams (e.g., elective procedures and ancillary services), direct more referrals internally, and rely on lower-cost clinicians."

doi:10.1001/jama.2019.21844


Journal of Graduate Medical Education

Report of the SI2025 Task Force

2025 Projected View

With the continued emergence of new technologies and the evolution of health care delivery models, there are increasingly blurred lines between physicians' roles and responsibilities and those of other health care professionals.

Health care (including rural health care) is often delivered at a distance, using remote technology and teams of other health care professionals with physician oversight.

A small number of large health care organizations will oversee the health care of an increasing proportion of the US population.

2025 Projected View

Physicians are increasingly evaluated on their ability to provide efficient and cost-efficient health care.

Health care structure is increasingly based on the service line and the delivery model. Bundled, global, and capitated payments within the context of pay-for-performance are increasingly the most common forms of financing care.

Almost all physicians are employed by health systems and health care organizations. Few physicians remain in private practice and even fewer seek to establish new private practices due to operational complexity.

An increasing number of health care services are bundled and/or commoditized.

doi.org/10.4300/1949-8349.9.6s.11


Journal of Graduate Medical Education

Report of the SI2025 Task Force

2025 Projected View

Physicians are increasingly evaluated on their ability to provide efficient and cost-efficient health care.

"The evolution of health care will increase in complexity and pace during the next decade due to driving forces such as democratization, **commoditization, & corporatization**."

health care professionals with physician oversight.

A small number of large health care organizations will oversee the health care of an increasing proportion of the US population.

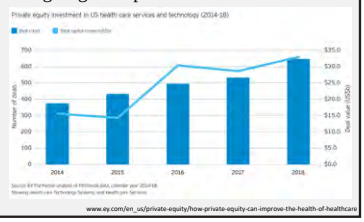
private practices due to operational complexity.

An increasing number of health care services are bundled and/or commoditized.

doi.org/10.4300/1949-8349.9.6s.11

- "The wasteful, siloed and fragmented nature of health delivery are a natural match for the traditional PE skills of enhancing value by eliminating inefficiencies, improving operating models and consolidating markets."
- "Health care is poised to continue not only as a significant economic force, but one subject to ongoing disruption."

"...and future opportunity will likely be strong."


Private equity investment in US health care services and technology (2014-18)

www.ey.com/en_us/private-equity/how-private-equity-can-improve-the-health-of-healthcare

- "If nothing else, PPMs will be remembered years from now for their sheer destructiveness."
- "The reasons for the emergence of this industry haven't disappeared. Doctors need capital and business discipline."

"You can't abdicate business decisions."


Physician Practice Management Companies... Going...Going...

PPMs: Going . . . going . . .

www.medicaleconomics.com/view/physician-practice-management-companies-goinggoing

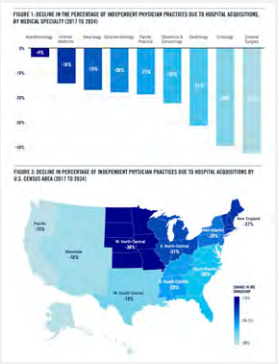
Current trends

- Beyond radiology, physician practices across much of medicine have been consolidating for many years [1,2]
- Vertical integration, the purchase of physician practices by hospitals and hospital systems, has been occurring for well over a decade [3]
- Insurance company consolidation and growth via mergers and acquisitions have also been going on for many years [4]
- Such activity is not limited to the private sector, with academic centers also taking part in similar integration [5]
- Consolidation is part of a general evolution of the health care ecosystem. Physician practices, including radiology groups, are a part of that ecosystem



1: 10.1377/hlthaff.2016.0130
2: 10.1377/hlthaff.2017.0054
3:10.1377/hlthaff.2017.1520
4: binsights.com/research/health-insurance-consolidation
5: news.emory.edu/stories/2018/09/ehc_dekalb_medical_celebrations_signage_unveils/index.html
pixabay.com/photos/stairway-staircase-stairs-outdoors-828883/

- The Progressive Policy Institute, a D.C. think tank, reviewed 70 different economic studies on consolidation
- Demonstrates a "rapid decline" in independent practice counts, with hospital acquisitions contributing to a sizable drop in physician ownership across nine specialties (up to 42%)
- Rural communities have been hit hardest with independent practice ownership falling 34% in these geographies compared to 22% in urban areas.



https://www.progressivepolicy.org/wp-content/uploads/2025/12/PPI-Hospital-Acquisitions-Dec2025.pdf

Radiology



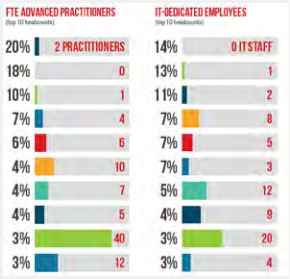
- Corporate ownership increased from ~10% in 2000 to 72% by 2005
- Aware of "the experience of physician practice management companies in the United States"
- "The impact of corporatization on radiologists varied depending on their career stages."



doi.org/10.1016/j.jacr.2007.10.006



"From mergers and acquisitions to joint ventures and other sorts of practice partnerships and fusions—not to mention hospital absorptions and investor gobble-ups—consolidation continues."



www.radiologybusiness.com

2011

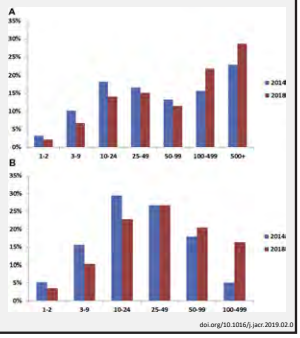


- Consolidation continues
- "Some major radiology service providers were eliminated from the survey because they were not radiologist owned. We will need to reconsider whether these should be included…"
- ARS continues its four-year run as the nation's largest radiology practice, adding seven radiologists (for a total of 113) in 2011.

www.radiologybusiness.com/topics/business-intelligence/75-largest-private-radiology-practices



- "In very recent years, the US radiologist workforce has consolidated, leading to increased practice sizes and a substantial decline in the number of distinct practices, disproportionately affecting single-specialty radiology practices."
- "The impact of this consolidation on cost, quality, and patient access merits further attention."



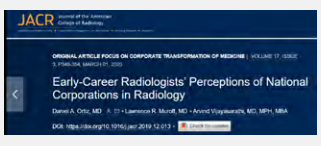
doi.org/10.1016/j.jacr.2019.02.0

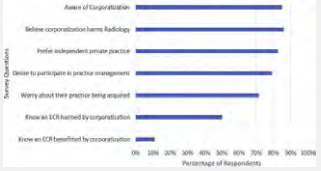


- Consolidation
- Corporatization
- Private Equity
- Venture Capital
- Corporate Ownership
- Private Ownership



doi.org/10.1016/j.jacr.2019.07.003







doi.org/10.1016/j.jacr.2019.07.003

Current trends

- "Small but growing percentage of radiology groups
- If a tipping point is reached, the practice opportunities for young radiologists will be diminished, and their compensation ceiling could be affected significantly.
- This combination of restricted opportunity and less compensation could alter the number and quality of those who chose to enter our specialty.
- Potential for major shift of radiologists from independent owners to shift workers, as has occurred in other specialties.
- Academia is not immune."



OPINION | ARTICLES IN PRESS

Will Venture Capital–Supported National Entities Change Radiology From a Specialty of Independent Owners to Employed Shift Workers?

Lawrence R. Muroff, MD

Published: March 04, 2021 • DOI: https://doi.org/10.1016/j.jacr.2021.02.005

doi.org/10.1016/j.jacr.2021.02.005

Current trends

- "Market forces like competition cannot stem the urge to merge among and between payers and providers"
- "The largest health insurers in the country…have also increased their degree of vertical integration… employing tens of thousands of doctors, contributing to an ongoing trend where independent physician practices have become increasingly rare… [and] may lead to greater market power for them as insurers."

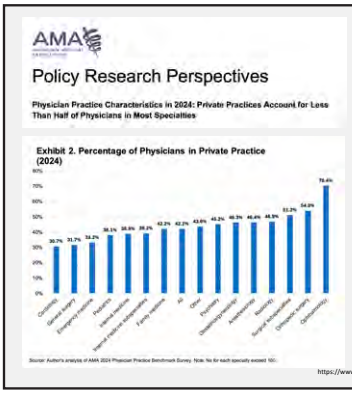


NBER

Competition in Health Insurance Markets

Martin Gaynor & Amanda Starc

https://www.nber.org/papers/w34928



AMA

Policy Research Perspectives

Physician Practice Characteristics in 2024: Private Practices Account for Less Than Half of Physicians in Most Specialties

Exhibit 2. Percentage of Physicians in Private Practice (2024)

Source: Author's analysis of AMA 2024 Physician Practice Benchmark Survey. Note: No N for each specialty except 100.

https://www.ama-assn.org/press-center/ama-press-releases/more-physicians-move-practices-owned-hospitals-private-equity



JSLS

Journal of The Society of Laparoscopic & Robotic Surgeons

Physician Employment in America: Private Practices Dominate Despite Increased Hospital Employment

https://pmc.ncbi.nlm.nih.gov/articles/PMC12072973/

Future trends

The Rise of DeepFake Medical Imaging: Radiologists' Diagnostic Accuracy in Detecting ChatGPT-Generated Radiographs



- Only 41% of purpose-blind radiologists spontaneously identified AI-generated radiographs
- After being informed that some radiographs were synthetic, the accuracy of the readers to differentiate synthetic ChatGPT-4o-generated multiregion radiographs from authentic images was 75%

Tordjman M and Yuce M et al. **Published:** March 24, 2026
https://doi.org/10.1148/radiol.252094

Radiology

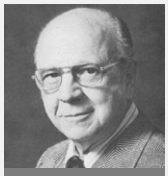
https://doi.org/10.1148/radiol.252094



www.reddit.com/r/weather/comments/1ohlej/boat_bearing_storm_on_lake_michigan/

"Today, the specialty of Radiology is faced with numerous serious problems, some of which threaten its very existence…

..it is now necessary that we take stock, analyze our strengths and weaknesses and prepare for the future."



Clyde Stevenson, MD
ARRS President's Address, 1966

Zeke Silva, MD

AI Isn't Coming for Everyone's Job

The rise and fall of the player piano indicates a robust demand for human labor that machines cannot replace.

By Adam Ozimek



https://www.theatlantic.com/ideas/2026/03/claude-piano-ai/686318/

WIRED **25 Years of WIRED Predictions: Why the Future Never Arrives**

"In the rush to identify the next industry that will be disrupted by (the digital) revolution, we underrate how fragile the business models of the disruptors themselves tend to be.

They usually have as much to fear as their old and lumbering counterparts….Yesterday's imagined futures just keep accruing, providing sedimentary layers that today's future can be built atop.

It seems to recognize that behind this patch of turbulence is probably another one."

www.wired.com/story/wired25-david-karpf-issues-tech-predictions/

SELF EVALUATION

The Future of Radiology Practice

1. T/F - The Medicare Sustainable Growth Rate (SGR) formula was repealed in 2015 and replaced by MACRA, which introduced MIPS and Alternative Payment Models (APMs).

2. Which trend has been increasingly observed in radiology and healthcare over the past decade?

a. Growth in small independent physician practices
b. Decreasing hospital employment of physicians
c. Consolidation through mergers, acquisitions, and vertical integration
d. Elimination of private equity investment in healthcare

3. According to the lecture, private equity firms typically expect approximately what annual return on their investments?

a. 5%
b. 10%
c. 15%
d. Greater than 20%

4. T/F - A survey of early-career radiologists found that most respondents preferred corporate ownership models over independent private practices.

5. Which statement best reflects a major concern discussed regarding corporatization of radiology practices?

a. It guarantees lower healthcare costs and better outcomes.
b. It may shift radiologists from owners and leaders to employees with less control over practice decisions.
c. It eliminates workforce mobility.
d. It removes the need for physician leadership.

Answer Key: 1. T, 2. C, 3. D, 4. F, 5. B

Intracranial Infections
Joshua P. Nickerson MD, FACR

Intracranial Infection

Joshua P Nickerson, MD FACR
Professor and Vice Chair for Academic Affairs
Department of Radiology
Oregon Health & Science University

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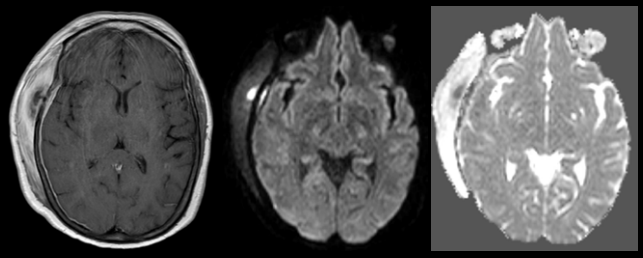
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I got a fever…

- Bacterial Infection
  - Epidural Abscess
  - Subdural Empyema
  - Meningitis
  - Cerebritis
  - Pyogenic Abscess
- Viral Infection
- Fungal Disease
- Parasitic Infection
- TORCH
- Bonus Cases

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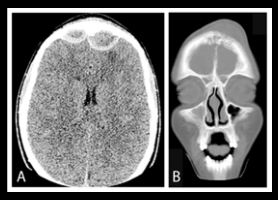
Case 1: Scalp swelling, diabetes



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Case 1: Epidural abscess

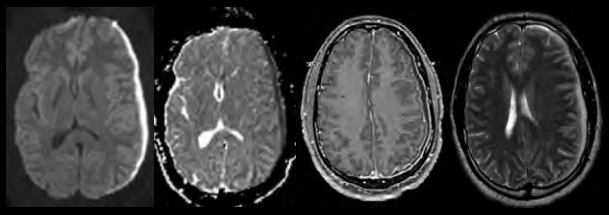
- Usually complication of sinusitis (2/3)
- Staph and Strep most common
- Typically focal lenticular shape
- May rarely be from penetrating trauma, iatrogenic, or hematogenous
- Pott's Puffy Tumor



Neuroimaging of pediatric intracranial infection--part 1: techniques and bacterial infections.
Nickerson JP, Richner B, Santy K, Lequin MH, Poretti A, Filippi CG, Huisman TA. J Neuroimaging. 2012 Apr;22(2):e42-51. doi: 10.1111/j.1552-6569.2011.00700.x. Epub

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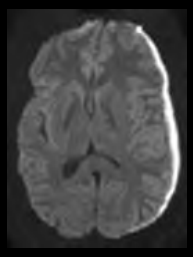
Case 2: Fever, headache, nasal congestion



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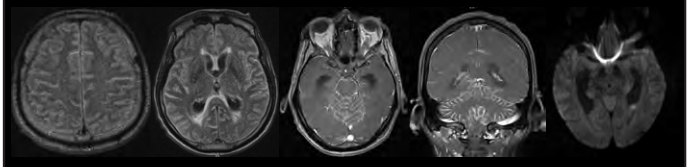
Case 2: Subdural empyema

- Also most frequently due to sinus infection
- May be concurrent with epidural purulence (infants!)
- As with all pyogenic collections, key to diagnosis is **DWI**



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Case 3: Headaches and neck pain

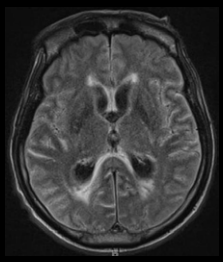


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Case 3: (Lepto)meningitis

- Purulent material within the subarachnoid space
- Most sensitive imaging finding: lack of CSF suppression on FLAIR
- HOWEVER imaging may be normal in ~50% of uncomplicated meningitis
- Diagnosis via CSF sampling

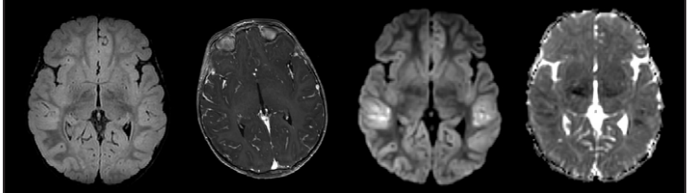


Hydrocephalus

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Case 4: 3 y/o with confirmed meningitis

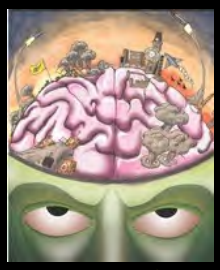


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Case 4: Cerebritis

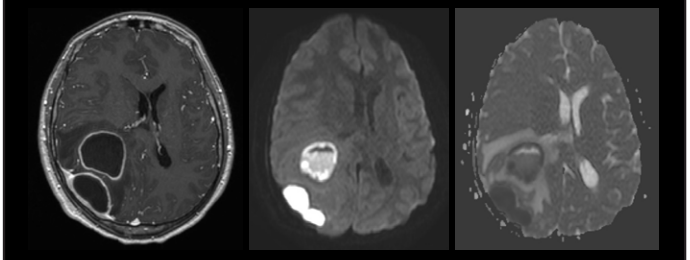
- May be acquired hematogenously (especially via shunts), via trauma, extension from meningitis
- Four stages
  - Early and Late Cerebritis
  - Early and Late Capsular
- Cerebritis treated with Abx
- Capsular abscess requires surgery



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Case 5: Seizure, IV drug use

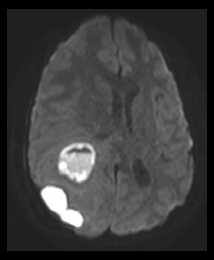


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Case 5: Cerebral abscess(es)

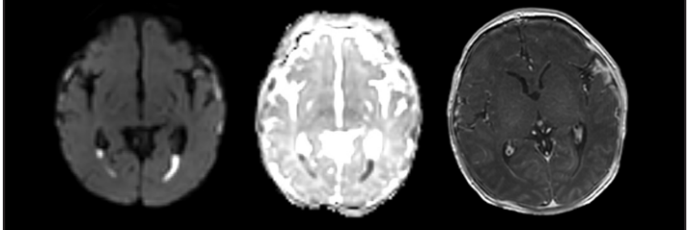
- Usually hematogenous in origin
- Require evacuation
- Mortality remains 2-4%
- Peripheral rim enhancement and avid central reduced diffusion



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Case 6: Toddler with meningitis

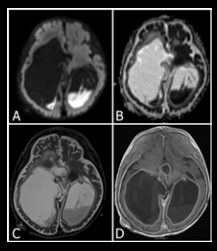


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Case 6: Ventriculitis

- May result from meningitis or rupture of periventricular abscess
- Poor outcomes- only 40% recover with good function
- DWI+ material layering in the atria
- Ependymal enhancement

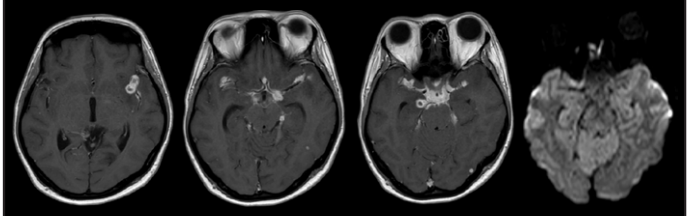


Neuroimaging of pediatric intracranial infection--part 1: techniques and bacterial infections. Nickerson JP, Richnar B, Santy K, Lequin MH, Poretti A, Filippi CG, Huisman TA. J Neuroimaging. 2012 Apr;22(2):e42-51. doi: 10.1111/j.1552-6569.2011.00700.x. Epub 2012 Feb 3.

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Case 7: 38 y/o with cranial nerve palsy

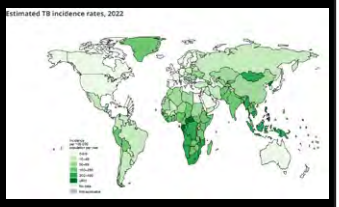


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Case 7: CNS tuberculosis

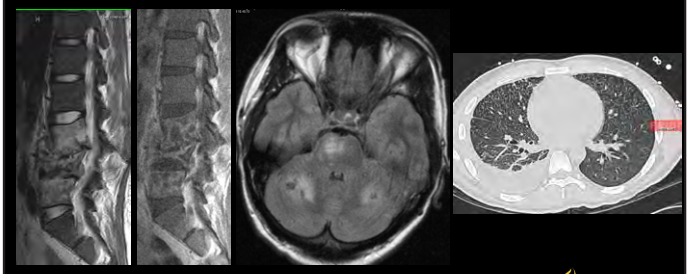
- Endemic in sub-Saharan Africa and Southeast Asia
- 95% meningitis, 5% tuberculoma, 1% tuberculous pseudoabscess
- Predilection for basal cisterns
- High rate of resultant hydrocephalus



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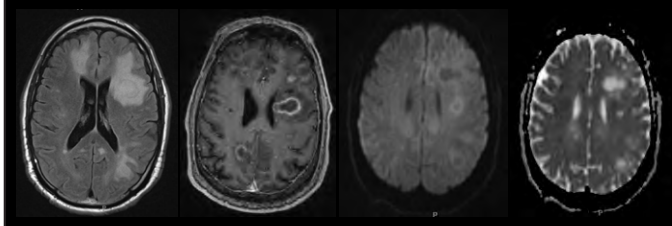
Case 7: CNS tuberculosis



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Case 8: Seizures, immunocompromise

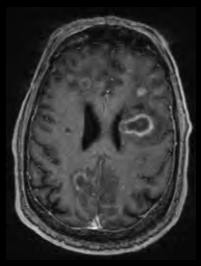


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Case 8: Toxoplasmosis

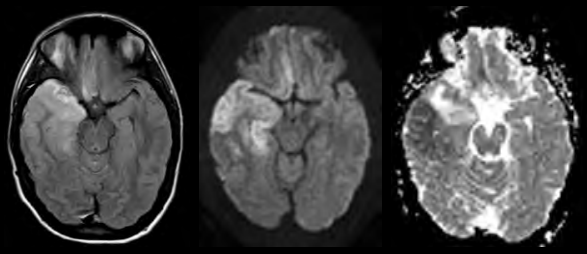
- Most common opportunistic infection/mass lesion in AIDS
- Caused by parasite *Toxoplasma gondii*
- Usually multiple, ring-enhancing lesions
- DWI often negative
- Low CBV may differentiate



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Case 9: New onset of seizures

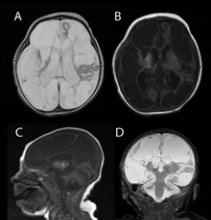


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Case 9: Herpes simplex encephalitis

- Most common viral encephalitis in adults
- Typically involves temporal and ventral frontal lobes
- Cortical DWI+, FLAIR hyperintensity
- HSV-2 in neonates

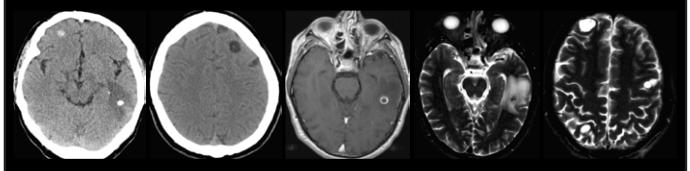


Nickerson JP, Richer B, Santy K, Lequin MH, Poretti A, Filippi CG, Huisman TA. J Neuroimaging. 2012 Apr;22(2):e42-51. doi: 10.1111/j.1552-6569.2011.00700.x. Epub 2012 Feb 3.

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Case 10: Seizure

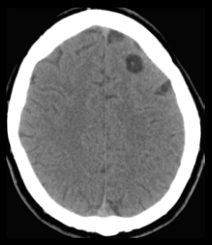


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Case 10: Neurocysticercosis

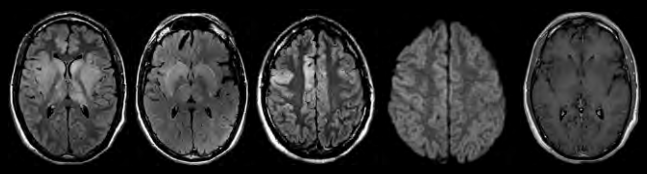
- Usually caused by the pork tapeworm *Taenia solium*
- Imaging dependent on life-cycle of the parasite
  - Encysted larvae
  - Larval death- inflammation
  - Chronic calcification



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Case 11: Seizures and respiratory failure

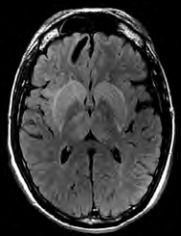


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Case 11: Eastern equine encephalitis

- Majority of viral encephalitis are non-specific on imaging
- May show cortical DWI+
- Hemorrhagic fevers may show SWI+
- High degree of suspicion in endemic areas

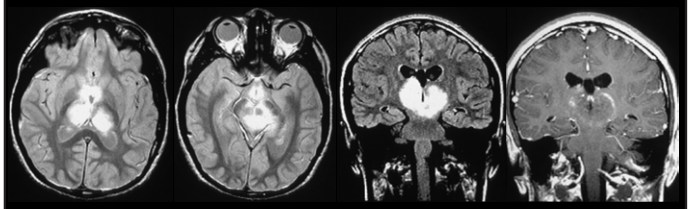


MRI findings in eastern equine encephalitis: the "parenthesis" sign. Nickerson JP, Kannabiran S, Burbank HN. Clin Imaging. 2016 Mar-Apr;40(2):222-3. doi: 10.1016/j.clinimag.2015.10.012. Epub 2015 Oct 30

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Case 12: Seizures

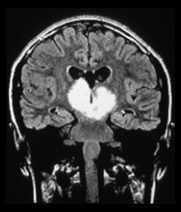


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Case 12: Japanese B encephalitis

- Most frequent in Asia and Western Pacific
- Children or unvaccinated populations
- Only 1% of infections result in encephalitis
- 25% mortality



Case courtesy of Dr. Erin Simon Schwartz, CHOP

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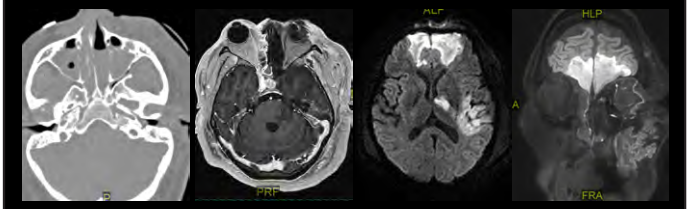
Fungal infections

- Candida
  - Fungemia in up to 5% of VLBW infants
  - Very poor outcome
- Aspergillus
  - Most common in chemotherapy/stem cell
  - Greater than 85% mortality in invasive variety
  - Results in fungal vasculitis
  - Paramagnetic hypae on SWI
- Mucor
  - Associated with sinus disease
  - Progression so rapid that imaging usually not helpful or acquired
- Others include cryptococcus and Pseudallescheria boydii
- DWI pattern differs from bacterial infections
- Contrast enhancement may be absent in immunocompromise

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Case 13: Seizures, immunocompromise

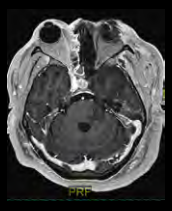


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Case 13: Invasive mucormycosis

- Rapidly progressive
- Necrosis of involved osseous structures and soft tissue results in no enhancement
- Causes extensive infarcts due to vascular invasion/vasculitis



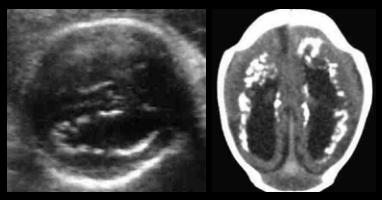
Case courtesy of Dr. Jennifer McCarty, MD Anderson

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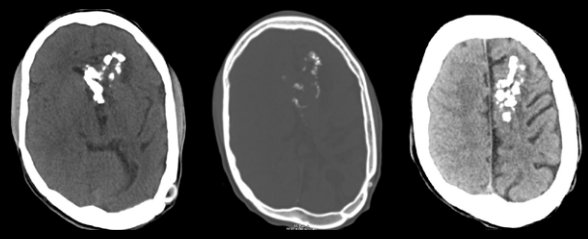
A word about TORCH

- Toxoplasmosis
- Other (Syphilis)
- Rubella
- CMV
- HSV
- Diverse group results in similar pathology due to prenatal infection



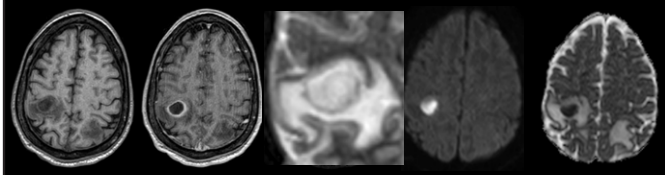
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TORCH Companion Case



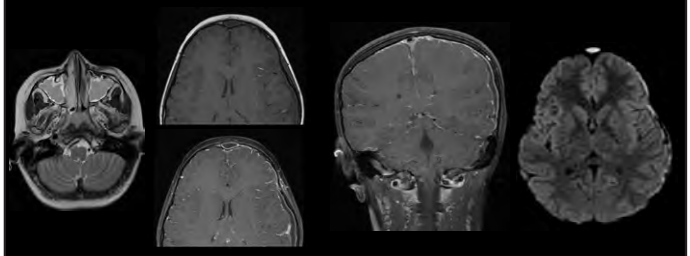
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Case 14: Endocarditis



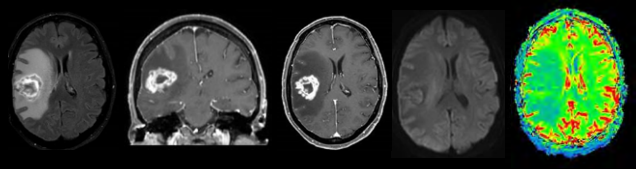
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Case 15: Facial swelling



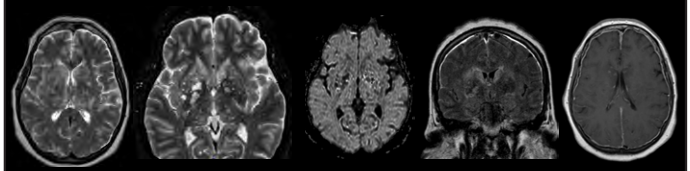
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Case 16: Seizure, AIDS



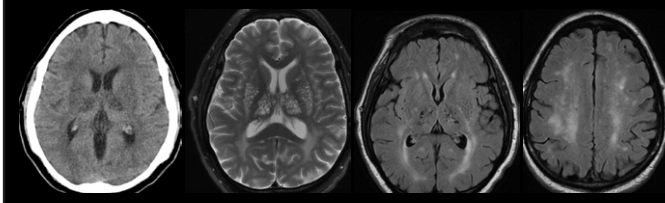
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Case 17: HIV, Headaches



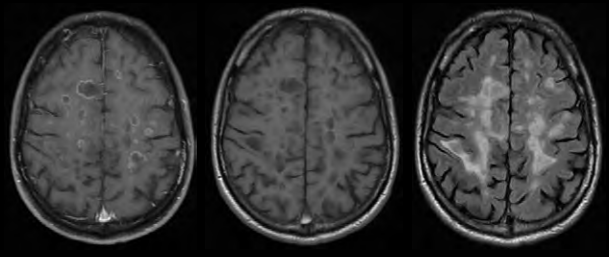
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Case 17: Companion Case



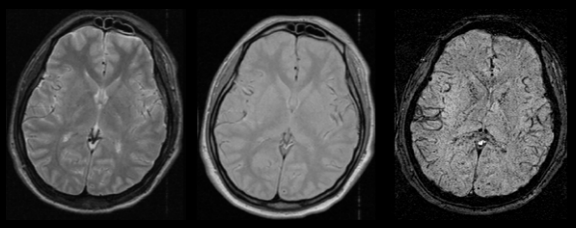
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Case 18: HIV, Headaches



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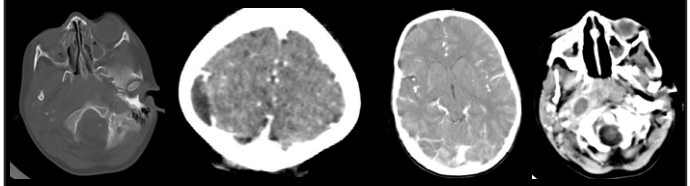
Case 19: Fevers



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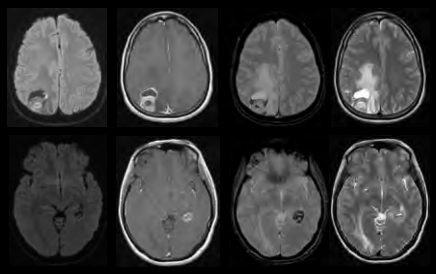
Case 20: Fevers



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Case 21: Headache



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Thank You

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SELF EVALUATION

Intracranial Infections

1. T/F - Diffusion-weighted imaging (DWI) is a key sequence for detecting pyogenic intracranial collections such as subdural empyema and cerebral abscess.

2. What is the most sensitive MRI finding of uncomplicated meningitis?

a. Ring enhancement
b. Lack of CSF suppression on FLAIR
c. Intraventricular debris
d. Restricted diffusion in the cortex

3. T/F - Cerebritis and a mature capsular brain abscess are typically managed identically with antibiotics alone.

4. Which intracranial infection is the most common opportunistic CNS mass lesion in patients with AIDS?

a. Neurocysticercosis
b. Tuberculoma
c. Toxoplasmosis
d. Cryptococcosis

5. Herpes simplex encephalitis most commonly involves which brain regions?

a. Occipital lobes and cerebellum
b. Temporal and ventral frontal lobes
c. Basal ganglia and thalami
d. Parietal lobes and corpus callosum

Answer Key: 1. T, 2. B, 3. F, 4. C, 5. B

Emergency Nuclear Medicine Cases

Don C. Yoo, MD, FACR

Emergency Nuclear Medicine Cases

Don C. Yoo, MD, FACR
Professor of Diagnostic Imaging, Clinician Educator
Director of Nuclear Medicine, Rhode Island and The Miriam Hospitals
Director of Medical Student Radiology Education



BROWN Health UNIVERSITY
BROWN Alpert Medical School

Disclosures

Consultant – Invicro (Perceptive)

NM Emergencies

1. Brain Death Studies
2. Meckel's scan
3. Hepatobiliary Scans
4. GI Bleeding scans
5. VQ Scans

What is the definition of brain death

"Irreversible unconsciousness with complete loss of brain function," including the brain stem, although the heartbeat may continue

Brain Death: Clinical Criteria

No respirations at a PCO2 level of at least 60 mmHg.

Unresponsiveness
- external visual, auditory, and tactile stimuli
- incapable of communication in any manner

Absence of cerebral and brain stem function
- Pupillary responses are absent
- The corneal and gag reflex are absent
- No facial or tongue movement
- The limbs are flaccid
- Primitive withdrawal movements mediated at a spinal cord levelcan occur.

Body temperature must be above 32 C to exclude hypothermia

No chance of drug intoxication or neuromuscular blockade. Patient is not in shock

Brain Death: Brown University Health

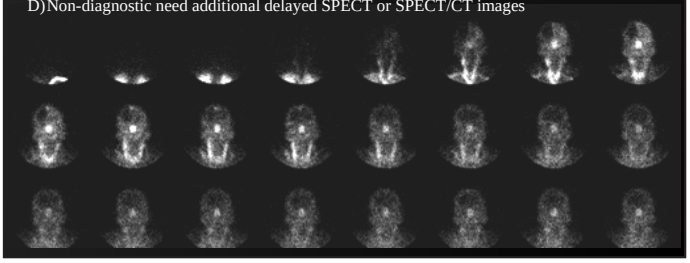
2 neurological examinations performed 6 hours apart
- -1 exam from Neurology or Neurosurgery

Single brain death examination with confirmatory nuclear medicine brain scan or 4 vessel angiogram

Case 1

Best interpretation for this NM brain death study using Tc99m DTPA?

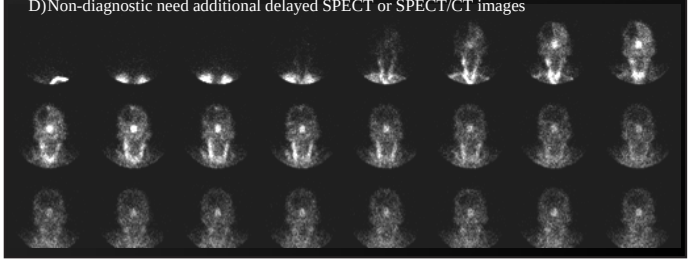
A) Positive brain death study
B) Negative brain death study
C) Non-diagnostic need additional delayed planar images
D) Non-diagnostic need additional delayed SPECT or SPECT/CT images

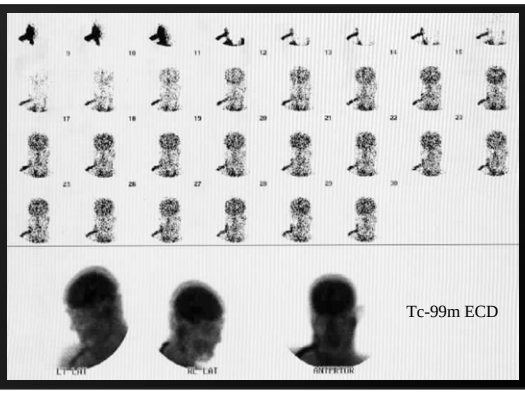


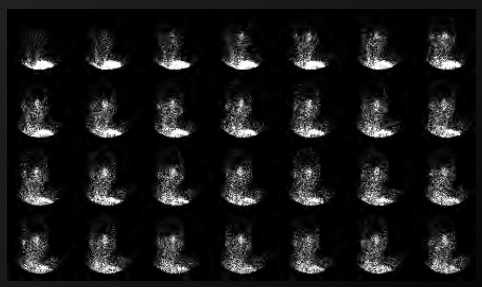
Case 1

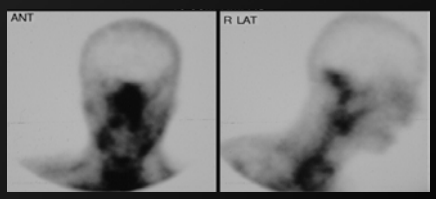
Best interpretation for this NM brain death study using Tc99m DTPA?

A) Positive brain death study
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C) Non-diagnostic need additional delayed planar images
D) Non-diagnostic need additional delayed SPECT or SPECT/CT images







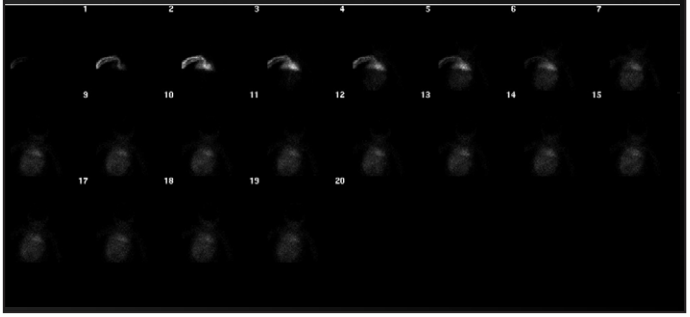


Brain Death Scintigraphy

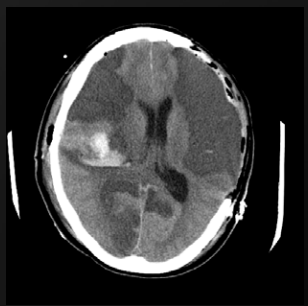
Tc-99m DTPA with angiographic phase imaging
- -No delayed imaging since does not cross blood brain barrier

Tc-99m HMPAO and Tc-99m ECD are perfusion agents that crosses blood brain barrier and will accumulate in brain (if there is flow)
- -Angiographic and static planar imaging
- -SPECT or SPECT/CT is optional

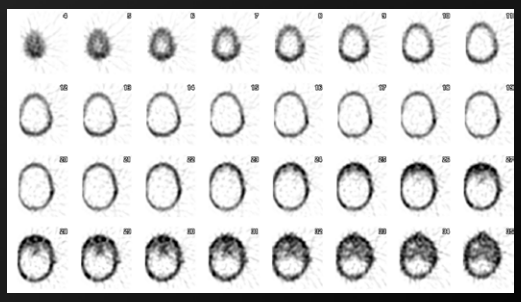
Brain Flow Tc99m DTPA



54 year old with cerebral aneurysm clipping, unresponsive.



Slide courtesy of Dr. Alan Siegel



Slide courtesy of Dr. Alan Siegel

Brain Death

Brain death is a clinical diagnosis and therefore scintigraphy is NOT "diagnostic" of brain death but can be confirmatory

Diagnosis requires complete absence of both venous and arterial flow

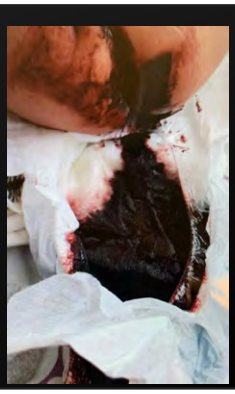
"Hot nose" sign: usually accompanies brain death, indicates collateral circulation

Previously healthy four-month-old boy presented to the emergency department after mom saw two large maroon colored stool which was sticky with red tinged edges

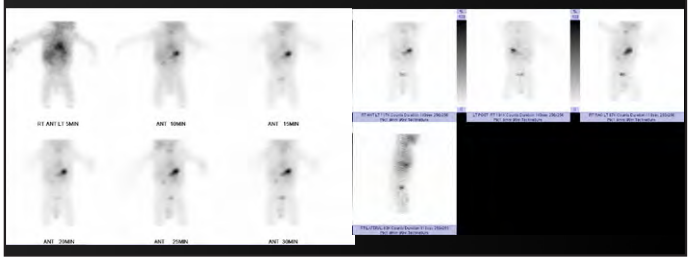
Hgb of 7.5

KUB -nonobstructive nonspecific bowel gas pattern

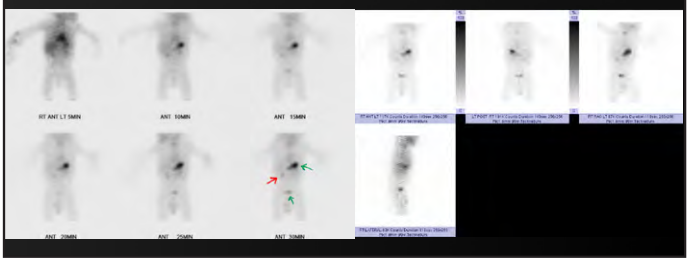
Ultrasound - no sonographic abnormalities and no visualized intussusception



Best interpretation for this Meckel's scan using Tc-99m Pertechnetate?
A) Positive Meckel's study in midline lower pelvis
B) Positive Meckel's study in right mid abdomen
C) No evidence of Meckel's diverticulum



Best interpretation for this Meckel's scan using Tc-99m Pertechnetate?
A) Positive Meckel's study in midline lower pelvis
B) Positive Meckel's study in right mid abdomen
C) No evidence of Meckel's diverticulum

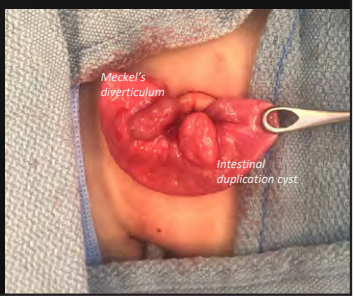


Surgery Performed at 4 am

Pathology two distinct cystic lesions

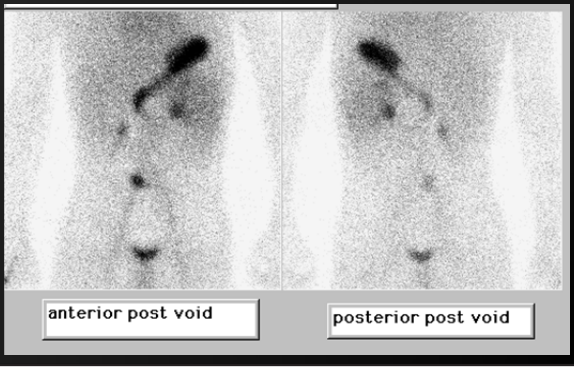
1. *Meckel's diverticulum*
Cystically dilated diverticulum lined by gastric epithelium

2. *Intestinal duplication cyst*
Cystic lesion with no luminal communication

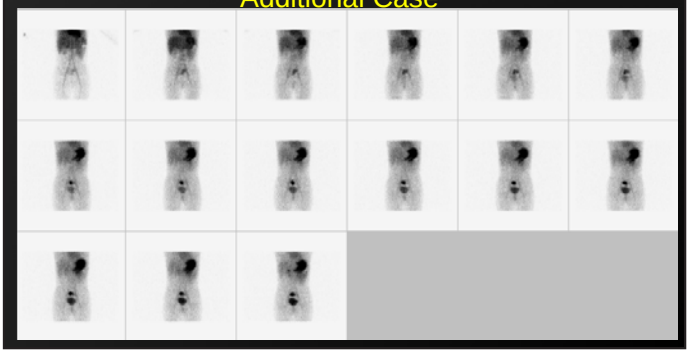


More obvious case

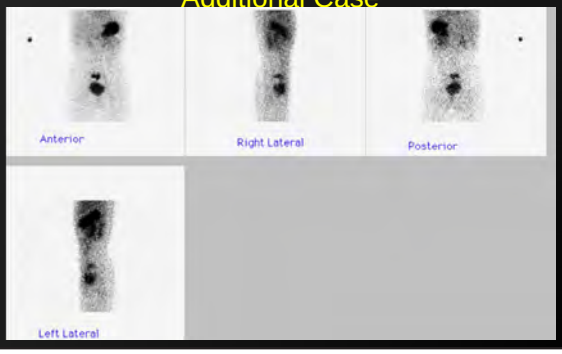




Additional Case



Additional Case



Classic Presentation

Painless lower gastrointestinal bleeding - Ulceration of the heterotopic gastric mucosa

Intestinal obstruction - Internal volvulus or intussusception

Inflammation - Pain either with or without intestinal perforation (can mimic appendicitis)

Meckel's diverticulum

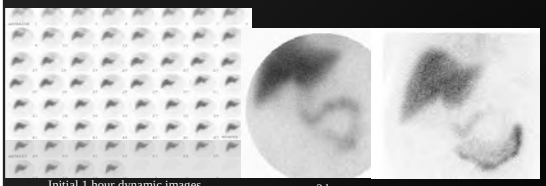
Vestigial remnant of omphalomesenteric duct

Rule of 2's
- 2% of the population
- 2 feet from the ileocecal valve
- 2 inches in length
- < 2 years old (association with esophageal atresia, imperforate anus, and omphalocele)

Majority of SYMPTOMATIC patients with Meckel's diverticulum have ectopic gastric mucosa

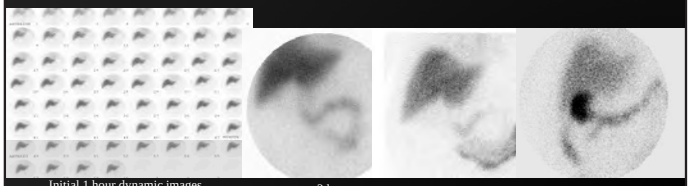
Case 3

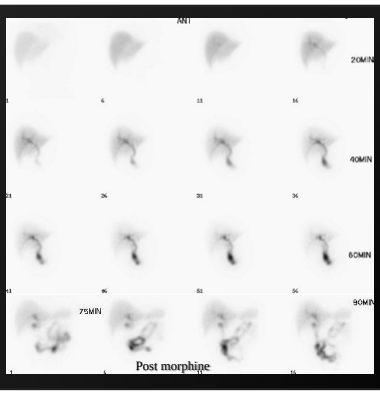
Hepatobiliary scan for evaluation of acute cholecystitis – Best Answer
A) Acute cholecystitis
B) SPECT or SPECT/CT should be performed
C) Morphine should be administered
D) Additional delayed images should be performed

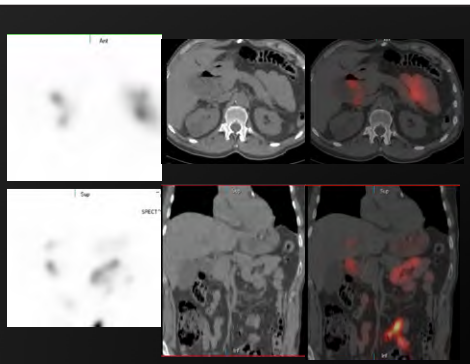


Case 3

Hepatobiliary scan for evaluation of acute cholecystitis – Best Answer
A) Acute cholecystitis
B) SPECT or SPECT/CT should be performed
C) Morphine should be administered
D) Additional delayed images should be performed







FALSE POSITIVES

Ingestion of fatty meal < 4 hrs before injection (contracted gallbladder)

Fasting > 24 hrs (full gallbladder)

Prolonged TPN/anorexia (atonic gallbladder)

CCK

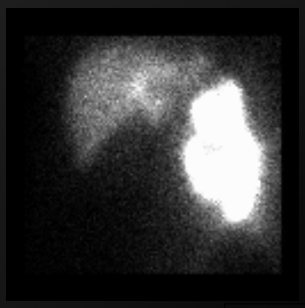
Clear gallbladder in an NPO patient > 24 hrs

Dosage: 0.02 microgram/kg over 1-2 minutes

Primary regulator of gallbladder emptying (opposes sympathetic nerves)

40 year old woman with RUQ pain, but no fever.





After morphine

MORPHINE

Induces spasm of sphincter of Oddi > forces backflow into gallbladder

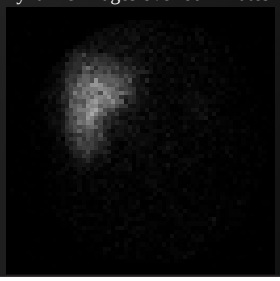
Give morphine, 0.04 mg/kg IV if GB is not seen 60 minutes post-injection

Non-visualization of gallbladder 30 minutes post-morphine injection: c/w acute cholecystitis

Visualization of gallbladder: not c/w acute cholecystitis

Case 4

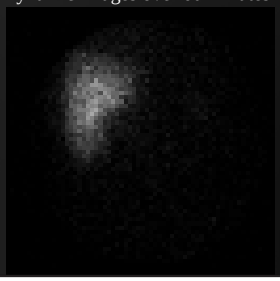
Dynamic Images over 60 minutes



Hepatobiliary scan for evaluation bile leak
A) Positive bile leak study
B) Negative bile leak study
C) Additional delayed images should be performed
D) Hepatic dysfunction or CBD obstruction

Case 4

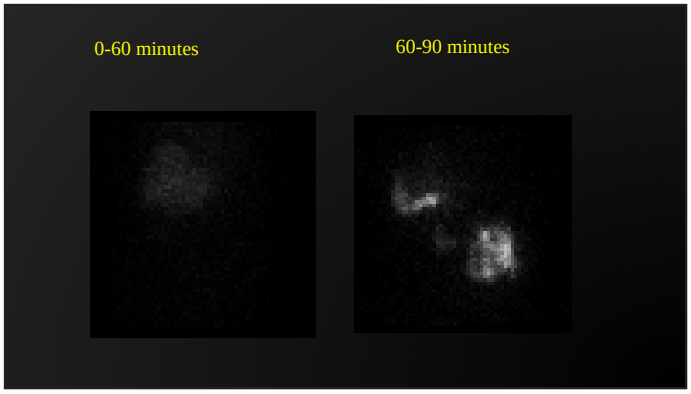
Dynamic Images over 60 minutes

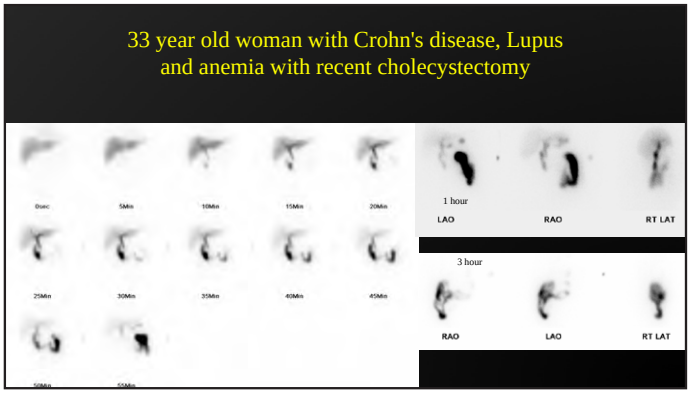


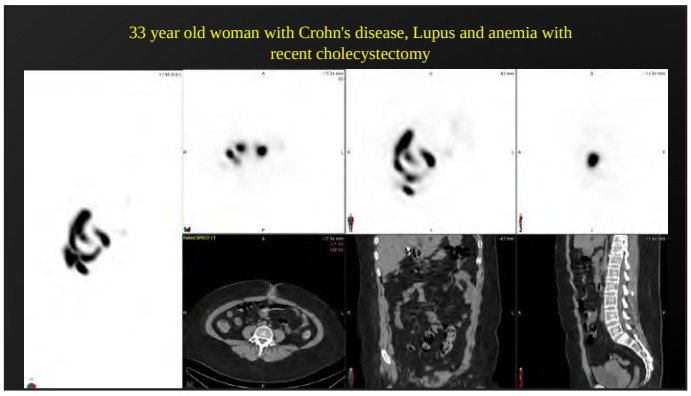
Hepatobiliary scan for evaluation bile leak
A) Positive bile leak study
B) Negative bile leak study
C) Additional delayed images should be performed
D) Hepatic dysfunction or CBD obstruction

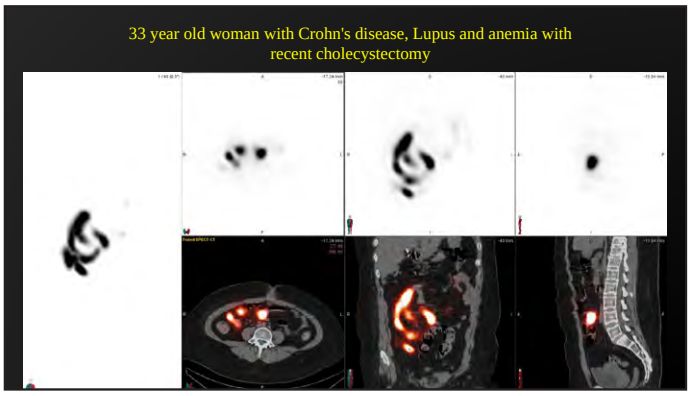
0-60 minutes

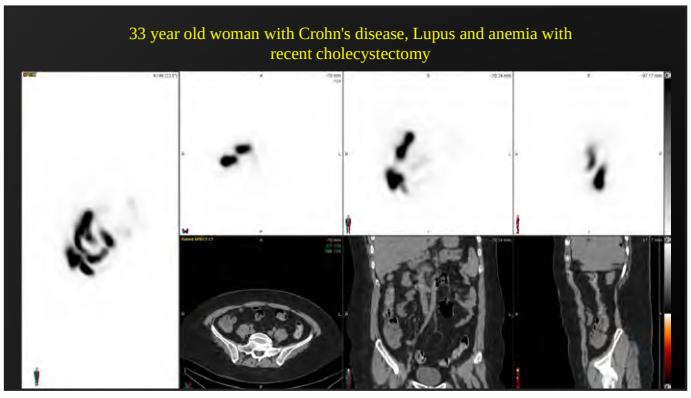


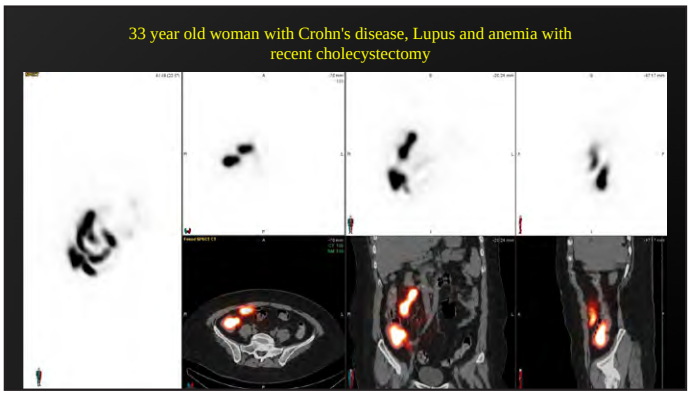












Teaching Points - Biliary Leak

Delayed imaging, different projections, SPECT/CT can helpful

Cine

What is the first line radiology study performed in the ER for acute lower GI bleed?

A) CTA (GI bleeding protocol)
B) NM bleeding scan (Tagged RBC scan)

GI Bleedings Scans

CTA is now first line study at many Institutions

NM Bleeding scan should now be performed after a negative CTA if the patients rebleeds

Management of gastrointestinal bleeding: Society of Abdominal Radiology (SAR) Institutional Survey. Abdom Radiol (NY). 2022 Jan;47(1):2-12.

Gastrointestinal Bleeding at CT Angiography and CT Enterography: Imaging Atlas and Glossary of Terms. Radiographics. 2021 Oct;41(6):1632-1656.

Revised 2020

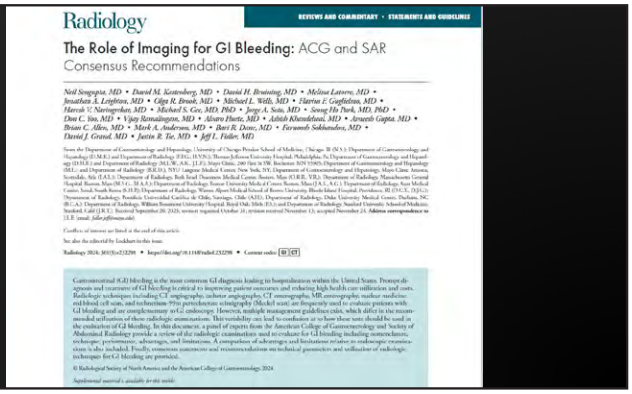
American College of Radiology
ACR Appropriateness Criteria®
Radiologic Management of Lower Gastrointestinal Tract Bleeding

Variant 1: **Lower gastrointestinal tract bleeding. Active bleeding clinically observed as hematochezia or melena in a hemodynamically stable patient. Next step.**

Procedure	Appropriateness Category
CTA abdomen and pelvis without and with IV contrast	Usually Appropriate
Diagnostic/therapeutic colonoscopy	Usually Appropriate
RBC scan abdomen and pelvis	Usually Appropriate
Transcatheter arteriography/embolization	May Be Appropriate
MRA abdomen and pelvis without and with IV contrast	Usually Not Appropriate
Surgery	Usually Not Appropriate

Variant 2: **Lower gastrointestinal tract bleeding. Active bleeding in a hemodynamically unstable patient or a patient who has required more than 5 units of blood within 24 hours. Next step.**

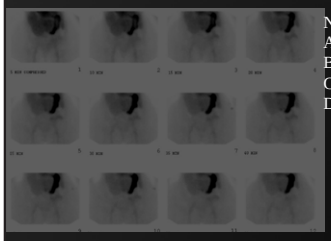
Procedure	Appropriateness Category
CTA abdomen and pelvis without and with IV contrast	Usually Appropriate
Transcatheter arteriography/embolization	Usually Appropriate
Diagnostic/therapeutic colonoscopy	May Be Appropriate (Disagreement)
Surgery	May Be Appropriate
MRA abdomen and pelvis without and with IV contrast	Usually Not Appropriate
RBC scan abdomen and pelvis	Usually Not Appropriate


Radiology

REVIEWS AND COMMENTARY • STATEMENTS AND GUIDELINES

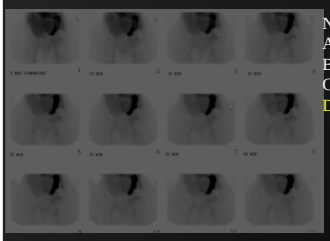
The Role of Imaging for GI Bleeding: ACG and SAR Consensus Recommendations

Case 6



NM Tagged RBC scan for evaluation BRBPR
A) Colonic bleed
B) Gastric bleed
C) Small bowel bleed
D) QA issue

Case 6

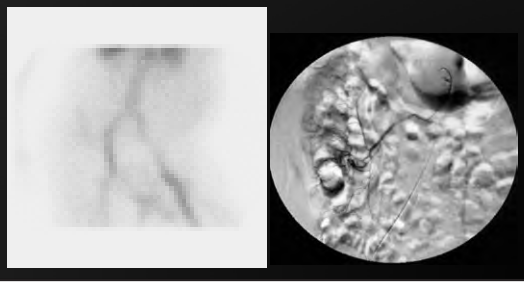


NM Tagged RBC scan for evaluation BRBPR
A) Colonic bleed
B) Gastric bleed
C) Small bowel bleed
D) QA issue

RBC labeling techniques

1. In-vivo (70-80% labeling efficiency)
   -inject Sn2+ or PYP, inject Tc-99m
2. Modified in-vivo (85-95% labeling efficiency)
   -inject Sn2+ or PYP, draw blood, mix with Tc-99m, reinject
3. In-vitro (> 95% labeling efficiency)
   -draw blood, use kit, add Tc-99m, reinject

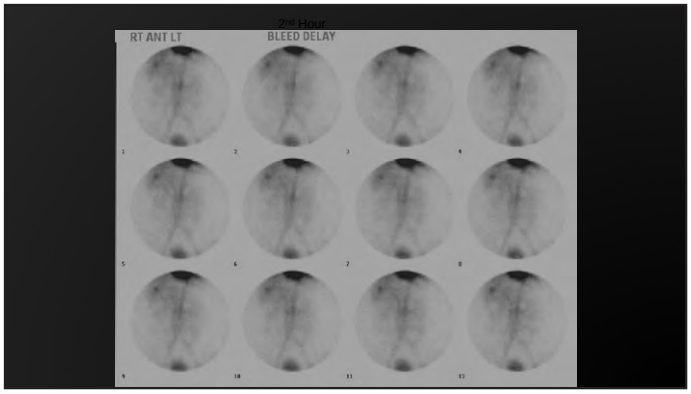
Additional Case

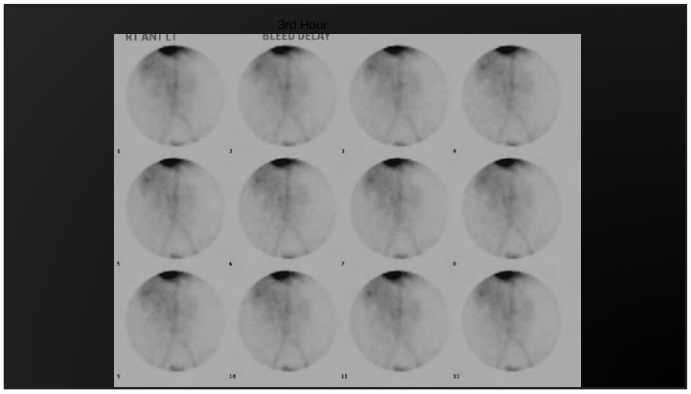


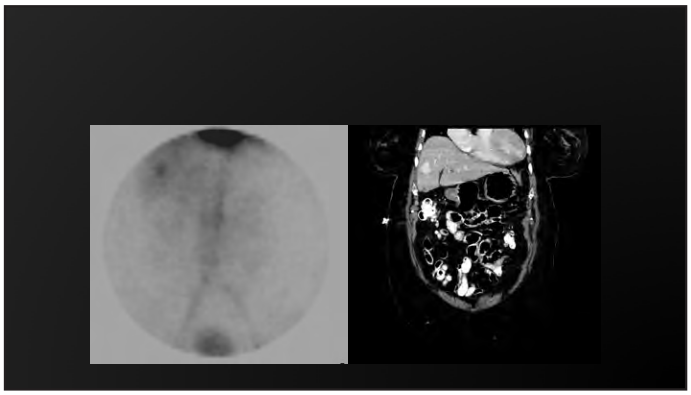
Teaching Points

Sensitivity to detect active GI bleeding

RBC scintigraphy: 0.1 mL/min
Contrast angiography: 1.0 mL/min





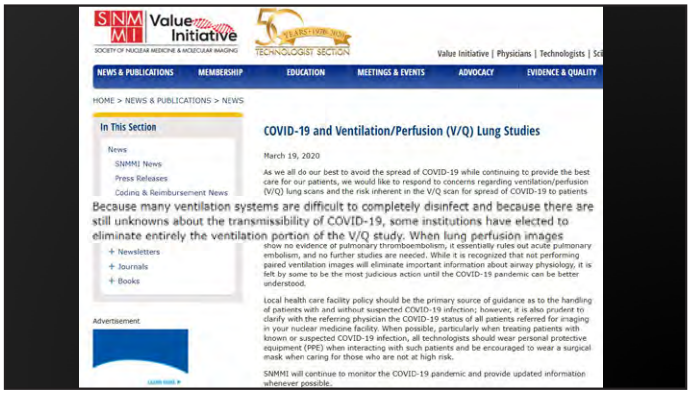


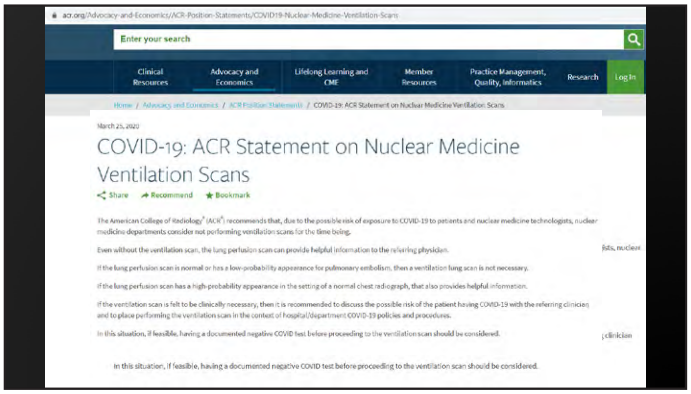
Teaching Points

Criteria for diagnosis bleed
- -activity that moves
- -changes in intensity

CINE

Pitfalls
- -vascular
- -genitourinary activity
- -free Tc





COVID-19 ACR Statement V/Q Scans - 3/25/2020

The ACR recommends that, due to the possible risk of exposure to COVID-19 to patients and nuclear medicine technologists, nuclear medicine departments consider not performing ventilation scans for the time being.

Even without the ventilation scan, the lung perfusion scan can provide helpful information to the referring physician.

If the lung perfusion scan is normal or has a low probability appearance for pulmonary embolism, then a ventilation lung scan is not necessary.

If the lung perfusion scan has a high probability appearance in the setting of a normal chest radiograph that also provides helpful information.

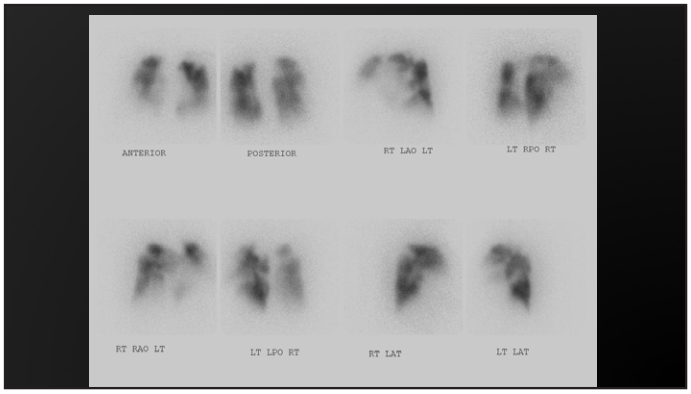
If the ventilation scan is felt to be clinically necessary, then it is recommended to discuss the possible risk of the patient having COVID-19 with the referring clinician and to place performing the ventilation scan in the context of hospital/department COVID-19 policies and procedures.

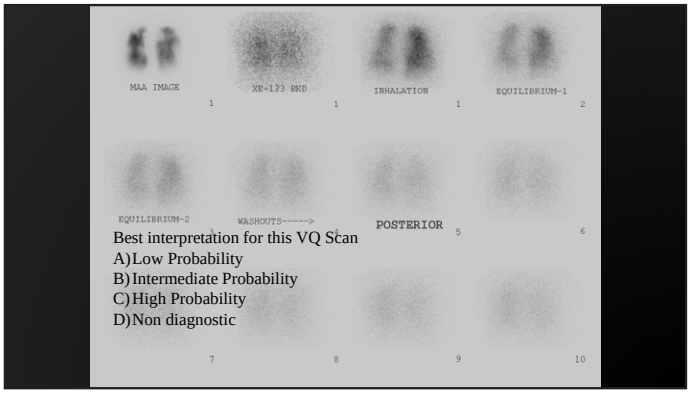
In this situation, if feasible, having a documented negative COVID test before proceeding to the ventilation scan should be considered.

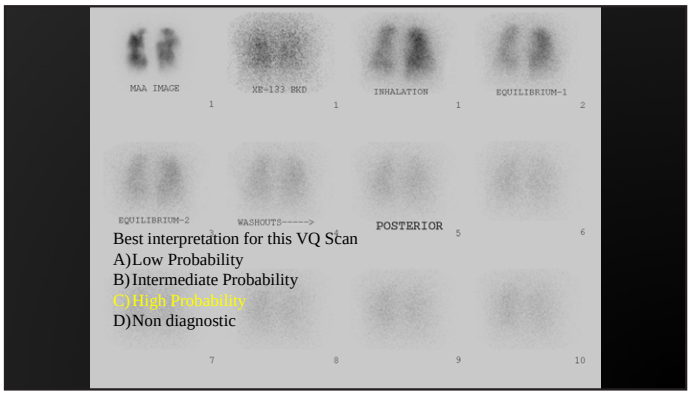
SNMMI Statement: COVID-19 and Ventilation/Perfusion (V/Q)

September 22, 2021

As the incidence and the prevalence of COVID-19 vary from time to time and region to region, it may be appropriate to follow your institutional/local regulatory guidelines to determine feasibility of a ventilation scan as part of the lung scan in the work up of a suspected pulmonary embolism. SNMMI will continue to monitor the COVID-19 pandemic and provide updated information whenever possible.







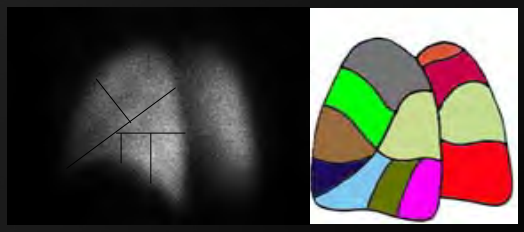
V/Q Scan Interpretation

Anatomy

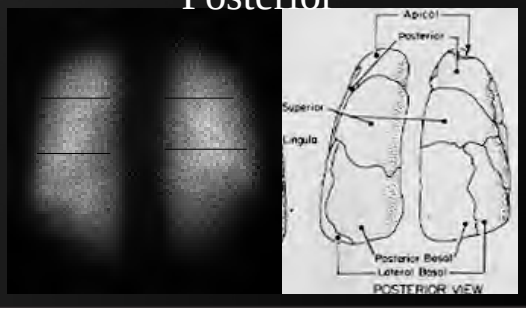
Criteria for Interpretation

CXR

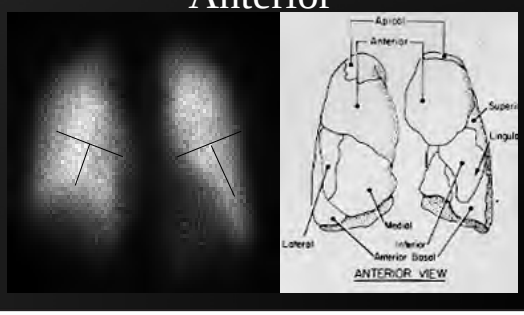
Anatomy
LPO



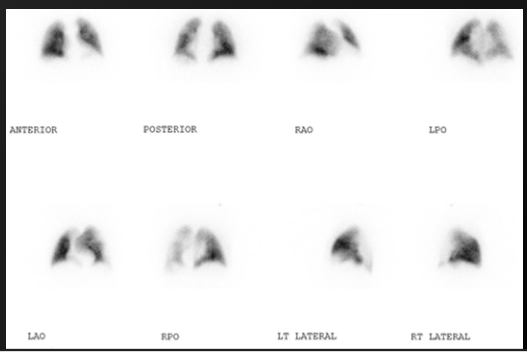
Anatomy
Posterior



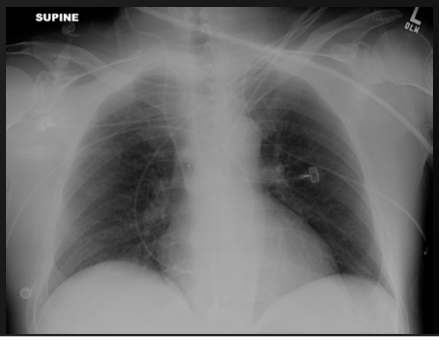
Anatomy
Anterior



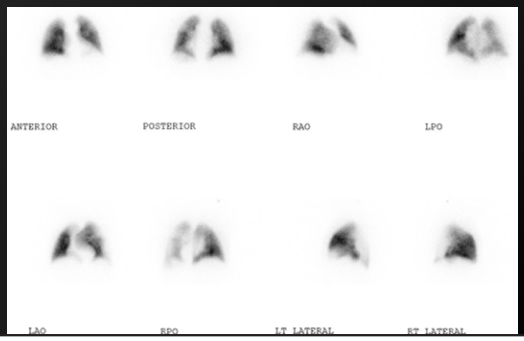
Case



Imaging Findings



Imaging Findings



Teaching Points – Lung defects

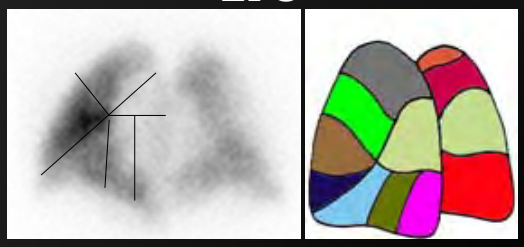
Segmental perfusion defect:
- wedge shaped, pleural based defect

- large - >75% of lung segment
- moderate - 25-75% of lung segment
- small - <25% of lung segment

Nonsegmental Defect
- Does not conform to segmental anatomy
- Does not appear wedge shaped
- Is not pleural based

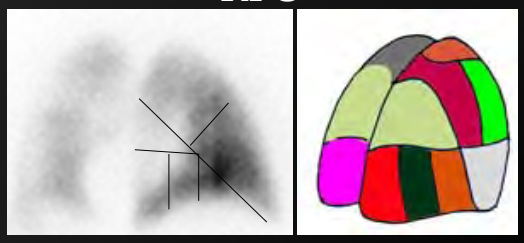
Imaging Findings

LPO



Imaging Findings

RPO



Differential Diagnosis

- Low probability V/Q scan
- Intermediate probability V/Q scan
- High probability V/Q scan

Teaching Points - Interpretation

V/Q Match: Both the perfusion and ventilation scans are abnormal in the same area

V/Q Mismatch: Abnormal perfusion in an area of normal ventilation

Differential Diagnosis: V/Q Mismatch

PE
Vasculitis
Tumor/hilar lymph node
Fibrosing mediastinitis
Pulmonary artery stenosis
IV drug abuse

Teaching Points - Criteria

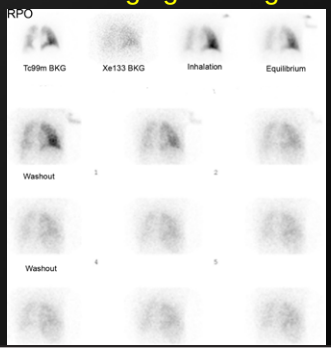
Modified PIOPED Criteria for Combined-Study Interpretation

High Probability: > 80% likelihood of PE
- Two or more large mismatched segmental defects (2 moderate = 1 large)

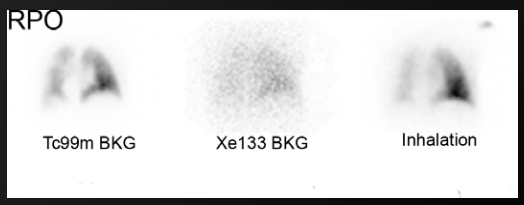
Intermediate Probability: 20-80% likelihood of PE
- one large + one moderate segmental mismatch
- one moderate segmental mismatch
- criteria for high and low probability not met

Low Probability: < 20% likelihood of PE
- nonsegmental perfusion defects, small subsegmental perfusion defects
- matched defects with normal CXR

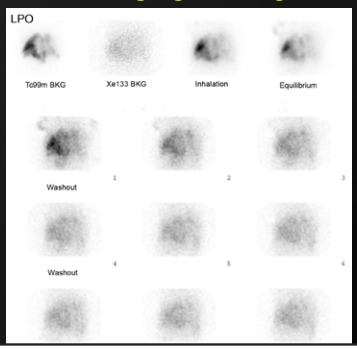
Imaging Findings



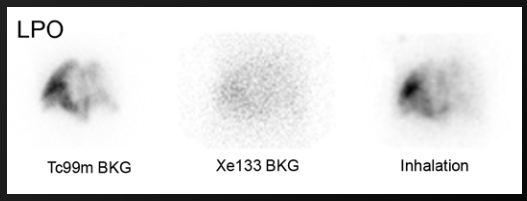
Imaging Findings



Imaging Findings



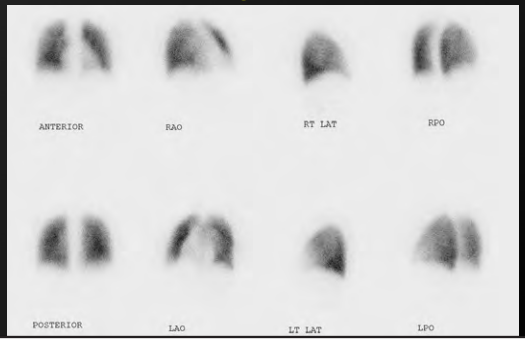
Imaging Findings



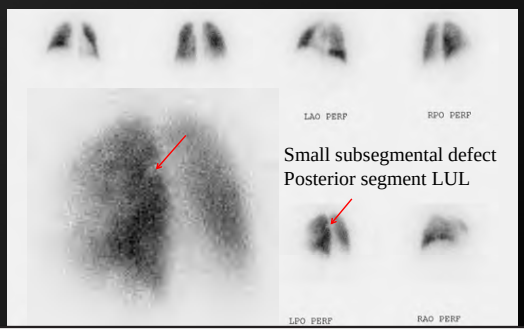
Diagnosis

Low Probability V/Q scan

Normal Lung Perfusion Scan

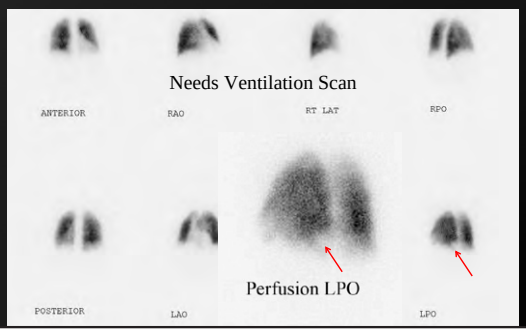


Low Probability Lung Perfusion Scan



Small subsegmental defect
Posterior segment LUL

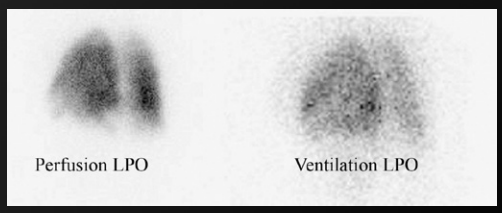
Moderate segmental defect in PB segment LLL



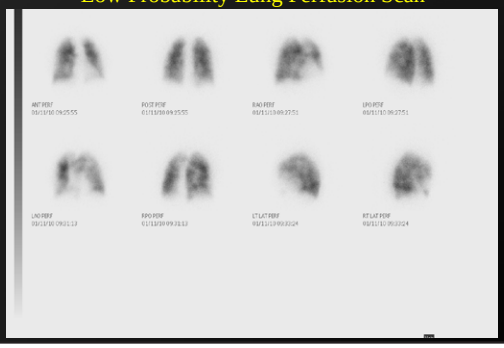
Ventilation Scan Normal



Intermediate Probability V/Q scan
1 moderate segmental V/Q mismatch



Low Probability Lung Perfusion Scan



Low Probability Lung Perfusion Scan



DDX heterogeneous perfusion

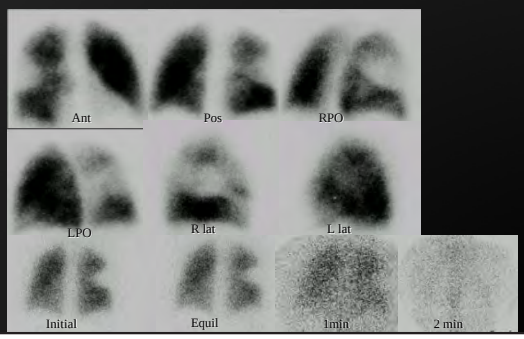
CHF
Vasculitis
Primary Pulmonary HTN
COPD
Chronic Interstitial Lung Disease
Lymphangitic carcinomatosis

Abnormal CXR

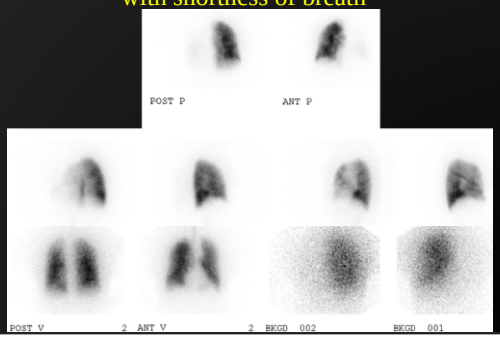
Additional Case



Additional Case



60 year old male with history of smoking with shortness of breath



Differential Diagnosis

Differential diagnosis for unilateral absence of lung perfusion includes

- -Tumor/Mediastinal Mass
- -Massive pleural effusion
- -Pneumothorax/pneumonectomy
- -Pulmonary agenesis
- -Pulmonary embolism

Further evaluation with CT of the chest is usually warranted

Imaging Findings



Imaging Findings



Diagnosis

Left suprahilar mass resulting in "high probability V/Q scan"

Unilateral complete mismatch is an unlikely pattern of pulmonary embolus and raises the suspicion of a central or hilar mass

VQ Scans in Pregnancy

Background - PE in pregnancy

PE in pregnancy occurs one in 1000–10,000 pregnancies

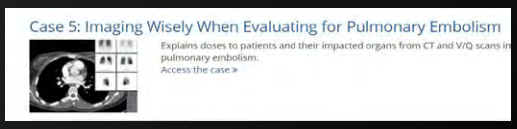
PE in pregnancy is five-times higher compared to non-pregnant women

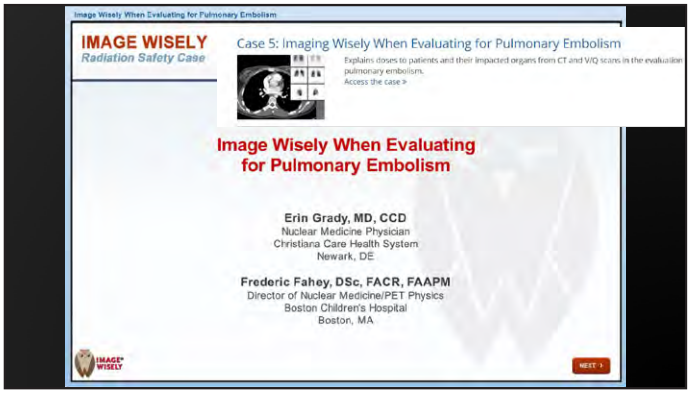
PE is the leading cause of maternal death (Mortality rate of up 30%)

Cannot use most common stratifying scores (Wells Criteria) or D-Dimer

Pabinger I, Grafenhofer H. Thrombosis during pregnancy: risk factors, diagnosis and treatment. Pathophysiol Haemost Thromb 2002; 32:322– 324

Imaging Wisely – Radiation Safety Cases





Imaging Wisely Radiation Safety Case	Low-Dose Perfusion[11]	Ventilation/ Perfusion (V/Q)[11]	Standard CTPA Protocol[11]
Breast (mGy)	0.2	0.9-1.4	15-50 ☹

Pahade JK1, Litmanovich D, Pedrosa I, et al. Quality initiatives: imaging pregnant patients with suspected pulmonary embolism: what the radiologist needs to know. Radiographics. 2009 May-Jun;29(3):639-54.

Litmanovich D1, Tack D, Lin PJ, et al. AJR Am J Roentgenol. 2011 Oct;197(4):929-34. Female breast, lung, and pelvic organ radiation from dose-reduced 64-MDCT thoracic examination protocols: a phantom study.

105

Imaging Wisely Radiation Safety Case	Low-Dose Perfusion[11]	Ventilation/ Perfusion (V/Q)[11]	Standard CTPA Protocol[11]
Breast (mGy)	0.2	0.9-1.4	15-50 ☹
Lung (mGy)	2.5	10.0	39.5 ☹

Pahade JK1, Litmanovich D, Pedrosa I, et al. Quality initiatives: imaging pregnant patients with suspected pulmonary embolism: what the radiologist needs to know. Radiographics. 2009 May-Jun;29(3):639-54.

Litmanovich D1, Tack D, Lin PJ, et al. AJR Am J Roentgenol. 2011 Oct;197(4):929-34. Female breast, lung, and pelvic organ radiation from dose-reduced 64-MDCT thoracic examination protocols: a phantom study.

106

Imaging Wisely Radiation Safety Case	Low-Dose Perfusion[11]	Ventilation/ Perfusion (V/Q)[11]	Standard CTPA Protocol[11]
Breast (mGy)	0.2	0.9-1.4	15-50 ☹
Lung (mGy)	2.5	10.0	39.5 ☹
Pelvis/Fetal (mGy)	0.1-0.2	0.9	0.02-0.04 🙂

Pahade JK1, Litmanovich D, Pedrosa I, et al. Quality initiatives: imaging pregnant patients with suspected pulmonary embolism: what the radiologist needs to know. Radiographics. 2009 May-Jun;29(3):639-54.

Litmanovich D1, Tack D, Lin PJ, et al. AJR Am J Roentgenol. 2011 Oct;197(4):929-34. Female breast, lung, and pelvic organ radiation from dose-reduced 64-MDCT thoracic examination protocols: a phantom study.

107

Imaging Wisely Radiation Safety Case	Low-Dose Perfusion[11]	Ventilation/ Perfusion (V/Q)[11]	Standard CTPA Protocol[11]
Breast (mGy)	0.2	0.9-1.4	15-50 ☹
Lung (mGy)	2.5	10.0	39.5 ☹
Pelvis/Fetal (mGy)	0.1-0.2	0.9	0.02-0.04 🙂
Whole Body Effective Dose (mSv)	0.4	1.9-2.3	5-13 ☹

Pahade JK1, Litmanovich D, Pedrosa I, et al. Quality initiatives: imaging pregnant patients with suspected pulmonary embolism: what the radiologist needs to know. Radiographics. 2009 May-Jun;29(3):639-54.

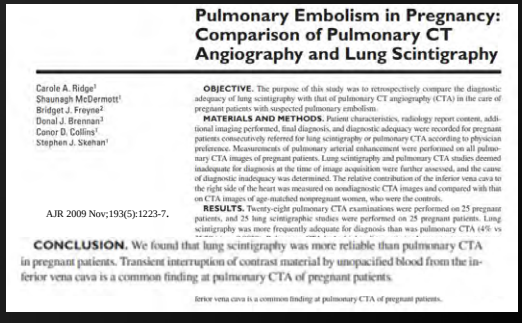
Litmanovich D1, Tack D, Lin PJ, et al. AJR Am J Roentgenol. 2011 Oct;197(4):929-34. Female breast, lung, and pelvic organ radiation from dose-reduced 64-MDCT thoracic examination protocols: a phantom study.

108

CTPA vs VQ
Which study is more affected by Pregnancy

Pregnancy-related physiological changes may affect quality of CT but not VQ

- Increased cardiac output
- Increased plasma volume
- Increased heart rate



Pulmonary Embolism in Pregnancy: Comparison of Pulmonary CT Angiography and Lung Scintigraphy

Carole A. Ridge[1]
Shaunagh McDermott[1]
Bridget J. Freyne[2]
Donal J. Brennan[1]
Conor D. Collins[1]
Stephen J. Skehan[1]

AJR 2009 Nov;193(5):1223-7.

OBJECTIVE. The purpose of this study was to retrospectively compare the diagnostic adequacy of lung scintigraphy with that of pulmonary CT angiography (CTA) in the care of pregnant patients with suspected pulmonary embolism.

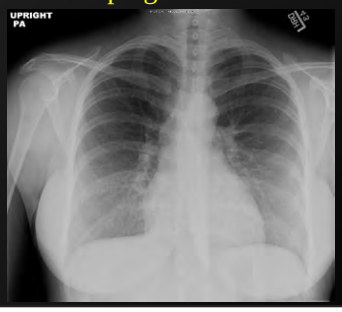
MATERIALS AND METHODS. Patient characteristics, radiology report content, additional imaging performed, final diagnosis, and diagnostic adequacy were recorded for pregnant patients consecutively referred for lung scintigraphy or pulmonary CTA according to physician preference. Measurements of pulmonary arterial enhancement were performed on all pulmonary CTA images of pregnant patients. Lung scintigraphy and pulmonary CTA studies deemed inadequate for diagnosis at the time of image acquisition were further assessed, and the cause of diagnostic inadequacy was determined. The relative contribution of the inferior vena cava to the right side of the heart was measured on nondiagnostic CTA images and compared with that on CTA images of age-matched nonpregnant women, who were the controls.

RESULTS. Twenty-eight pulmonary CTA examinations were performed on 25 pregnant patients, and 25 lung scintigraphic studies were performed on 25 pregnant patients. Lung scintigraphy was more frequently adequate for diagnosis than was pulmonary CTA (4% vs

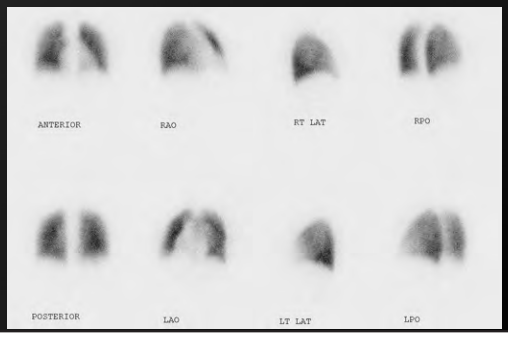
CONCLUSION. We found that lung scintigraphy was more reliable than pulmonary CTA in pregnant patients. Transient interruption of contrast material by unopacified blood from the inferior vena cava is a common finding at pulmonary CTA of pregnant patients.

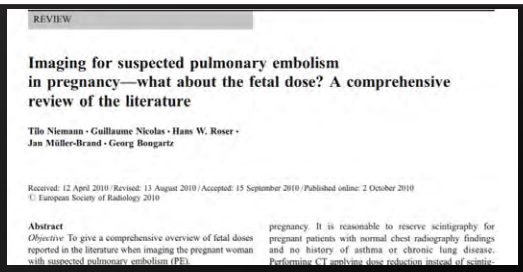
ferior vena cava is a common finding at pulmonary CTA of pregnant patients.

22 year-old woman
26 weeks pregnant with SOB



Normal Lung Perfusion Scan -Homogenous





REVIEW

Imaging for suspected pulmonary embolism in pregnancy—what about the fetal dose? A comprehensive review of the literature

Tilo Niemann · Guillaume Nicolas · Hans W. Roser · Jan Müller-Brand · Georg Bongartz

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Abstract
Objective To give a comprehensive overview of fetal doses reported in the literature when imaging the pregnant woman with suspected pulmonary embolism (PE).

pregnancy. It is reasonable to reserve scintigraphy for pregnant patients with normal chest radiography findings and no history of asthma or chronic lung disease. Performing CT applying dose reduction instead of scintic-

1687 papers reviewed - Fetal Dose

CTA	Lung perfusion
0.013 - 0.026 mGy Early pregnancy	0.1-0.6 mGy Early pregnancy
0.06 - 0.1 mGy Late pregnancy	0.6-0.8 mGy Late pregnancy

Ventilation with Tc99m-aerosol gas dose 0.1-0.3 mGy

Chance of Fetal Malformation or Malignancy

<50mGy - Negligible

100mGy - Risk of Malformation and Childhood Malignancy Combined is about 1%

1. McCollough CH, Schueler BA, Atwell TD, et al. Radiation exposure and pregnancy: when should we be concerned? RadioGraphics 2007;27:909–918.
2. ACOG Committee on Obstetric Practice. ACOG Committee Opinion. No. 299, September 2004 (replaces No. 158, September 1995): guidelines for diagnostic imaging during pregnancy. Obstet Gynecol 2004;104:647–651.
3. ICRP, 2000. Pregnancy and Medical Radiation. ICRP Publication 84. Ann. ICRP 30

Risk for Breast Cancer?

30-100X greater radiation dose to the breast from CTA compared to V/Q scan

Depending on the radiosensitivity of the tissue and age of exposure

-radiation dose can have more variable effect

-pregnant patient with proliferating breast tissue at higher risk

PIOPED II guidelines

PIOPED II guidelines for the workup of pregnant patients suspected of having pulmonary embolism:

69% recommended pulmonary scintigraphy

31% recommended CTA

Stein et al. Diagnostic pathways in acute pulmonary embolism: Recommendations of the PIOPED II Investigators. Radiology. Jan 2007

Society Recommendations

SNMMI - Avoid using a computed tomography angiogram to diagnose pulmonary embolism in young women with a normal chest radiograph; consider a radionuclide lung study ("V/Q study") instead.

American Thoracic Society – Although the fetal dose is marginally higher, a VQ scan is recommended if the patient is stable and has a normal chest radiograph

American College of Obstetrics and Gynecology – VQ scan endorsed

ACR Appropriateness Criteria

Variant 3: **Suspected pulmonary embolism. Pregnant patient.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	9		☢
US duplex Doppler lower extremity	8	This procedure may be an initial examination prior to CTA, which may prevent the need for ionizing radiation in the appropriate clinical setting.	O
CTA chest with IV contrast	7	This procedure should be optimized for pulmonary circulation.	☢☢☢
CT chest with IV contrast	7	This procedure should be optimized for pulmonary circulation. This procedure may be an alternative to CTA, but both should not be performed.	☢☢☢
Tc-99m V/Q scan lung	7	This procedure may be an alternative to CTA, but both should not be performed. Ventilation should be done only if necessary.	☢☢☢

Review - PE evaluation in Pregnancy (True or False)

1. V/Q is more likely to be non-diagnostic than CT
   False

2. V/Q has slightly decreased radiation dose to the breast compared to CT
   False

3. V/Q has a higher radiation dose than CT to the fetus
   True

NM Emergencies

1. Brain Death Studies
2. Meckel's scan
3. Hepatobiliary Scans
4. GI Bleeding scans
5. VQ Scans

SELF EVALUATION

Emergency Nuclear Medicine Cases

1. T/F - Brain death scintigraphy is considered a confirmatory test because brain death itself is a clinical diagnosis.

2. Which radiopharmaceutical is commonly used for a Meckel's diverticulum scan?

a. Tc-99m MDP
b. Tc-99m Pertechnetate
c. Tc-99m Sulfur Colloid
d. In-111 WBC

3. If the gallbladder is not visualized 60 minutes after radiotracer injection during a hepatobiliary scan, what pharmacologic agent may be administered to help evaluate for acute cholecystitis?

a. Furosemide
b. Glucagon
c. Morphine
d. Atropine

4. T/F - CT angiography (CTA) has become the preferred first-line imaging study for many institutions evaluating acute lower gastrointestinal bleeding.

5. According to modified PIOPED criteria, which finding indicates a high-probability V/Q scan for pulmonary embolism?

a. One moderate mismatched segmental defect
b. Two or more large mismatched segmental defects
c. Small matched subsegmental defects
d. Heterogeneous nonsegmental perfusion defects

Answer Key: 1. T, 2. B, 3. C, 4. T, 5. B

FACULTY

Summer Kaplan, MD

Summer Kaplan, MD is a pediatric radiologist in the Department of Radiology at The Children's Hospital of Philadelphia (CHOP) and an Associate Professor of Clinical Radiology at the University of Pennsylvania School of Medicine. Dr. Kaplan is certified in diagnostic radiology and Pediatric Radiology by the American Board of Radiology. She holds positions on the Clinical Information Technology Advisory Committee, the Education Committee and the Quality and Safety Committee at CHOP. Dr. Kaplan is a nationally recognized and frequent speaker on topics in pediatric radiology.

You may contact Dr. Kaplan with any questions or comments by email at KaplanS2@chop.edu.

Pediatric Trauma Imaging
Summer Kaplan, MD

Pediatric Trauma Imaging

Summer L. Kaplan, MD MS
Associate Professor of Clinical Radiology
Children's Hospital of Philadelphia

Objectives & Disclosures

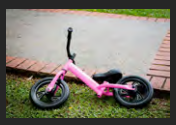
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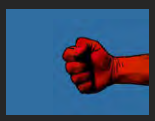
1. Discuss CT protocols and radiation safety.
2. List reasons CT would be needed in pediatric trauma.
3. Understand critical findings on pediatric trauma CT.

No conflicts of interest to disclosure.

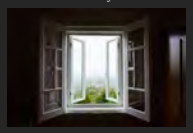
Pediatric Trauma

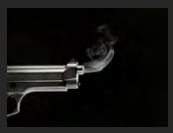

Motor Vehicle Collisions (MVC)


Bicycles


Child Abuse


Playgrounds


Falls


Gun Violence

Pediatric Trauma Imaging

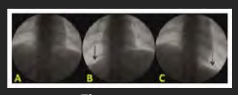


X-ray


Ultrasound


MRI


CT



Fluoroscopy

Radiation Risks

Children have higher risk of future cancer development
- More dividing cells
- Longer lifespan for cancer to develop



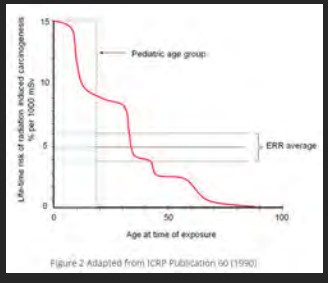
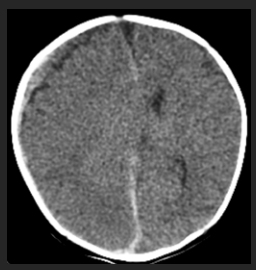


Figure 2 Adapted from ICRP Publication 60 (1990)

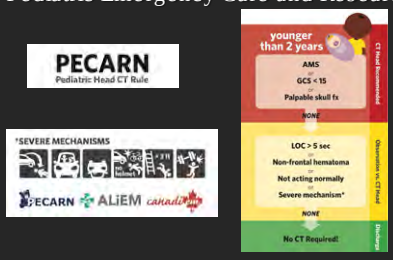
Radiation Reduction

- Size-specific protocols
  - Protocols depend on type of CT scanner
    - Use dose monitoring software
    - Compare with published average doses
  - Allow images with more artifact
- Single phase scans
- Selective use of CT



Head Trauma – Who Needs CT?

Pediatric Emergency Care and Research Network (PECARN)



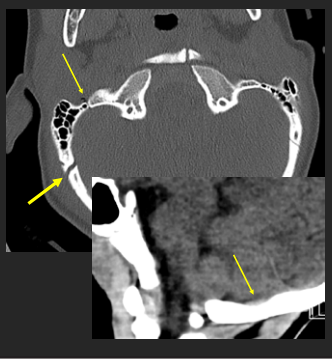
Infant Trauma Head CT



5-week old, Glasgow coma scale 3

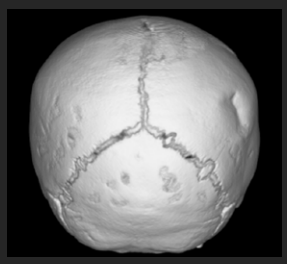
- Extra-axial hemorrhage most common
- Mass effect may be minimal, especially with infarct
- Intracranial hemorrhage/mass effect in infants may present as seizure or abnormal eye movements

Sutures



- Sutures appear serrated
- Fractures appear linear, asymmetric
- Watch for diastasis of sutures
- Injury in children ≤ 2-years old needs 3D bone recons

Ping-pong fracture



- Relatively pliable bone
- Often palpable, prompts CT
- Not specific for abuse

Head Trauma – Who Needs CT?

Pediatric Emergency Care and Research Network (PECARN)



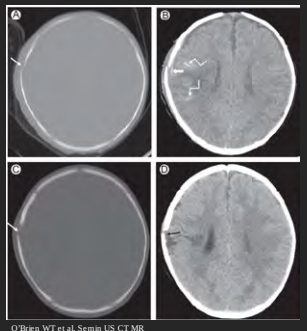
Child Trauma Head CT



14-year old, hit head on pole

- Intracranial injury in children similar to adult
- Fewer baseline abnormalities
- Soft tissue clues

Leptomeningeal cyst

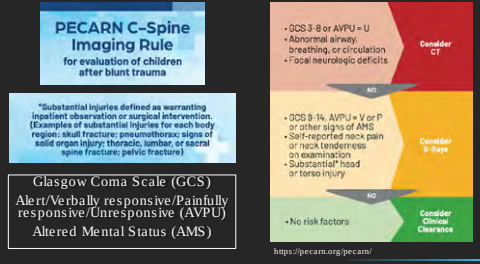


O'Brien WT et al. Semin US CT MR

- Ages ≤ 3-years old
- èGrowing fractureê results from CSF pulsation at fracture
- Several months to evolve
- May contain CSF or brain tissue

Spine Trauma – Who Needs CT?

Pediatric Emergency Care and Research Network (PECARN)



Cervical Spine CT



Normal exam + Normal C-Spine XR = low probability CT



15-year old dove into pool, hitting head

Spine Imaging Field of View

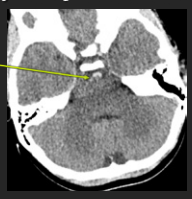
- XR: first line for stable patients
  - Pseudosubluxation
- CT: Consider occiput í C3 for ≤ 8-years old
  - Ligamentous injuries without fractures are more common
  - Dissociation, subluxation
- MR: for persistent neurological deficits despite no fracture



Retroclival Hemorrhage



- Associated with C-spine flexion-extension injury
- May compress brainstem



9-year old, car accident

Facial Trauma



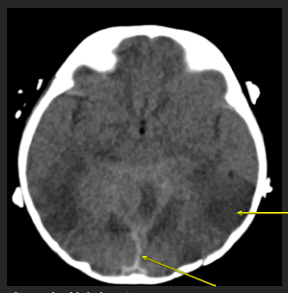
- Children have smaller midface, larger head
- → Soft tissue clues to site of injury
- → Look carefully at superior orbital rim in pediatric blunt head/face trauma

3-yo fall down stairs



6-month old, lethargic

Child Abuse



Hemorrhage
- Subdurals, differing ages
- Subarachnoid
- Diffuse axonal injury (shaking)

Infarcts
- Bilateral symmetric →global hypoxia

Needs skeletal survey x-rays

6-month old, lethargic

Chest Trauma – Who Needs CT?

CXR screening tool for hemodynamically stable patients

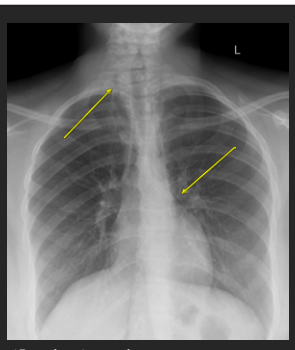
Abnormalities occult on CXR are unlikely clinically relevant

Concerning signs include:
- Large pneumothorax
- Pleural fluid
- Soft tissue gas





Pneumomediastinum



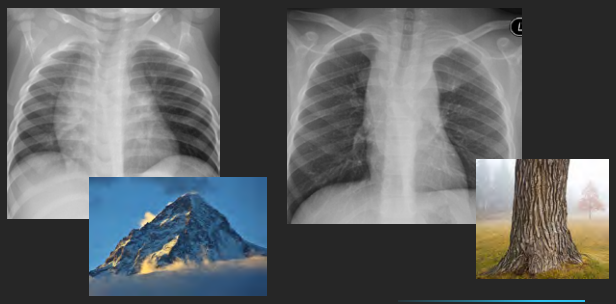


Pneumomedistinum self-resolves in children.

CT only for penetrating injury.

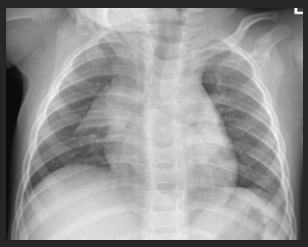
17-yo, dove into pool

Pediatric Mediastinum

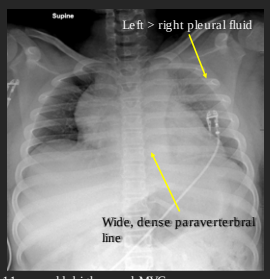


Mediastinum

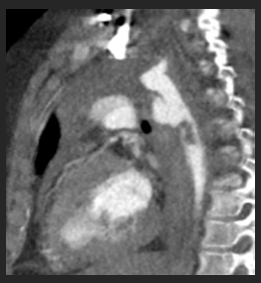
- Thymus
  - Involutes gradually, 6-7 years old
  - May rebound
- Danger signs
  - Wide superior/posterior mediastinum
  - Wide paravertebral line
  - Loss aortic silhouette
  - Left > right pleural fluid



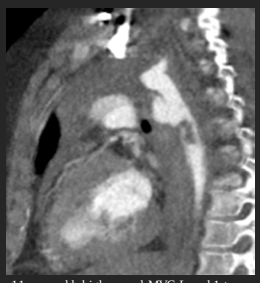
Chest trauma



11-year old, high speed MVC



Aortic rupture (transection)



11-year old, high speed MVC Level 1 trauma

- Tear at the ligamentum arteriosum
  - Posterior mediastinal fluid
  - Left pleural fluid
- In-hospital mortality 40-66%
- →Clinical assessment can be misleading

Diaphragmatic Rupture



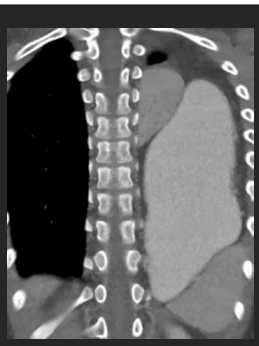
11-year old, vomiting

Posterolateral left most common



7 years earlier

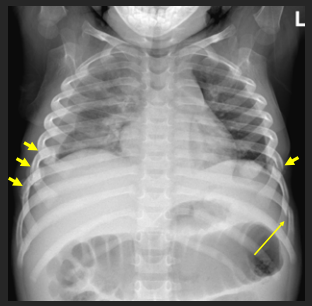
Diaphragmatic Rupture



11-year old, vomiting

- Delayed presentation may occur
  - Spleen or liver may occlude the tear
- Present with mesentero-axial gastric volvulus

Non-Accidental Trauma

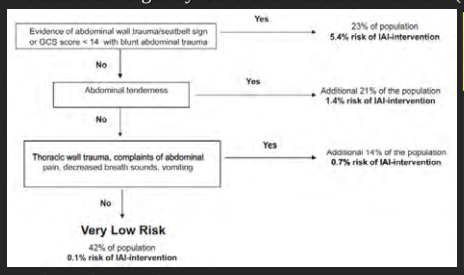


2-year old, abuse suspected

- Fractures of varied ages
- Child ≤ 2-years old
  - Aligned posterior rib fractures 95% predictive
- Occult fractures show healing changes at 2-week follow-up

Abdominal Trauma – Who Needs CT?

Pediatric Emergency Care and Research Network (PECARN)



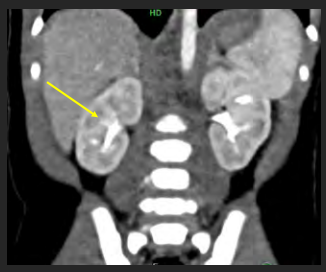
2013 Holmes JF, et al. Ann Emerg Med

12,000 children
20 emergency departments

Focused Assessment with Sonography for Trauma (FAST) negative = **no need for abdominal surgery**

CT Techniques

- With contrast only
  - Non-contrast not needed
- Abdomen use split bolus technique
  - Allows complete renal study
- CT Angiogram
  - Known or suspected vascular injury



2024. Rocha AC et al. Ped Radiol

American Association for Surgery in Trauma (AAST) Guide

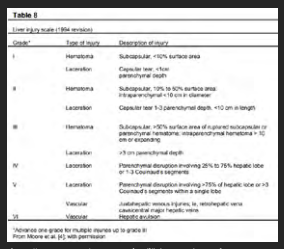


Table II

Liver injury scale (1994 revision)

Grade*	Type of injury	Description of injury
I	Hematoma	Subcapsular, <10% surface area
	Laceration	Capsular tear, <1cm parenchymal depth
II	Hematoma	Subcapsular, 10% to 50% surface area; intraparenchymal <10 cm in diameter
	Laceration	Capsular tear 1-3 parenchymal depth, <10 cm in length
III	Hematoma	Subcapsular, >50% surface area of ruptured subcapsular or parenchymal hematoma; intraparenchymal hematoma > 10 cm or expanding
	Laceration	>3 cm parenchymal depth
IV	Laceration	Parenchymal disruption involving 25% to 75% hepatic lobe or 1-3 Couinaud's segments
V	Laceration	Parenchymal disruption involving >75% of hepatic lobe or >3 Couinaud's segments within a single lobe
	Vascular	Juxtahepatic venous injuries, ie, retrohepatic vena caval/central major hepatic veins
VI	Vascular	Hepatic avulsion

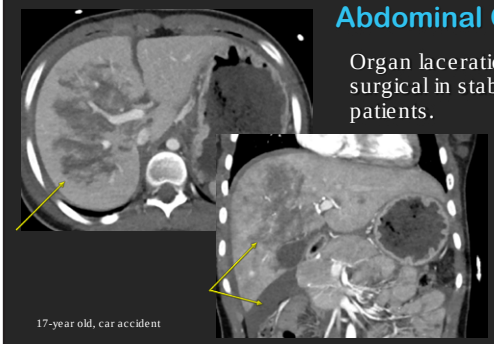
*Advance one grade for multiple injuries up to grade III
From Moore et al. [n], with permission

- Discharge
- Admit – floors
- Admit – ICU
- To OR

Use with caution in small children: Not size-specific

https://www.aast.org/resources-detail/injury-scoring-scale

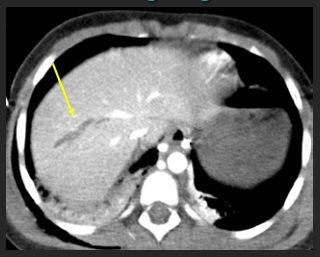
Abdominal CT



Organ lacerations often non-surgical in stable pediatric patients.

17-year old, car accident

Liver Injury



10-year old, car accident. Grade 2.
Laceration <10 cm → no intervention

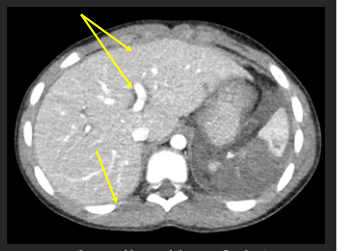


4-year old, car accident. Grade 5.
Left portal vein transection with devascularization > 75% lobe, on-going hemodynamic instability → IR embolization

Splenic Injury

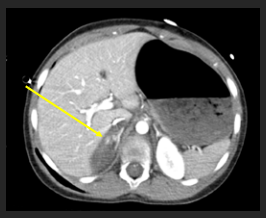


11-year old, car accident. Grade 2.
Laceration >1.0 cm, vitals stable ,

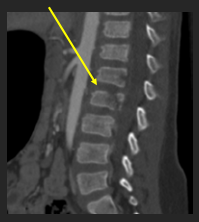


8-year old, struck by car. Grade 4.
Laceration <10 cm → no intervention

Adrenal Injury



6-year old, car crash. Right adrenal hemorrhage

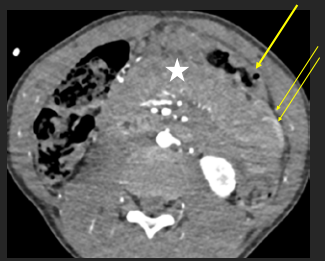


L2 burst fracture



Multi-level vertebral compression and edema

Bowel Injury



16-year old, car accident. Transverse colon thickened. Focal contrast pooling splenic flexure. Regional free air.

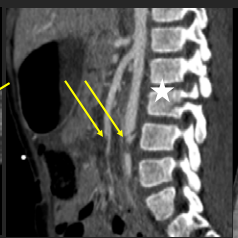


Small bowel focal wall defect → Surgical resection

Specific: Lap Belt Injury



16-year old, car crash.
Bowel injury and free air.

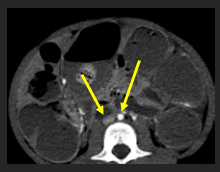


L3 Chance fracture. Irregular aorta and superior mesenteric artery.

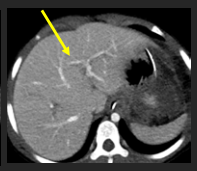


Aortic intramural hematomas.

Specific: Hypoperfusion Complex



4-yo, MVC. Small caliber aorta and flattened IVC. Diffusely dilated, thin-walled bowel. Bowel wall may be hyper-enhancing.



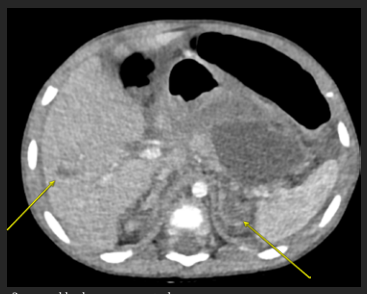
Angiographic appearance solid organs.



Hyperenhancing adrenals.

Normal BP → Precipitous hypotension within 10 minutes
Emergent communication to referring physician!

Non-Accidental Trauma



2-year old, abuse suspected

CT abdomen/pelvis for:

- Bruising
- Abdominal pain
- Abnormal liver or pancreas serology
- Altered mental status with normal head CT

US in Abdominal Trauma

- Focused Assessment with Sonography in Trauma (FAST)
  - Low risk blunt trauma with GCS ≥14 and normal FAST → No CT
- Contrast-Enhanced Ultrasound (CEUS)
  - No radiation, bedside exam, real-time & repeat assessment
  - Operator dependent
  - Meta-analysis 364 pediatric patients
    - Sensitivity 88.5%; Spleen > Liver
    - Specificity 98.5%; Kidney > Liver



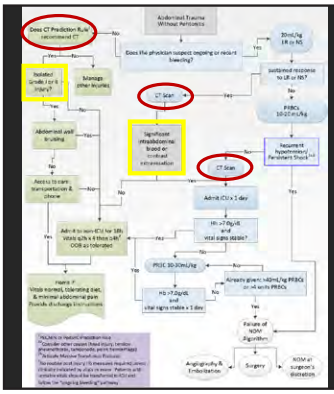
Spleen- Parenchymal Phase

Pediatric Pan Scans

- CT Head, C-Spine, Chest, Abdomen/Pelvis
  - +/- T- & L-Spine, extremity run-off
- Meta-analysis 30 papers trauma center CT use
  - Pooled rates CT for blunt trauma (all $p < 0.05$)

CT Exam	Pediatric	Adult/Mixed
Head	37%	43%
C-Spine	23%	45%
Chest	14%	25%
Abdomen/Pelvis	35%	45%
≥1 CT scan	54%	70%

Hassakanl A, et al. Emerg Radiol, 2023.



Surgical Decision Support

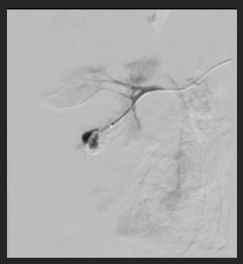
ATOMAC + Pediatric Trauma Research Network

https://aptrn.org/wp-content/uploads/2023/01/SOI-Algorithm_v12.0-v7.3.pdf

- Discharge
- Admit – floors
- Admit – ICU
- To OR

Interventional Procedures

- Liver injury
  - Hemodynamically unstable → consider embo
- High grade spleen injury
  - Hemodynamically unstable → consider embo after trial of non-operative management
  - Hemodynamically stable → no intervention
- Renal injury, active bleeding
  - Hemodynamically stable → consider selective embo to improve salvage

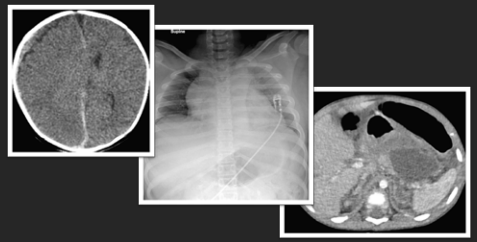


Annam A, et al. J Vasc Interv Radiol, 2024.

Key Points

- Reduce radiation in children
  - Size-specific protocols, single phase CT, and selective scanning
- Facial fractures in kids
  - More likely to be fronto-orbital due to smaller midface
- Chest CT may be useful for
  - Pleural fluid or free air on XR
- PECARN abdominal CT guidelines
  - Recommend against imaging extremely low risk patients.
- Abdominal hypoperfusion complex characterized by
  - Small aorta, flat IVC, and hyperenhancing adrenals, among other findings.

Pediatric Trauma Imaging



Dr. Summer L. Kaplan

SELF EVALUATION

Pediatric Trauma Imaging

1. Appropriate radiation use in pediatric trauma imaging includes:

a. Using size-specific CT protocols
b. Focus on injured body part
c. Single phase CT
d. All of the above

2. Fracture more likely to occur in children than adults is:

a. Fronto-orbital
b. Lacrimal duct
c. Zygomatic arch
d. Temporal

3. Chest CT may be warranted in child with:

a. GCS 15
b. Fall from height
c. Chest XR showing pleural fluid or free air
d. Age < 2-years old

4. PECARN guidelines for blunt abdominal trauma imaging recommend against abdominal CT for:

a. Children with low velocity mechanism
b. Children with non-surgical injury
c. Children with distracting injury elsewhere
d. Children with very low probability of injury

5. Hypoperfusion complex is characterized by:

a. Bowel perforation, free fluid, pneumoperitoneum
b. Small aorta, flat IVC, hyperenhancing adrenals
c. Hypoenhancing kidneys, collapsed bladder, free fluid
d. Flat aorta, portal hypertension, splenomegaly

Answer Key: 1. D, 2. A, 3. C, 4. D, 5. B

FACULTY

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David M. Yousem, MD, MBA earned his M.D. from the University of Michigan, completed his radiology residency at Johns Hopkins, and a neuroradiology fellowship at the University of Pennsylvania. An internationally recognized expert in neuroradiology, he has authored or edited four textbooks, published more than 350 peer-reviewed articles, and lectured on five continents. He received the RSNA Educator Award and the Gold Medal of the American Society of Neuroradiology. Dr. Yousem is a past President of the American Society of Neuroradiology and remains active in national and international radiologic leadership.

You may contact Dr. Yousem with your questions or comments at dyousem1@jhu.edu.

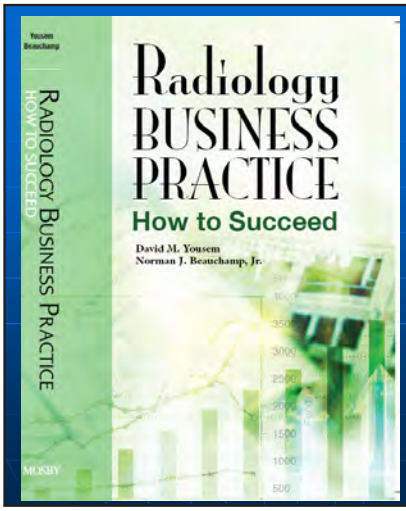
Physician Employment Contracts: Avoiding the Mistakes That Cost Careers
David M. Yousem, MD, MBA

Physician Employment Contracts

David M Yousem, MD, MBA
Credits to Julie Muroff, JD

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RSNA Educational Scholar Grant

Purpose

- Demystify employment contract
- Analyze the basic definition and types of a contract
- Identify significant contractual terms and protections
- Teach via "The Big Mistakes"
- *"The big print giveth and the small print taketh away"*

Big Mistake #1:
"They promised me in our discussions"

- *"Memorialize" it on paper or via email with acknowledgement*
- *Add addendum/codicil*



Definition of a Contract

- Legal terms:
- A promise for the breach of which the law provides a remedy, or for the performance of which the law recognizes a duty

Oral "Agreements"

- Some groups avoid formalizing their agreements in writing, relying instead on verbal commitments of employment with their members
  - Subject to memory
- To achieve greater leverage or flexibility relative to their individual members by declining to commit specific terms of employment in writing

Promissory Estoppel in Verbal Agreements

- Legal doctrine that can make a **spoken (oral) promise legally enforceable**, even when there is **no written contract and not all the usual elements of a contract are present**

Written Agreements

- Less susceptible to the enforcement challenges of oral agreements
- More conducive to establishing the certainty of contractual terms
- Facilitate a proper assessment of the parties' obligations

Parol Evidence Rule

- When parties put their final agreement in writing, you generally cannot use earlier or contemporaneous outside statements (oral or written) to change, contradict, or add to the written contract
  - Prevents "he said" "she said" fights
  - Everything that preceded the contract is void

Big Mistake #2
"They offered me the highest salary of my job offers so I signed with them"

- Think in terms of the total **compensation plan** and work demands
  - BENEFITS
  - DAYS ON SERVICE



Salary

- "Reasonable value for physician's specialty within a geographic area"
  - "The amount of money you are underpaid" LOL
- Productivity based salary or added bonus

Salary

- Common Compensation Structures Used
  - Fixed Base Salary (e.g. 1-2 years of guaranteed base salary)
  - Fixed Base Salary plus (Productivity) Bonus
- Other Salary Considerations
  - Annual adjustment? COLA
  - Is a bonus prorated/paid if employment ends prior to end of term?
  - What is the measurement period for bonus? Quarterly? Annual?
  - What is the timing on payment of productivity bonus?
  - Are advances given? If so, might have to pay back advance
  - Lag in time between when services provided/paid for
  - How is compensation paid after expiration/termination of employment agreement?

Benefits: $$$

- Deferred compensation, retirement and disability benefits health and life insurance, continuing education stipend, the provision of office supplies and equipment, stock options, buy in
  - Is it based on salary?
  - Hopkins clause

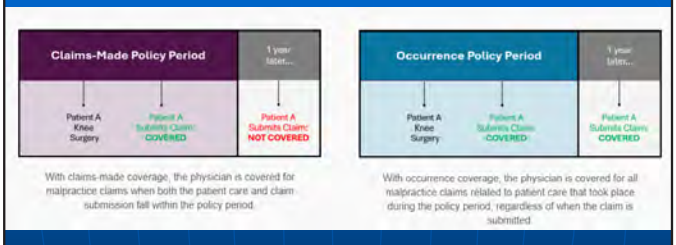
Days of Work

- Paid Time Off (PTO) - may include vacation, sick time and CME
  - Does unused vacation time carry forward to subsequent years?
  - If unused vacation time at end of employment, do you get paid for it?
- Seminars/CME – Days allowed (? Deducted from vacation?)
- Maternity/Paternity leave
- Bereavement leave
- Part-time options

Benefit: Malpractice Insurance

- Who pays
- For how much
- For how long after termination
- Employer wants claims made (take place and reported during contract) not occurrence (while policy is in effect no matter when it is reported)
- Payment for tail of claims made

Basic Difference



- Given an option, choose Occurrence Policy if they are paying

Claims Made "Extras"

- Tail (extended reported period = ERP): for claims made after termination of coverage by that insurer (2016-2026 → 2026-2031)
  - First year 74.8% (lag for claim), 2nd 122%, 3rd 146%, 4th 162%: can be as high as 2.5X original premium for 5 years
- Important for retirement, changing practices, changing carriers
- Provided by the carrier you LEAVE!

Policies Which Should be Explicit

- Leave
- Altered workload
- Partial retirement
- Impairment
- Behavior
- Sexual harassment
- Hostile workplace
- Disability

Big Mistake #3

"Yes there was a non-compete clause, but they said it was pretty standard"

- If you plan to remain in that geographic area (family, ties), negotiate for a less restrictive "non-compete"
- Or none at all (DX versus IR)



Exclusivity:

1. Exclusive employment with the group
2. Covenant not to compete

Exclusive Employment

- A group's employment contract may state "Employee shall not engaged in the practice of medicine except as the Employee of Employer, unless authorized by Employer."
  - Moonlighting
  - Locum tenens
  - Doctors without borders

Covenant Not to Compete

- High stakes!
- Non-compete covenants tend to be the most common source of litigation between radiology groups and their former members !
- A conflict resulting in a law suit: state law will determine the enforceability of the non-compete provision

AKA Restrictive Covenant

- Intent is to restrict employee from providing professional services that compete with employer's practice
- Contain geographic and time based restrictions (how long after hired, how long after leaving …. at what distance)
- May require loss of hospital privileges
- Why? Prevent loss of insider knowledge, poaching of fellow employees, diversion of patients/referrors

Restrictive Covenants

- Non-Solicitation
  - No solicitation or hiring of employee, independent contractor or agent of employer during "Restricted Period"
  - No solicitation of any patient of employer through advertisement, circular, newsletter or other means of communication
  - No solicitation of client relationships?
- Non-Disparagement: No back-stabbing….
  - Is the provision mutual?
  - What is the duration of non-disparagement provision?
  - Who is within the group of persons or entities that receive the protections from the provision?

Big Mistake #4

"They can't just fire me, can they? OMG!"

1. What are the "termination clauses"
   - With or without cause?
   - With or without opportunity to remediate?



Meaningful Consequences for Infractions

- Certain infractions require measured or graded reactions, whereas others warrant a zero-tolerance position
- E.g. extended call or abbreviated vacation may apply to unprofessional behavior, such as late or missed call, whereas termination may apply to unlawful behavior, such as sexual harassment

Termination Without Cause

- Either party can end the contract **for any reason or no reason** with advance notice.
- No misconduct required
- No breach required
- Just requires **notice** (e.g., 60, 90, 180 days)
- Typical language: "Either party may terminate this Agreement without cause upon 90 days' written notice."

Termination with Cause

- The employer can terminate you **immediately or after short cure period** because you did something wrong.
- **Usually requires serious misconduct**
  - **Fraud, sexual misconduct, falsified records**
- **Material breach** of contract
  - Productivity, call coverage, policy breach
- **Legal / licensure / compliance problem**
  - Immediate or after a "cure" period
- Academics: Not able to be promoted

Termination with cause

A group has flexibility regarding which causes for termination to designate within its agreements

- Discretion will be limited by federal and state laws
- E.g. antidiscrimination laws generally prohibit employer from terminating an employee on the basis of the employee's race, alien, age, gender, or other protected status

Co-termination of Rights

- Implications of terminating a member extend beyond the immediate practice
- e.g. terminating a member's hospital privileges at the conclusion of group employment
- In this case, a contract between a radiology group and its member may require an executed power of attorney permitting the group's president to execute a resignation from the hospital staff on behalf of a terminated employee

Big Mistake #5

"They're taking MY assets because the group committed fraud? How is that possible?"

1. What is my liability vis a vis the activities of the group?
   - Personal assets?
   - Funded retirement benefits?



Protection Against Sale or Repossession of Group Assessments

- The objective to protect a group from the bankruptcy of its members, or from the vulnerability of a member's property rights due to other life events, including divorce
- The need for protection becomes even more significant at the point of members' termination

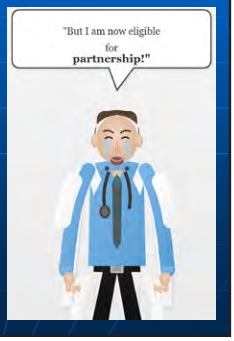
Variables

- **Safest structures: Professional Corporation (PC) / Professional Association , LLC or PLLC, Limited Liability Partnership)**
  - **No personal liability (you can be a corporation)**
- **Indemnification Clause (Critical)**
  - The group agrees to **defend, indemnify, and hold you harmless** from any claims, losses, penalties, or legal costs arising from acts of: the group, other physicians, administrators, billing company, employees
- Insurance for GROUP

Big Mistake #6

"They promised me 3 years to partnership"

1. Written contract
2. On and off ramps
3. Check hiring / firing history



Ownership/Partnership Considerations

- Does your employment agreement address the opportunity to own a part of the employer?
- If so, what exactly does this mean?
  - Will you have an equal ownership in the employer?
  - Are you allowed to fully participate in ownership, or does the employer require a staged investment?
  - Will you participate in all of the revenues of the practice?
  - Will you have a voice in governance issues?

Ownership/Partnership Considerations

- Buy-in and Buy-out:
  - Does the contract specify when the opportunity will be presented and how much it will cost?
  - Will costs be withheld from future distribution or due in cash?
  - What will you receive on the buy-out from the employer? How are the funds paid?

Bottom Line: Get a Lawyer!

- Oral Agreements
- Salary vs Compensation
- Exclusivity / Non-Competes
- Termination
- Liability
- Partnership terms

SELF EVALUATION

Physician Employment Contracts: Avoiding the Mistakes That Cost Careers

1. What is the best solution to handle oral agreements in contract negotiations

a. Avoid them
b. Record them
c. Have a transcript of them in Zoom
d. Get them in writing
e. None of the above

2. The Parol Evidence Rule implies that:

a. Everything agreed upon before the final contract is binding
b. The final contract supercedes any other prior oral or written agreements
c. You will be eligible for parole if the evidence is not strong enough
d. All of the above

3. When considering the compensation plan, what are additional perks to inquire about?

a. Bonuses
b. Retirement plan benefits
c. Malpractice insurance
d. CNE expense account
e. All of the above

4. T/F - The practice decides to contract due to bad economic forecasting. They serve you notice that your contact will not be renewed. This is considered “termination with cause”.

5. “Restrictive covenants” do not include

a. Preventing someone from practicing in a certain geographic region
b. Preventing someone from poaching employees
c. Time frames for the restriction
d. Inclusion of family members in restrictions

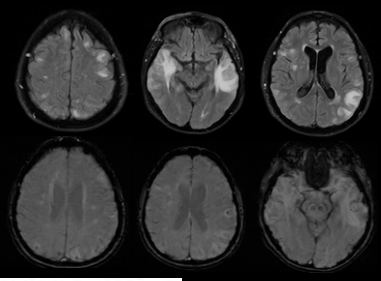
Answer Key: 1. D, 2. B, 3. E, 4. F, 5. D

Neurodegenerative Disease

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Professor and Vice Chair for Academic Affairs
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Case 1: 75-year-old follow up scan



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ARIA in 2026

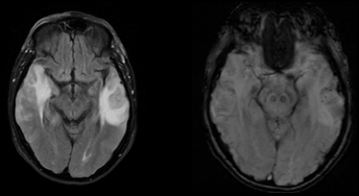
- Initial monoclonal antibody trials targeting beta-amyloid in the early 2000s
- Early trials failed due to poor efficacy or complications
- 2021: Aducanamab approved (but since discontinued)
- Lecanemab (Leqembi) and Donanemab (Kisunla) currently available as IV infusions
- Both have been shown to slow, although not stop, progression of Alzheimer Disease



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ARIA in 2026

- So, where does radiology come into the story?



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ARIA in 2026

- How frequent is this?

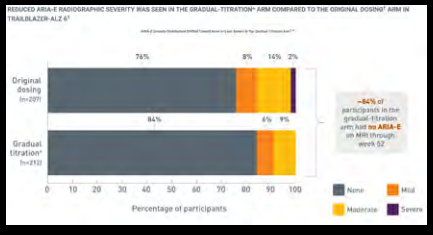
Discussion

Although limited by small sample size and cohort-level data, our meta-analysis shows the adjusted pooled incidence of ARIA-E was 25.5% and the pooled incidence of ARIA-H was 17.8% in the recent phase 3 RCTs of anti-Aβ immunotherapy. Homozygous *APOE* ε4 carriers have a 5.6-fold higher risk of developing ARIA-E than noncarriers.

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ARIA in 2026

- How frequent is this?



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ARIA in 2026

- How frequent is this?



ARIA in 2026

- How should we report this?

ARIA Type	Radiological Severity		
	Mild	Moderate	Severe
ARIA-E			
Size	<5 cm	5–10 cm	>10 cm
Location	Limited to a single site within sulcus or cortex/subcortical white matter.	One or multiple brain locations	Significant involvement in the sulcus or subcortical white matter in one or more distinct sites
ARIA-H			
New incident of microhemorrhages	≤4	5–9	≥10
Focal areas of superficial siderosis	1	2	>2

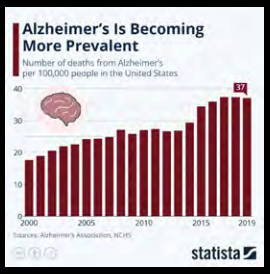
Sin MK, Zamrini E, Ahmed A, Nho K, Hajjar I. Anti-Amyloid Therapy, AD, and ARIA: Untangling the Role of CAA. J Clin Med. 2023 Oct 27;12(21):6792. doi: 10.3390/jcm12216792. PMID: 37959255;

ARIA in 2026

- What are the implications of our report?
  - Symptomatic ARIA: dose reduction or cessation of treatment
  - Mild asymptomatic ARIA: may continue treatment
  - Moderate/Severe ARIA: discontinue treatment and image every 4-6 weeks. May resume following resolution of ARIA-E following discussion of risks
  - There are no formal guidelines for management and treatment

Withington CG, Turner RS. Amyloid-Related Imaging Abnormalities With Anti-amyloid Antibodies for the Treatment of Dementia Due to Alzheimer's Disease. Front Neurol. 2022 Mar 23;13:862369. doi: 10.3389/fneur.2022.862369. PMID: 35401412;

ARIA in 2026



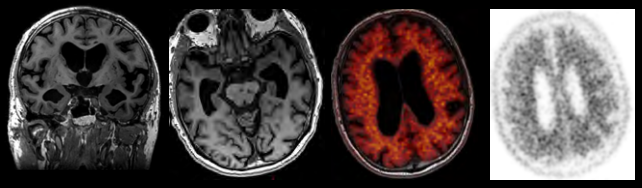
ARIA in 2026

- Lecanemab: $26,500 per year
- Donanemab: $32,000 per year
- These prices reflect only the medication, not:
  - Imaging costs
  - Infusion costs
  - Safety monitoring visits



Eisai and Eli Lilly

Case 2: 86-year-old with dementia

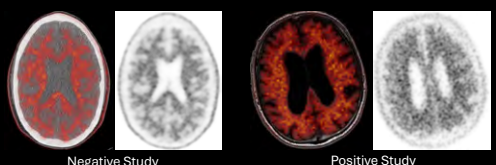


Case 2: Alzheimer Disease

- F-18 Florbetapir PET Imaging (Amyvid)
  - Has largely replaced C-11 Pittsburgh Compound B
  - Half-life of 110 minutes (PIB was 20 min)
  - Binds to amyloid-β plaques
  - Positive study will accumulate tracer in the cortex



Case 2: Alzheimer Disease

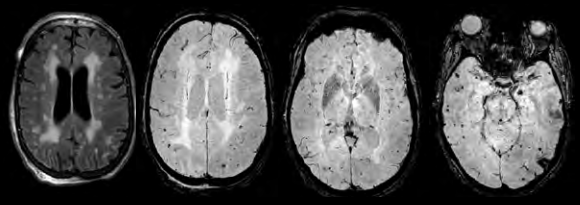


Negative Study

Positive Study

18-F Florbetapir PET

Case 3: 85-year-old with dementia

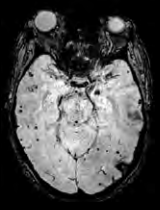


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Case 3: Cerebral amyloid angiopathy

- CAA and AD often coexist, and are both associated with amyloid-β, but are distinct processes
  - AD is associated with amyloid-β neuritic plaques in the brain parenchyma
  - CAA results from amyloid-β deposition in the vessel walls
- Since both are the result of impaired clearance of amyloid-β, their co-occurrence exceeds that of other vascular and neurodegenerative processes
- CAA is associated with peripheral microbleeds which usually spare the deep nuclei
- May also result in lobar hemorrhage, superficial siderosis as a result of subarachnoid blood

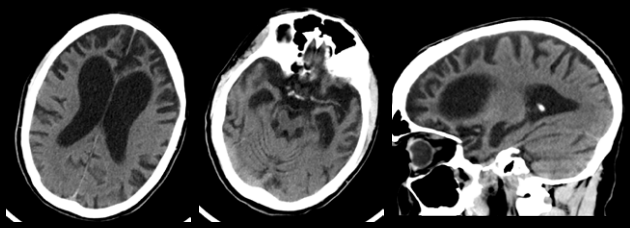


Greenberg, S.M., Backai, B.J., Hernandez-Guillamon, M. *et al.* Cerebral amyloid angiopathy and Alzheimer disease — one peptide, two pathways. *Nat Rev Neurol* **16**, 30–42 (2020). https://doi.org/10.1038/s41582-019-0281-2

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Case 4: 45-year-old with personality change

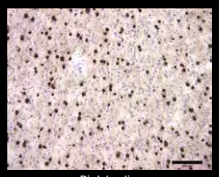


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Case 4: Frontotemporal dementia

- Three variants
  - Frontal (40%)
  - Temporal (40%)
  - Nonfluent aphasia (20%)
- Statistical association with ALS
- Typically present with psychiatric symptoms first
- "Knife-edge" gyri
- Pick disease imaging appearance similar, requires presence of "Pick bodies" (Tau protein) on microscopy

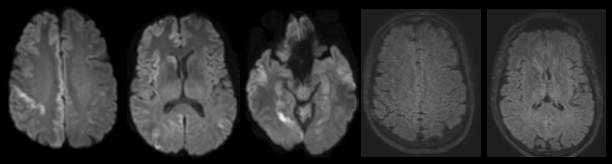


Pick bodies

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Case 5: 60-year-old with rapidly progressive dementia



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Case 5: Creutzfeldt-Jakob Disease

- Result of accumulation of prion protein
- Myoclonus/rigidity
- Results in spongiform degeneration due to vacuolization of neurons
- Additional prionopathies:
  - Heidenhain-variant CJD
  - Gerstmann-Straussler-Scheinker
  - Variant CJD (Mad Cow)
  - Fatal familial insomnia
  - Chronic wasting disease (elk)
  - Scrapie (sheep)
  - Kuru

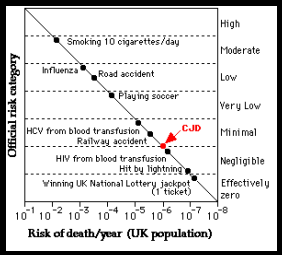


Dr. Stanley B Prusiner
Nobel Prize 1997

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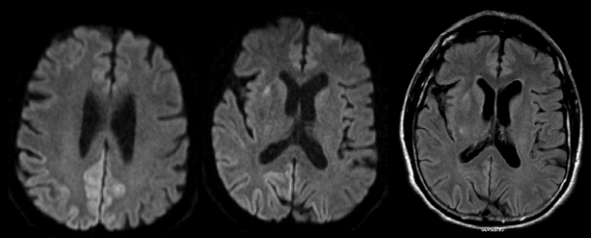
Case 5: Creutzfeldt-Jakob Disease



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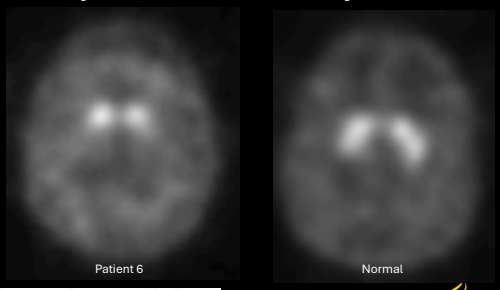
Case 5.5: Creutzfeldt-Jakob Disease



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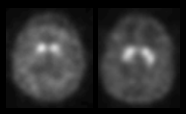
Case 6: 79-year-old with bradykinesia



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Case 6: Parkinson disease

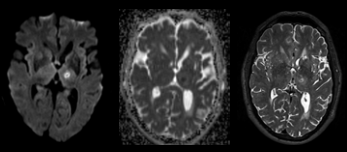
- May be assessed with I-123 Ioflupane (DaTscan)
- **D**opa**T**ransporter **Scan**
- Normal- comma-shaped uptake in the lentiform nucleus
- Abnormal- lack up uptake in the putamen
- Half-life 13.2 hours
- Study also positive in multisystem atrophy and progressive supranuclear palsy



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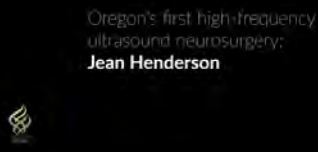
Parkinson disease

- Often traditionally treated with deep brain simulators
- New treatment: HIFU ablation of the ventral intermediate nucleus of the thalamus for relief of tremor
- This is also effective for essential tremor



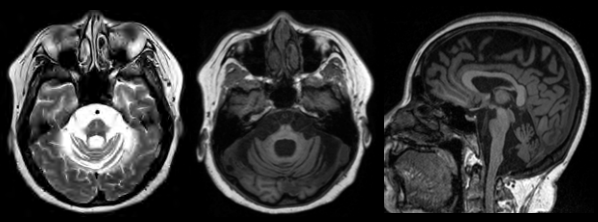
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Parkinson disease



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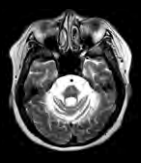
Case 7: 54-year-old with ataxia



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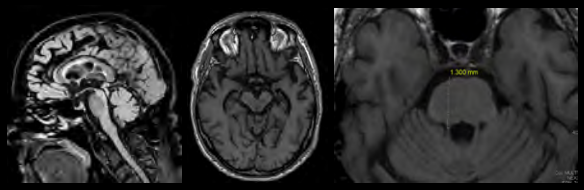
Case 7: Multisystem atrophy

- Two types:
  - MSA-C: cerebellar type, previously known as olivopontocerebellar atrophy
  - MSA-P: parkinsonian type, previously striatonigral degeneration
- Cannot reliably distinguish types on MRI
- "Hot-cross bun" sign
- Middle cerebellar peduncle <10mm
- Pontine atrophy
- I-123 ioflupane



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Case 8: 64-year-old with vision changes



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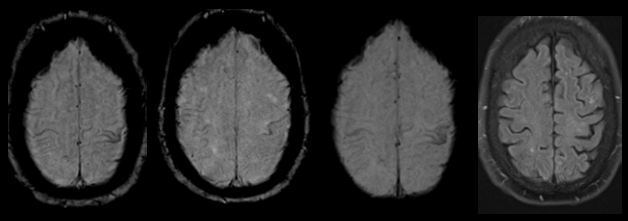
Case 8: Progressive supranuclear palsy

- Paralysis of downgaze
- Parkinsonism
- Psychiatric manifestations
- Tau protein deposition
- Imaging:
  - Midbrain atrophy
  - Enlarged interpeduncular cistern
  - Superior colliculi atrophy
  - Superior cerebellar peduncle <2mm



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Case 9: 46-year-old with fasciculations

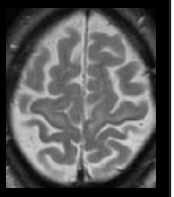


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Case 9: Amyotrophic lateral sclerosis

- AKA Lou Gehrig Disease
- Upper motor neuron degeneration
- Typically results in death 3-6 years from diagnosis
- No dementia
- May see susceptibility early in the motor cortex
- Progressive decline in FA in the internal capsule
- Eventual atrophy/T2 hyperintensity in corticospinal tracts



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Case 10: 50-year-old with abnormal movement



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Case 10: Huntington disease

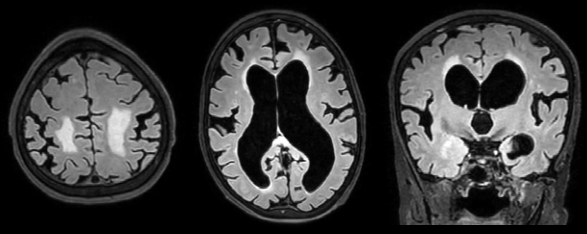
- Huntingtin gene Chromosome 4
- Autosomal dominant
- Choreoathetoid movement
- Severe memory loss
- CAG trinucleotide repeat
- Imaging:
  - Profound caudate atrophy
  - Putamen atrophy
- No treatment available, death in ~15 years



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Case 11: Gait abnormality

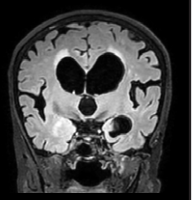


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Case 11: Normal pressure hydrocephalus

- Clinical triad of dementia, incontinence, gait instability
- Ventricular caliber enlarged out of proportion to sulcal enlargement
- Sulcal crowding at the vertex
- Callosal angle and Evans index

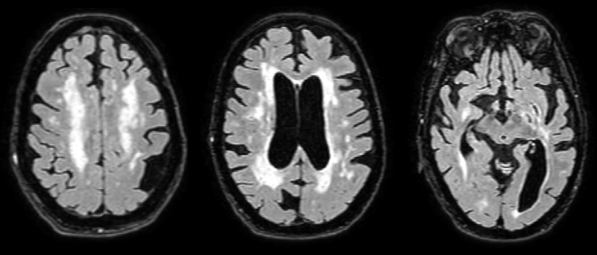


Ryska P, Slezak O, Eklund A, Salzer J, Malm J, Zizka J. Variability of Normal Pressure Hydrocephalus Imaging Biomarkers with Respect to Section Plane Angulation: How Wrong a Radiologist Can Be? AJNR Am J Neuroradiol. 2021 Jul;42(7):1201-1207.

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Case 12: 85-year-old with memory loss



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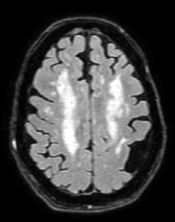
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Case 12: Vascular dementia

- AKA multi-infarct dementia
- Often stepwise decline in mentation
- Fazekas scoring:

Periventricular
- 0 = absent
- 1 = "caps" or pencil-thin lining
- 2 = smooth "halo"
- 3 = irregular periventricular signal extending into the deep white matter

Deep white matter (DWM)
- 0 = absent
- 1 = punctate foci
- 2 = beginning confluence
- 3 = large confluent areas



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SELF EVALUATION

Neurodegenerative Disorders

1. T/F - Amyloid-related imaging abnormalities (ARIA) can occur in patients receiving anti-amyloid monoclonal antibody therapy for Alzheimer disease.

2. Which imaging finding is most characteristic of cerebral amyloid angiopathy (CAA)?

a. Deep basal ganglia microbleeds
b. Peripheral lobar microbleeds that spare the deep nuclei
c. Bilateral thalamic calcifications
d. Diffuse pontine atrophy

3. The classic MRI sign associated with multisystem atrophy is the:

a. Hummingbird sign
b. Pulvinar sign
c. Hot-cross bun sign
d. Eye-of-the-tiger sign

4. T/F - Progressive supranuclear palsy commonly presents with paralysis of downgaze and midbrain atrophy.

5. Which neurodegenerative disorder is associated with profound caudate atrophy on imaging?

a. Parkinson disease
b. Huntington disease
c. Frontotemporal dementia
d. Amyotrophic lateral sclerosis

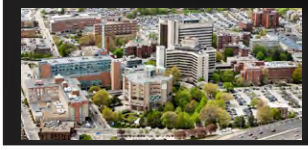
Answer Key: 1. T, 2. B, 3. C, 4. T, 5. B

Nuclear Medicine for Infection and Inflammation

Don C. Yoo, MD, FACR

Nuclear Medicine for Infection and Inflammation

Don C. Yoo, MD, FACR
Professor of Diagnostic Imaging, Clinician Educator
Director of Nuclear Medicine, Rhode Island and The Miriam Hospitals
Director of Medical Student Radiology Education



BROWN Health UNIVERSITY

BROWN Alpert Medical School

Disclosures

Consultant – Invicro (Perceptive)

Objectives

1. Describe the role of general nuclear medicine studies in the evaluation of infection and inflammation

2. Discuss the evolution of PET/CT in evaluation of infection and inflammation

Types of Imaging for Infection/Inflammation

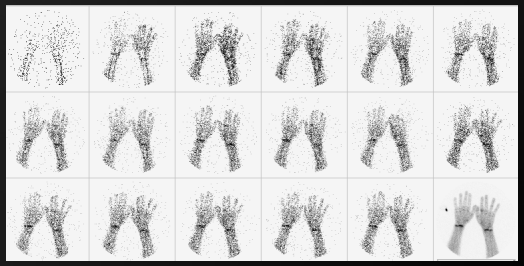
3 phase bone scan
Indium-111 oxine labeled WBC
Tc-99m HMPAO labeled WBC
Gallium-67 Citrate
PET/CT

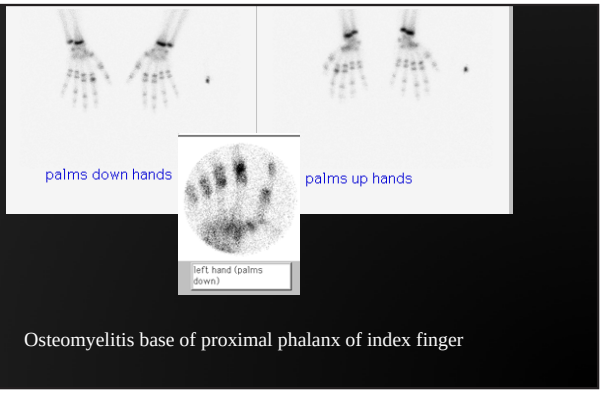
3 Phase Bone scan

Technique

Inject I.V.
1 minute blood flow
5-10 minute immediate static
3 hour delayed statics

5 year old bit in hand by a dog 2 weeks ago with fever, redness and pain



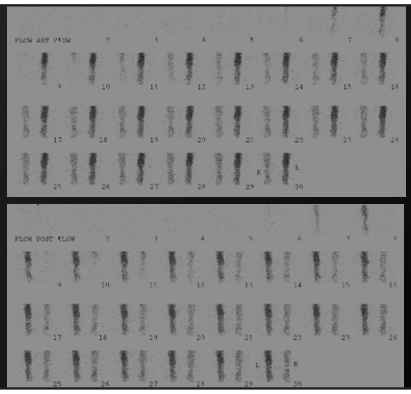


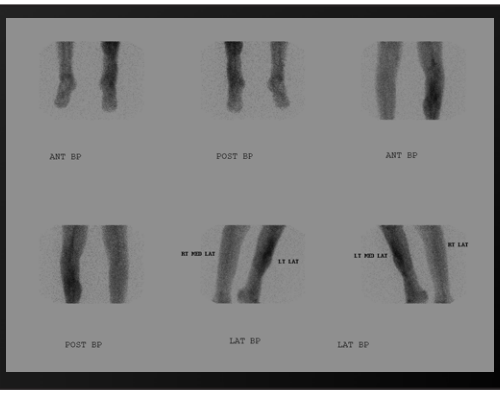
Osteomyelitis base of proximal phalanx of index finger

3-phase bone scan for infection
Very sensitive, *Not specific*

- Osteomyelitis
- Fracture
- Malignant bone tumor







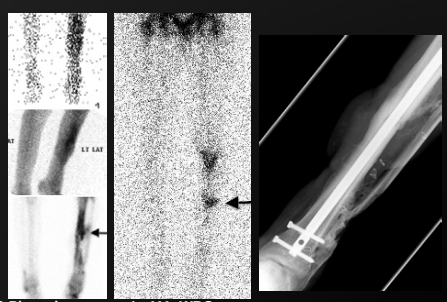


Differential Diagnosis

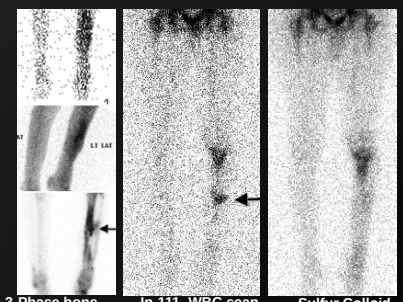
Fracture
Loosening of orthopedic hardware
Normal post-operative appearance
Osteomyelitis and cellulitis



3-Phase bone



3-Phase bone In-111- WBC scan



3-Phase bone | In-111- WBC scan | Sulfur Colloid

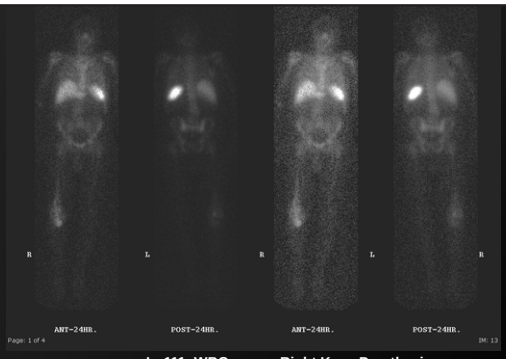
Diagnosis

Osteomyelitis and cellulitis

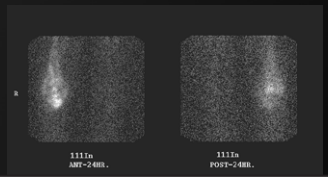
Teaching Points

Three phase bone scan

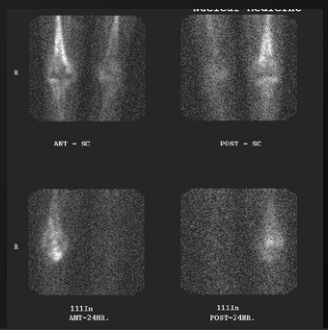
- Highly sensitive for osteomyelitis in 'pristine' non-violated bone
- Sensitivity and specificity decreases in the setting of trauma or intervention/surgery due to expected osteoblastic activity in injured or repairing bone
- Normal flow/soft tissue phase makes infection very unlikely



In-111- WBC scan – Right Knee Prosthesis

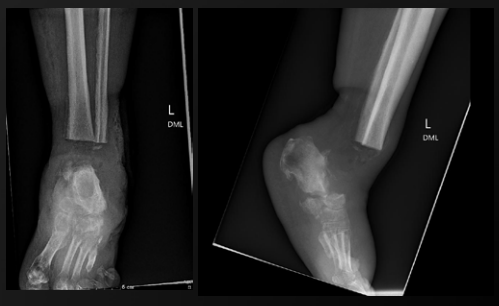


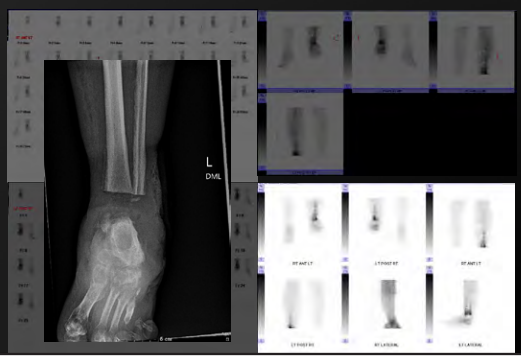
In-111- WBC scan

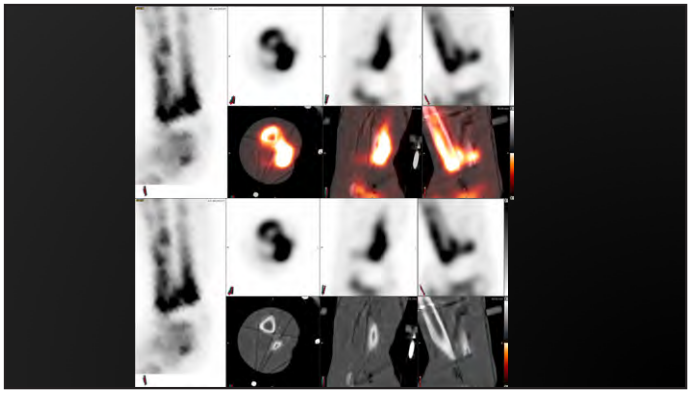


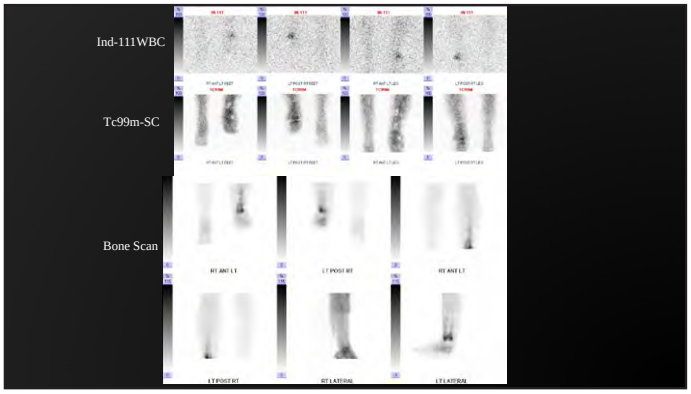
Tc-99m-Sulfur Colloid

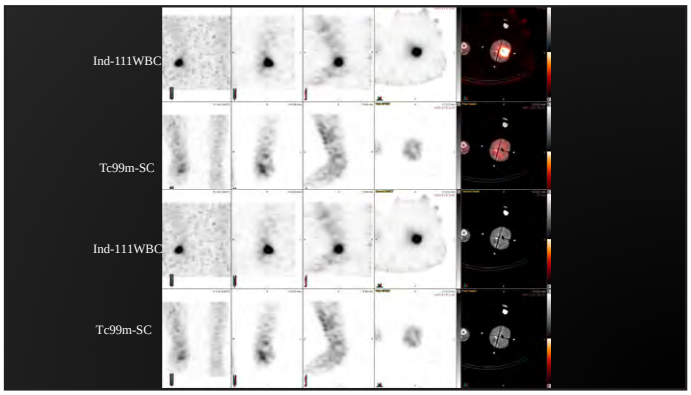
In-111- WBC scan













Foot & Ankle Surgery: Techniques, Reports & Cases

Case Reports and Series

Novel advanced imaging method to differentiate acute osteomyelitis from acute charcot neuroarthropathy in presence of chronic ulcer: A case report

Woo Y. Chun, D.P.M [1,*], April Wong, D.P.M [1], Lee tiberi, D.P.M [1], Alexander Trottier, D.P.M [1], Don C. Yoo, M.D [2], Glod Douglas, D.P.M [3]

ARTICLE INFO

ABSTRACT

Teaching Points

Labeled WBC Imaging

- In-111 or Tc-99m-HMPAO labeled WBCs
- Very sensitive and specific for acute osteomyelits in non-violated bone (90-95%).
- More sensitive for acute infection
- WBCs localize to normal marrow elements besides infection
- Normal marrow can become redistributed following prosthesis placement, injury, surgery

Teaching Points

Tc-99m-Sulfur Colloid - 'marrow road map'

- Improves specificity of WBC imaging.
- Differentiate marrow 'hot spots' which may develop at the distal end of long bone prostheses
- Performed same time of In-111-WBC scan
  - -Image different energy windows

^{111}In-WBC



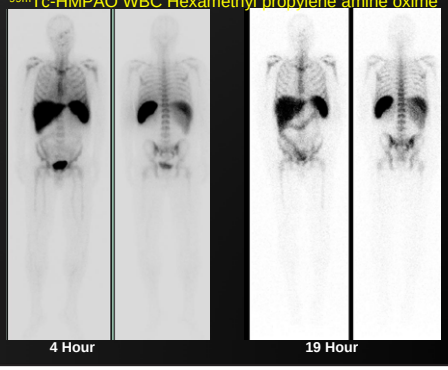
Normal Distribution

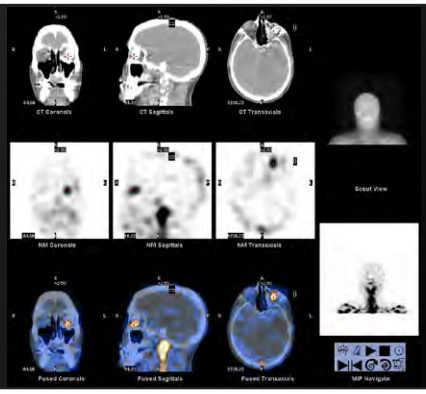
- Spleen >> Liver > Marrow
- No renal activity
- No GI activity

Helpful findings

- Hot spleen
- Relatively low-count study

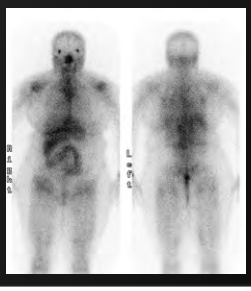
^{99m}Tc-HMPAO WBC Hexamethyl propylene amine oxime



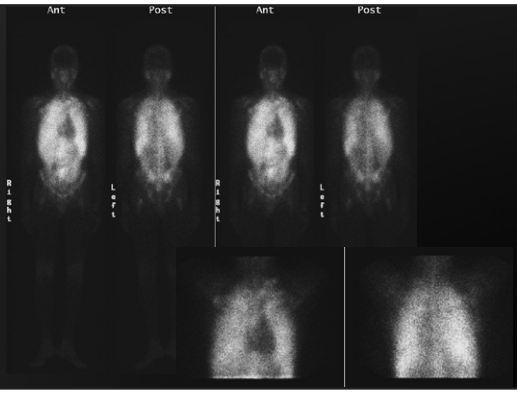


Gallium

Gallium Scan



Lacrimal Glands!!
Low counts
Marrow activity
Liver uptake > spleen
Bowel uptake





Case based Review of Applications of PET/CT for Infection and Inflammation

CMS allows Medicare Administrative Contractors to Cover FDG PET for Infection and Inflammation

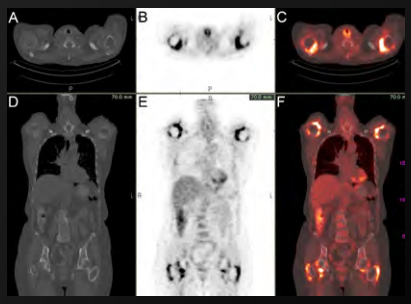
FDG PET can successfully image active infections and inflammatory processes

This literature allowed ASNC, SNMMI, ACNP and ACR to convince CMS to overturn the national non-coverage determination for FDG PET in infection/inflammation effective January 1, 2021

60 year-old woman admitted to the hospital for hypercalcemia

History:
Breast cancer
Hypothyroidism
Rheumatoid arthritis
Irritable bowel syndrome
Chronic fatigue syndrome





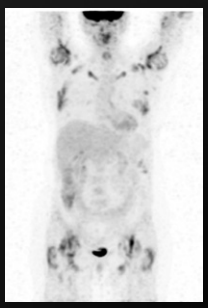
Diagnosis?

a) Metastatic disease

b) Osteoarthritis

c) Rheumatoid arthritis

d) Synovitis, PVNS



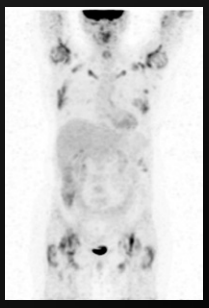
Diagnosis?

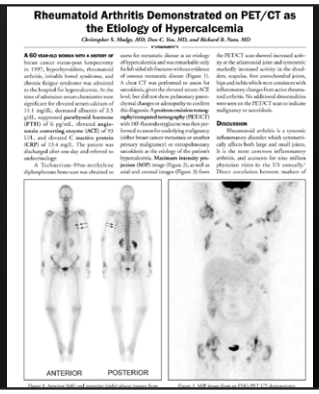
a) Metastatic disease

b) Osteoarthritis

c) Rheumatoid arthritis

d) Synovitis, PVNS



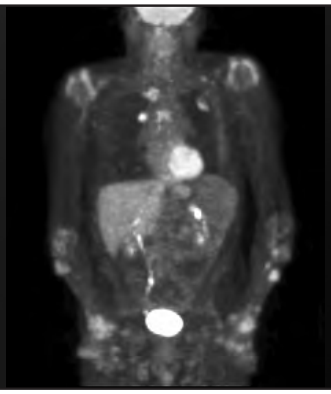


Rheumatoid Arthritis Demonstrated on PET/CT as the Etiology of Hypercalcemia

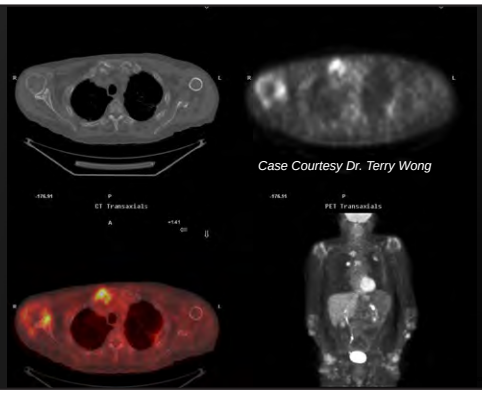
Christopher S. Madge, MD, Don C. Yoo, MD, and Richard B. Nuss, MD

ANTERIOR POSTERIOR

Medicine and Health Rhode Island 2012; 95(2): 54-56



Case Courtesy Dr. Terry Wong



Case Courtesy Dr. Terry Wong

Teaching Points:

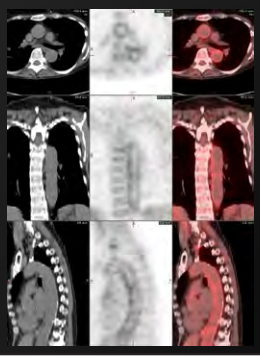
Symmetric periarticular distribution suggests rheumatoid arthritis

PET activity correlates with disease activity

Rheumatoid nodules in the lung can have variable activity on PET

63 year old female with SPN



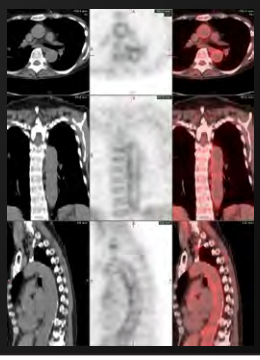


Vascular activity in the aorta

a. Normal Variant

b. Atherosclerotic disease

c. Large vessel arteritis



Vascular activity in the aorta

a. Normal Variant

b. Atherosclerotic disease

c. Large vessel arteritis

63 year old female with elevation in the sedimentation rate, constitutional symptoms, loss of libido, multiple pulsations, abdominal bruit



Initial PET/CT

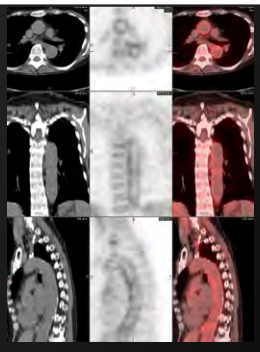
63 year old female with elevation in the sedimentation rate, constitutional symptoms, loss of libido, multiple pulsations, abdominal bruit

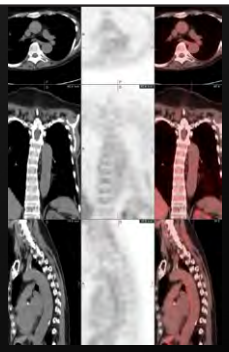


Initial PET/CT



Followup PET/CT





Initial PET/CT Followup PET/CT

Takayasu's arteritis

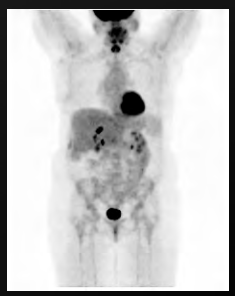


Case Courtesy Dr. Terry Wong

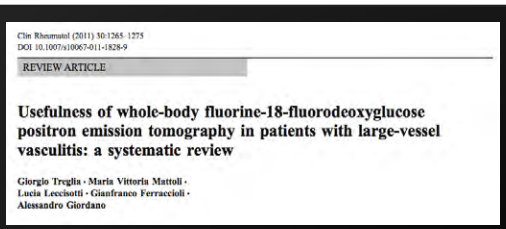
Takayasu's arteritis



Case Courtesy Dr. Terry Wong



Followup PET/CT



Clin Rheumatol (2011) 30:1265–1275
DOI 10.1007/s10067-011-1828-9

REVIEW ARTICLE

Usefulness of whole-body fluorine-18-fluorodeoxyglucose positron emission tomography in patients with large-vessel vasculitis: a systematic review

Giorgio Treglia · Maria Vittoria Mattoli · Lucia Leccisotti · Gianfranco Ferraccioli · Alessandro Giordano

Treglia G et al, Clin Rheumatol 2011; 30:1265

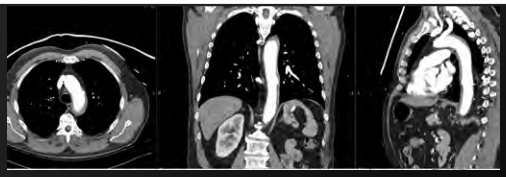
Meta-analysis: 32 studies, > 400 pts

PET/CT useful for early dx and extent of disease

Potential uses

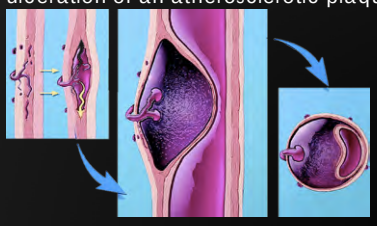
- **Correlation with serum markers**
- **Evaluation of treatment response**
- **Disease activity during therapy**

Treglia G et al, Clin Rheumatol 2011; 30:1265

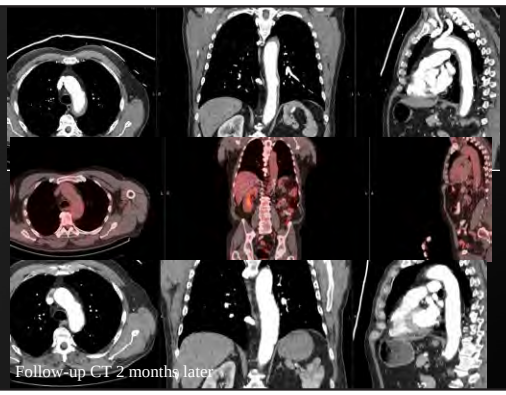


Intramural Hematoma

IMH results from rupture of aortic vasa vasorum or ulceration of an atherosclerotic plaque



Macura K J et al. AJR 2003;181:309-316



Follow-up CT 2 months later

Detection of inflammation in patients with acute aortic syndrome: comparison of FDG-PET/CT imaging and serological markers of inflammation

H Kuehl,[1] H Eggebrecht,[2] T Boes,[3] G Antoch,[1] S Rosenbaum,[4] S Ladd,[1] A Bockisch,[4] J Barkhausen,[1] R Erbel[2]

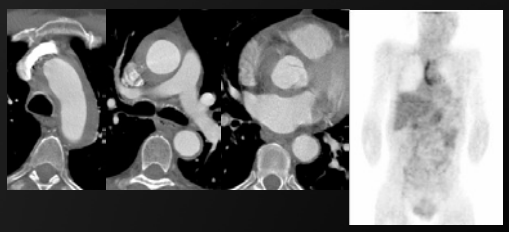
11 of 33 patients showed elevated tracer uptake within the aortic pathology

-9 of 11 PET-positive patients (82%) showed progression of AAS.

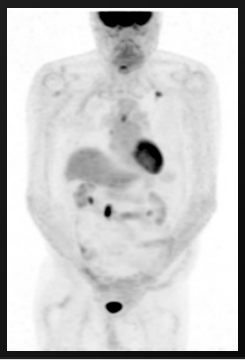
22 patients were PET-negative

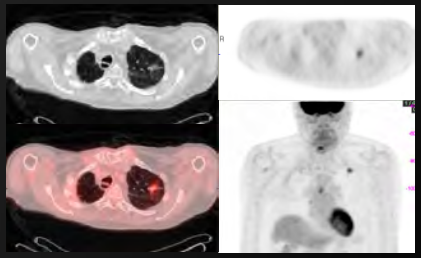
- 13 of PET-negative patients (59%) showed stable disease or regression

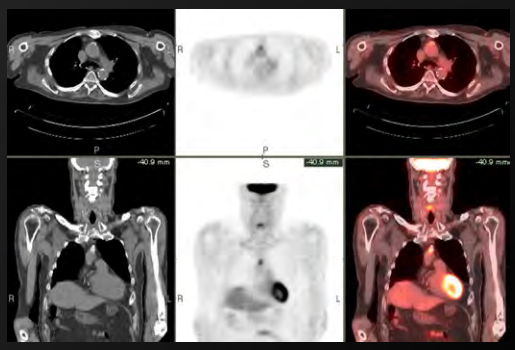
Case Courtesy of Dr. Michael Atalay



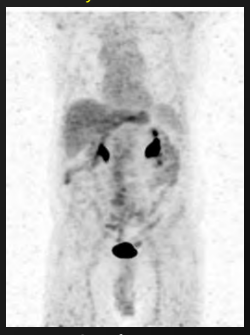
Vasculitis







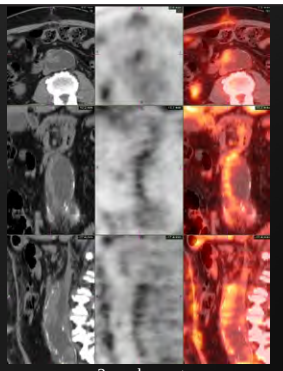
71 year old man with colon cancer recent Aortic graft



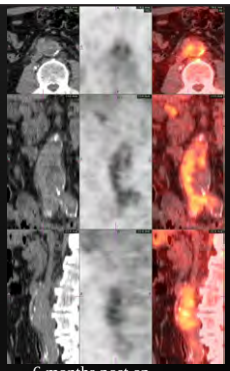
2 weeks post op



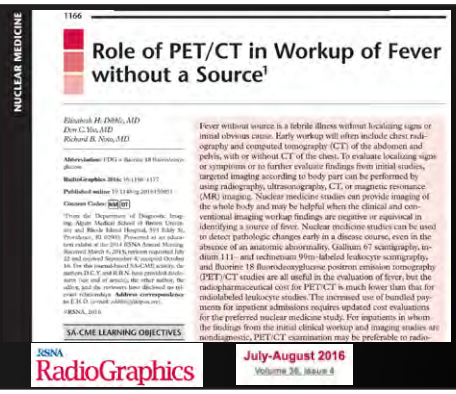
6 months post op



2 weeks post op



6 months post op



Fever Without Source (FWS)

Common problem among all ages worldwide

FWS = Febrile illness without localizing signs or initial obvious etiology

- Fever of unknown origin (FUO) is a subtype of FWS defined as fever on several occasions and illness lasting longer than 3 weeks after appropriate workup

Most common etiology of FWS: Infection

- Etiologies of FUO:
  - Infection
  - Neoplasm
  - Inflammatory Disease



Whole Body Imaging

Nuclear medicine can provide WB imaging

Often last resort when initial studies and workup negative or equivocal

Can detect pathologic changes early in disease course even in absence of anatomic abnormality

PET/CT for ID'ing source of fever

- Sensitivity: 89-100%
- Specificity: 23-87% (nonspecific)
  -infection/inflammation/malignancy



PET/CT for Infection

Now reimbursed by CMS

We use it at RIH in inpatients with suspected infection, negative initial workup

- Bundled payments, radiopharmaceutical cost differences



Radiopharmaceutical Costs

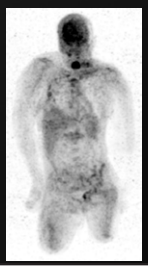
Study	Radiopharmaceutical Cost
Ga-67	5X
In-111 WBC	19x (most expensive)
Tc-99m WBC	16x
PET/CT	x (least expensive)

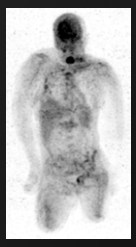
PET/CT for Fever

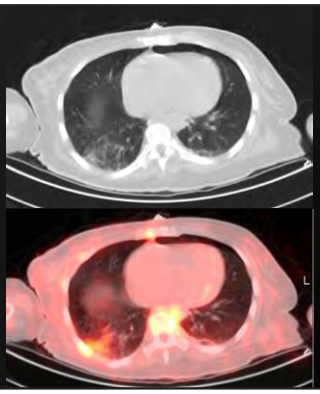
Radiopharmaceutical cost for PET/CT is much lower than that for In-111 or Tc-99m tagged WBC studies

Per-study labor costs, equipment costs, and effectiveness in identifying sources of fever are similar, so we perform PET/CT for inpatients with a diagnosis of fever without source

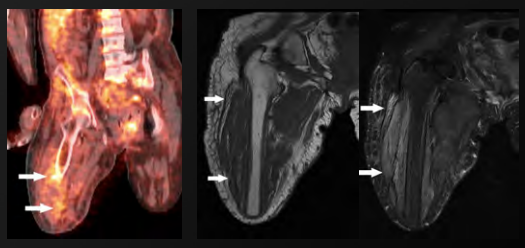
47-year-old female with history of PVD, status post B/L AKAs more than one year ago who presented with fever and right lower extremity erythema







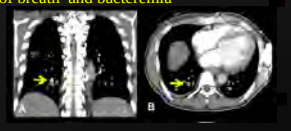
Aspiration



Cellulitis/Myositis – No Osteomyelitis

47-year-old man with end stage renal disease and HeRO graft placed 4 months prior for hemodialysis access who presented with shortness of breath and bacteremia

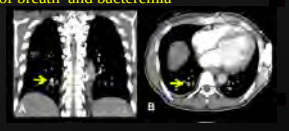
Right lower lobe pulmonary embolus (yellow arrows).



47-year-old man with end stage renal disease and HeRO graft placed 4 months prior for hemodialysis access who presented with shortness of breath and bacteremia

Right lower lobe pulmonary embolus (yellow arrows).

TEE was negative for endocarditis.

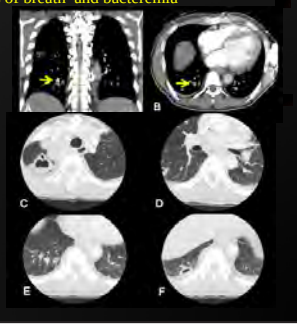


47-year-old man with end stage renal disease and HeRO graft placed 4 months prior for hemodialysis access who presented with shortness of breath and bacteremia

Right lower lobe pulmonary embolus (yellow arrows).

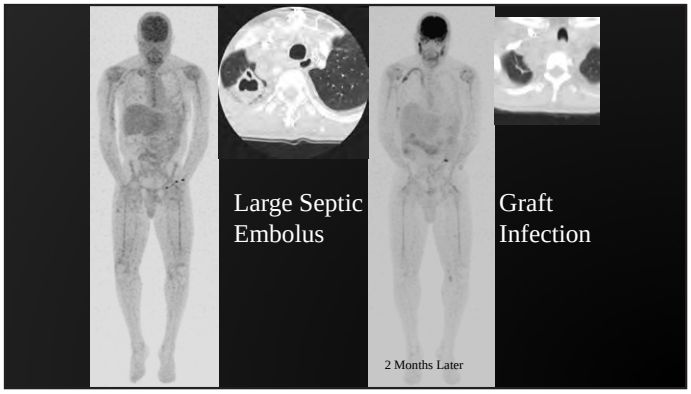
TEE was negative for endocarditis.

New cavitary lung lesions
septic emboli



47-year-old man with end stage renal disease and HeRO graft placed 4 months prior for hemodialysis access who presented with shortness of breath and bacteremia

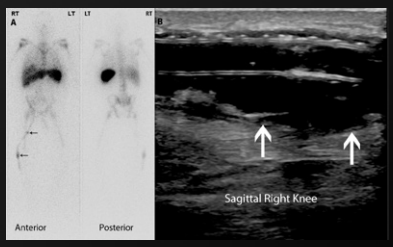




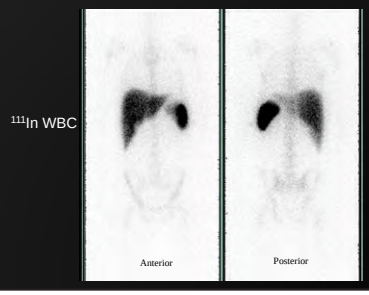
FDG PET/CT of Infection: Should It Replace Labeled Leukocyte Scintigraphy of Inpatients?

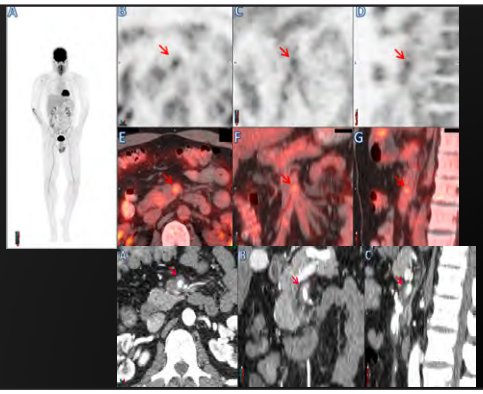
RESULTS. Fifty-seven patients (30 men, 27 women; median age, 65 years; range, 21–91 years) underwent whole-body labeled leukocyte scintigraphy. Forty-two patients (30 male patients, 12 female patients; median age, 62.5 years; range, 12–91 years) underwent PET/CT for suspected infection. Labeled leukocyte scintigraphy was 66.7% sensitive, whereas the sensitivity of PET/CT was 89.7% ($p = 0.0485$). The higher sensitivity of PET/CT did not come at a cost to specificity, which was 73.3% as opposed to 76.9% for labeled leukocyte scintigraphy ($p = 0.8050$). The odds of a positive study being helpful increased 4.6-fold for PET/CT versus labeled leukocyte scintigraphy ($p = 0.0412$). From 2009 to 2011, 33 labeled leukocyte scintigraphic examinations were performed versus two PET/CT examinations; and from 2012 to 2014, 16 labeled leukocyte scintigraphic versus 22 PET/CT examinations; from 2015 to 2017, eight labeled leukocyte scintigraphic versus 18 PET/CT examinations. The cost of labeled leukocytes increased between 2009 and 2017, but that of FDG decreased. By 2017, a labeled leukocyte radiopharmaceutical dose was approximately 10 times the cost of an FDG dose.

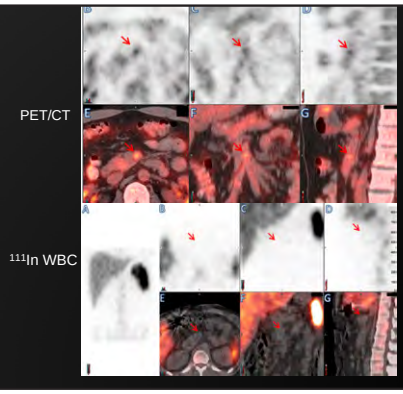
CONCLUSION. PET/CT was more sensitive than and as specific as labeled leukocyte scintigraphy for identifying a source of infection in inpatients, and it was more helpful to referring clinicians. Use of PET/CT increased over time and was associated with substantial savings in radiopharmaceutical cost.



38 year old man fever of unknown origin, and vasculitis who presented with acute severe epigastric pain, vomiting, and nausea. Elevated ESR of 26 and CRP of 40

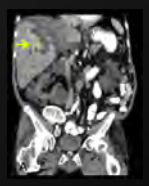






74-year-old man with PCKD, 1 week fevers

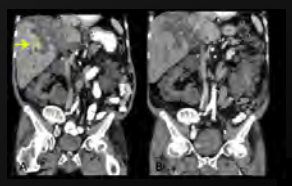
Enhancement around multiple cysts in the liver

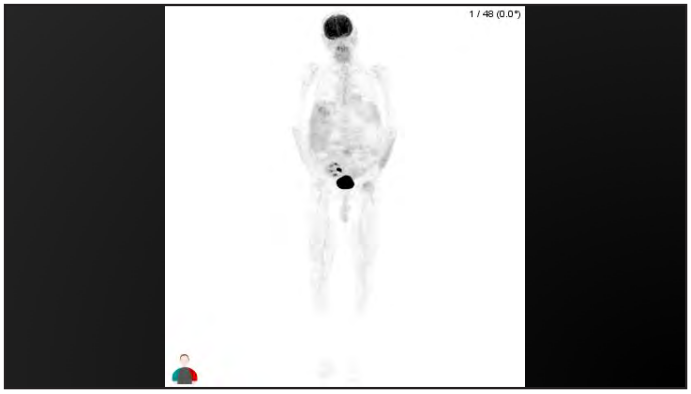


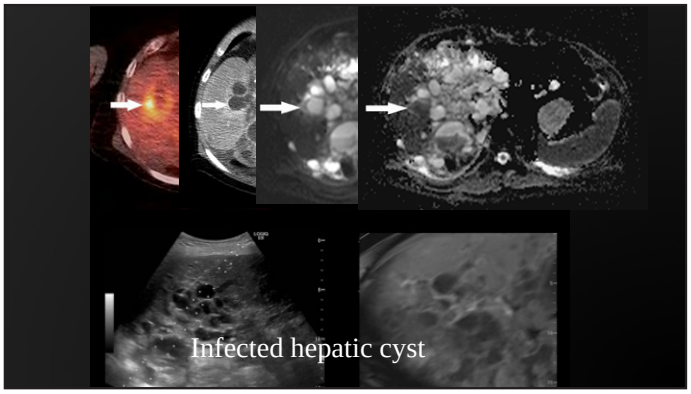
74-year-old man with PCKD, 1 week fevers

Enhancement around multiple cysts in the liver

New from 3 months prior

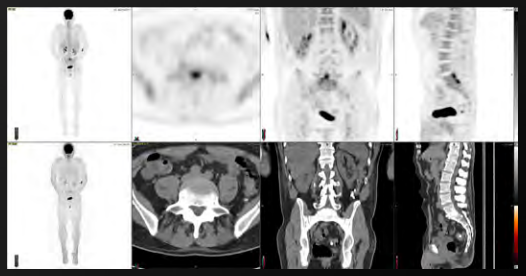


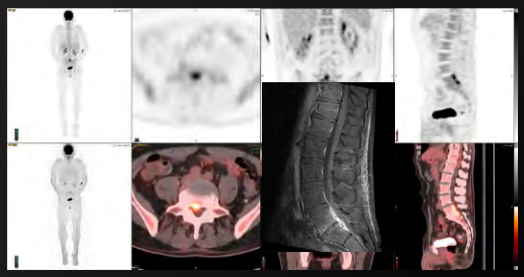


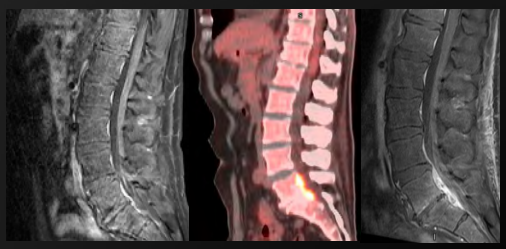


60-year-old man with back pain









Initial MRI 1 week before PET PET MRI 1 day after PET

85-year-old woman with gastric cancer with liver metastases status post chemotherapy

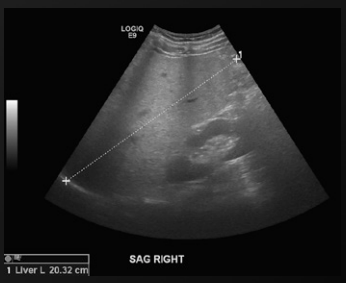
40-year-old man from Nepal presented with 1 week of intermittent fevers and vomiting

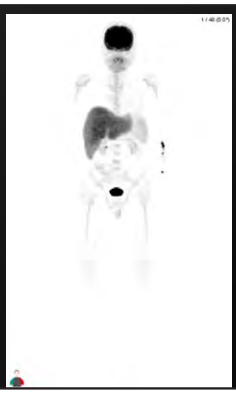


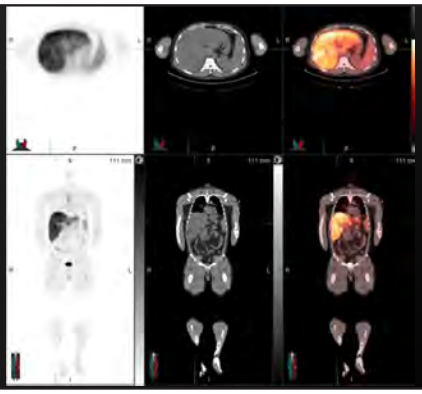


Represented 5 days later with temp of 106 and elevated LFTs

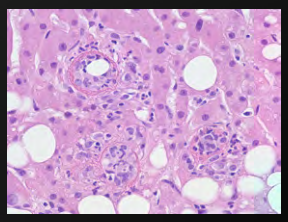








Ring Granulomas – Q Fever (Coxiella burnetii)



The infection results from contact with the milk, urine, feces, vaginal mucus, or semen of infected animals.



A Case of Acute Q Fever Hepatitis Diagnosed by F-18 FDG PET/CT



SUMMARY

Reviewed 3 phase bone scan, Indium-111 oxine labeled WBC, Tc-99m HMPAO labeled WBC, Gallium-67 Citrate, PET/CT

Oncology patients are subject to concurrent inflammatory processes

PET/CT can be helpful in evaluating fever and may be more cost-effective than tagged leukocyte studies because of the large difference in radiopharmaceutical costs

New applications for FDG-PET in evaluating inflammation/infection

SELF EVALUATION

Nuclear Medicine for Infection and Inflammation

1. T/F - A normal flow and soft-tissue phase on a three-phase bone scan makes osteomyelitis very unlikely.

2. Which nuclear medicine study is considered highly sensitive and specific (approximately 90–95%) for acute osteomyelitis in non-violated bone?

a. Gallium-67 scan
b. FDG PET/CT
c. Labeled white blood cell scan (In-111 or Tc-99m HMPAO)
d. Sulfur colloid scan

3. What is the primary role of Tc-99m sulfur colloid imaging when performed with an In-111 WBC scan?

a. Detect septic emboli
b. Measure bone turnover
c. Provide a “marrow road map” to improve specificity
d. Assess vascular perfusion

4. T/F - FDG PET/CT is now reimbursed by CMS for evaluation of infection and inflammation.

5. According to the lecture, what is the most common cause of fever without source (FWS) or fever of unknown origin (FUO)?

a. Malignancy
b. Autoimmune disease
c. Drug reaction
d. Infection

Answer Key: 1. T, 2. C, 3. C, 4. T, 5. D

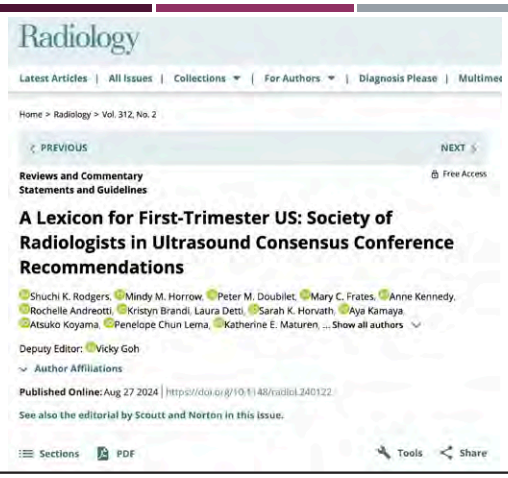
Standardizing Imaging Reports
Andrew Moriarity, MD, MBA

STANDARDIZING IMAGING REPORTS

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College of Human Medicine
MICHIGAN STATE UNIVERSITY

Advanced Radiology Services



OBJECTIVES

- Introduction & Background
- Consensus Process
- General Terms
- Early Development
- Pregnancy Location
- Early Pregnancy Loss
- Key Terminology Changes
- Figures & Tables
- Summary & Q&A

INTRODUCTION & BACKGROUND

- First-trimester US is a common diagnostic exam.
- Terminology inconsistencies caused confusion.
- SRU convened a multispecialty panel to build a consensus lexicon.
- Goals: clarity, patient-centered language, reduce harm.

CONSENSUS PROCESS

- Multispecialty collaboration (SRU, ACOG, AIUM, SMFM, ACEP, ASRM, etc.).
- Modified Delphi process with ≥80% agreement threshold.
- Extensive literature review and iterative voting.
- Final lexicon endorsed by all societies involved.

GENERAL TERMS

- Pregnancy = hCG > 5 mIU/mL.
- Gestational age = weeks + days, best obstetric estimate.
- First trimester ≤ 13 weeks 6 days.
- Preferred: “first-trimester US exam.”
- Avoid: “normal first-trimester pregnancy.”

SRU FIRST TRIMESTER ULTRASOUND LEXICON: GENERAL TERMS

Term(s) *Alternate Term(s)*	Application/ Definition	Term(s) to Avoid	Comments
hCG	Human chorionic gonadotropin		• Produced by trophoblastic cells • *Beta* modifier may no longer be used by some laboratories
Pregnant	Serum hCG >5 mIU/mL		• Refer to local laboratories for discriminatory hCG value • hCG ≤5 mIU/mL may occur in healthy non-pregnant patients • Rarely, elevated hCG may be unrelated to pregnancy such as with pituitary dysfunction or neoplasia
Gestational age *Menstrual age* *Gestational duration* *Clinical age or dates*	Duration of pregnancy		• Reported as # weeks # days • Based on 1st day of LMP and/or early dating US • In setting of assisted reproductive technologies, pregnancy is dated by clinical factors such as time of intrauterine insemination or embryo transfer, etc.
First (1st) trimester	GA ≤13 weeks 6 days		
First (1st) trimester US *Early pregnancy US* *Obstetrical (OB) US*	US exam in the 1st trimester of pregnancy	'Viability' scan	• *Normal* modifier may be used to describe the US examination or pregnancy location; caution against: 'normal 1st trimester pregnancy' as anomalies may be missed early in pregnancy • Clinical indications include confirmation of pregnancy, dating, presence of cardiac activity, determining pregnancy location and number, vaginal bleeding, pain, etc.

SRU = Society of Radiologists in Ultrasound; hCG = human chorionic gonadotropin; mIU/ml = milli-international units per milliliter; # = number; LMP = last menstrual period; GA = gestational age; US = ultrasound

EARLY DEVELOPMENT

- Gestational sac, yolk sac, embryo, and cardiac activity.
- Definite pregnancy: yolk sac seen.
- Probable pregnancy: sac without yolk sac or embryo.
- Preferred: "cardiac activity."
- Avoid: "heartbeat," "live," "viable."
- Embryo ≤10w6d; Fetus ≥11w0d.
- Use crown-rump length for dating; avoid "pole."

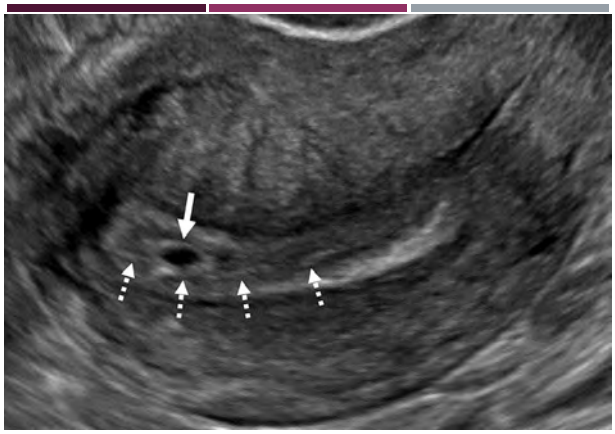
SRU FIRST TRIMESTER ULTRASOUND LEXICON: EARLY DEVELOPMENT

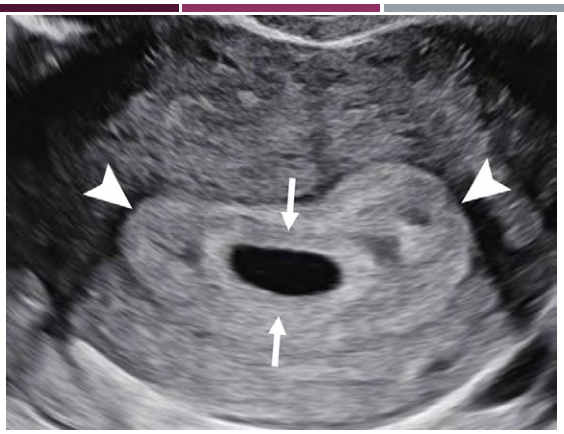
Term(s) *Alternate term(s)*	Image Example(s)	Image Key	Definitions/ Applications	Term(s) to Avoid	Comments
Gestational sac: *Pregnancy*		Arrow = GS	Round or oval fluid collection surrounded by hyperechoic rim of trophoblastic tissue, + YS, + embryo		• Visualized on TVUS at ~ 5 weeks GA • May be intrauterine or ectopic • No YS or embryo = ***probable GS/pregnancy*** • With YS or embryo = ***definite GS/pregnancy*** • ***Intradecidual sign*** and ***double decidual sac sign*** helpful when seen but not required • ***Mean sac diameter (MSD)*** = (L+W+H)/3; used for calculating GA before embryo is seen
Yolk sac		Arrow = YS	Thin rimmed circular structure eccentrically located in GS		• Visualized on TVUS at ~ 5 ½ weeks GA • Confirms ***definite GS/pregnancy*** • Typically, <6 mm
Embryo/Fetus	 	Caliper = embryo (CRL = 25 mm) Caliper = fetus (CRL = 74 mm)	Embryo = GA ≤10 weeks 6 days Fetus = GA ≥11 weeks 0 days	Embryonic 'pole' Fetal 'pole'	• Embryo with cardiac activity is visualized on TVUS at ~ 8 weeks GA • ***Crown-rump length (CRL)*** = greatest dimension of embryo/fetus; used for dating when embryo/fetus present • Per AIUM Practice Parameters: ○ Embryonic/fetal number required to determine singleton vs. twins vs. higher order multiples • Report chorionicity (# of sacs) and amnionicity (when possible) for all multi-gestation pregnancies
Cardiac activity *Cardiac motion*		Arrow = embryo Left half of screen = M-mode	Rhythmic pulsations in embryo/fetus	'Heart' 'Live', 'living' 'Viable'	• Avoid all phrases containing "heart" (e.g., "heart motion", "heartbeat", "heart tones", etc.) and "live", "living" and "viable" in 1st trimester • Document with M-mode or cine clip • ***Beats per minute (bpm)*** = rate of cardiac activity
Amnion		Arrow = amnion	Thin membrane surrounding embryo/fetus within GS		• Visualized on TVUS at ~ 7 weeks GA • ***Amniotic cavity*** = fluid-filled space contained by amnion • YS always outside amniotic cavity
Intracavitary Fluid *Endometrial cavity fluid*		Arrow = abnormal collection	Fluid in endometrial cavity with pointed/non-curved margins, + internal echoes	'Pseudo-gestational sac' 'Pseudosac'	• Avoid 'pseudogestational sac' and 'pseudosac' as may be misinterpreted as indicating presence of ectopic pregnancy (even without other findings) leading to clinical errors

SRU = Society of Radiologists in Ultrasound; GS = gestational sac; "+" = with or without; YS = yolk sac; TVUS = transvaginal US; "~" = approximately; L = length; W = width; H = height; GA = gestational age; AIUM = American Institute of Ultrasound in Medicine; 1st = first

PREGNANCY LOCATION

- Categories: Normal, Abnormal, Unknown.
- Normal = intrauterine pregnancy (IUP).
- Abnormal = ectopic pregnancy (EP): tubal, cervical, cesarean scar, ovarian, abdominal.
- Unknown = pregnancy of unknown location (PUL).
- Avoid: "cornual," "angular," "eccentric" (alone), "pseudosac."





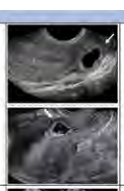
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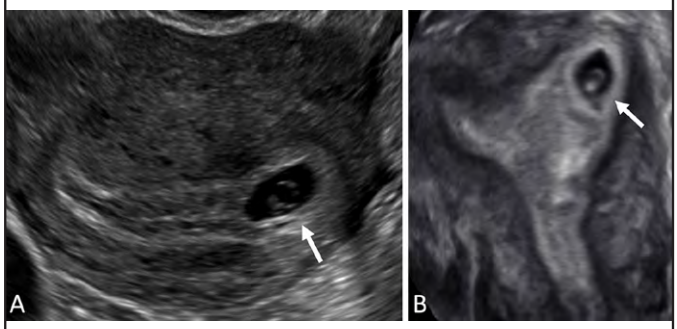
SRU FIRST TRIMESTER ULTRASOUND LEXICON: PREGNANCY LOCATION

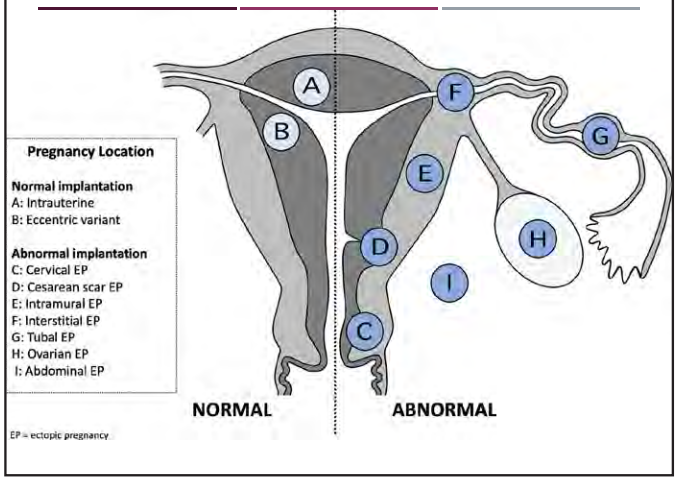
Term(s) *Alternate Term(s)*	Image Example(s)	Image Key	Definitions/ Applications	Term(s) to Avoid	Comments
NORMAL					
Intrauterine pregnancy (IUP) *Normally located pregnancy/IUP*		Arrow = IUP	Pregnancy implanted in a normal location		• In early pregnancy, GS normally located in upper 2/3 of uterus
Variants: -*Eccentrically located GS completely surrounded by endometrium*		Arrow = IUP (transverse plane)		‘Angular pregnancy’ ‘Cornual pregnancy’ ‘Eccentric pregnancy’	• Conclude as IUP • Optional to include description/term in report findings • Short-interval follow-up or 3D TVUS may help differentiate from interstitial EP in uncertain cases
-Describe location of GS in uterus with Müllerian duct anomaly		Arrow = IUP in right horn of septate uterus (3D coronal reconstructed plane)		‘Unicornuate pregnancy’ ‘Bicornuate’ pregnancy’	• Reporting examples: ○ *GS within a unicornuate uterus* ○ *GS within right horn of a septate uterus*

ABNORMAL

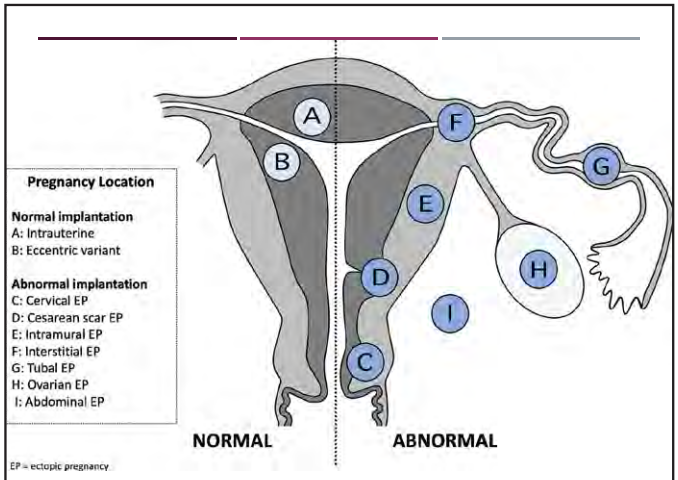
Ectopic pregnancy		Arrow = GS in left interstitial segment of tube (transverse plane) Arrow = GS sac	Pregnancy implanted in an abnormal location	‘Cornual EP’ ‘Cesarean scar pregnancy’ ‘Cervical pregnancy’ ‘Live/living EP’ ‘Viable EP’	• Poses risk of maternal morbidity/mortality if untreated • General term; report laterality (if applicable) and location as follows: ○ ***Tubal EP*** (includes ampullary, *isthmic*, & *fimbrial*) ○ ***Interstitial EP*** (intra-myometrial segment of tube) ○ ***Cesarean scar EP, cervical EP, ovarian EP, abdominal EP, intramural EP*** • Report YS, embryo/fetus and cardiac activity when seen to assist with treatment planning ○ No YS or embryo/fetus = ***probable EP*** ○ With YS or embryo/fetus = ***definite EP*** ○ When in LUS/endocervix, must differentiate from EPL in progress; short-interval follow-up may help in uncertain cases • With co-existing IUP = ***heterotopic pregnancy***
-***Extraovarian Mass*** *Adnexal mass*		Solid arrow = extraovarian mass Calipers = ovary	Adnexal mass, separate from ovary, of variable echogenicity and vascularity		• When no IUP, high likelihood of tubal EP • *Adnexal mass* preferred when ovary not seen • ***Sliding sign*** helpful to confirm separate from ovary or uterus
-***Tubal ring*** *Adnexal ring* *Adnexal GS*		Solid arrow = tubal ring Dotted arrow = ovary	GS in adnexa separate from ovary, = peripheral vascularity	‘Bagel’ sign ‘Donut’ sign	• When no IUP, high likelihood of tubal EP (even without YS or embryo) • Important to differentiate from exophytic corpus luteum ○ Echogenicity, ovarian ***claw sign*** and ***sliding sign*** on TVUS may be helpful • Color Doppler not useful as both may have a ring of peripheral vascularity
UNKNOWN					
Pregnancy of unknown location (PUL)		Arrows = ovaries (transverse plane)	No findings of probable or definite IUP or EP on TVUS		• Differential diagnosis = non-visualized early IUP, non-visualized EP and completed EPL; correlate with trending serum hCG values and follow-up US ○ Most IUPs seen with serum hCG ≥3000 mIU/ml • Should NOT be used when TVUS shows: ○ ***Probable GS/IUP*** = any round/oval intrauterine fluid collection with a hyperechoic rim (even without YS or embryo) ○ ***Probable EP*** = no findings of IUP and extraovarian mass or tubal ring (even without YS or embryo)

SRU = Society of Radiologists in Ultrasound; GS = gestational sac; 3D = three dimensional; TVUS = transvaginal US; EP = ectopic pregnancy; CS = cesarean section; YS = yolk sac; LUS = lower uterine segment; EPL = early pregnancy loss; “+” = with or without; hCG = human chorionic gonadotropin

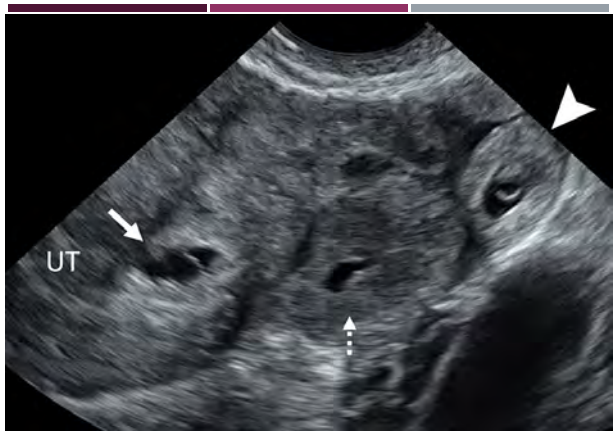


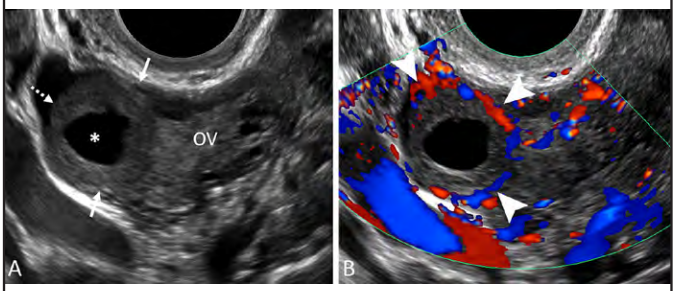


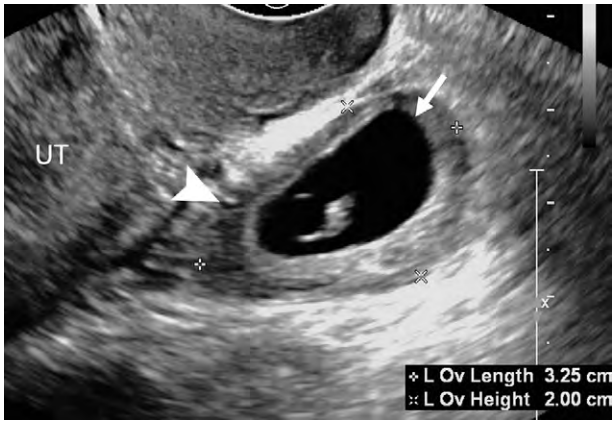
EP = ectopic pregnancy

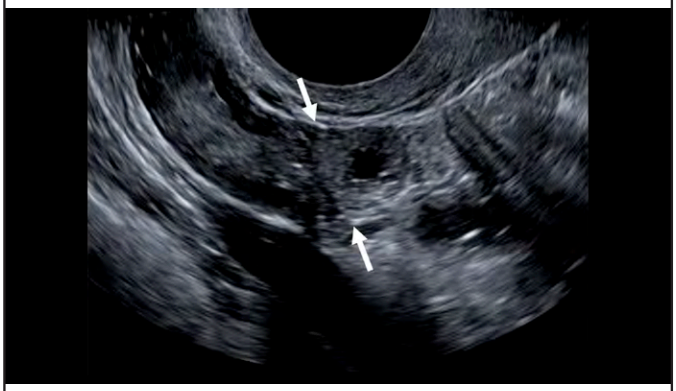


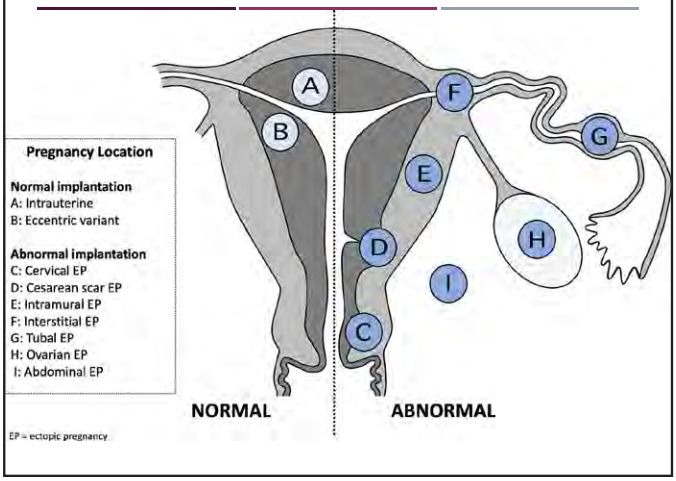
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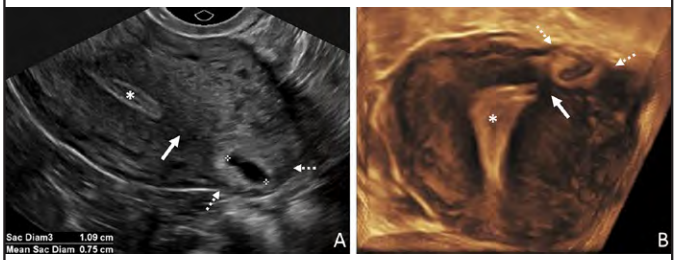

UT

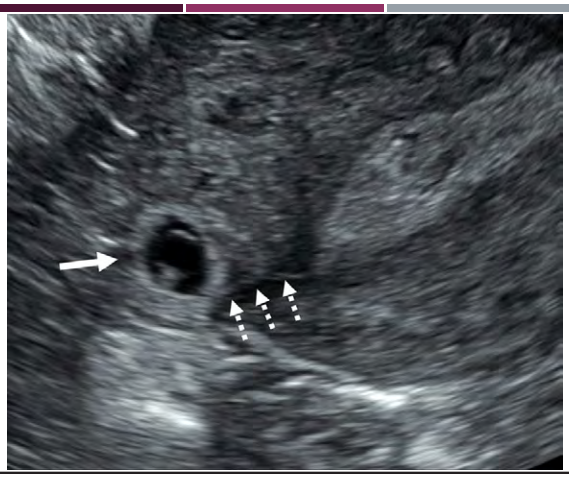

OV
A
B

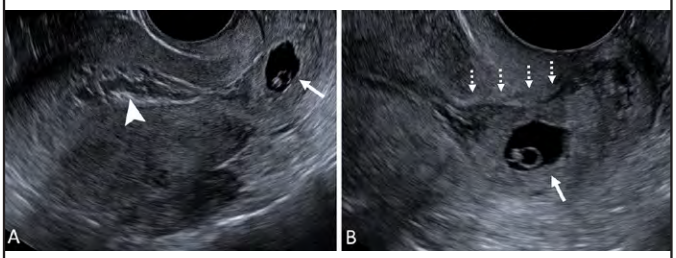

UT
L Ov Length 3.25 cm
L Ov Height 2.00 cm




Pregnancy Location
Normal implantation
A: Intrauterine
B: Eccentric variant
Abnormal implantation
C: Cervical EP
D: Cesarean scar EP
E: Intramural EP
F: Interstitial EP
G: Tubal EP
H: Ovarian EP
I: Abdominal EP
A
B
C
D
E
F
G
H
I
NORMAL
ABNORMAL
EP = ectopic pregnancy

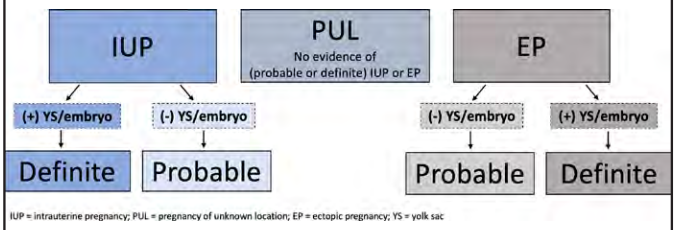

Sac Diam3 1.09 cm
Mean Sac Diam 0.75 cm
A
B





PREGNANCY LOCATION

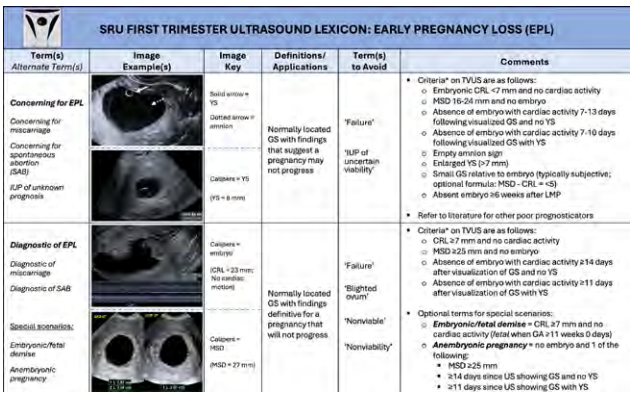
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- Avoid: "cornual," "angular," "eccentric" (alone), "pseudosac."



IUP = intrauterine pregnancy; PUL = pregnancy of unknown location; EP = ectopic pregnancy; YS = yolk sac

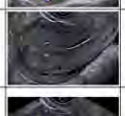
EARLY PREGNANCY LOSS (EPL)

- EPL replaces "pregnancy failure."
- Categories: Concerning for, Diagnostic of, In progress, Incomplete, Completed.
- Preferred: "miscarriage" or "spontaneous abortion" (with equivalence clarified).
- Avoid: "blighted ovum," "nonviable pregnancy," "retained tissue."
- Use "enhanced myometrial vascularity" instead of AVM terminology.

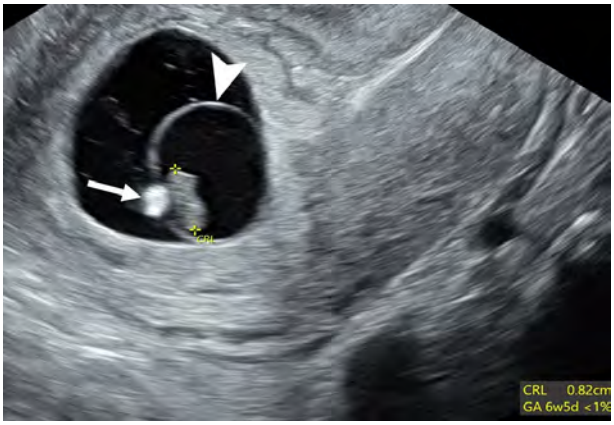


SRU FIRST TRIMESTER ULTRASOUND LEXICON: EARLY PREGNANCY LOSS (EPL)

Term(s) *Alternate Term(s)*	Image Example(s)	Image Key	Definitions/ Applications	Term(s) to Avoid	Comments
Concerning for EPL *Concerning for miscarriage* *Concerning for spontaneous abortion (SAB)* *IUP of unknown prognosis*		Solid arrow = YS Dotted arrow = amnion Calipers = YS (YS = 8 mm)	Normally located GS with findings that suggest a pregnancy may not progress	'Failure' 'IUP of uncertain viability'	• Criteria* on TVUS are as follows: ○ Embryonic CRL <7 mm and no cardiac activity ○ MSD 16-24 mm and no embryo ○ Absence of embryo with cardiac activity 7-13 days following visualized GS and no YS ○ Absence of embryo with cardiac activity 7-10 days following visualized GS with YS ○ Empty amnion sign ○ Enlarged YS (>7 mm) ○ Small GS relative to embryo (typically subjective; optional formula: MSD - CRL = <5) ○ Absent embryo ≥6 weeks after LMP • Refer to literature for other poor prognosticators
Diagnostic of EPL *Diagnostic of miscarriage* *Diagnostic of SAB* Special scenarios: *Embryonic/fetal demise* *Anembryonic pregnancy*		Calipers = embryo (CRL = 23 mm; No cardiac motion) Calipers = MSD (MSD = 27 mm)	Normally located GS with findings definitive for a pregnancy that will not progress	'Failure' 'Blighted ovum' 'Nonviable' 'Nonviability'	• Criteria* on TVUS are as follows: ○ CRL ≥7 mm and no cardiac activity ○ MSD ≥25 mm and no embryo ○ Absence of embryo with cardiac activity ≥14 days after visualization of GS and no YS ○ Absence of embryo with cardiac activity ≥11 days after visualization of GS with YS • Optional terms for special scenarios: ○ ***Embryonic/fetal demise*** = CRL ≥7 mm and no cardiac activity (*fetal* when GA ≥11 weeks 0 days) ○ ***Anembryonic pregnancy*** = no embryo and 1 of the following: ▪ MSD ≥25 mm ▪ ≥14 days since US showing GS and no YS ▪ ≥11 days since US showing GS with YS

EPL in progress *Miscarriage in progress* *SAB in progress*		Arrow = embryo in LUS/upper cervix (No CM)	GS located in cavity of lower uterine segment or endocervical canal in process of expulsion		• If cardiac activity present, consider cervical or cesarean scar ectopic pregnancy • Color Doppler, ***sliding sign*** on TVUS or short-interval follow-up US may be helpful in uncertain cases
Incomplete EPL *Retained (or residual) products of conception (RPOC)* *Incomplete Miscarriage/SAB* Description of findings in lieu of term		Calipers = endometrial thickness (ET = 14 mm) Solid arrow = RPOC Dotted arrow = EMV	Residual intracavitary tissue or thickened endometrium following EPL, typically with internal vascularity; = persistent GS	'Embryonic tissue' 'Fetal tissue'	• Option to substitute *residual* for *retained* as tissue may spontaneously expel and retained may imply tissue is fixed prompting unnecessary intervention; treatment is based on clinical factors or persistent GS ○ If GS in lower uterine segment/endocervix, see EPL in progress above • Vascular flow in endometrial cavity confirms tissue • Endometrium <10 mm without vascular flow is unlikely to represent incomplete EPL • Enhanced myometrial vascularity (EMV) typically seen
Completed EPL *Completed miscarriage* *Completed SAB*		Calipers = endometrial thickness (ET = 7 mm)	No intracavitary tissue or persistent GS following EPL		• Used in following scenarios: ○ Prior visualized GS that is no longer seen and no residual intracavitary tissue ○ In differential diagnosis of pregnancy of unknown location (PUL)
- Enhanced myometrial vascularity (EMV)		Arrow = EMV	Focal myometrial vascularity deep to prior pregnancy implantation site		• Transient/expected finding following EPL (incomplete or completed); typically, resolves spontaneously • Should NOT be confused with: ○ Arterio-venous fistula (AVF): rare; most commonly due to sharp curettage ○ Arterio-venous malformation (AVM): rare; congenital anomaly ○ Subinvolution of the placental site (SIPS): pathologic diagnosis

SRU= Society of Radiologist in Ultrasound; IUP = intrauterine pregnancy; cm = centimeters; YS = yolk sac; GS = gestational sac; *Doubilet et.al. NEJM 2013, PMID 24106937, DOI 10.1056/NEJMra1302417; TVUS = transvaginal US; MSD = mean sac diameter; CRL = crown-rump length; LMP = last menstrual period; GA = gestational age; CM = cardiac motion; SAG =sagittal; COR = coronal; "+" = with or without; ET = endometrial thickness



KEY TERMINOLOGY CHANGES

- EPL replaces “failure.”
- Cardiac activity replaces “heartbeat” and “heart motion.”
- EP defined as any abnormal implantation, including cesarean scar.
- Avoid outdated or distressing terminology to improve patient care.

SUMMARY OF MAJOR LEXICON CHANGES: TERMS TO USE

Terms to Use	Comments
Early Pregnancy Loss (EPL)	• General term endorsed by OB-Gyn communities and societies to describe a pregnancy that may or will not progress, is in the process of expulsion, or has incompletely or completely passed; replaces 'failure' • Modifiers to differentiate above scenarios are as follows: ○ ***Concerning for*** = GS normally located but with findings that it may not progress ○ ***Diagnostic of*** = GS normally located but with findings that it will not progress ○ ***In progress*** = GS located in cavity of LUS or endocervical canal in process of expulsion ○ ***Incomplete*** = Intracavitary tissue, thickened endometrium or persistent GS following EPL ▪ Alternate terms: ▪ *Retained* (or *residual*) *products of conception (RPOC)* ▪ Description of findings in lieu of a term (e.g., *intracavitary vascularized tissue*, etc.) ○ ***Completed*** = No persistent GS or intracavitary tissue following EPL • Alternate terms for EPL to be used along with above modifiers: ○ *Miscarriage* ▪ Preferred by patients in one survey ○ *Spontaneous abortion in progress (SAB)* ▪ If using, consider reporting as synonymous with miscarriage for patient clarity
Cardiac activity	• Term for embryonic/fetal rhythmic pulsations; replaces 'heart', 'heart motion', 'heartbeat', etc. • Alternate term: *cardiac motion* • Avoid the terms 'live', 'living' and 'viable' in the 1st trimester
Ectopic Pregnancy	• Defined as a pregnancy implanted in an abnormal location, whether extrauterine or intrauterine ○ Clarifies cervical and Cesarean scar sites as ectopic pregnancies • Use ***probable*** if no YS or embryo seen • Use ***definite*** if YS or embryo seen

OB-Gyn = Obstetrical and Gynecologic; GS = gestational sac; LUS = lower uterine segment; YS = yolk sac; 1st = first

SUMMARY & TAKE-HOME POINTS

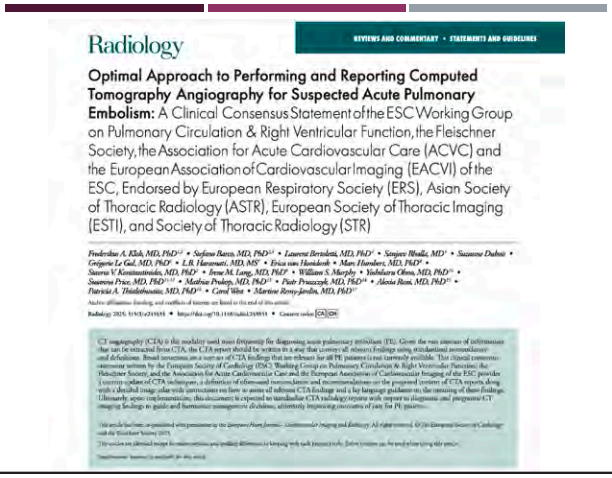
- Standardized lexicon improves clarity and safety.
- Patient-centered terms reduce distress.
- SRU consensus endorsed across societies.
- Key updates: EPL terminology, cardiac activity, EP definition, avoid obsolete terms.

SUMMARY OF MAJOR LEXICON CHANGES: TERMS TO AVOID

Terms to Avoid	Lexicon Terms
Embryonic 'pole' or fetal 'pole'	***Embryo*** or ***fetus***
'Heart', 'heartbeat', 'heart motion', etc.	***Cardiac activity*** OR *cardiac motion*
'Live', 'living', 'viable'	***Cardiac activity*** OR *cardiac motion*
'Viability' scan	***First trimester US exam***
'IUP of uncertain viability'	***IUP of uncertain prognosis*** OR ***concerning for EPL***
'Failure'	***Early pregnancy loss (EPL)***
'Blighted ovum'	***Anembryonic pregnancy*** OR ***diagnostic of EPL***
'Pseudogestational sac', 'pseudosac'	***Intracavitary fluid*** OR *endometrial cavity fluid*
'Cesarean scar pregnancy'	***Cesarean scar ectopic pregnancy***
'Cervical pregnancy'	***Cervical ectopic pregnancy***
'Angular pregnancy', 'cornual pregnancy', 'eccentric pregnancy'	***IUP*** OR if describing, use: *eccentrically located GS completely surrounded by endometrium* (and conclude as IUP)
'Cornual ectopic pregnancy'	***Interstitial ectopic pregnancy***
'Unicornuate pregnancy', 'bicornuate pregnancy'	Describe GS relative to uterine MDA (e.g., *GS in right horn of septate uterus*)

US = ultrasound; IUP = intrauterine pregnancy; EPL = early pregnancy loss; GS = gestational sac; MDA = Müllerian duct anomaly




Radiology

REVIEWS AND COMMENTARY • STATEMENTS AND GUIDELINES

Optimal Approach to Performing and Reporting Computed Tomography Angiography for Suspected Acute Pulmonary Embolism: A Clinical Consensus Statement of the ESC Working Group on Pulmonary Circulation & Right Ventricular Function, the Fleischner Society, the Association for Acute Cardiovascular Care (ACVC) and the European Association of Cardiovascular Imaging (EACVI) of the ESC, Endorsed by European Respiratory Society (ERS), Asian Society of Thoracic Radiology (ASTR), European Society of Thoracic Imaging (ESTI), and Society of Thoracic Radiology (STR)

OBJECTIVES

- Why PE CTA reporting matters
- CTPA technique: what makes a study diagnostic
- Assessing image quality and exam limitations
- How to identify and describe acute PE
- Standardized terminology and common pitfalls
- Key report elements that add clinical value
- Practical reporting template for daily use
- Case-based examples and take-home points

OJBECTIVES

- Recognize the technical requirements of a diagnostic-quality CTPA
- Identify and accurately describe acute pulmonary embolism
- Use standardized PE reporting terminology
- Include the most clinically important findings in the report
- Apply a practical template for reporting PE CTA

WHY PE CTA REPORTING MATTERS

- CT pulmonary angiography is the primary imaging test for suspected acute pulmonary embolism when imaging is indicated
- The radiology report should do more than confirm or exclude PE
- Reports can directly influence triage, anticoagulation, admission level, and follow-up
- Key findings such as clot location, right heart strain, and features of chronic thromboembolic disease add important clinical value
- Standardized reporting improves clarity, consistency, and communication with treating teams

CONSENSUS PROCESS

- Task force convened by the ESC Working Group, Fleischner Society, ACVC, and EACVI
- Literature review of CT technique, terminology, image quality, and prognostic findings
- Standardized glossary of PE CTA terms
- Online 3-round modified Delphi process using the RAND/UCLA method
- Only findings with prognostic relevance were considered
- Agreement threshold: 80% early rounds, 70% final round
- Results categorized into must-have and nice-to-have report elements
- Final product included a practical image atlas and patient-facing langua

TECHNIQUE

- Use the shortest rotation time and thinnest collimation
- Cover the entire thorax
- Prefer low-kV imaging when appropriate to improve contrast and reduce dose
- Reconstruct 1-mm axial images
- Review both mediastinal and lung windows

TECHNIQUE

- Standard contrast setup:
  - Antecubital IV access
  - 3–5 mL/s injection rate
  - 300–370 mg I/mL contrast
  - 80–100 mL total volume
- In dyspneic patients, vital-capacity breath hold or shallow breathing may be better tolerated
- Caudocranial acquisition can help reduce motion artifact in the lung bases in severely dyspneic patients

Table 1: Optimal CTA Scan Protocol for Routine Clinical Practice

Acquisition parameters	
Tube voltage	• 80–140 kV according to BMI • Possibility to use automatic kV selection *(low kV in slim patients)*
Tube current	• Tube current varies based on the kilovoltage, patient size, and region thickness *(image quality factor determined in protocol)* • Use of automatic tube current modulation
Rotation time	• Shortest rotation time
Collimation	• Thinnest collimation
Scanning direction	• Cranio-caudal or caudo-cranial • Alternative for severely dyspneic patients: caudo-cranial imaging to decrease respiratory motion artifacts in the lung bases
Respiratory instructions	• Breath-hold at deep inspiration • Breath-hold at vital capacity or shallow breathing if chest pain/dyspnea
Reconstruction parameters	
Section thickness	• 1-mm thick transverse CT sections
Field of view	• Adapted to the patient size
Kernels of reconstruction	• Soft tissue and high-spatial-resolution kernels for mediastinal and lung images, respectively
Reconstructions	• Iterative reconstruction or deep learning reconstruction
Injection parameters	
Venous access	• > 20G in antecubital vein; smaller if poor venous access
Flow rate	• 3–5 mL/s in antecubital vein; lower if poor venous access *(with higher iodine concentration)*
Concentration of iodinated contrast material	• 300–370 mg I/mL
Volume administered	• 80–100 mL

IS THIS CTPA DIAGNOSTIC?

- Diagnostic exam requires:
  - Good pulmonary arterial opacification
  - Minimal motion artifact
- Typical minimum enhancement: ~200–250 HU
- Review both mediastinal and lung windows
- Only call a study negative to the level you can evaluate
- Central arteries only visible = **indeterminate for PE**
- Pulmonary arteries not analyzable = **nondiagnostic**

"A study is only as negative as the smallest vessel you can confidently assess."

Table 3: Relevance of the Level of Analyzability of the Pulmonary Arteries for the Diagnostic Value of CT

Mediastinal Images			
Level of Analyzability of Pulmonary Arteries	Diagnostic Value of Mediastinal Images Alone	Perfusion Images	Diagnostic Value of CT Based on Combined Readings of Mediastinal and Perfusion Images
PAs analyzable down to the subsegmental level	Negative down to the subsegmental level	No segmental/subsegmental perfusion defects	Truly negative
PAs analyzable down to the segmental level	Negative down to the segmental level *(does not exclude subsegmental clots)*	No *segmental/subsegmental* perfusion defects	Truly negative
		Presence of *segmental/subsegmental* perfusion defects	Peripheral acute PE (after combined assessment of perfusion and morphology)
Only central PA analyzable	Only central clots excluded	No diagnostic value of perfusion images	Indeterminate for PE images
PAs not analyzable	PE not excluded	No diagnostic value of perfusion images	Nondiagnostic examination

"A study is only as negative as the smallest vessel you can confidently assess."

COMMON CAUSES OF NONDIAGNOSTIC CTPA

- Poor opacification
- Transient interruption of contrast
- Respiratory motion
- Patient motion
- Cardiac motion
- Streak artifact

Know the cause before labeling the study "limited" or "nondiagnostic"

Table 4: Causes of and Solutions to Nondiagnostic CTA

Finding	Potential Etiology	Proposed Solution
Poor level of opacification within Pas	Incorrect placement of the ROI Inadequate HU threshold to start exam Delayed transit time • Due to low cardiac output (most often RV) • Due to increased pulmonary vascular resistance (acute airspace disease, focal lung abnormalities) Dilution of the column of contrast • Due to patent foramen ovale • Septal defects • Retrograde systemic-to-pulmonary artery shunt	Repeat after correct positioning of the ROI Repeat after correction Repeat • After selecting a longer start delay (if CTA) • Repeat with a ROI in the ascending aorta/left atrium (general CTA protocol) • Repeat after mild inspiration • No attempt to repeat • No attempt to repeat
Transient interruption on contrast (TIC)	Deep inspiration in a patient with large volume of unopacified blood from the inferior vena cava diluting the bolus of contrast material Veno-arterial extracorporeal membrane oxygenation (ECMO) may cause changes in the filling of the pulmonary arteries	Repeat using mild inspiration or simple apnea ECMO flow should be reduced to a minimum during the CTA
Motion artifacts	Causes: • Respiratory motion • Patient movement during the examination • Cardiac motion; usually most pronounced in left lower lobe and lingula and on older scanners	• Repeat (caudo-cranial) if patient cooperation possible • Repeat (caudo-cranial) with shallow breathing if patient cooperation is impaired • Repeat (caudo-cranial) if patient cooperation possible • No attempt to repeat
Streak artifact	Beam-hardening artifacts due to: • Dense contrast material • Metal implants or bullets	• No attempt to repeat • Postprocessing with algorithms suppressing metal artifacts (manufacturer dependent) or reconstruction of high-energy images (if acquisition with DECT/PCD CT)

[a]Potential alternative: administration of more contrast (120–150 mL), at low flow rate (3 mL/s) with a long start delay (>30 s) to ensure opacification of pulmonary arteries as well as shunt veins.

Term	Definition / Reporting Use
Central PE	Embolus in the **pulmonary trunk, main pulmonary arteries, or lobar arteries**
Peripheral PE	Embolus in the **segmental or more distal pulmonary arteries**
Subsegmental PE	Embolus limited to a **subsegmental pulmonary artery**
Isolated subsegmental PE	**Single or multiple subsegmental emboli** without more proximal PE
Saddle embolism	Embolus **straddling the bifurcation** of the main pulmonary artery
Acute PE	Clot that is **central or eccentric with acute angles** to the vessel wall; may enlarge the vessel
Chronic PE	Clot that is **eccentric, web-like, band-like, or irregular**, often with vessel narrowing/retraction
Pulmonary artery filling defect	General descriptive term for a **low-attenuation intraluminal defect** in an opacified artery
Reduced pulmonary contrast enhancement	**Pitfall/artifact** where poor opacification can mimic PE
In situ pulmonary thrombus	Thrombus forming **within the pulmonary artery**, rather than embolized from elsewhere

Term	Definition / Reporting Use
Embolus	Thrombus that has **dislodged** and traveled from its site of origin
Incidental PE	PE found on CT performed for a reason **other than suspected PE**
Pulmonary thrombosis	Thrombus in the pulmonary arteries; may be embolic or **locally formed**
Right ventricular dilatation	Enlargement of the RV, often assessed by **RV/LV ratio**
Right ventricular hypertrophy	RV free wall thickness **>4 mm**
Subacute PE	Embolus with evolving lysis and **more irregular/concave** morphology
Thrombus	Intravascular blood clot that remains at its **site of origin**

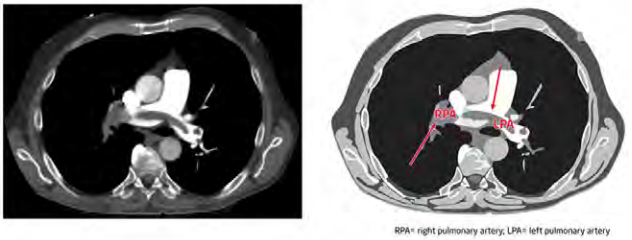
Table 5: Continued Developments in CT Technology Have Led to Marked Improvement in Spatial Resolution and Improved Detection of All Types of Intraluminal Filling Defects at CT Pulmonary Angiography. However, Not All Filling Defects Represent Acute Pulmonary Emboli. The Following Glossary of CT Findings Define the Spectrum of Pulmonary Artery Filling Defects

Term	Definition
Acute PE	Acute PE is characterized by filling defects within the pulmonary arteries that essentially retain the cylindrical shape of the dislodged thrombi that either may remain intact or may fragment on their way through the heart. On images perpendicular to the vessel, acute emboli present as round filling defects in the center of a pulmonary artery or, when eccentric, they tend to form acute angles with the vessel wall. No signs of deformation due to (unreflective) activity of the embolus are seen. Acute emboli may totally occlude a pulmonary artery. No contrast enhancement is seen beyond this point. As a result, the diameter of the artery expands to its normal, usually larger than anteries of comparable anatomic locations elsewhere, to concealment emboli. Flow may be seen distal to the filling defect. Emboli tend to be more common at arterial bifurcations.
Central PE	PE is located in either the pulmonary trunk, main pulmonary artery, or lobar pulmonary artery.
Chronic PE	Persistent filling defects after acute PE. The cross-section of these filling defects is thrombus, bandlike, webbing, or irregular but not round. Round cross-sections usually suggest recurrent acute PE.
Embolus	An embolus is a thrombus that has dislodged and is located at a site different from its origin of origin.
Incidental PE	PE identified on a CT scan ordered for any other reason than suspected PE.
Acute pulmonary thrombus	Acute pulmonary thrombus presents as a wall-adherent filling defect, usually in large or enlarged pulmonary arteries. The most common location is along the superior aspects of the main right pulmonary artery and intralobar pulmonary artery. These filling defects may be associated with some calcification. Unlike with chronic pulmonary emboli, vessel enlargement is unusual. It oftentimes occurs in the setting of slow flow and pulmonary hypertension. They are commonly seen in various causes of pulmonary hypertension, most notably Eisenmenger syndrome in the setting of a longstanding right-to-left shunt.
Isolated subsegmental PE	Subsegmental PE limited to a single subsegmental artery.[a]
Peripheral PE	PE located in a segmental or more distal pulmonary artery.
Pulmonary artery filling defect	Pulmonary arteries on contrast-enhanced CT essentially show heterogeneous contrast enhancement. Filling defects are areas within an affected pulmonary artery that show no internal enhancement while other pulmonary arteries do enhance. Pulmonary artery filling defects are caused by pulmonary emboli, pulmonary thrombosis, or intravascular tumor.
Pulmonary thrombosis	Thrombi in the pulmonary arteries are usually the result of venous thromboembolism, but may also be local pulmonary thrombosis. This has been recognized in patients with pulmonary hypertension, chronic obstructive pulmonary disease, sickle cell disease, and rather extensively in patients with COVID-19. Differentiation between venous thromboembolism and in situ thrombosis can currently not be reliably made based on CTA.
Reduced pulmonary contrast enhancement	Filling defects must be distinguished from regions of reduced contrast enhancement due to early timing of a test series on contrast-enhanced CT or due to slow flow. They are artifacts associated with scan timing or patient factors (breathing or pulsation artifacts). The measured CT attenuation is higher than that of an unenhanced pulmonary artery but lower than that of a well-enhanced vessel.
Right ventricular dilatation	A number of methods have been studied to define right ventricular dilatation based on CTA findings with or without ECG alignment. A practical approach consists of measuring the largest ventricle diameters in the axial view in both ventricles, as defined by the distance between the interventricular septum. As a confirmation, the same measurement can be done taking the largest ventricle diameters at the level of the heart valves. RV/LV ratio measured at CT may be different from measured at echocardiography when the CT is performed without ECG alignment.
Right ventricular hypertrophy	Increased thickness of the right ventricle free wall, exceeding 4 mm.
Saddle embolism	A large central PE that straddles the pulmonary trunk bifurcation.
Subacute PE	The shape of the emboli begins to change due to lytic activity instead of a round cross-section, concave portions may occur, and the cross-sections become increasingly irregular. Findings of chronic emboli (namely, mosaic attenuation and enlarged bronchial arteries) are usually absent.
Subsegmental PE	A contrast defect in a subsegmental artery, ie, the first arterial branch division of any segmental artery bifurcation of artery diameter visible in at least two consecutive axial slices using a CT scanner with a detector maximum collimation width of 45 mm.[a]
Thrombus	An intravascular blood clot that remains at its site of origin.

HOW TO DIAGNOSE ACUTE PE

- Look for a well-defined filling defect
- Confirm on axial + another plane
- Acute PE is usually:
  - Central and round, or
  - Eccentric with acute angles
- Occlusive PE may enlarge the vessel
- Nonocclusive PE may show contrast distal to clot
- Beware slow flow / poor enhancement mimicking clot

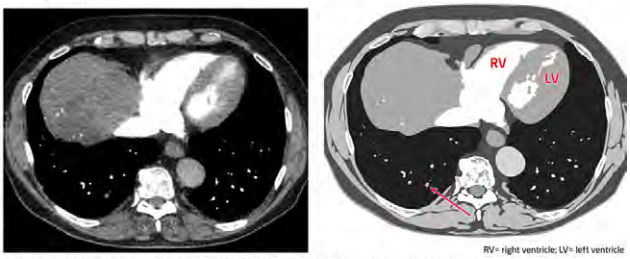
2 Central PE



RPA= right pulmonary artery; LPA= left pulmonary artery

Saddle pulmonary embolism. Contrast-enhanced CT shows a central filling defect (arrows) that crosses the pulmonary artery bifurcation in keeping with saddle embolism. PE located in either the pulmonary trunk, main pulmonary artery or lobar pulmonary artery is referred to as 'central PE'.

3 Subsegmental PE



RV= right ventricle; LV= left ventricle

Subsegmental pulmonary embolism without right heart strain. Contrast-enhanced CT shows a filling defect in a subsegmental artery (arrow) of the right posterobasal segment. Note the RV and left ventricle LV retain their normal sizes. A contrast defect in a subsegmental artery, i.e. the first arterial branch division of any segmental artery independent of artery diameter, visible in at least two subsequent axial slices using a CT scanner with a desired maximum collimator width of ≤1mm, is referred to as 'subsegmental PE'. Subsegmental pulmonary embolism limited to a single subsegmental artery is referred to as 'isolated' subsegmental PE.

WHAT EVERY REPORT SHOULD INCLUDE

- PE present or absent
- Location: central, lobar, segmental, subsegmental
- Isolated subsegmental PE?
- RV/LV ratio
- Septal deviation
- Signs of chronic thromboembolic disease
  - webs/bands
  - PA retraction
  - bronchial artery dilatation
  - RV hypertrophy

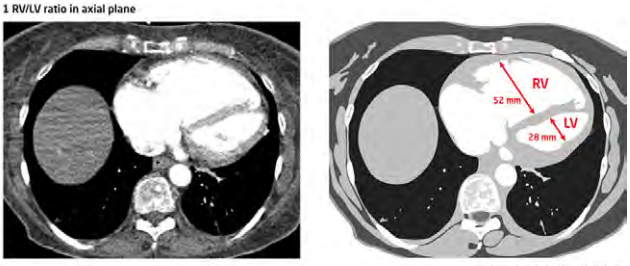
Table 6: Result of the Delphi Analysis on Core CTA Findings to Be Included in CTA Radiology Reports: Percentage Agreement is Indicated. In the First 2 Rounds, Agreement Was Defined as an 80% Majority; in the Third Round, This Was 70% Majority

CTA Findings	Excluded	Included	Specifics
1. RV/LV ratio (axial images)		100%	92% "must have"
2. Central location		100%	85% "must have"
3. (Isolated) subsegmental PE		92%	81% "must have"
4. Septum deviation		85%	81% "must have"
5. IVC reflux	81%		
6. PA trunk diameter		81%	75% "nice to have"
7. Coronary artery calcification score	81%		
8. Qanadli score	85%		
9. Organized mural thrombi		85%	75% "nice to have"
10. Complete arterial occlusion		94%	75% "nice to have"
11. Intravascular webs or bands		100%	75% "must have"
12. Pulmonary artery retraction		87%	75% "must have"
13. Bronchial artery dilatation		87%	80% "must have"
14. RV hypertrophy		94%	75% "must have"

RIGHT HEART STRAIN ON CTPA

- RV/LV ratio
- Septal bowing / deviation
- RV enlargement suggests higher-risk PE
- Include strain findings in the impression
- Absence of strain is also worth stating

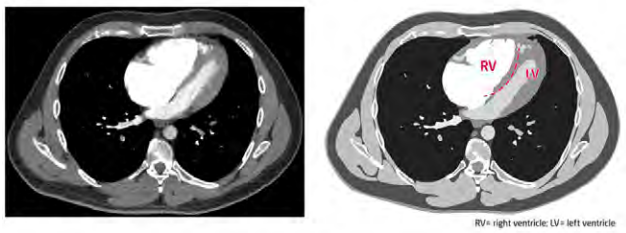
1 RV/LV ratio in axial plane



RV= right ventricle; LV= left ventricle

RV/LV ratio. To determine RV/LV ratio, the largest transverse diameter of RV (which is perpendicular to the long axis of the ventricle) is divided by that of the LV; these are often found on separate images. If a corrected four chamber view is used (as in this case), the diameters may be obtained on the same image.

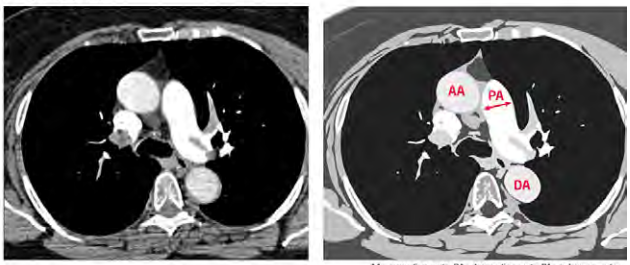
4 Septum deviation



RV= right ventricle; LV= left ventricle

Intraventricular septal deviation. Contrast-enhanced CT shows a right lower pulmonary embolism and deviation of the interventricular septum in the direction of the LV (dotted line). Note the RV is enlarged compared with the left ventricle LV but there is no right ventricle hypertrophy, suggesting the RV enlargement is from acute elevation of pressure.

5 PA drunk diameter



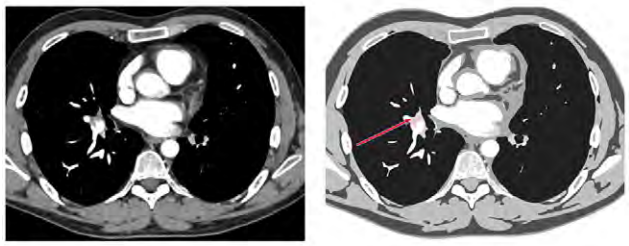
AA= ascending aorta; DA= descending aorta; PA= pulmonary artery

Pulmonary artery trunk diameter. The pulmonary artery should be smaller than the aorta when transverse measurements are obtained. In the setting of acute PE, the pulmonary artery may transiently enlarge and its enlargement should be reported. The dimension should be obtained orthogonal to the long axis as shown above. Enlargement may be a sign of elevated pulmonary pressures. In cases where the aorta is obliqued, the differences in size can be confirmed by measurements obtained orthogonal to the long axis of each vessel.

CHRONIC THROMBOEMBOLIC DISEASE

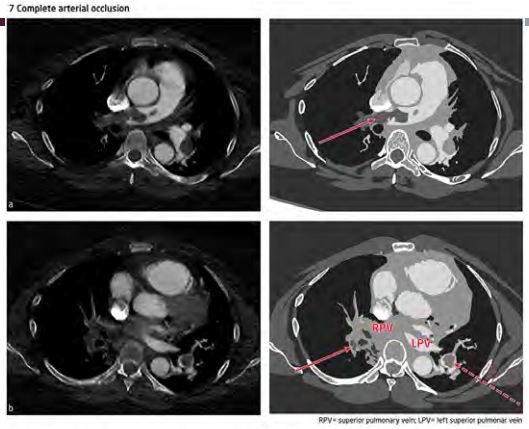
- Webs or bands
- Pulmonary artery retraction
- Bronchial artery dilatation
- RV hypertrophy
- Suggests possible chronic thromboembolic disease / CTEPH
- Important even on a study ordered for acute PE

6 Organized mural thrombus



Organized mural thrombus. The visualization of an eccentric flat filling defect (arrow) or organized mural thrombus should be reported as 'Organized mural thrombus"

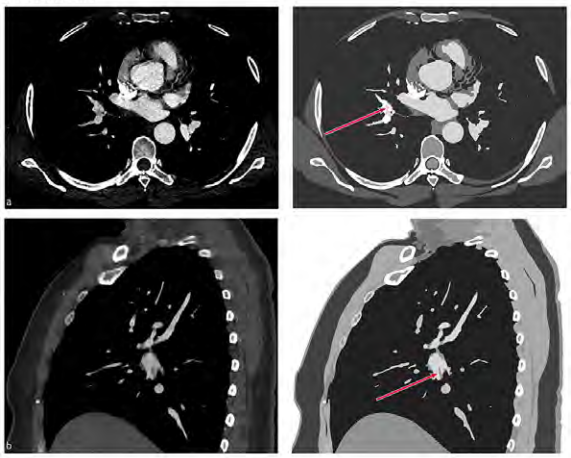
7 Complete arterial occlusion



RPV= superior pulmonary vein; LPV= left superior pulmonar vein

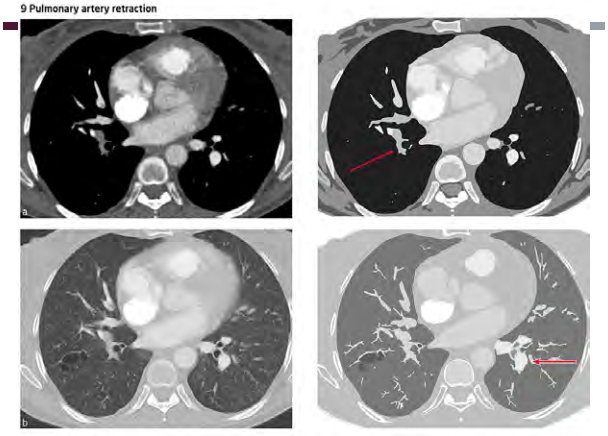
Arterial occlusion from acute PE. Contrast-enhanced CT transaxial images demonstrate bilateral acute PE. On the right, the PE is occlusive (arrow in A) with minima contrast in the expanded vessel. The RPV poorly opacifies compared to the left LPV because of the markedly diminished blood flow from the occlusive embolism. Occlusive emboli can be seen in the right interlobar artery (right arrow in B) and middle lobe artery. On the left, the PE is nearly occlusive with some flow of contrast around the embolism (dashed arrow in B).

8 Intravascular web

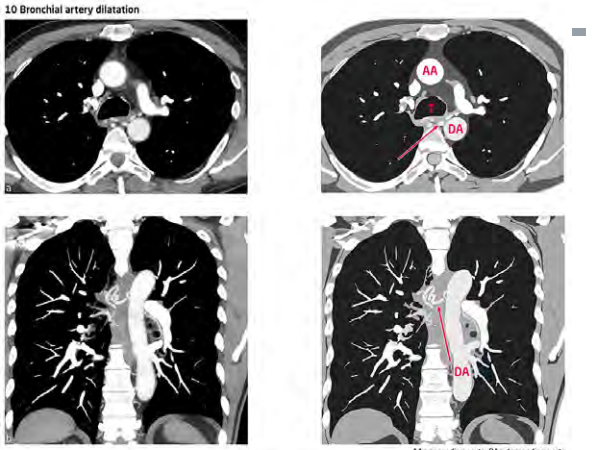


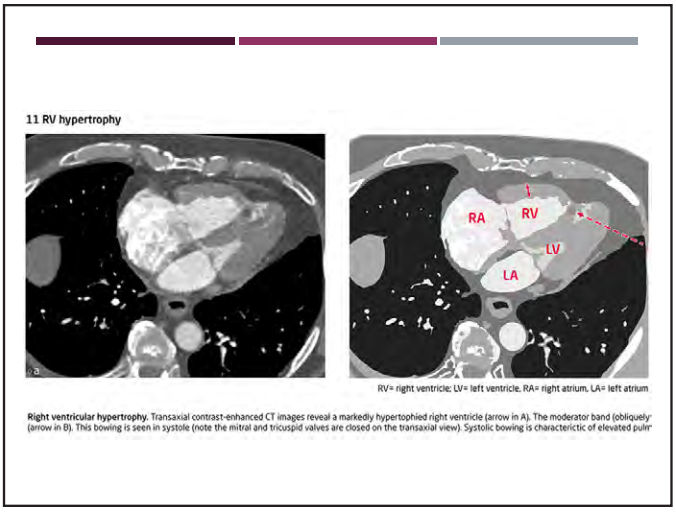
Intravascular web. Axial (A) and sagittal (B) CTA images demonstrate a web in the right lower lobe basilar pulmonary artery trunk.

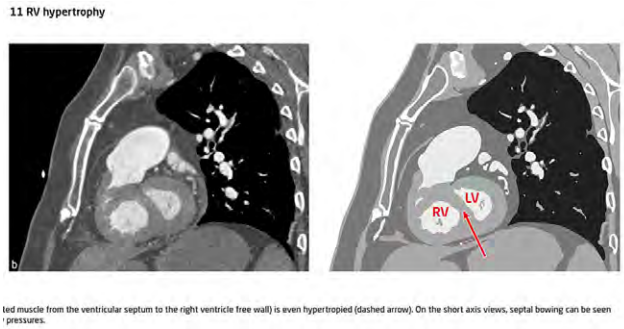
9 Pulmonary artery retraction



Pulmonary artery retraction. CT with contrast illustrates retraction of the right lower lobe pulmonary artery (arrow in A). Often retraction is better seen on the lung windows (B) as every bronchus should have an accompanying artery. A bronchus without an artery should raise suspicion for a retracted pulmonary artery. The left lung serves as a nice control and shows the normal pulmonary artery adjacent to the bronchus (arrow in B).







COMMON REPORTING PITFALLS

- Calling a limited study negative
- Overcalling clot on a poorly opacified exam
- Not stating the most proximal clot location
- Omitting RV strain findings
- Missing signs of CTEPH / chronic disease
- Using vague or inconsistent terminology

PRACTICAL REPORTING TEMPLATE

- Exam quality: diagnostic, limited, or nondiagnostic
- PE: present or absent
- Location: central, lobar, segmental, subsegmental
- RV strain: RV/LV ratio, septal bowing
- Chronic features: webs, bands, PA retraction, RV hypertrophy
- Impression: clear summary with highest-value findings

TAKE-HOME POINTS

- Start with exam quality
- Use standard PE terminology
- Report the most proximal clot
- Include RV strain findings
- Look for chronic thromboembolic disease
- Make the impression clear and actionable

SELF EVALUATION

Standardizing Imaging Reports

1. T/F - The Society of Radiologists in Ultrasound (SRU) consensus recommends using the term “cardiac activity” instead of “heartbeat” or “heart motion” in first-trimester ultrasound reports.

2. Which term should be used instead of “pregnancy failure” when describing a non-progressing first-trimester pregnancy?

a. Nonviable pregnancy
b. Blighted ovum
c. Early pregnancy loss (EPL)
d. Retained products of conception

3. According to the consensus terminology for pulmonary embolism CTA reporting, a central pulmonary embolism involves which vessels?

a. Segmental and subsegmental arteries only
b. Subsegmental arteries only
c. Pulmonary trunk, main pulmonary arteries, or lobar arteries
d. Peripheral pulmonary veins

4. T/F - A CTPA study should only be reported as negative for pulmonary embolism to the level of the pulmonary arteries that can be confidently evaluated.

5. Which of the following findings is considered an important indicator of right heart strain that should be included in a positive PE CTA report?

a. Coronary artery calcium score
b. RV/LV ratio enlargement
c. Pleural effusion size
d. Aortic diameter

Answer Key: 1. T, 2. C, 3. C, 4. T, 5. B

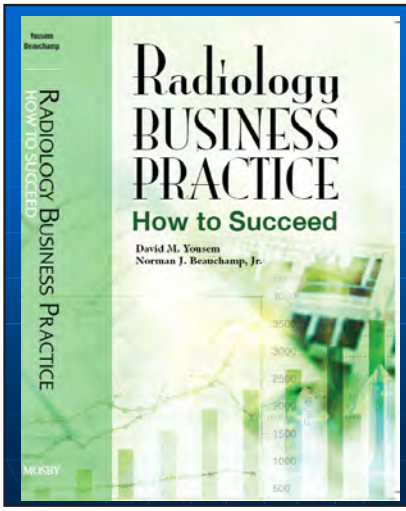
Understanding the RBRVS System: How Physicians Are Valued and Paid
David M. Yousem, MD, MBA

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Disclosures

- **None specific to this talk**
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Components of a Typical Bill

- Global =
- Technical +
- Professional fees

- Valued usually by RVUs
- Translated by CMS into Dollars
- Procedure defined by CPT code

What is Covered under TC

- **Equipment:** The cost of using medical devices and machinery
- **Supplies:** The cost of all materials and consumables used during the procedure
- **Facility:** The charges for using the physical space, such as a hospital or clinic
- **Staff:** The salaries of the technicians and other personnel who help perform the procedure

When are PC (modifier 26) and TC separated?

- When the facility that owns the equipment and employs the technicians is different from the physician who interprets the results
  - Hospital vs Physician Group
  - VC company vs Hired Physicians
- Often employed by Pathology and Radiology groups

Typical Radiology Procedures

Technical vs Professional Component RVUs (2025 Medicare Physician Fee Schedule)

Prof = Modifier 26 (Interpretation); TC = Modifier TC (Equipment/Staff); Global = Both components

CPT	Description	Prof RVU (26)	Tech RVU (TC)	Global RVU	% Professional
70553	MRI Brain w/ and w/o Contrast	1.75	8.61	10.36	16.9%
75625	Abdominal Aortogram	1.13	1.92	3.05	37.0%
74270	Barium Enema	0.69	2.40	3.09	22.3%
71046	Chest X-ray, 2 Views	0.18	0.71	0.89	20.2%
78306	Tc-99m Bone Scan (Whole Body)	0.72	6.87	7.59	9.5%
76700	Abdominal Ultrasound, Complete	0.74	2.55	3.29	22.5%
74220	Barium Esophagram	0.48	1.83	2.31	20.8%
36224-50	Bilateral Internal Carotid Arteriogram	6.30	5.70	12.00	52.5%
77066	Diagnostic Mammogram, Bilateral	0.87	2.12	2.99	29.1%
70450	CT Brain w/o Contrast	0.76	3.33	4.09	18.6%
71275	CT Pulmonary Angiogram	1.38	6.21	7.59	18.2%
74018	KUB (Abdomen X-ray, 1 View)	0.14	0.33	0.47	29.8%
74177	CT Chest/Abdomen/Pelvis w/ Contrast	1.82	6.13	7.95	22.9%
73721	MRI Knee w/o Contrast	1.30	4.89	6.19	21.0%

Radiology wRVUs

Top 10 Radiology CPT Codes by Medicare Volume (2025)

Rank	CPT	Description	Work RVU	Global RVU
1	77067	Screening Mammography, Bilateral	0.70	2.01
2	77063	Digital Breast Tomosynthesis	0.56	1.40
3	71046	Chest X-ray, 2 Views	0.18	0.89
4	77080	DEXA Bone Density	0.20	0.87
5	71045	Chest X-ray, 1 View	0.15	0.53
6	74177	CT Abdomen/Pelvis w/ Contrast	1.74	7.95
7	72148	MRI Lumbar Spine w/o Contrast	1.52	7.39
8	70553	MRI Brain w/ & w/o Contrast	2.07	10.36
9	76856	US Pelvis, Complete	0.74	3.29
10	71250	CT Chest w/o Contrast	1.16	4.87

Non-Radiology CMS Charges

Top Medicare CPT Codes by Volume - RVUs (2025)

Rank	CPT	Description	Work RVU	Global RVU
1	99214	Office Visit, Est Pt (30-39 min)	1.92	3.81
10	80053	Comprehensive Metabolic Panel	0.00	1.26
20	90837	Psychotherapy, 60 min	2.35	4.19
30	99215	Office Visit, Est Pt (40-54 min)	2.80	5.54
40	93000	ECG, Complete	0.17	0.79
50	71046	Chest X-ray, 2 Views	0.18	0.89
60	99223	Initial Hospital Care, High	3.99	4.26
70	93306	Echo (TTE) w/ Doppler	1.30	6.42
80	45380	Colonoscopy w/ Biopsy	3.56	10.19
90	43239	EGD w/ Biopsy	2.39	7.98

Comparisons



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RBRVU

- Resource Based Relative Value Unit
- A scale to determine Medicare/Medicaid (CMS) reimbursement for procedures established in 1992
- A comparative scale across all specialties

CPT Valuation

- New procedure = US elastography
- FDA approved and commercially available
- Submitted by ACR to AMA for CPT-RVU assessment by its CPT Editorial panel and Advisory Committee
  - Key strategic "seat"
  - Maintains and assigns RVUs for CPTs
  - Must have seat at AMA House of Delegates

Categories of Codes

- Category I: "consistently performed, FDA approved, in wide use" RVUs define payment
- Category II: "performance measurement codes for quality care assessment and outcomes measures", not tied to reimbursement
- Category III: "temporary without RVUs assigned, used for data collection to substantiate use", not yet approved for reimbursement
  - Requires 1 year of use
  - If not moved to Category 1 in 5 years, deleted

CPT code

- Each CPT code is assigned an RVU
  - Technical
  - Professional
    - Physician work
    - Practice expense
    - Malpractice expense
- Adopted by most insurers
- Requirement for reimbursement

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Professional RVUs

- 3 Components
  - Physician work (work RVUs) = 55%-67%
  - Practice expense = 42%
  - Malpractice insurance = 3%

Payment

- "Global Payment" = technical component plus professional component
- Technical component goes to whoever owns the machine (or the deal brokered)
- Professional component goes to entity reading the study
- Technical fee is about 5X Pro-fee

Tech fee vs Profee Varies

CPT	Tech RVU	Profee RVU	%
CXR	0.66	0.3	31
NCCT	4.98	1.17	19
MRIB	26.3	3.24	11
AbdCT	7.22	1.75	19
NM	4.5	1.19	21
ICA	13.3	2.31	15

On average Profee is 15-20% of global

Non-Radiology "Procedures" (Facility fee = Technical fee)

Technical vs Professional RVUs - Non-Radiologist Procedures

2025 CMS Medicare Physician Fee Schedule / OPPS

Procedure	Technical RVU	Professional RVU
TTE Complete w/ Doppler (93306)	5.13	2.36
Stress Echo (93350)	4.41	2.82
Cardiac Catheterization, Left Heart (93458)	18.52	5.83
Colonoscopy, Diagnostic (45378)	9.47	4.68
Colonoscopy w/ Biopsy (45380)	10.12	5.17
EGD w/ Biopsy (43239)	7.84	3.49
Total Knee Arthroplasty (27447)	45.23	29.58
Knee Arthroscopy Meniscectomy (29881)	12.56	6.79
Rotator Cuff Repair, Arthroscopic (29827)	22.18	19.58
EEG, Extended Monitoring (95717)	8.94	2.41

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Geographic Practice Cost Indices

- GPCIs adjust for variability of cost of living across the country, based on a norm of 1.0
  - Work, Practice Expense, and Malpractice GPCIs vary for a CPT code
  - For Work GPCIs
    - Alabama = 1.0, San Francisco = 1.06, LA = 1.04, CT = 1.038, DC = 1.048, N NJ = 1.058 but S NJ = 1.043, Balto = 1.012, Utah = 1.0
  - Malpractice GPCIs
    - Arkansas 0.438, Miami 2.269, Detroit 2.74, Idaho 0.459, Boston 0.823, Balto 0.947

Average Union Longshoreman Salary by State

State	Annual Salary	Hourly Wage
NY	$51.8K	$24.88
TN	$47.8K	$22.97
DE	$44.4K	$21.38
Iowa	$43.1K	$20.71
NM	$40.9K	$19.67
NC	$36.6	$17.60

Geographic Practice Cost Indices

- Colorado:
  - PW: 1.005
  - PE: 1.050
  - MP: 0.797
- Baltimore:
  - PW: 1.024
  - PE: 1.087
  - MP: 1.311

Geographic Practice Cost Indices

Impact of Malpractice Rates/ Premiums

- Colorado:
  - PW: 1.005
  - PE: 1.050
  - MP: 0.797
- Baltimore:
  - PW: 1.024
  - PE: 1.087
  - MP: 1.311

Malpractice Insurance Rates

- $20.7K on average nationally
  - IR > DR
- State by State variability (2005) (median)
  - Higher rates in Florida ($45.5K), Illinois ($32K), Ohio ($30K), New Jersey (30K), WV ($38K)
  - Lowest in NE ($8K), ME (8K), MN ($7.5), SD ($6.8), ID (9K)
- Academic less than PP

State CAPs

- NM: total 600k plus future med exp
- CO: total 1M, 300k non-econ
- IN: total 1.25M
- MA: 500k non-econ
- NE: total 1.75M
- VA: total 1.95M
- CA, ID, KS, TE, MO: 250K non-econ
- OK: 300k non-econ
- MO, NV, HI, AK: 330-400K non-econ

State/Specialty Rate Variation

State	Intern	Surgeons	Ob/GYN
IN	$4,023	$14,574	$19,486
SD	$4,150	$13,853	$18,633
ND	$6,609	$16,238	$24,971
HI	$7,156	$25,756	$42,928
MO	$7,334	$26,775	$40,693
UT	$9,244	$37,299	$45,588
NM	$7,802	$35,915	$35,915
CA	$10,098	$28,693	$48,704
MI	$26,146	$71,713	$88,945
AVG US	$12,355	$36,564	$49,530

http://aspe.hhs.gov/daltcp/reports/mlupd1.htm



5. Occurrence Policy Cost Estimates

Specialty	Location	Year 1	Year 2	Year 3	Year 4	Total
Orthopedic Surgeon	Miami, FL	$80,000	$80,000	$80,000	$80,000	$320,000
Neurosurgeon	Los Angeles, CA	$60,000	$60,000	$60,000	$60,000	$240,000
Plastic Surgeon	Atlanta, GA	$50,000	$50,000	$50,000	$50,000	$200,000
General Surgeon	Pittsburgh, PA	$45,000	$45,000	$45,000	$45,000	$180,000
Anesthesiologist	Chicago, IL	$35,000	$35,000	$35,000	$35,000	$140,000
OB/GYN	Austin, TX	$40,000	$40,000	$40,000	$40,000	$160,000

6. Claims-Made Policy Cost Estimates

Specialty	Location	Year 1	Year 2	Year 3	Year 4	Tail	Total
Orthopedic Surgeon	Miami, FL	$22,000	$44,000	$58,000	$65,000	$130,000	$319,000
Neurosurgeon	Los Angeles, CA	$18,000	$35,000	$48,000	$55,000	$110,000	$266,000
Plastic Surgeon	Atlanta, GA	$17,000	$34,000	$42,000	$45,000	$90,000	$228,000
General Surgeon	Pittsburgh, PA	$15,000	$30,000	$37,000	$40,000	$80,000	$202,000
Anesthesiologist	Chicago, IL	$12,000	$24,000	$30,000	$33,000	$60,000	$160,000
OB/GYN	Austin, TX	$14,000	$28,000	$33,000	$35,000	$70,000	$180,000

Variation in Rates

- Specialty
- Geography
- Years out
- Pain and Suffering limits
- Wrongful death limits
- Deductibles

Mean Professional Liability Premiums per Self-Employed Physician

ANNUAL PREMIUMS (in thousands of dollars)

	1994	1996	1998	2000	2024*
Family Practice	10.2	8.4	10.9	13.8	15.8
Internal Medicine	8.6	8.9	16.5	13.7	16.8
Surgery	22.3	21.7	22.8	23.6	34.0
Pediatrics	7.6	8.3	9.0	11.5	15.2
OB/GYN	37.4	35.2	35.8	39.2	46.0
Radiology	**11.2**	**11.3**	**12.3**	**19.3**	**20.7**
Psychiatry	9.4	5.2	5.4	12.9	10.5

1994-2000: AMA, Socioeconomic Characteristics of Medical Practice 2003

**2024: Industry estimates from Griffith & Harris, Malpractice Insurance Finder, AMA reports*

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Conversion Factor

- CF = multiplier used to convert RVUs to dollars for each CPT code
- Set annually by Congress for Medicare budget

CMS Conversion Factor

- 2026: $33.40
- 2025: $32.35
- 2024: $32.74
- 2023: $33.06
- 2022: $34.61
- 2021: $34.89
- 2020: $36.09

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Assume the a CXR global RVUs are 0.96, what is the equivalent number of CXRs you would have to read to be paid the same as a Family Practice Doctor spending 60 minutes with a patient in a new patient visit?

E & M codes

		New pt	F/u
I	10 min	0.97 RVU	0.57
II	20 min	1.72	1.02
III	30 min	2.56	1.39
IV	**60 min**	**3.62**	2.18
V	75 min	4.60	3.17

- Based in part on H&P, Decision making, counseling vs coordination of care, necessity, time spent

How many CXRs for 60 min E&M

- 3.63 RVUs / 0.96 = 3.8 CXRS
- Caveat?
- CXR TC: 0.66 PC: 0.3
- 3.63 RVUs / 0.3 = 12 CXRS
- Hospital owns Machines

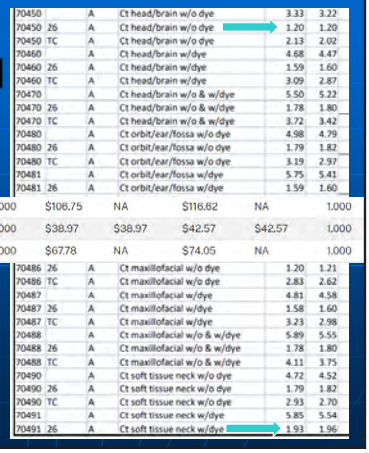
Can I, a PCP, Bill for CXR

- Yes
  - If you own the equipment and interpret the study, Global
  - If you own the equipment but hire the radiologist, the TC
  - If you send it out to be done, but interpret it yourself, the PC
  - If the VC owns the equipment in the office, but you interpret it, the PC
  - It is generally not a violation of Stark Laws for internists to perform and interpret a CXR in their office, as this falls under the "in-office ancillary services exception"

How many NCCT Heads for 60 min E&M

- 3.63 RVUs/ 1.2 RVUs

2022



70450		Ct head/brain w/o dye	0000000	$106.75	NA	$116.62	NA	1.000
70450	26	Ct head/brain w/o dye	0000000	$38.97	$38.97	$42.57	$42.57	1.000
70450	TC	Ct head/brain w/o dye	0000000	$67.78	NA	$74.05	NA	1.000

- 3 NCCTs
- 20 minutes a NCCT
- 2 neck CTs

How many NCCT Heads for 60 min E&M

- 3.63 RVUs/ 0.85 RVUs

2024 RVUs

70450		Ct head/brain w/o dye	A	1	0.85	2.36	
70450	26	Ct head/brain w/o dye	A	1	0.85	0.30	
70450	TC	Ct head/brain w/o dye	A	1	0.00	2.06	

- 4.2 NCCTs
- 13 minutes a NCCT
- 3 neck CTs

Orthopedic Surgeon

- Total Hip (CPT code 27130)
  - RVU = 19.6 wRVU, CMS look-up $1388
    - MPRVU 3.99
- Knee arthroscopy (CPT 29870)
  - RVU = 5.19, CMS $568.94
- Treatment of a fractured wrist (CPT code 25622)
  - RVU 2.79, CMS $378.79

Orthopedic Surgeon

- Total hip 19.6 wRVU and Knee arthroscopy RVU = 5.19, CMS $568.94 = 24.79 RVU day
- PCP: 60 minute new patient 3.82 RVUs
- 24.79/3.82 = 6.5 new patients X 60 minutes each
- Three THR = 15.4 hours of seeing new patients

How much do you get paid? (Provide the equation)

GI endoscopist
(non-facility limiting charge)
ERCP = $701
Upper GI endoscopy: $368
Colonoscopy: $455

Answer

- GPCI X RVU X CF X % profee X % work component
- CF for 2006 set by Congress: 2024 = $32.74
- For Colonoscopy in Baltimore = 1.024 GPCI X 4.89 RVU X $32.74 = $107.28 x 0.65 (PW) = $106.56
- NON-CMS!!!!!: Contract at X times CMS

I want to bill $1M

- How many colonoscopies per day do I have to do to bill $1M
- $1M/$455 = 2197 colonoscopies in a year
- 40 weeks of work at 4.5d/week = 180 days of work
- 2197 colonoscopies / 180 work days = 12.2 colonoscopies per day = $5557 per day
- But 2/3 of my practice is not CMS and non-CMS pays 2X Medicare
- (4 x $455) + (8 X $910) = $9100/ day: $9100 X 180 = $1.6M or I can do 3 CMS and 6 Non-CMS = $1.23M

Most Common CPT Codes Billed

- **Office visits** for established patients
  - 99213: 1.3 wRVU (20-29 min)
  - 99214: 1.92 wRVU (30-39 min)
- **Physical therapy** (97110): 0.45 wRVU 97530: 0.44 wRVU
- **Routine blood draws** (36415): 0 wRVU (bundled into lab charge) (85004) CBC 0 wRVUs with DX code

ICD Codes are:

1. Codes used to determine what procedure the patient had
2. Codes used to describe who read a case
3. Codes used to match diagnoses to CPT codes
4. Codes used to match charges to CPT codes

ICD

- The **International Statistical Classification of Diseases and Related Health Problems** (most commonly known by the abbreviation **ICD**) provides codes to classify diseases and a wide variety of signs, symptoms, abnormal findings, complaints, social circumstances and external causes of injury or disease. Every health condition can be assigned to a unique category and given a code, up to six characters long. Such categories can include a set of similar diseases.

ICD codes

- International Classifications of Diseases (10th revision) Clinical Modification = ICD-10-CM
- ICD codes must be appropriate for the CPT code or no reimbursement
- Cannot legally restrict ICD codes to CPT codes to insure payment
- Change annually with CPT code book
- A physician responsibility

Examples of ICD-10 codes

- 389.05 Conductive hearing loss, unilateral
- 389.06 Conductive hearing loss, bilateral
- 389.13 Neural hearing loss, unilateral
- 389.17 Sensory hearing loss, unilateral
- 389.20 Mixed hearing loss, unspecified
- 389.21 Mixed hearing loss, unilateral
- 389.22 Mixed hearing loss, bilateral

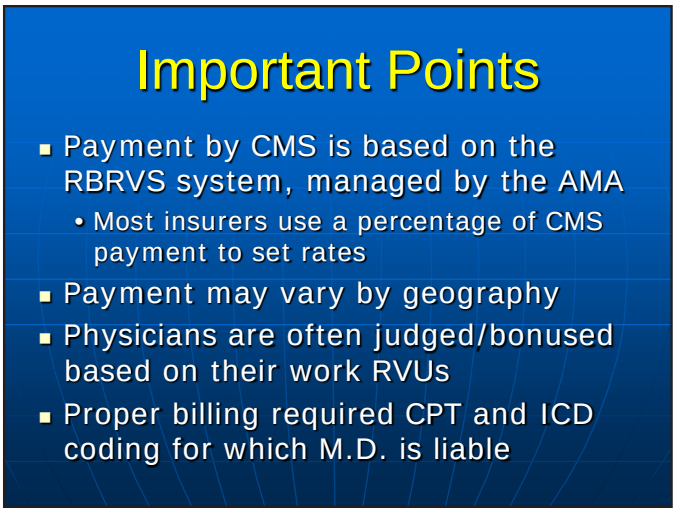
Most Common Errors in Coding

Coding errors and their consequences

- **Unbundling and upcoding:**
  - **Unbundling:** Billing for individual components of a service that should be reported as a single, bundled code.
  - **Upcoding:** Billing for a service that is more complex or higher-level than what was actually performed.
  - **Consequences:** Both can lead to claim denials or audits.
- **Mismatched CPT and diagnosis codes:**
  - Failing to link a CPT code to a diagnosis code that justifies the medical necessity of the service.
  - **Consequences:** Claim denials, as the payer may not see the service as justified.
- **Incorrect use of modifiers:**
  - Failing to apply the correct modifier, using the wrong one, or not understanding what a modifier is meant to clarify.
  - **Consequences:** Denials, rejections, and increased scrutiny from payers.

Most Common Errors in Coding

- **Inaccurate time-based coding:**
  - Billed-based-on-time services, such as psychotherapy, are coded with incorrect durations.
  - **Consequences:** Inaccurate billing and potential penalties.
- **Lack of specificity:**
  - Failing to code with enough detail for either the procedure (CPT) or diagnosis (ICD-10).
  - **Consequences:** Denials and potential revenue loss.


Important Points
Payment by CMS is based on the RBRVS system, managed by the AMA
Most insurers use a percentage of CMS payment to set rates
Payment may vary by geography
Physicians are often judged/bonused based on their work RVUs
Proper billing required CPT and ICD coding for which M.D. is liable

SELF EVALUATION

Understanding the RBRVS System: How Physicians Are Valued and Paid

1. Who decides on the RVU value of a given procedure?

a. CMS
b. Congress
c. AMA
d. ACR

2. What is the geographic practice cost index?

a. The cost of living adjustment by state
b. The way the CMS adjusts payments by locale
c. The combination of malpractice and labor costs in a state
d. The method of determining RVU values based on risk

3. In radiology, on average, the technical fees are…..

a. Equal to the professional fees
b. Are lower than the professional fees
c. Are substantially higher than the professional fees
d. Are marginally higher than the professional fees

4. The ultimate responsibility for the accuracy of the ICD and CPT coding resides with the:

a. Billings and Collections Department
b. Legal
c. The practice
d. The provider of the service
e. All of the above

5. What is the conversion factor?

a. A factor submitted by the AMA to convert CPT codes to RVUs
b. A factor determined by CMS to convert the technical and professional RVUs to Global RVUS
c. A value set by Congress that converts RVUs to dollars
d. A value set to convert time spent with patients in the office to RVUs

Answer Key: 1. C, 2. B, 3. C, 4. D, 5. C

Facial Trauma Imaging: Fracture Patterns, Complications, and High-Risk Findings
David M. Yousem, MD, MBA

Facial Trauma Imaging: Fracture Patterns, Complications, and High-Risk Findings

David M. Yousem, MD, MBA
Johns Hopkins University School of Medicine

Kudos to colleagues who contributed to this talk:
Doris Lin, Mike Kraut, Bidyut Pramanik

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- Consulting (medicolegal)
- MRIOnline.com/Medality/TrueLearn: consultant fees, speakers' fees, board member, stockowner

Clinical Scenario: Facial/ Neck trauma

- Facial fractures
- MVC, falls, altercation
- Soft tissue neck pain, r/o dissection
- Seatbelt sign

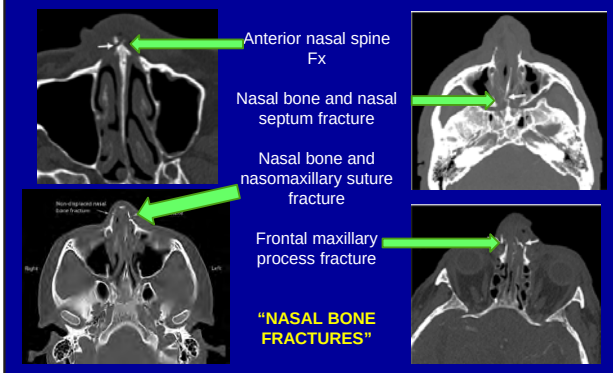
Most Common Facial Fractures

- Nasal Bones
- Orbital walls *
- Mandible #

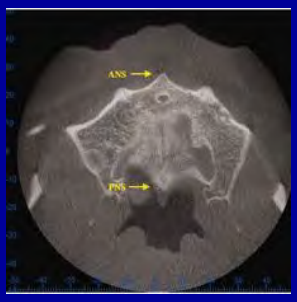
- * Personal experience (Done!)
- # Literature

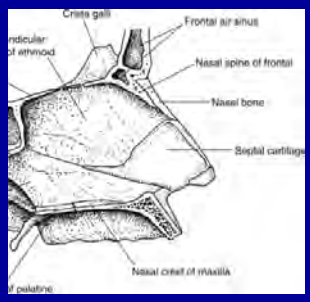
Nasal bone anatomy
Dreizin Radiographics 2018





Anatomy of "Nasal Spines"



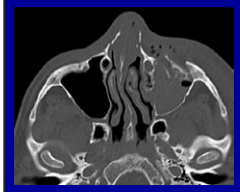


Anterior maxillary spine = anterior nasal spine

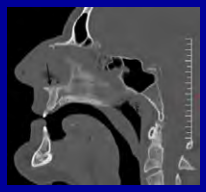
Important Pearl

- Nasal septum fractures are important to note since the septum maintains integrity of the midline
  - Deformity may be cosmetic but airway compromise is more functional
- Cartilage fractures more readily than bone, but are less obvious
- Necrosis can cause saddle nose deformity
  - Beware hematomas

Orbital rim, orbital floor, nasal bone. nasomaxillary suture, anterior nasal (maxillary) spine, nasolacrimal duct, medial max wall



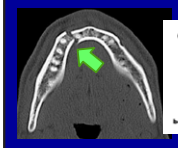


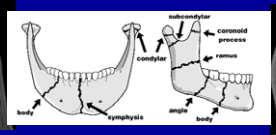


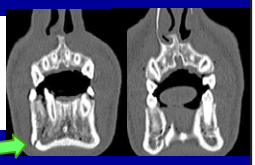
Mandibular Fractures

Condyle	31%
Body	21%
Symphysis	14%
Angle	10%
Ramus	3%
Alveolar Ridge	3%
Coronoid Process	2%

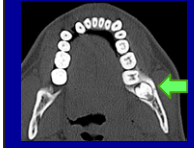
- **Complications:**
  - **Tooth Loss**
  - **Mal-union or non-union**
  - Avascular necrosis condyle
  - **Displacement/deformity**
  - **TMJ derangement/ankylosis**
  - **Malocclusion**
  - **Infection**







Mandibular Ring





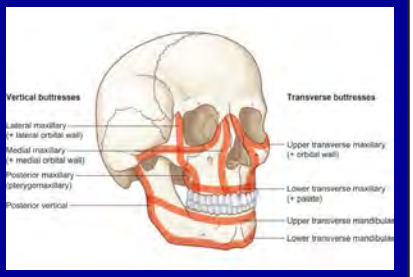


Consider:
Airway compromise (symphyseal)
Tooth dislocation/fracture
Mandibular nerve canal



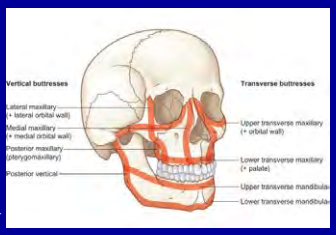
Midface Buttresses

- 2 transverse buttresses
  1. Squamosal temporal bone to nasofrontal jn across zygomatic arch and inferior orbital rim
  2. Maxilla to hard palate



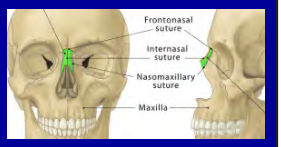
Midface Buttresses

- 2 vertical buttresses
  1. Posterior maxillary molars to zygomaticmaxillary suture and body of zygoma, lateral orbital rim, zygomaticofrontal suture, lat wall max sinus
  2. Anterior nasal spine to maxilla to nasofrontal junction to frontal bone, medial orbital wall



Naso-orbito-ethmoid (NOE) Fxs

- Usually involve the nasolacrimal duct, frontonasal duct, frontal sinus– a central fragment
  - Cardinal tracts / fracture lines
    - 1) Lateral nose and piriform aperture, 2) nasomaxillary buttress, 3) inferior orbital rim and floor, 4) medial orbital wall and 5) frontomaxillary suture
- 3D views are helpful for identification

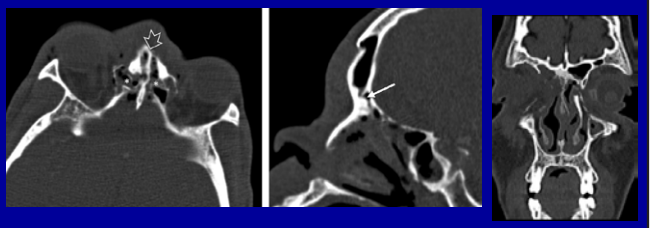


- Treatment is to preserve normal sinus and lacrimal flow

Naso-orbito-ethmoid (NOE) Fxs

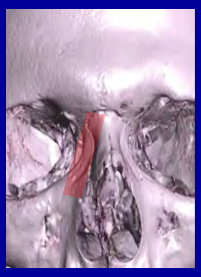
- Medial maxillary buttress, medial orbital wall and floor
- Need to support medial canthus
  - I: large fracture piece, easy repair
  - II: Comminuted, canthus attaches to a bone fragment
  - III: Canthus avulsion from anterior medial orbital wall at the level of the lacrimal fossa bone

NOE Fracture Radiographics 2018, Radiopaedia



Markowitz-Manson Classification of NOE

- Grade I: Single Fragment
  - Medial canthal tendon ok
- Grade II: Comminuted Fragment
  - MCT attached to a fragment
- Grade III: Severe comminution
  - medial canthal tendon avulsion, or with tendon inserted onto small fracture fragment that can't be fixated by plate/screw hardware



RadFYI by Logan Young
Markowitz and Manson Classification

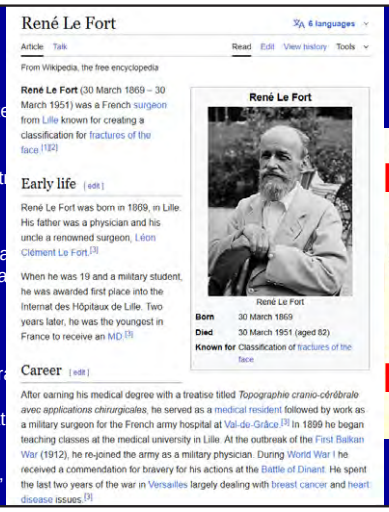


Left: *Type I*, Intact medial canthal tendon connected to single large fracture fragment; **Center:** *Type II*, Intact medial canthal tendon connected to single comminuted fracture fragment; **Right:** *Type III*, Disrupted medial canthal tendon with severe comminution about the lacrimal fossa

Report on NOE

- Degree of comminution of vertical max buttress at lacrimal fossa
- Distance between medial canthi
- Frontal recess integrity
  - Late mucocele development
  - May need to be obliterated to avoid mucoceles

- I: Hard palate separation involving maxillary antr
- II: Defect through antra inferior orbita rims, nasion
- III: Defect through later orbital walls and zygomat arches "craniofacial dissociation"



René Le Fort

6 languages

Article Talk | Read Edit View history Tools

From Wikipedia, the free encyclopedia

René Le Fort (30 March 1869 – 30 March 1951) was a French surgeon from Lille known for creating a classification for fractures of the face.[1][2]

René Le Fort

René Le Fort

Born 30 March 1869

Died 30 March 1951 (aged 82)

Known for Classification of fractures of the face

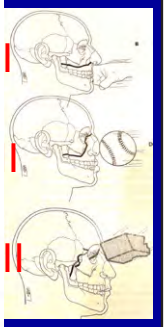
Early life [edit]

René Le Fort was born in 1869, in Lille. His father was a physician and his uncle a renowned surgeon, Léon Clément Le Fort.[3]

When he was 19 and a military student, he was awarded first place into the Internat des Hôpitaux de Lille. Two years later, he was the youngest in France to receive an MD.[3]

Career [edit]

After earning his medical degree with a treatise titled *Topographie cranio-cérébrale avec applications chirurgicales*, he served as a medical resident followed by work as a military surgeon for the French army hospital at Val-de-Grâce.[3] In 1899 he began teaching classes at the medical university in Lille. At the outbreak of the First Balkan War (1912), he re-joined the army as a military physician. During World War I he received a commendation for bravery for his actions at the Battle of Dinant. He spent the last two years of the war in Versailles largely dealing with breast cancer and heart disease issues.[3]

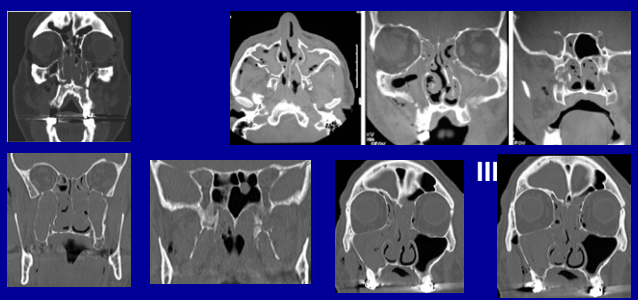


Le Fort (Mid-Face) Fracture Pearls

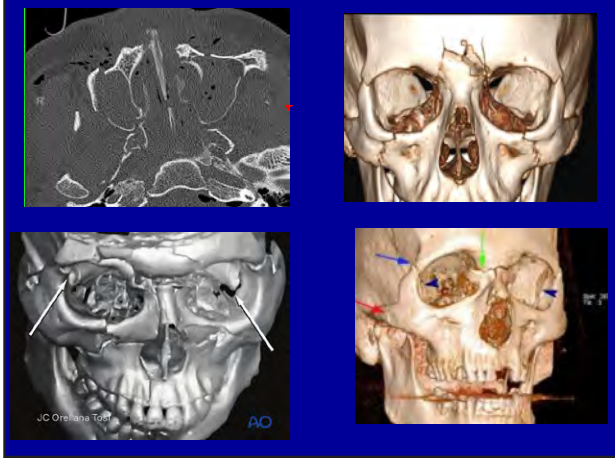
- Describe fractures, not Le Forts but know where to look
- Le Fort I—issue is malocclusion
  - Impacted and incomplete fractures are at risk
  - Comminution makes easier mobilization but harder fixation with bars
- Le Fort II, III—beware ZMC, NOE issues
  - Palate fractures may coexist– airway compromise

Le Fort Fractures

I II III

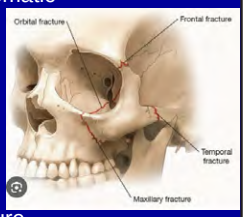


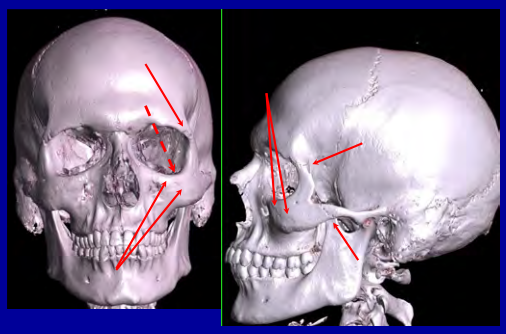
Le Fort Fractures



Zygomaticomaxillary Complex (Tripod) Fracture (diastatic sutural fractures)

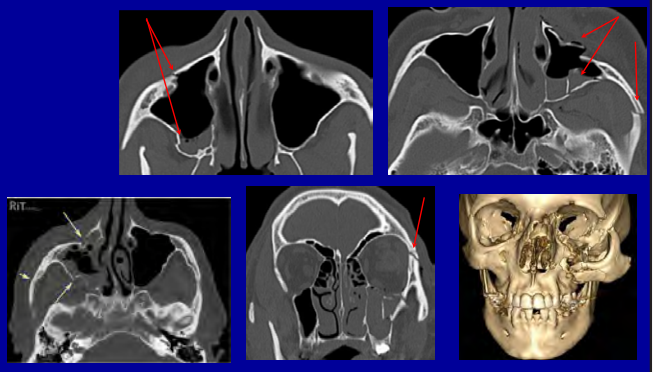
- Typically fractures through all four zygomatic articulations
  - Zygomaticomaxillary
  - Zygomaticofrontal
  - Zygomaticotemporal arch
  - Zygomaticosphenoidal
- Can be associated with LeFort III
- Less common is isolated zygoma fracture
- Important for cosmesis

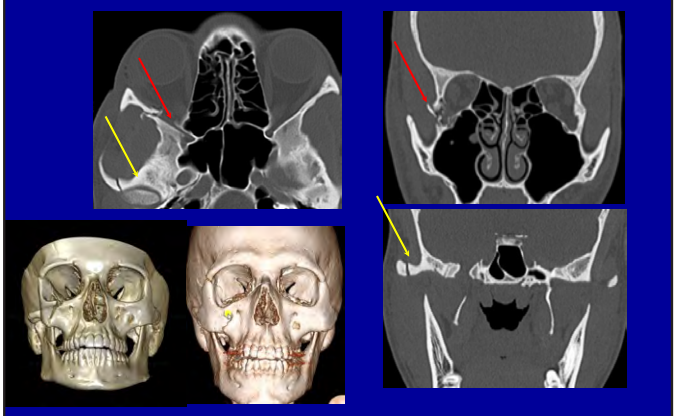




ZMC Pearls

- Depressed zygomatic arch fractures interfere with mandible coronoid
- Beware orbital floor and rim concomitant fractures with rotation
- Facial asymmetry and enophthalmos are complications

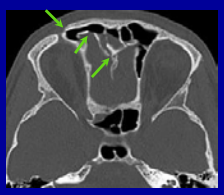




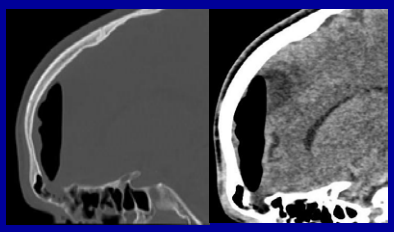
Capo de Tutti Fractures Don't miss these!

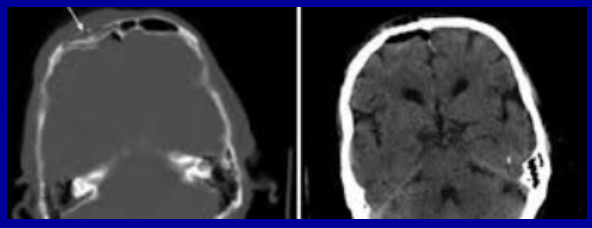
- Fractures that lead to CSF leaks
  - Ethmoid, temporal bone, sphenoid
- Fractures that lead to pseudoaneurysms
  - Sphenoid sinus, petrous temporal bone, lesser wing sphenoid
- Fractures that disrupt the venous sinuses
  - Temporal bone/Occipital bone – transverse sinus
  - Parasagittal – SSS
- Temporal bone fractures in general

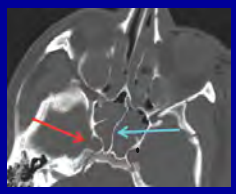
CSF ? Air leak

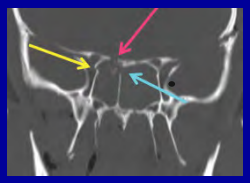


- Complications:
  - Meningitis
  - Meningoencephalocele
  - Arterial/venous thrombosis injury

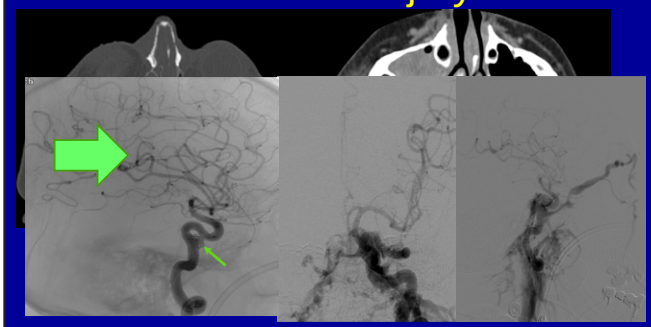








Vascular Injury

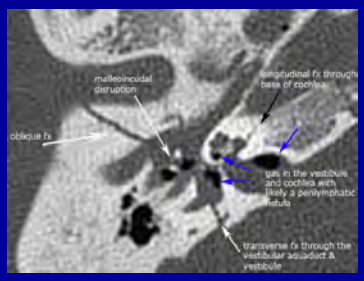


Temporal Bone Fractures

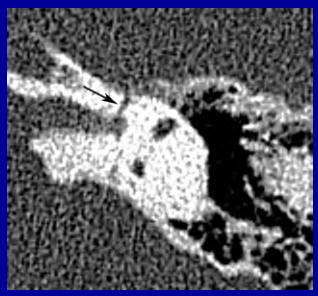
- Longitudinal 20% (along axis), transverse 50% rate of facial nerve injury
- Oblique, longitudinal are 80%
  - Higher rate of ossicular anomalies
- Transverse higher rate of SNHL

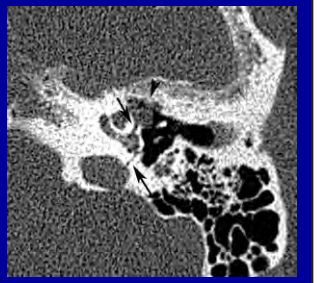
New classification

- Otic capsule violating/involving versus otic capsule sparing fractures
  - Violating has higher SNHL, facial n injury, CSF leak
  - Sparing has higher CHL and ossicle injuries



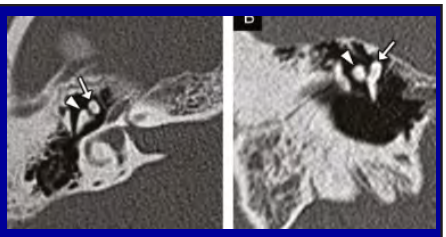
Temporal Bone Fractures





Ossicular Dislocation

Incudostapedial most common incudomalleolar next INCUS Fx and dislocation most common



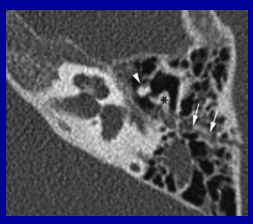


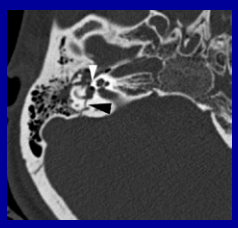


Temporal Bone Fractures

Complications:
- Vascular injury
- Ossicular disruption
- Facial weakness
- Sensorineural hearing loss
- Intracranial injury

- Cholesteatoma
- CSF leak
- Meningoencephalocele
- Perilymphatic fistula

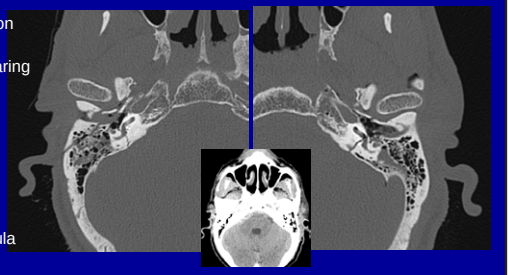


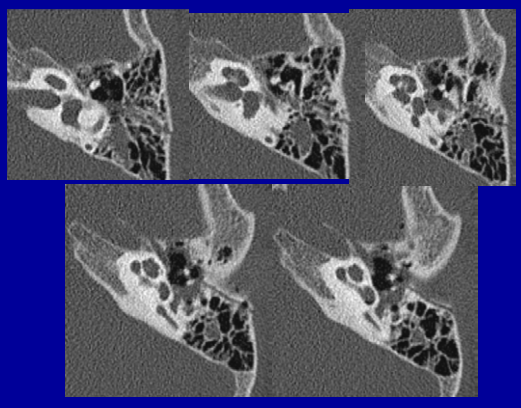


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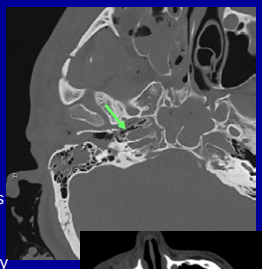


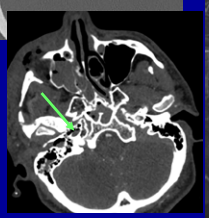


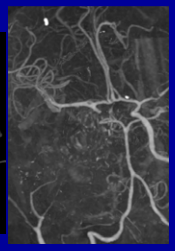
Temporal Bone Fractures

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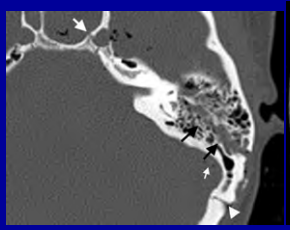


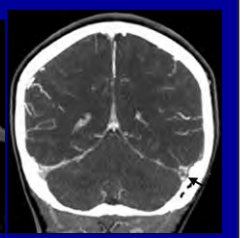


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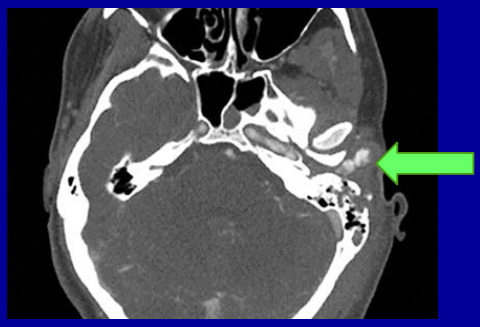
- Cholesteatoma
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- Meningo-encephalocele
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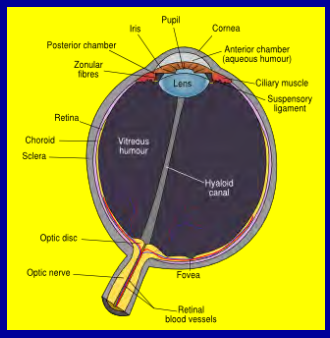
Complications:
Vascular injury
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Facial weakness
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CSF leak
Meningo-encephalocele
Perilymphatic fistula



Anatomic Considerations

- Ocular anatomy
  - Anterior Segment
    - Anterior Chamber
    - Posterior chamber
    - Cornea
    - Iris*
    - Ciliary Body
    - Lens
  - Vitreous
  - Membranes
    - Sclera, Choroid*, Retina



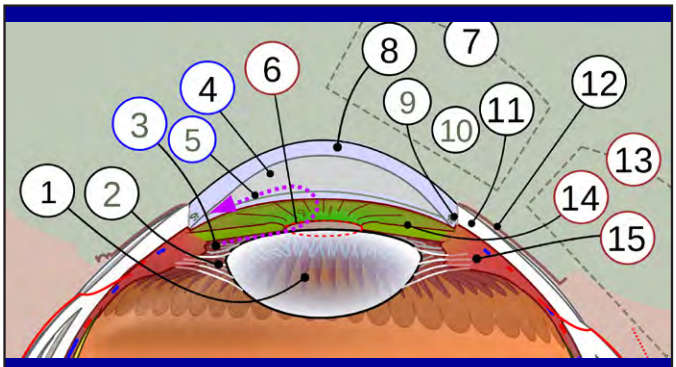


Diagram of **anterior segment** of a human eye (horizontal section of the right eye) 1. Lens, 2. Zonule of Zinn or ciliary zonule, 3. Posterior chamber and 4. Anterior chamber with 5. Aqueous humour flow; 6. Pupil, 7. Corneosclera with 8. Cornea, 9. Trabecular meshwork and Schlemm's canal, 10. Corneal limbus and 11. Sclera; 12. Conjunctiva, 13. Uvea with 14. Iris, 15. Ciliary body.

Anatomic Considerations

- Anterior segment
  - Superficial injury
  - Anterior chamber
    - Rupture
    - Hyphema
    - Cataract
    - Keratitis
    - Periorbital cellulitis

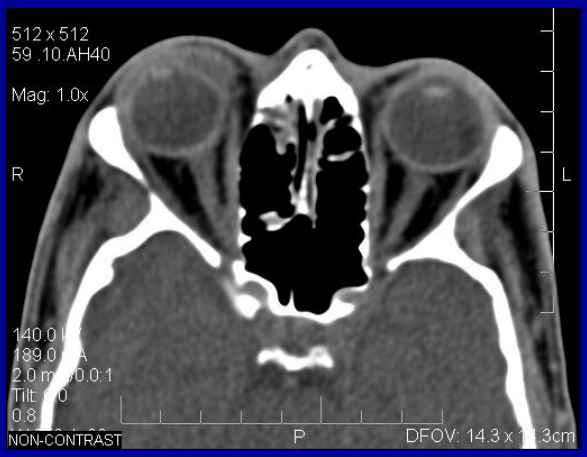
Corneal Injury



Thin sections



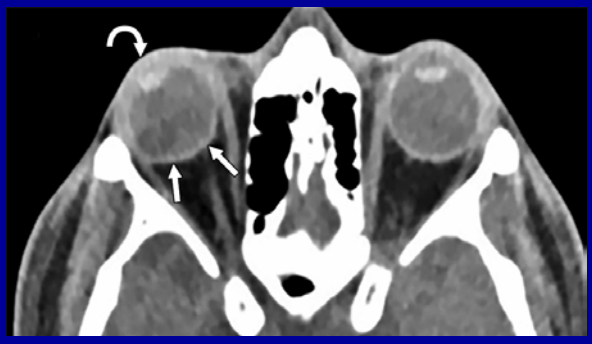
Thick Sections



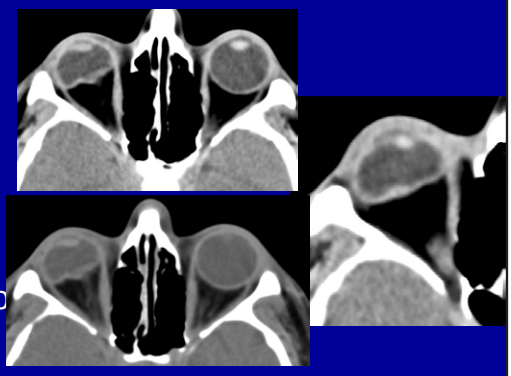
Blood locations:

- Anterior chamber: anterior hyphema
- Posterior chamber: posterior hyphema
- Vitreous: vitreous hemorrhage
- Choroidal detachment
- Retinal detachment

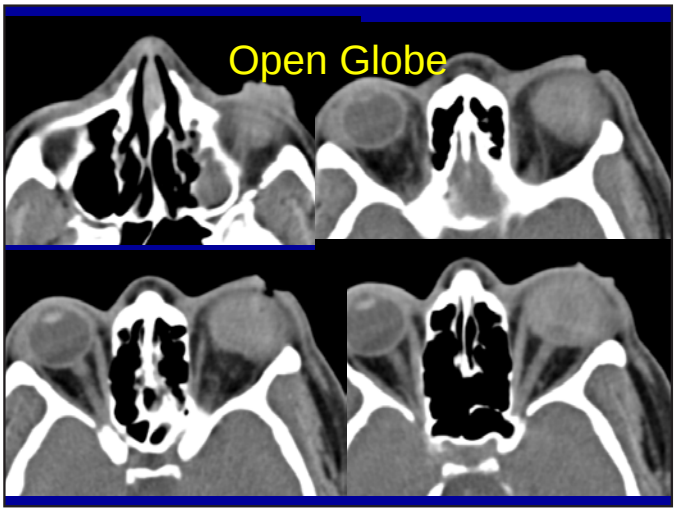
Anterior Chamber Rupture

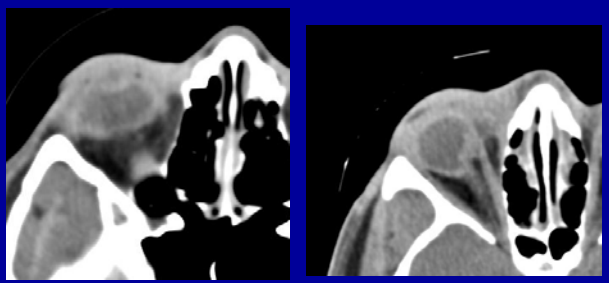


- Globe rupture includes AC and Vitreous
- Blood too



Open Globe





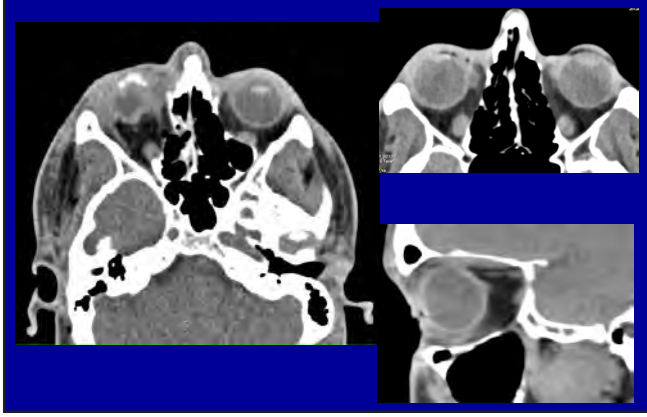
Open Globes are Acutely Repaired

Due to Risk of Endophthalmitis: Blindness

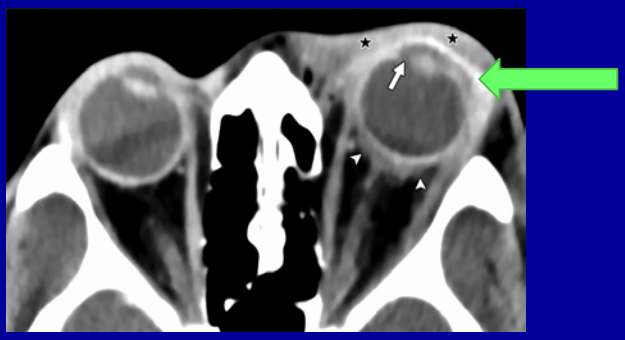
Wood FB, Anterior Hyphema



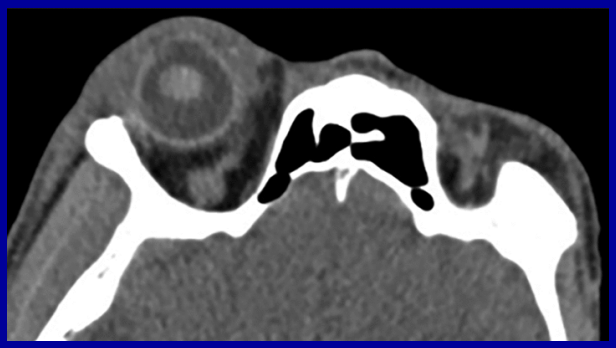
Foreign Bodies: Acute Rx

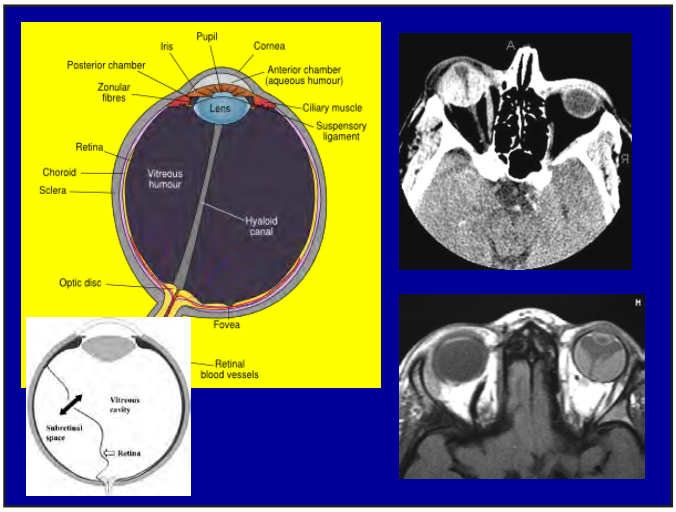


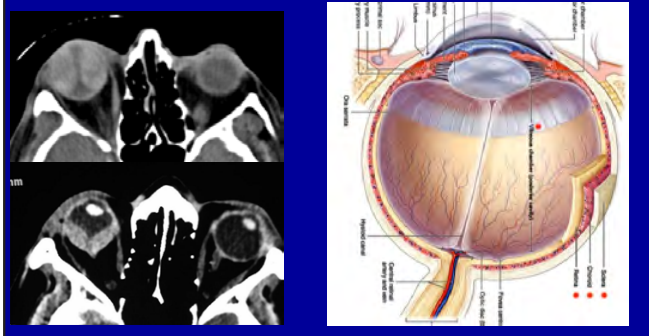
Lens Subluxation, Anterior Chamber Rupture Laterally



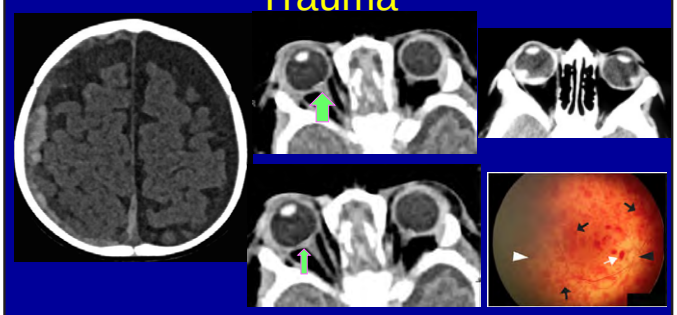
Posterior Lens Dislocation







Non-Accidental Trauma



Early Ocular Intervention

- Open globe
- Foreign bodies
- Corneal abrasions
- Hyphema
- Globe lacerations
- Detachments
  - Scleral buckling / vitrectomy
    - Suck vitreous, treat retina, reinflate oil/gas/saline

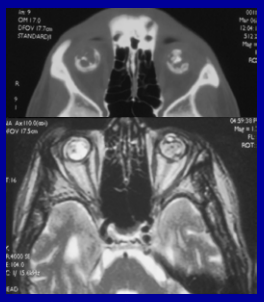
Complications

- Phthisis bulbi
- Endophthalmitis in 10% of open globes
  - Staph, Bacillus, Strep
  - Antibiotics mandatory
- Glaucoma
- Staphyloma

Phthisis Bulbi: End Result

- A small shrunken calcified globe usually secondary to trauma or inflammation



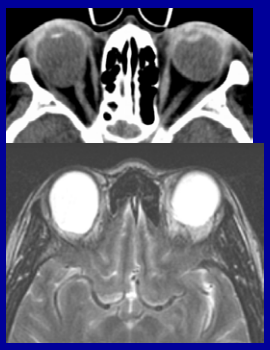


c/o Bidyut Pramanik

Staphyloma

- Acquired defects in the sclera or cornea
- Posterior staphyloma is associated with increasing globe size
- Usually on the temporal side of optic nerve
- Outward bulging with uveoscleral thinning
- Anterior staphyloma is seen with RA

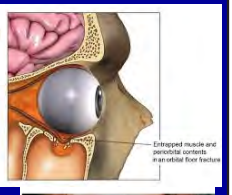
c/o Bidyut Pramanik



Non-Ocular Orbital Trauma

- Fractures
- Entrapment
- Hematoma



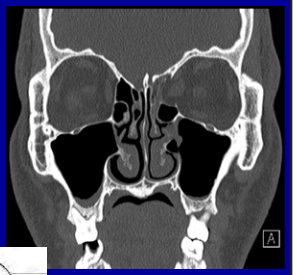


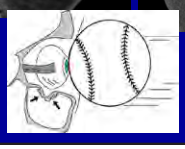




Orbital Blow Out Fractures





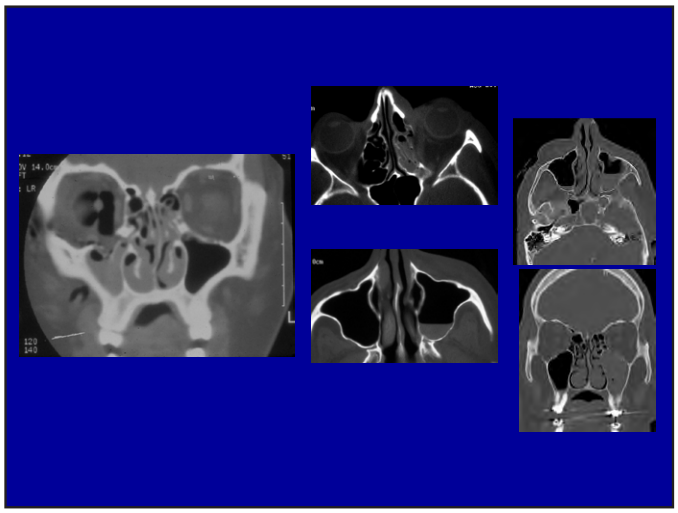


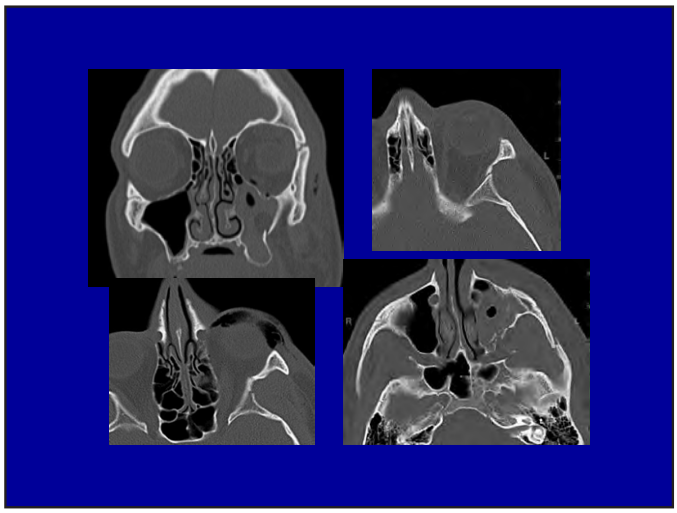
Orbit Fracture

- Orbital floor
  - Assess IR for shape and position to assess fascial sling of globe
    - If round and inferior then fat and periorbita and muscle herniate
    - In children trap door Fx entrapment needs urgent correction
- Medial Orbit
  - High rate of diplopia, enophthalmos from MR injury

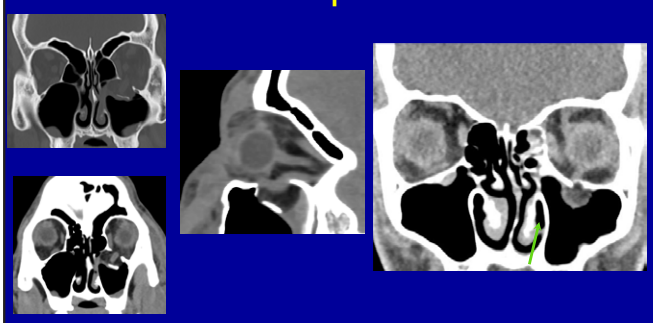
Orbital Fracture Pearls

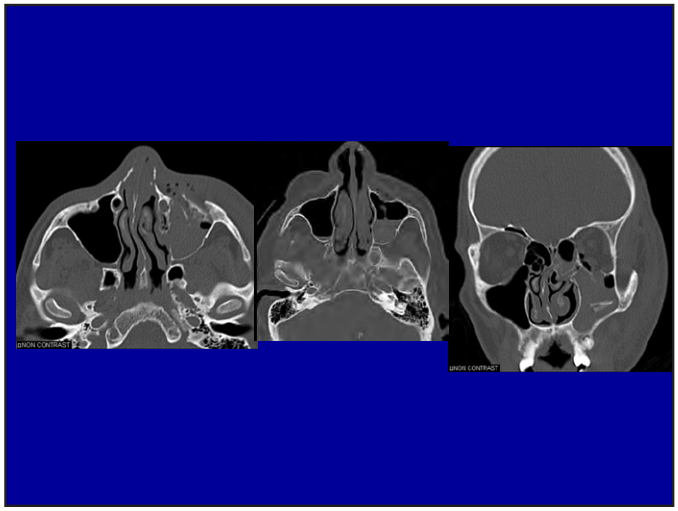
- "Impure fractures" involve orbital rim, need realignment
  - Residents rarely call rim fractures, only orbital floor
- If lateral wall is involved, think tripod and look elsewhere
- Roof fractures have lots of intracranial complications
  - Frequently displaced intracranially
- Coronal recons from thin section images are key!
- Beware retrobulbar hematoma and orbital apex encroachment





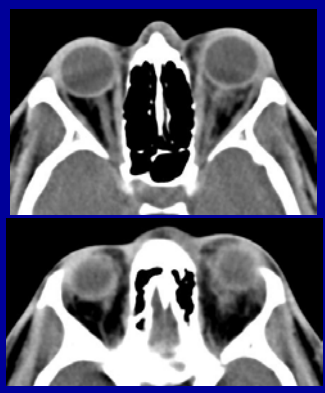
Entrapment





More on Orbital Fractures

- Orbital Apex Fracture
  - Surgical if optic nerve is in jeopardy
  - Hematoma or bone fragment
- Orbital Roof Fracture
  - Frequent dural tears and exophthalmos needing repair
- OVERALL
  - Comment on high-risk CT features for noticeable (>2–3 mm) late enophthalmos: defect size more than 25%–50% of the orbital floor; internal orbital buttress collapse; and soft-tissue herniation greater than 1.5 mL
  - CT findings of entrapment are often false-positive findings in adults
  - Comment on implant positioning at postoperative CT; implant angulation can cause enophthalmos and incarceration

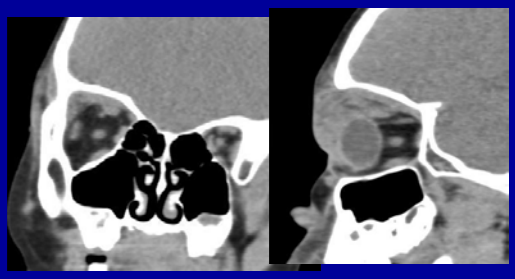


Retrobulbar Hematoma

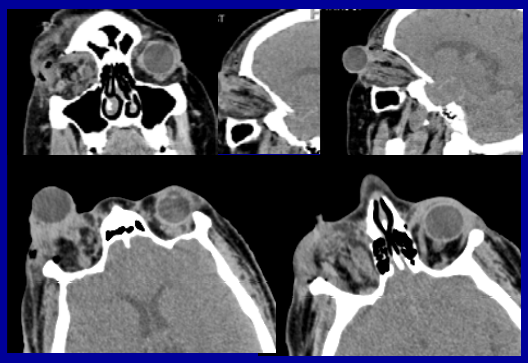
-Danger is that acute intraorbital pressure may result in retinal artery occlusion, optic nerve ischemia

-Lateral canthotomy decompression

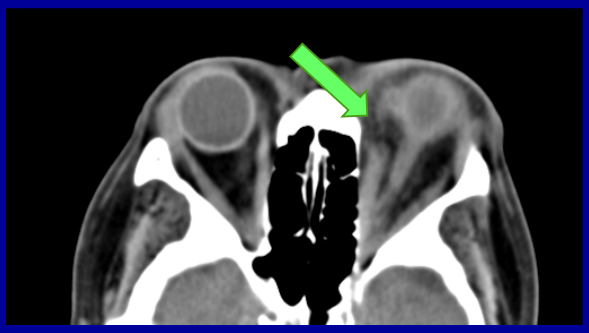
Extraconal Hematoma



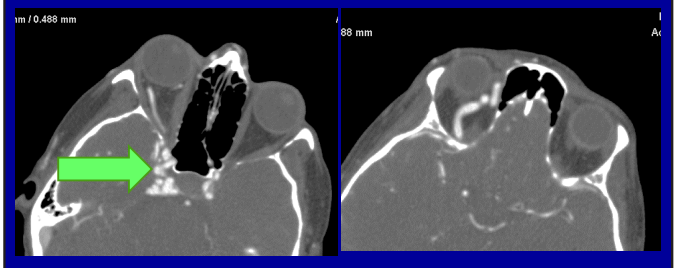
Hematomas



Muscle Avulsion



Post-traumatic CC Fistula



Indications for Surgery for Orbital Fractures

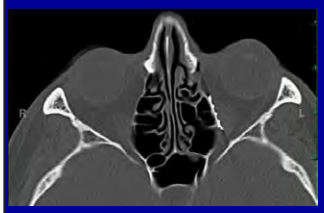
- Enophthalmos > 2 mm (> 50% of floor)
- Hypoglobus (downward displaced globe)
- Diplopia
  - Edema, heme, n. palsy, direct trauma
- Increase in orbital volume > 1 cc
  - Correlates with enophthalmos
- Limited mobility (entrapment of EOM)
- Compressive optic neuropathy

Kontio R, Lindquist C. OMFC 2009: 21: 209-220

Controversies in Surgery

- When to repair orbital fractures
  - Rarely considered emergent
  - ? Adhesions when delayed
  - ? Benefit of decreased swelling
  - Some say 14-21 days
    - Unless optic neuropathy
  - Oculocardiac reflex: vagus
  - Children get operated earlier d/t increased entrapment
  - Early surgery for penetration

Kontio R, Lindquist C. OMFC 2009: 21: 209-220





Implant malpositioning at postoperative CT / implant angulation can cause enophthalmos and incarceration

Summary

- Patterns of facial fractures are often stereotypical, be descriptive
- Multiplanar reconstructions are critical
- Complications abound that include risks to optic nerve, blood vessels, CSF leaks, +/- brain

SELF EVALUATION

Facial Trauma Imaging: Fracture Patterns, Complications, and High-Risk Findings

1. Which of the following is not a common facial bone to be fractured?

a. Nasal bone
b. Mandible
c. Orbital wall
d. Frontal sinus
e. None of the above

2. The fracture most commonly associated with carotid dissection in facial trauma is:

a. Sphenoid sinus
b. Styloid process
c. Cervical spine
d. Nasal bone
e. None of the above

3. Tripod fractures are also known as:

a. Zygomaticomaxillary complex fractures
b. Orbital wall fractures of the medial, inferior and superior wall
c. Ring fractures of the mandible
d. Nasal spine fractures

4. The new classification of temporal bone fractures emphasizes:

a. Ossicular disruption
b. CSF leakage
c. Vascular injury
d. Cochlea and vestibule and semicircular canal involvement
e. All of the above

5. Which of the following is not an anterior segment injury to the globe?

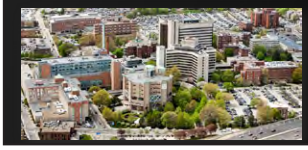
a. Lens dislocation
b. Hyphema
c. Retinal detachment
d. Corneal laceration
e. None of the above

Answer Key: 1. D, 2. A, 3. A, 4. D, 5. C

Importance of Patient Preparation for PET/CT
Don C. Yoo, MD, FACR

Importance of Patient Preparation for PET/CT (Oncology and Cardiac Sarcoidosis)

Don C. Yoo, MD, FACR
Professor of Diagnostic Imaging, Clinician Educator
Director of Nuclear Medicine, Rhode Island and The Miriam Hospitals
Director of Medical Student Radiology Education



BROWNHealth UNIVERSITY
BROWN Alpert Medical School

Disclosures

Consultant – Invicro (Perceptive)

Objectives

1. Discuss the challenges in patient preparation for FDG PET/CT for oncology and cardiac sarcoidosis

2. Review recommendations from ACR, SNMMI, NCI on patient preparation prior to PET/CT

3. Discuss the issues in performing PET/CT scans on diabetic patients and learn ways to optimize the glucose level

Guidelines for Patient Preparation Oncology

ACR

ACR-SPR practice guideline for performing FDG-PET/CT in oncology. American College of Radiology Web site. http://wwwacrorg/~/media/ACR/Documents/PGTS/guidelines/FDG_PET_CTpdfPublished 2009 Updated 2012 Updated 2016 Updated 2021

SNMMI

Procedure guideline for tumor imaging with 18F-FDG PET/CT 1.0. Journal of nuclear medicine : official publication, Society of Nuclear Medicine.

Delbeke D, Coleman RE, Guiberteau MJ, Brown ML, Royal HD, Siegel BA, et al. Journal of nuclear medicine : Society of Nuclear Medicine. 2006;47(5):885-95.

Guidelines for Patient Preparation Oncology

NCI – Consensus recommendations

Consensus recommendations for the use of 18F-FDG PET as an indicator of therapeutic response in patients in National Cancer Institute Trials.

Shankar LK, Hoffman JM, Bacharach S, Graham MM, Karp J, Lammertsma AA, et al. Journal of nuclear medicine : Society of Nuclear Medicine. 2006;47(6):1059-66.

18F-FDG PET and PET/CT patient preparation: a review of the literature. J Nucl Med Technol. 2014 Mar;42(1):5-13. Surasi DS, Bhambhvani P, Baldwin JA, Almodovar SE, O'Malley JP.

Guidelines for Patient Preparation Cardiac Sarcoidosis

HRS expert consensus statement on the diagnosis and management of arrhythmias associated with cardiac sarcoidosis.

Birnie DH, Sauer WH, Bogun F, Cooper JM, Culver DA, Duvernoy CS, Judson MA, Kron J, Mehta D, Cosedis Nielsen J, Patel AR, Ohe T, Raatikainen P, Soejima K.

Heart Rhythm. 2014 Jul;11(7):1305-23. doi: 10.1016/j.hrthm.2014.03.043.

Patient Preparation Prior to F18-FDG PET/CT

- Fasting
- Low Carbohydrate meal
- Limiting Exercise
- Hydration
- Oral Contrast
- Sedation
- Diabetic Patients

How long do you recommend fasting prior to oncologic F18-FDG PET/CT?

A) Recommend minimum of 4 hours
B) Recommend minimum of 4-6 hours
C) Recommend minimum of 6 hours
D) Recommend minimum of 7 hours or more

Fasting prior to administration of 18F-FDG Oncologic PET/CT

ACR - "Fasting instruction (a minimum of 4 hours) with no parenteral nutrition or oral/intravenous fluids containing sugar or dextrose for the same period. No candy, mints, gum, or over-the-counter medicines containing sugar. Even "sugar-free" items may contain traces of sugar"

SNMMI - "Patients should be instructed to fast and not consume beverages, except for water, for at least 4–6 h"

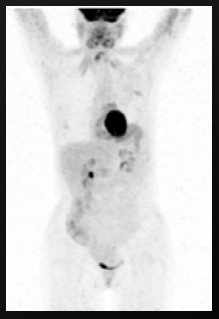
NCI – "Patients should fast for a minimum of 4 h…"



Pre-treatment

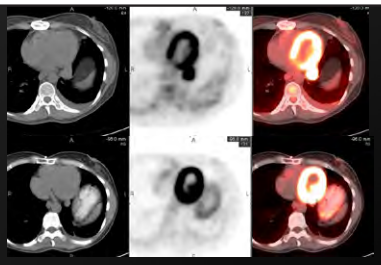


Pre-treatment



6 Month FU

Pre-treatment

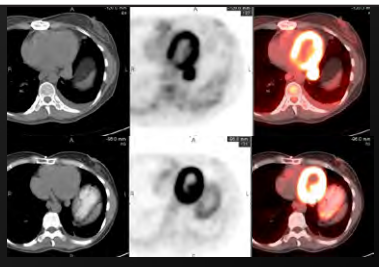


6 Month FU

Best Interpretation

a. No evidence of residual FDG-avid active malignancy.
b. Evidence of residual active FDG-avid malignancy.
c. Non-diagnostic.

Pre-treatment

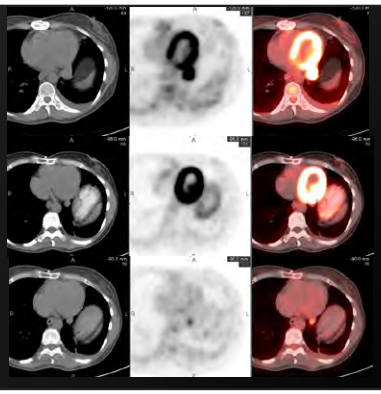


6 Month FU

Best Interpretation

a. No evidence of residual FDG-avid active malignancy.
b. Evidence of residual active FDG-avid malignancy.
c. Non-diagnostic.

Pre-treatment



6 Month FU

4 Days later

Cardiac Sarcoidosis
Importance of Patient Preparation for PET/CT

Dietary prep for FDG sarcoid study
Fast for at least 12 hours

What to eat 1-2 days before study

Eggs, cheese (natural), bacon, chicken or meat (not breaded)

Drink water or tea (no sugar or milk)

Dietary prep for FDG sarcoid study
Fast for at least 12 hours

What to eat 1-2 days before study

Eggs, cheese (natural), bacon, chicken or meat (not breaded)

Drink water or tea (no sugar or milk)

What not to eat

Sugar, Splenda, or Truvia

Fruit or fruit juices, no jelly or jam

Pastas, potatoes, rice, or grains

Breads, cookies, crackers, or cereals

Candy, gum, mints or cough drops

Peanut butter or nuts

Processed meats, sausages or cheese

Ice cream

Starchy vegetables such as corn, peas, carrots, and beans

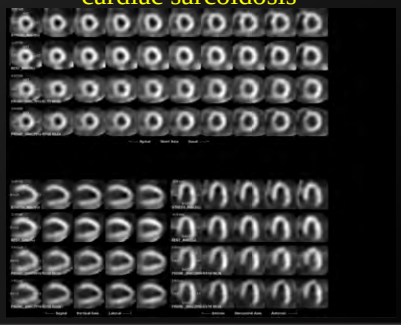
Milk, diet soda, or alcoholic beverages

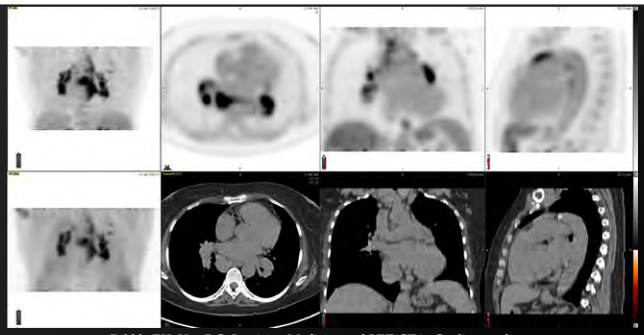
Fasting prior to administration of 18F-FDG Oncologic PET/CT

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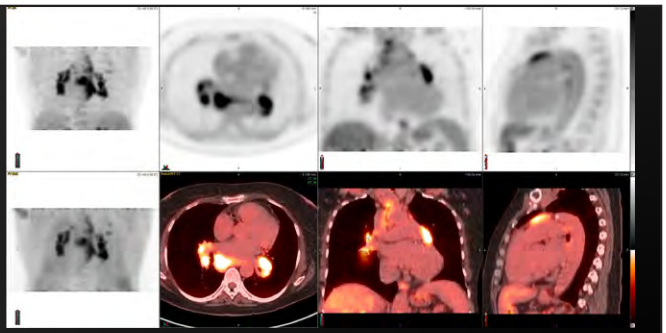
ACR-SPR practice guideline for performing FDG-PET/CT in oncology. American College of Radiology Web site. http://wwwacrorg/~/media/ACR/Documents/PGTS/guidelines/FDG_PET_CTpdfPublished 2009 Updated 2012 Updated 2016 Updated 2021

63 year old man for evaluation of cardiac sarcoidosis



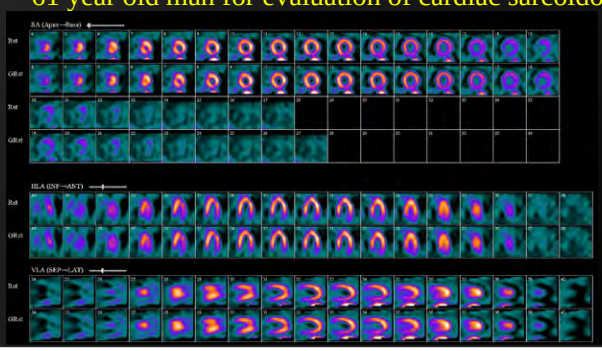


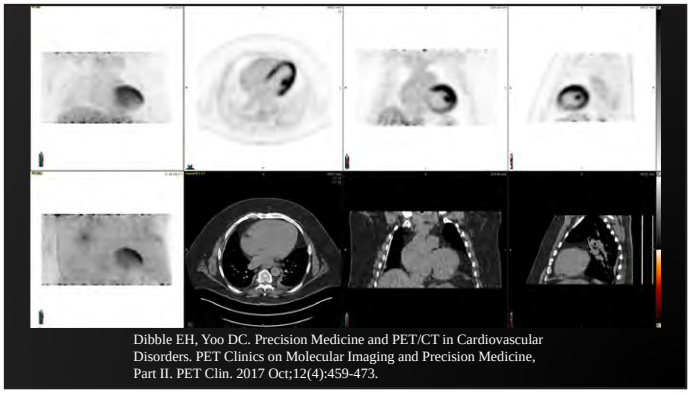
Dibble EH, Yoo DC. Precision Medicine and PET/CT in Cardiovascular Disorders. PET Clinics on Molecular Imaging and Precision Medicine, Part II. PET Clin. 2017 Oct;12(4):459-473.



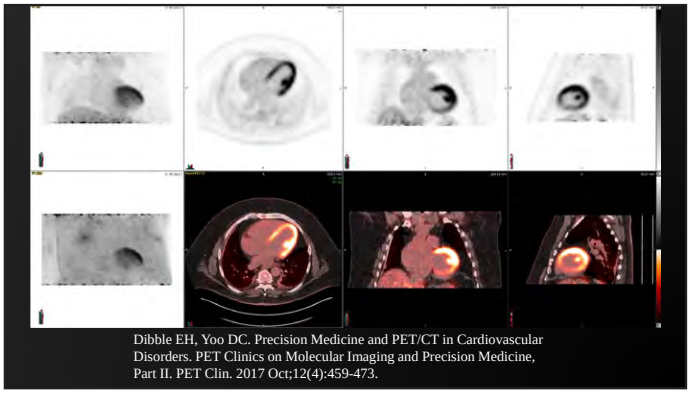
Dibble EH, Yoo DC. Precision Medicine and PET/CT in Cardiovascular Disorders. PET Clinics on Molecular Imaging and Precision Medicine, Part II. PET Clin. 2017 Oct;12(4):459-473.

61 year old man for evaluation of cardiac sarcoidosis

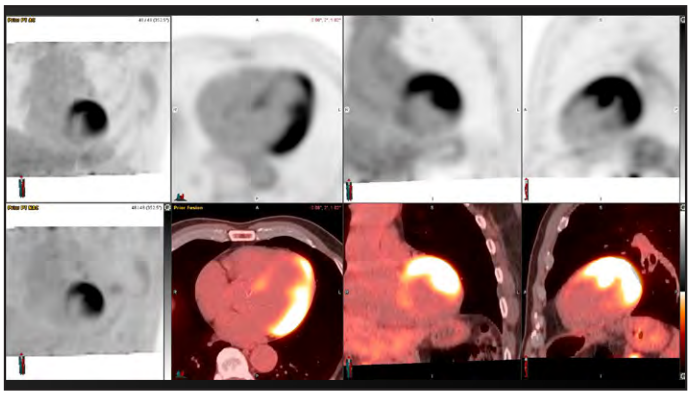


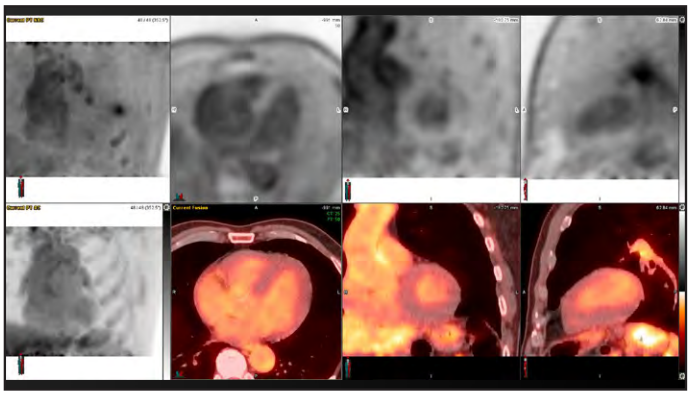


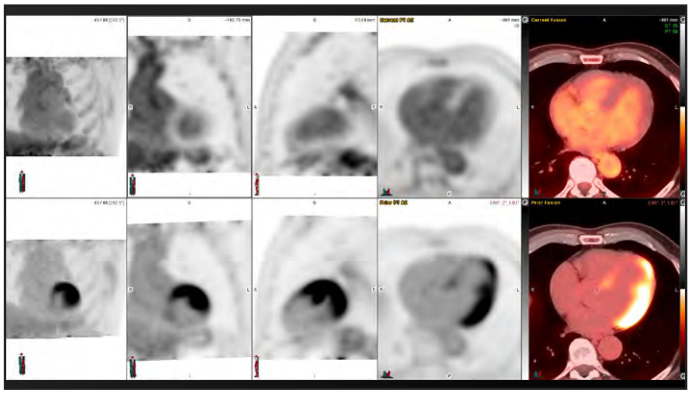
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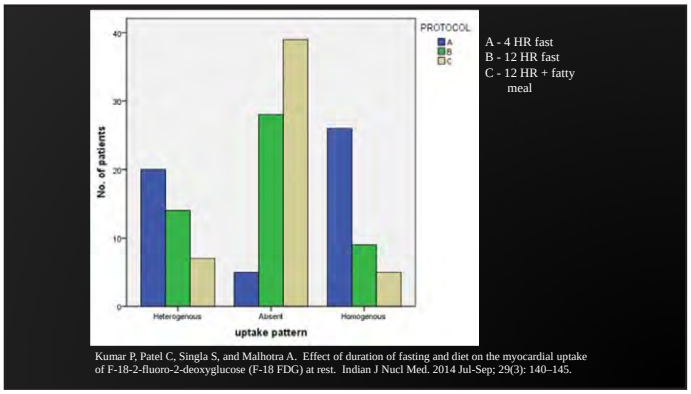


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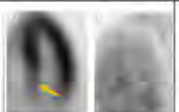


A - 4 HR fast
B - 12 HR fast
C - 12 HR + fatty meal

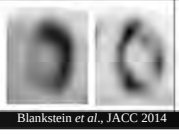
Kumar P, Patel C, Singla S, and Malhotra A. Effect of duration of fasting and diet on the myocardial uptake of F-18-2-fluoro-2-deoxyglucose (F-18 FDG) at rest. Indian J Nucl Med. 2014 Jul-Sep; 29(3): 140–145.

Rest Perfusion	FDG	Frequency	Example		Interpretation / Comment
			Perfusion	FDG	
Normal perfusion and metabolism					
Normal	Normal (negative)	32 (27%)			Normal
Normal	Diffuse (non-specific)	15 (12%)			Diffuse FDG most likely due to failure to suppress FDG from normal myocardium

Blankstein *et al*., JACC 2014

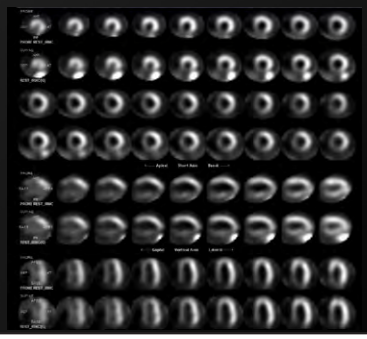
Rest Perfusion	FDG	Frequency	Example		Interpretation / Comment
			Perfusion	FDG	
Abnormal perfusion or metabolism					
Normal	Focal	20 (17%)			Nonspecific pattern; focal increase in FDG may represent early disease vs. normal variant
Positive	Negative	17 (14%)			Rest perfusion defect may represent scar from cardiac sarcoidosis or other etiologies

Blankstein *et al*., JACC 2014

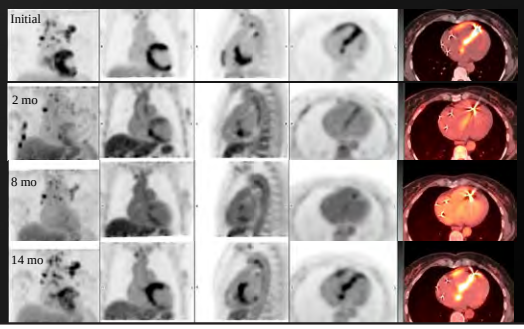
Rest Perfusion	FDG	Frequency	Example: Perfusion	Example: FDG	Interpretation / Comment
Abnormal perfusion and metabolism					
Positive	Focal increase ("mismatch pattern")	23 (19%)			Presence of active inflammation ± scar in the same location
Positive	Focal on diffuse	6 (5%)			Similar to above but also areas of inability to suppress FDG from normal myocardium vs. diffuse inflammation

Blankstein *et al.*, JACC 2014

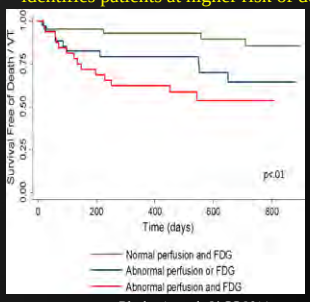
62 year old woman with known Sarcoidosis



62 year old woman with known Sarcoidosis



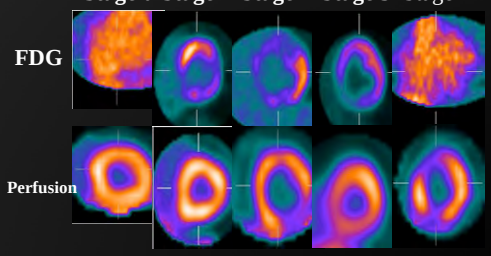
Abnormal cardiac PET with MPI identifies patients at higher risk of death / VT



118 patients
F/u avg 1.5 yrs
31 events (26%)

Blankstein *et al.*, JACC 2014

Stage 0 **Stage 1** **Stage 2** **Stage 3** Stage 4



General Interpretation Principles

	Spectrum of disease by PET/CT to evaluate rest perfusion and metabolism					
	Normal perfusion and metabolism		Abnormal metabolism		Abnormal perfusion and/or metabolism	
Perfusion						
	Normal	Normal	Normal	Abnormal	Abnormal	Abnormal
FDG						
	Normal (Negative)	Diffuse (non-specific)	Focal increase	Focal increase	Focal increase (different areas)	Normal (Negative)
Interpretation	Normal	Non-specific*	Early Disease	Mismatch Pattern	Scar and Inflammation	Scar

*Likely failure to suppress FDG uptake by normal myocardium although rarely can also be seen with diffuse disease

Chareonthaitawee et al. JNC. 2017.

Low carbohydrate meal

Do you recommend low carbohydrate meals 1 or 2 days prior to Oncologic FDG PET/CT?

A) Yes

B) No

Low carbohydrate meal

ACR - Recommend low-carbohydrate meals for 24 hours prior to FDG injection

SNMMI – No recommendation

NCI - No recommendation



PET Scan Controlled Carbohydrate *Sample* Menu

The purpose of this sample menu is to provide a diet that contains a moderate amount of carbohydrates, in high fiber form, to maintain normal blood sugars. High blood sugars can interfere with the accuracy of your test. These foods, or something similar, are to be eaten in the 24 hours leading to your PET scan. You should not eat for 4 – 6 hours before your scan. During this 4 – 6 hours, you can have plain water and medications only.

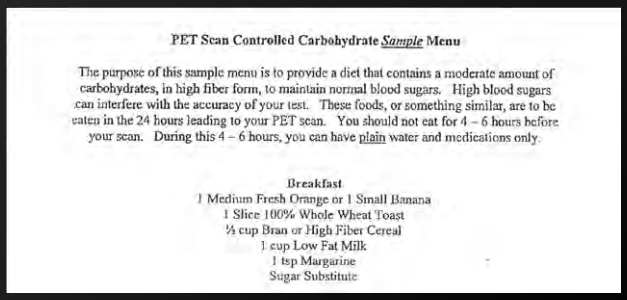
Breakfast
1 Medium Fresh Orange or 1 Small Banana
1 Slice 100% Whole Wheat Toast
½ cup Bran or High Fiber Cereal
1 cup Low Fat Milk
1 tsp Margarine
Sugar Substitute

Lunch
3 oz Turkey, Tuna or Roast Beef Sandwich on 100% Whole Wheat Bread
Lettuce and Tomato
2 tsp Mayonnaise
1 cup Low Fat Milk
1 Small Fresh Apple

Dinner
3 oz Meat, Poultry, or Fish
2/3 cup Brown Rice or Whole Wheat Pasta
1 cup Non-Starchy Vegetable (such as broccoli, spinach, green beans, etc)
1 cup Tossed Salad
1 tsp Margarine
1 tbsp Salad Dressing
1 cup Low Fat Milk
1 cup Berries

Snack
1 – 2 oz Cheese
6 Whole Grain Crackers

Remember to avoid caffeinated beverages.
Drink 8 cups of fluid per day in the form of milk, sugar free drinks, and water.



PET Scan Controlled Carbohydrate *Sample* Menu

The purpose of this sample menu is to provide a diet that contains a moderate amount of carbohydrates, in high fiber form, to maintain normal blood sugars. High blood sugars can interfere with the accuracy of your test. These foods, or something similar, are to be eaten in the 24 hours leading to your PET scan. You should not eat for 4 – 6 hours before your scan. During this 4 – 6 hours, you can have plain water and medications only.

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1 cup Tossed Salad
1 tsp Margarine
1 tbsp Salad Dressing
1 cup Low Fat Milk
1 cup Berries

Snack
1 – 2 oz Cheese
6 Whole Grain Crackers

High protein, low carbohydrate, low sugar diet 24 hours prior to your scan

Follow the special diet below:
- Chicken or Fish without breading
- Pork, including bacon or ham
- Beef
- Tofu
- Egg/Cheese/Milk
- Non-starchy vegetables, such as lettuce, tomatoes, peppers, green beans, broccoli, cauliflower, asparagus, mushrooms, peas, greens, spinach, chickpeas.
- Brown rice
- Low sugar bran
- Whole wheat, whole grain bread
- Whole wheat, whole grain pasta

Avoid sugars and carbohydrates:
- Fruit and fruit juice
- Jelly and Jam
- White Bread/rolls/cakes
- Chips/crackers/popcorn
- Desserts/candy
- Pizza
- Soft drinks
- Coffee/ tea

Limiting Exercise

Do you limit exercise?

A) Yes

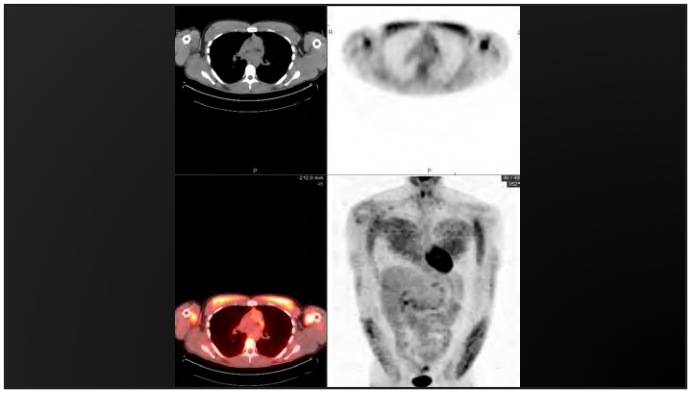
B) No

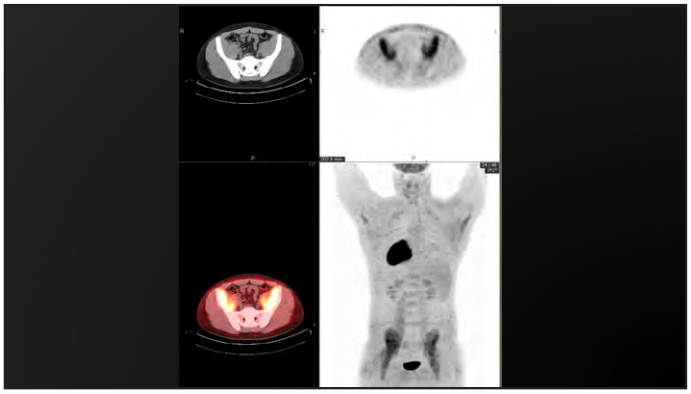
Limiting Exercise

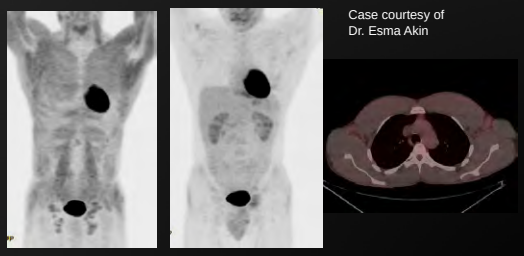
ACR – "Instruct patients to avoid strenuous activity 24 hours prior to FDG injection."

SNMMI – No recommendation. "For body imaging, the patient should remain seated or recumbent for 18F-FDG administration and the subsequent uptake phase to avoid muscular uptake."

NCI - Patients should avoid strenuous exercise for 24 h before the 18F-FDG PET study to minimize uptake of the radiotracer in muscles.







Case courtesy of
Dr. Esma Akin

Follow-up after chemotherapy

Hydration

Do you recommend hydration?

A) Yes

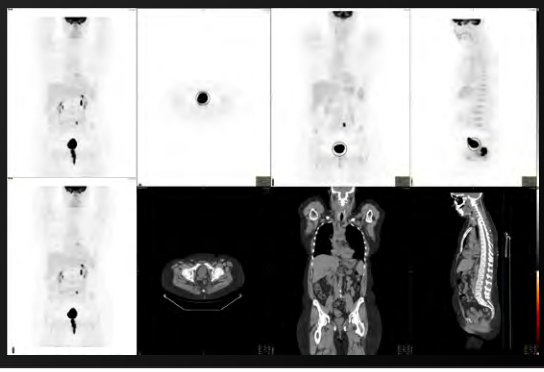
B) No

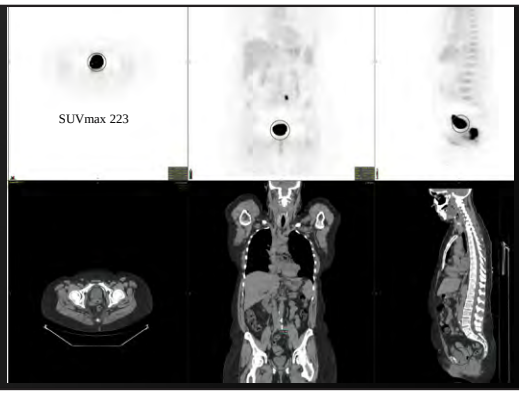
Hydration

ACR - “Encourage oral hydration with a goal of 1 L (34 oz) in 2 hours prior to appointment”

SNMMI -”Oral hydration with water is encouraged.”

NCI - “While fasting, patients should consume at least two to three 355-mL (12-oz) glasses of water to ensure adequate hydration…If possible, patients should drink 500 mL of water after injection”





Do you routinely give Oral Contrast?

A) Yes

B) No

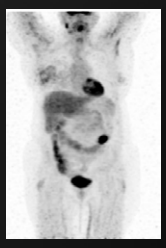
Should you give Oral Contrast?

ACR - No recommendation

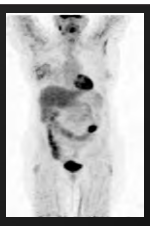
SNMMI - No recommendation

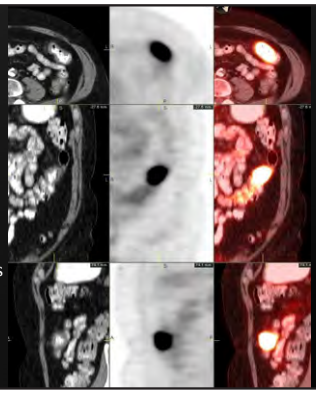
NCI - No recommendation

56-year-old woman with a newly diagnosed infiltrating right breast cancer with metastatic disease to multiple right axillary lymph nodes and over a 30lb weight loss in the last 6 months.

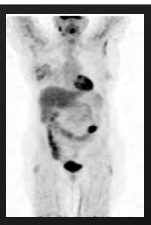


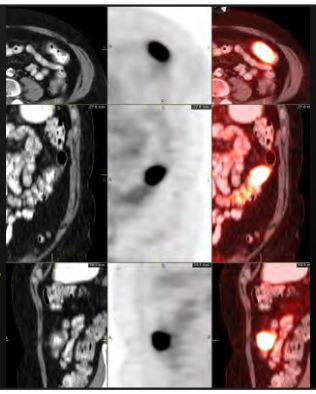
a) Benign or malignant primary colonic mass
b) Focal colitis
c) Physiologic activity
d) Metastatic disease





a) Benign or malignant primary colonic mass
b) Focal colitis
c) Physiologic activity
d) Metastatic disease





a) Benign or malignant primary colonic mass
b) Focal colitis
c) Physiologic activity
d) Metastatic disease

Sedation

Do you recommend sedation?

A) Yes

B) No

Sedation

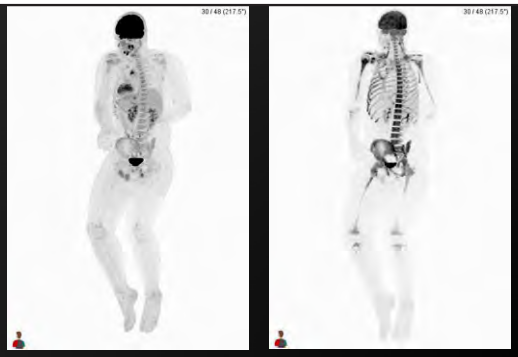
ACR - Oral beta-blockers or benzodiazepines can be given prior to injection to help minimize physiologic brown fat uptake.

SNMMI - No recommendation

NCI - “Diazepam or other mild sedative may be used at clinician’s discretion to decrease uptake in muscle.”

Brown Fat Activity



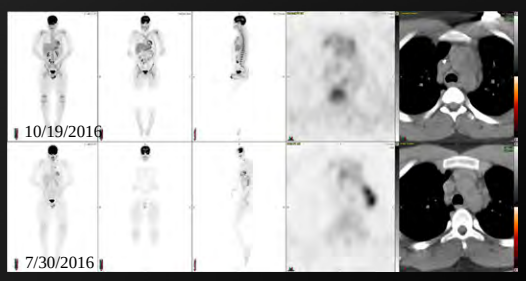


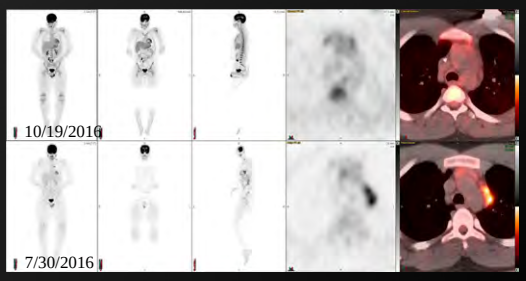


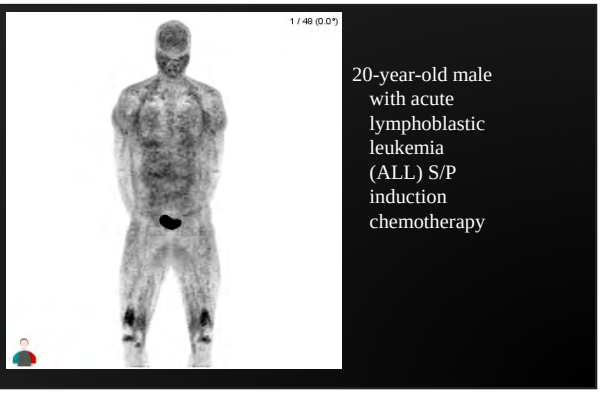


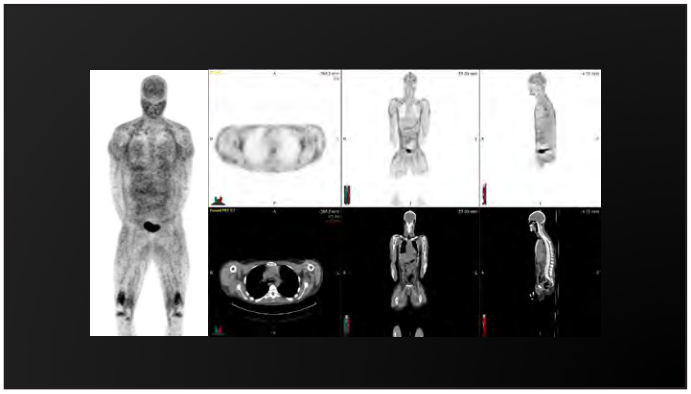
Patient had repeat PET/CT 10/19/2016 with anxiolytics



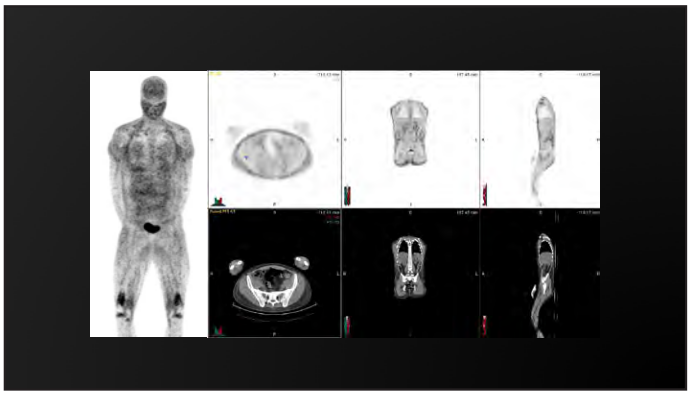


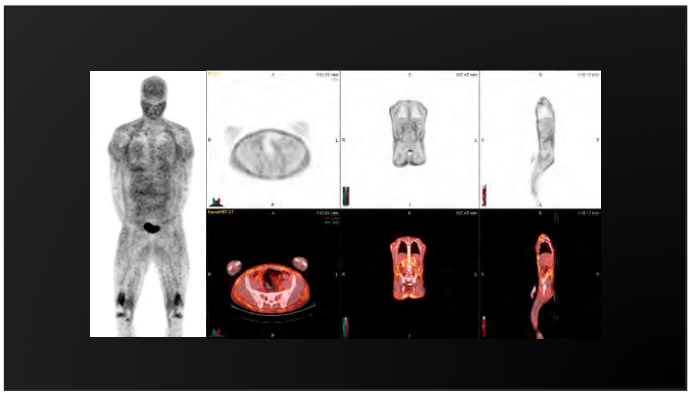


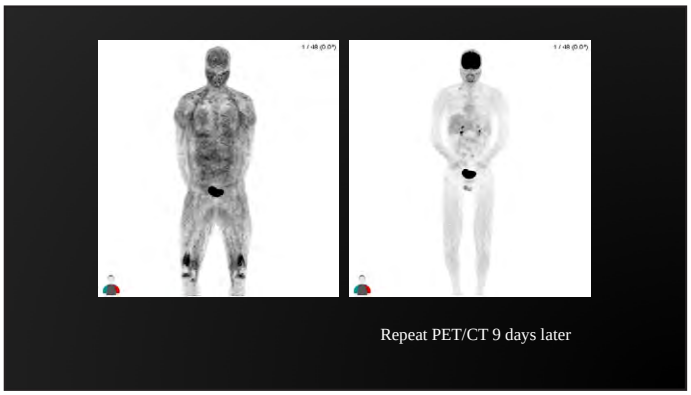

20-year-old male with acute lymphoblastic leukemia (ALL) S/P induction chemotherapy

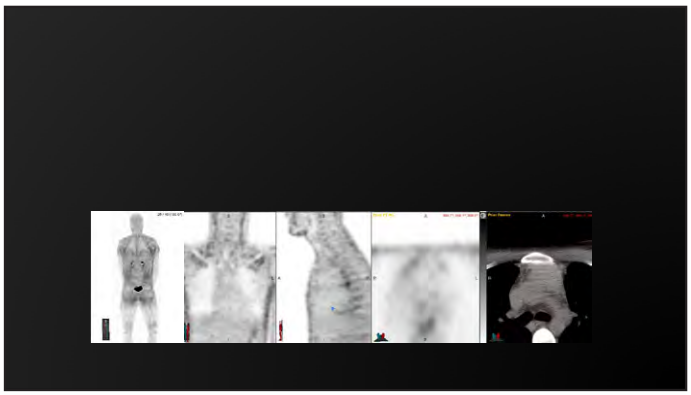


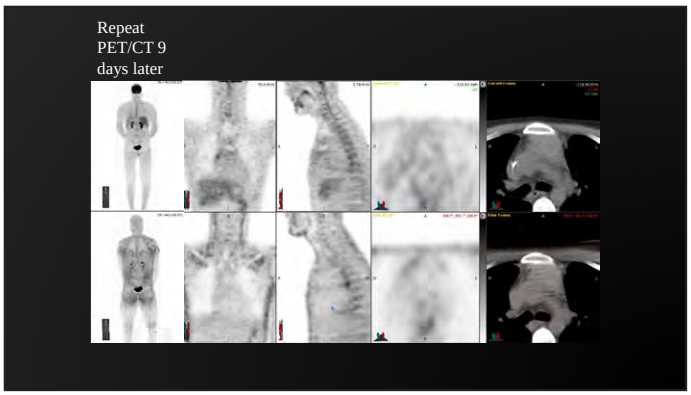




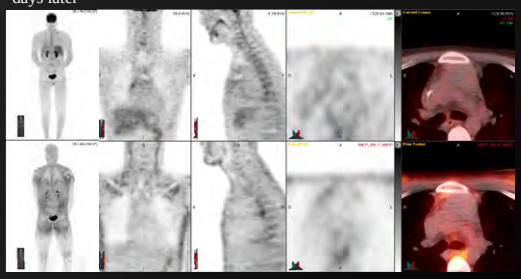



Repeat PET/CT 9 days later

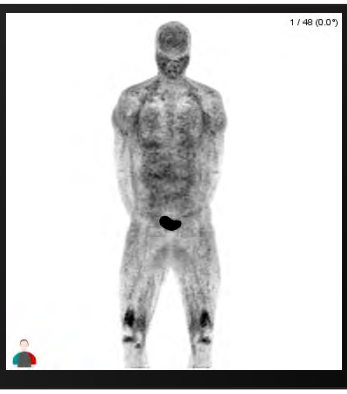



Repeat
PET/CT 9
days later

Repeat PET/CT 9 days later



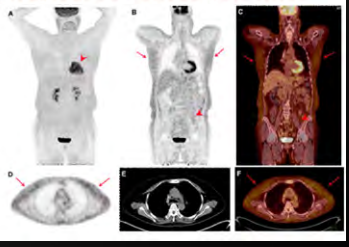
Response to therapy. No evidence of FDG-avid active lymphoma



20-year-old male with acute lymphoblastic leukemia (ALL) S/P induction chemotherapy on high-dose prednisone chemotherapy

Editorial Note

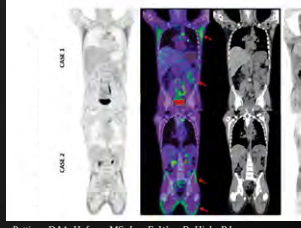
Causes of ^{18}F-FDG uptake on white adipose tissue



Hwang DY1, Lee JW, Lee SM, Kim S.
Causes of (18)F-FDG uptake on white adipose tissue.
J Nucl Med. 2016 Jan-Apr;19(1):7-9. Epub 2016 Mar 1.

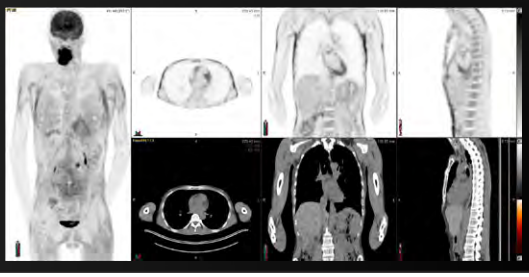
Enhanced White Adipose Tissue Metabolism in Iatrogenic Cushing's Syndrome With FDG PET/CT

Pattison et al — Iatrogenic Cushing's Syndrome on PET/CT

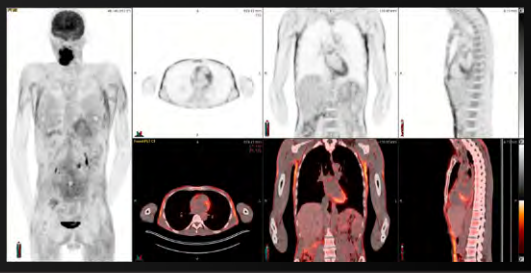


Pattison DA1, Hofman MS, Lau E, Ware R, Hicks RJ.
Enhanced white adipose tissue metabolism in iatrogenic Cushing's syndrome with FDG PET/CT.
J Clin Endocrinol Metab. 2014 Sep;99(9):3041-2.. Epub 2014 Feb 14.

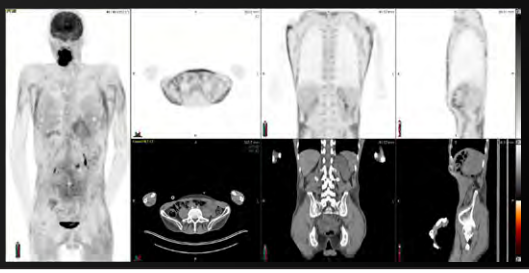
50-year-old male with squamous cell carcinoma of the tongue



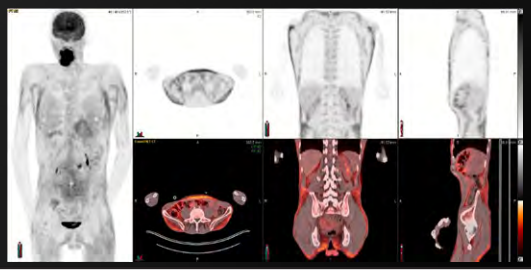
50-year-old male with squamous cell carcinoma of the tongue



50-year-old male with squamous cell carcinoma of the tongue

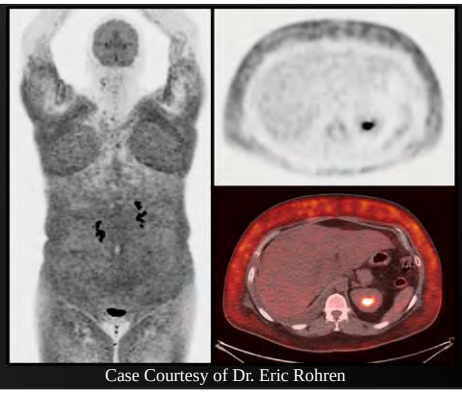


50-year-old male with squamous cell carcinoma of the tongue



Altered Biodistribution of Diffuse Subcutaneous White Adipose Tissue (not Brown Fat) likely due to Nicotine patch





Case Courtesy of Dr. Eric Rohren

Nicotine effects

Nicotine is known to increase FDG uptake in adipose tissue in rats

21mg nicotine patch releases the nicotine equivalent of 1 pack of cigarettes over the course of 12-24 hours.

Baba S, Tatsumi M, Ishimori T, et al. Effect of nicotine and ephedrine on the accumulation of 18F-FDG in brown adipose tissue. J Nucl Med. 2007;48:981-6.

ACR

No caffeine, alcohol, or nicotine 12 hours prior to FDG injection

Diabetic Patients

Recommendations on performing PET/CT scans on diabetic patients

SNMMI

"The blood glucose level should be checked before 18F-FDG administration. Tumor uptake of 18F-FDG is reduced in hyperglycemic states. Most institutions reschedule the patient if the blood glucose level is greater than 150–200 mg/dL"

Delbeke et al. Procedure guideline for tumor imaging with 18F-FDG PET/CT 1.0. Journal of nuclear medicine : Society of Nuclear Medicine. J Nucl Med 2006;47(5):885-95.

NCI

18F-FDG injection <= 150-200 mg/dL

Diabetics not excluded from clinical trials but scanned early in the morning before the first meal.

Shankar et. al. Consensus recommendations for the use of 18F-FDG PET as an indicator of therapeutic response in patients in National Cancer Institute Trials. J. Nuc Med 2006;47(6):1059-66.

NCI

Insulin and hypoglycemic medication titrated appropriately the night before and morning of the study.

Diabetics should test their plasma glucose levels after fasting, while avoiding insulin close to the time that FDG would be administered.

Shankar et. al. Consensus recommendations for the use of 18F-FDG PET as an indicator of therapeutic response in patients in National Cancer Institute Trials. J. Nuc Med 2006;47(6):1059-66.

ACR

"Serum glucose analysis performed immediately prior to FDG administration (<200 mg/dl acceptable"

Many recommendations for diabetic patients

ACR–SPR PRACTICE GUIDELINE FOR PERFORMING FDG-PET/CT IN ONCOLOGY 2016

ACR Diabetic Patient Guidelines:

PET scan should be scheduled early in the morning (if possible)

-Usual insulin or oral medications doses the day before.
-Fast (except for water) and non-diabetic medications after MN
-On the morning of the PET scan, hold all insulin or oral medications

ACR Diabetic Patient Guidelines:

If PET scan is scheduled after 10 am
-Eat low-carbohydrate breakfast at least 4 hours before
-inject ½ of usual regular (short-acting) insulin or regular dose of oral medications at least 4 hours before your appointment.
-Do not use long-acting or mixed (70/30) insulin after midnight.
-If on insulin pump preferred to turn off 4 hours prior to the study, but if unable to do so setting should be on night/basal setting

ACR Diabetic Patient Guidelines:

After completion of the PET scan:

Eat breakfast immediately

-Take ½ dose usual morning dose of insulin or regular dose of oral medications with the post PET meal.

NM Attending notified

Hyperglycemia >200 mg/dl
-Wait 25-30 minutes and repeat FS

Hypoglycemia <70 mg/dl
-Wait 25-30 minutes and repeat FS

If symptoms of hypoglycemia we reschedule the study

Obstacles to Glycemic Control

Infection or Stress

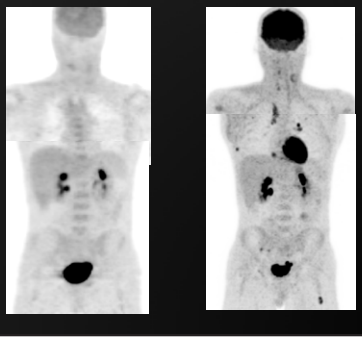
New medications
-Corticosteroids

Variable compliance with medications

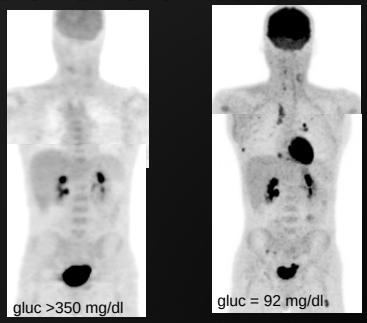
Nutrition

What can happen when you image a patient with high glucose?

PET Scans 2 days apart



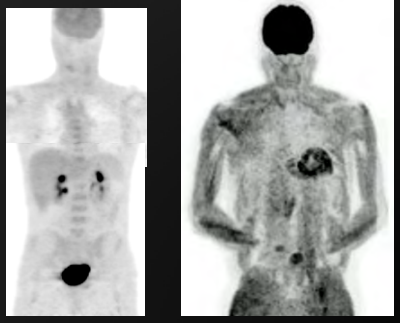
FDG PET and Plasma Glucose



Why can't you give insulin in a hyperglycemic patient?

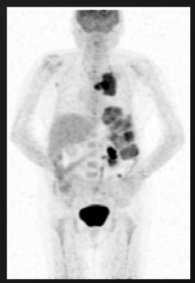


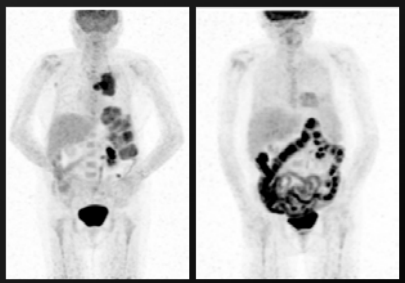
What is worse high glucose or normal glucose in a patient with recent insulin or non-fasting state?



Should you ever perform a PET/CT on a patient with hyperglycemia?

Technologist comes in and tells you the next patient for a PET/CT has glucose of 269 mg/dl.

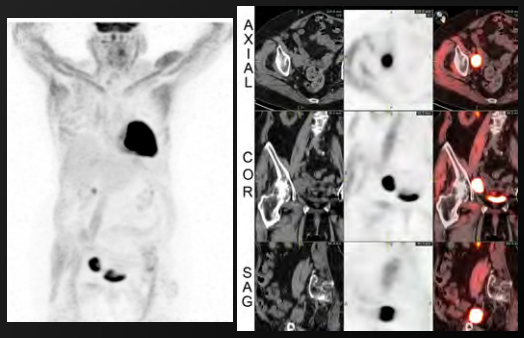




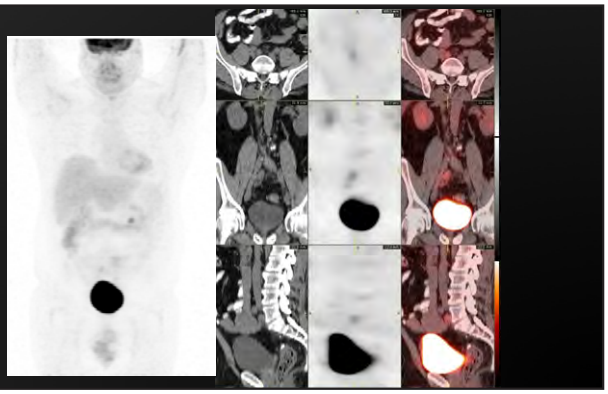
If a patient has altered biodistribution what do I do?



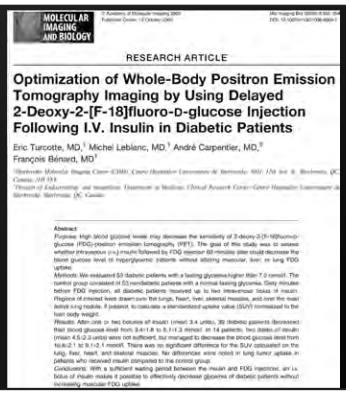








Can you give insulin to a diabetic patient with hyperglycemia if the PET/CT scan is absolutely necessary?



MOLECULAR IMAGING AND BIOLOGY

RESEARCH ARTICLE

Optimization of Whole-Body Positron Emission Tomography Imaging by Using Delayed 2-Deoxy-2-[F-18]fluoro-D-glucose Injection Following I.V. Insulin in Diabetic Patients

Eric Turcotte, MD,[1] Michel Leblanc, MD,[1] André Carpentier, MD,[2] François Bénard, MD[1]

MOLECULAR IMAGING AND BIOLOGY

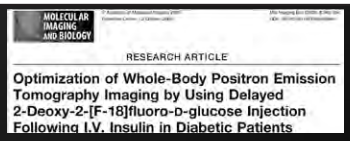
RESEARCH ARTICLE

Optimization of Whole-Body Positron Emission Tomography Imaging by Using Delayed 2-Deoxy-2-[F-18]fluoro-D-glucose Injection Following I.V. Insulin in Diabetic Patients

53 Diabetic patients with elevated glucose given IV bolus of insulin 60 minutes prior to FDG injection

IV insulin has 95% clearance at 1 hour

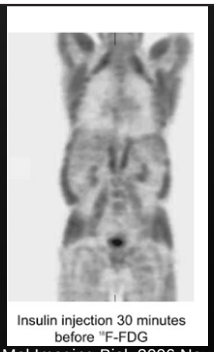
Subcutaneous insulin is released for over 4 hours


MOLECULAR IMAGING AND BIOLOGY

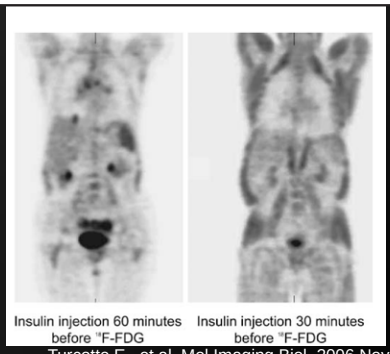
RESEARCH ARTICLE

Optimization of Whole-Body Positron Emission Tomography Imaging by Using Delayed 2-Deoxy-2-[F-18]fluoro-D-glucose Injection Following I.V. Insulin in Diabetic Patients

Concluded that IV insulin can lower glucose without significantly reducing SUV or increasing muscle activity with a sufficient waiting period of 1 hour


Insulin injection 30 minutes before ^{18}F-FDG

Turcotte E, et al Mol Imaging Biol. 2006 Nov-Dec;8(6):348-54.


Insulin injection 60 minutes before ^{18}F-FDG

Insulin injection 30 minutes before ^{18}F-FDG

Turcotte E, et al Mol Imaging Biol. 2006 Nov-Dec;8(6):348-54.

Summary: Patient Preparation for F18-FDG PET/CT

Fasting
Low Carbohydrate meal
Limiting Exercise
Hydration
Oral Contrast
Sedation
Diabetic Patients

Summary

1. Discussed the challenges in patient preparation for FDG PET/CT for oncology and cardiac sarcoidosis

2. Reviewed recommendations from ACR, SNMMI, NCI on patient preparation prior to PET/CT

3. Discussed the issues in performing PET/CT scans on diabetic patients and learn ways to optimize the glucose level

SELF EVALUATION

Importance of Patient Preparation for PET/CT

1. According to ACR guidelines, what is the minimum fasting period recommended before an oncologic FDG PET/CT examination?

a. 2 hours
b. 4 hours
c. 8 hours
d. 12 hours

2. T/F - Patients undergoing FDG PET/CT should avoid strenuous exercise for approximately 24 hours before the study.

3. For evaluation of cardiac sarcoidosis with FDG PET/CT, which preparation is recommended to suppress normal myocardial glucose uptake?

a. High-carbohydrate meal the night before
b. No dietary restrictions
c. Prolonged fasting with a low-carbohydrate/high-fat diet
d. Drinking fruit juice before the scan

4. T/F - Hyperglycemia can significantly alter FDG biodistribution and reduce tumor uptake, potentially affecting PET interpretation.

5. According to the lecture, which substance should be avoided for at least 12 hours before FDG injection because it may alter FDG uptake patterns?

a. Calcium supplements
b. Vitamin D
c. Nicotine
d. Aspirin

Answer Key: 1. B, 2. T, 3. C, 4. T, 5. C

FACULTY

Anil K. Attili, MD

Anil K. Attili, MD is a board certified radiologist and Clinical Professor in the Department of Radiology, Division of Cardiothoracic Imaging at the University of Michigan. He has a joint appointment at the Veterans Administration Hospital Ann Arbor where he serves as the director of Cardiovascular Radiology. Dr. Attili's areas of expertise and clinical interests include Cardiac CT for Coronary Artery disease and Structural Heart disease, Cardiac MR evaluation of Ischemic Heart Disease, Cardiomyopathies and Congenital Heart Disease, HRCT evaluation of Interstitial Lung Disease, Lung Cancer Screening. He is a nationally recongized speaker on these topics.

You may contact Dr. Attili with your questions and comments at aattili@med.umich.edu.

Cardiac MR and CT Case Reviews

Anil Kumar Attili, MD

Cardiac MR and CT Case Reviews

Applications in Clinical Practice

Anil Attili, MD
Professor of Radiology
University of Michigan

CMR Case Reviews: Introduction

Basic CMR sequences

- **Cine MR for function and morphology (Bright blood GRE /SSFP)**
- **Late Gadolinium enhancement (LGE) for tissue characterization**
- Myocardial 1st pass perfusion
- Other tissue characterization sequences e.g. T2 weighted black blood imaging for edema and inflammation, T1 black blood , T2* imaging, T1 and T2 mapping
- Phase contrast imaging for flow

Approach to interpretation of CMR

- Are the ventricles dilated or normal in size?
- Is there wall motion abnormality in either ventricles? - If Yes, is it regional (Hypokinetic, Akinetic or Dyskinetic) or Global ? *
- Is the LV EF and RV EF visually normal (> 55%), mildly reduced (45-50%) , moderately reduced (35-45%) or severely reduced (< 35%) ?
- Is there LVH or LV wall thinning? *
- Is LGE present ? if Yes is it in an ischemic or non ischemic pattern? If non ischemic what is the pattern and distribution *
- Most likely diagnosis ?
- How will MRI (or CT) affect management ?

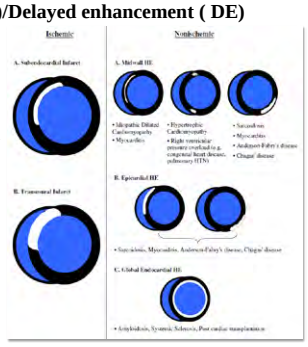
*Use AHA 17 segment model to describe wall motion and LGE locations and other relevant abnormalities

CMR Advantages: Myocardial tissue characterization

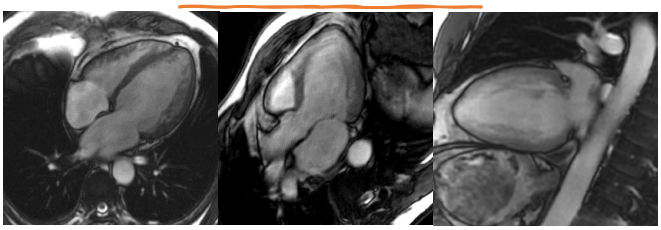
Late Gadolinium enhancement (LGE)/Delayed enhancement (DE)

MRI Late gadolinium enhancement

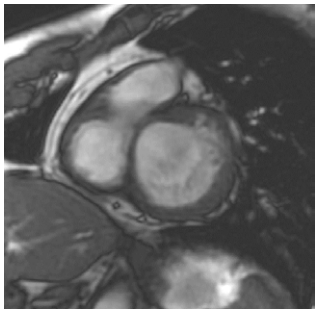
- Gadolinium- Extravascular, extra cellular agent that accumulates in regions of infarcted, inflamed, fibrotic or infiltrated myocardium
- The subendocardium is more vulnerable to ischemia

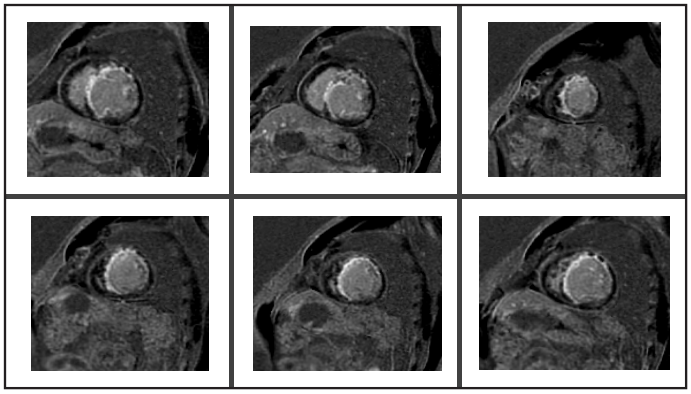


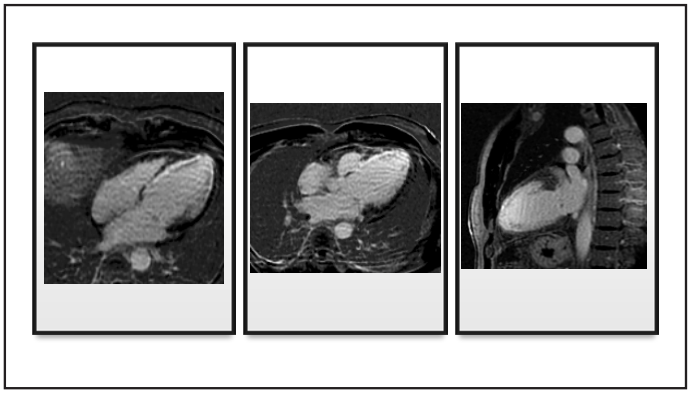
Case 1



Case 1









The left ventricular ejection fraction is severely decreased at 22.5%.

Akinesia in the anterior wall, anterior septum ,anterior lateral wall in the basal mid ventricular segments and in all the apical segments. The remaining myocardial segments are severely hypokinetic.

Near full thickness **nonviable myocardial infarct scar in the LAD distribution** involving the anterior wall, anterior septum and anterolateral wall basal and mid ventricular segments and in all the apical segments.

Viability is present by MRI criteria in the inferior lateral wall, inferior wall and inferior septum basal and mid ventricular segments where the transmural thickness of enhancement is 50% or less i.e. RCA and LCx distributions.

RV EF is severely decreased at 28%. Severe RV global hypokinesis

CT surgery note Pre CMR

- 61 male with history of T2DM (A1c 6.5%), HTN, tobacco use transferred from Detroit VA for recently diagnosed heart failure and severe multivessel CAD, for CABG evaluation.
- **LHC showed severe 3v disease including prox LAD, ostial OM, and an occluded RCA.**
- 61-year-old male with recently diagnosed ICM with EF 20-25% and newly diagnosed severe 3-vessel CAD, RV dysfunction, and moderate MR and TR. **He will likely benefit from CABG and may also need intervention on his mitral valve.**
- - Continue medical heart failure management
- - Please obtain TEE to better characterize valvular disease
- - **Please obtain MRI viability scan**
- - **Will continue planning for surgery following this testing**

Management post CMR

- 61-year-old male with T2DM who presented to Detroit VA with heart failure transferred to AAVA for CABG workup found to have **non-viable LAD-territory** admitted for heart failure management.
- Recommend maintenance of euvolemia through PRN diuretic, initiation of GDMT and outpatient follow-up.
- Summary of recommendations:

- Preload: Recommend initiation of weight-based oral diuretic dosing. Can trial 40mg PO lasix for weight gain >2lbs in a day. If weight gain continued, recommend patient reach out to cardiology department

-GDMT : lisinopril 2.5mg. Metoprolol succinate 12.5mg .Start spironolactone 25mg. If tolerated, add SGLT2i

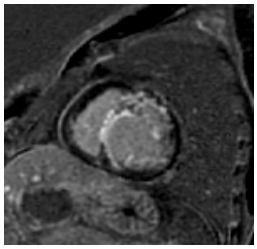
-Refer to ANN CARD HFT NP/MD in the next 4-8 weeks

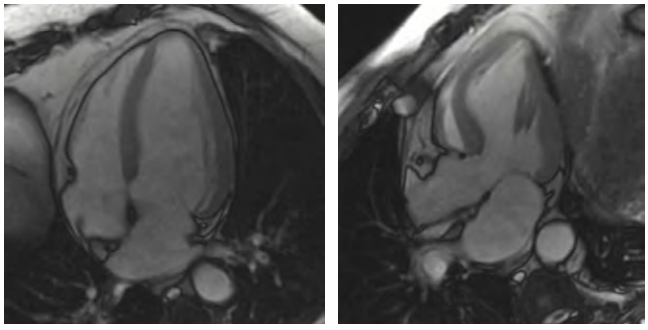
-Refer to ANN CARD HFT pharmacist for visit in the next 2-4 weeks for GDMT titration

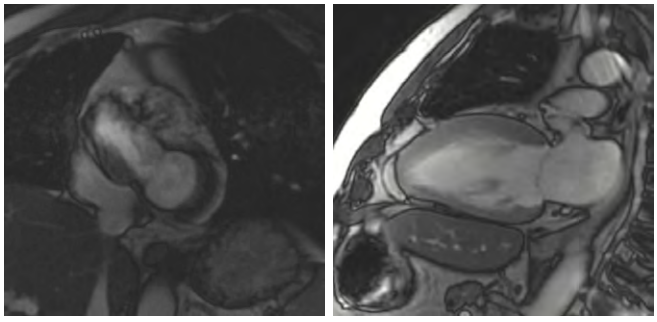
-CAD :Continue ASA; Continue Statin

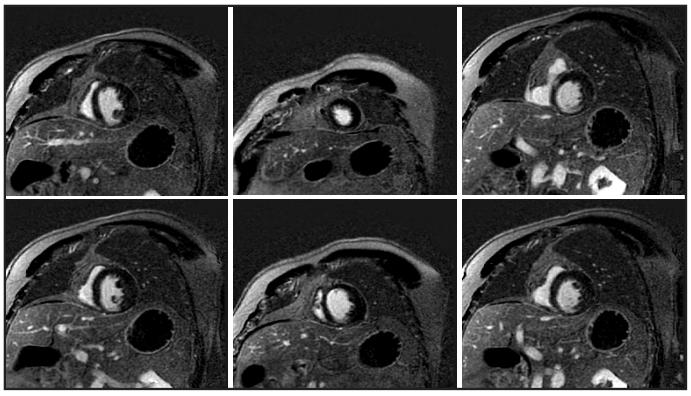
-Refer to CARD INTERVENTIONAL NP/MD for consideration of PCI to circumflex territory

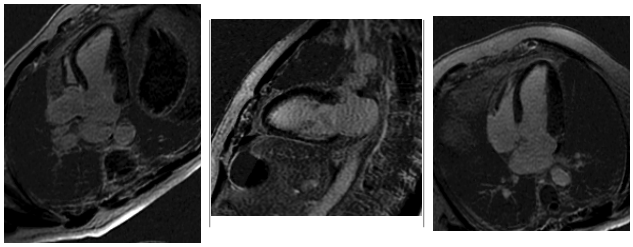
-AF - Switch from heparin to oral anticoagulant

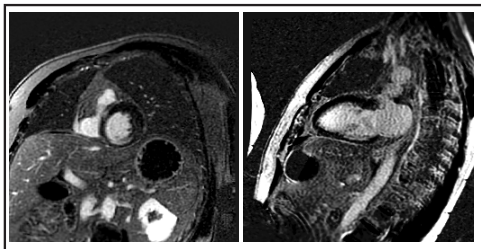












Viable infarct in the inferior wall of the left ventricle basal and mid ventricular segments (less than 50% transmural thickness enhancement involving the subendocardium).

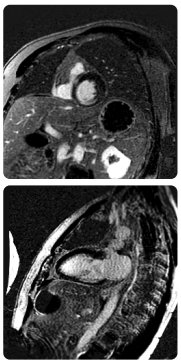
No other regions of delayed enhancement notably in the LAD and LCx distributions.

Overall myocardial viability in all coronary artery distributions is preserved.

LV ejection fraction is severely decreased at 34%.

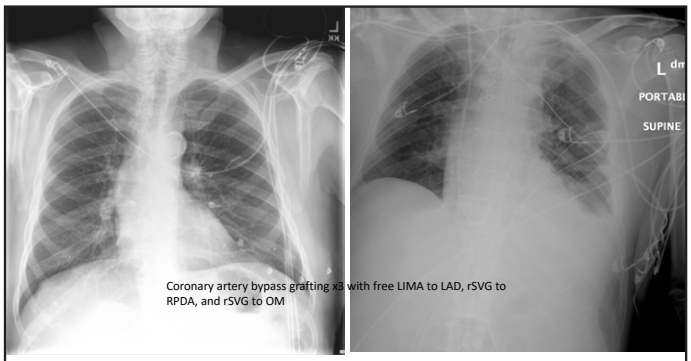
Case 2

- 71y/o. veteran with history of hypertension, hyperlipidemia, BPH, and diabetes who presents with an NSTEMI now s/p LHC which revealed severe 3-vessel CAD.
- Last summer 7 months ago while mowing the lawn he initially felt left upper chest pain which resolved with rest. This pain has occurred intermittently since that time over the past approximately 7 months. He states that when increased in severity the pain sometimes radiates across the top of his chest and to his back. The pain is relieved with rest, and he has not taken any medications to attempt to relieve it at home. Angina progressively worsened.



Cath report

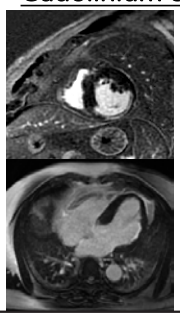
- Left Main : Ostial calcified 50% stenosis and a distal 50% stenosis
- LAD: Calcified proximal 50-60% stenosis and a mid 30% stenosis
- CIRCUMFLEX: No significant angiographic stenosis.
- RCA : Dominant with a heavily calcified ostial 90% stenosis. The RCA, rPDA and RPL fill antegrade as well as through left to right collaterals
- No significant angiographic stenosis in the diagonals, OM and PDA



Coronary artery bypass grafting x3 with free LIMA to LAD, rSVG to RPDA, and rSVG to OM

CXR 1-day pre and post CMR

Evaluation of myocardial viability : CMR late Gadolinium enhancement (LGE)



Almost transmural LGE
Nonviable

Small subendocardial MI
Viable

Transmural extent of infarct scar is inversely related to the likelihood of functional recovery after revascularization

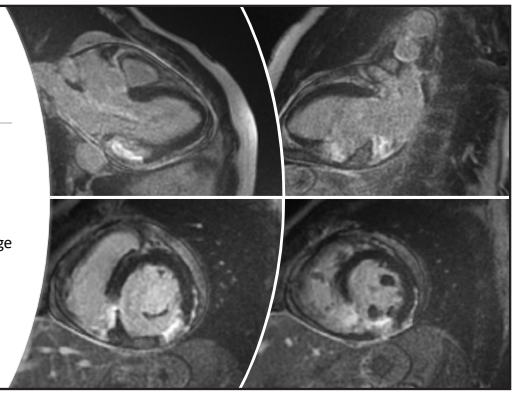
<25% viable; 25-50% is mixed, mostly viable, 51-75% is mixed, mostly non-viable; > 75% is non-viable

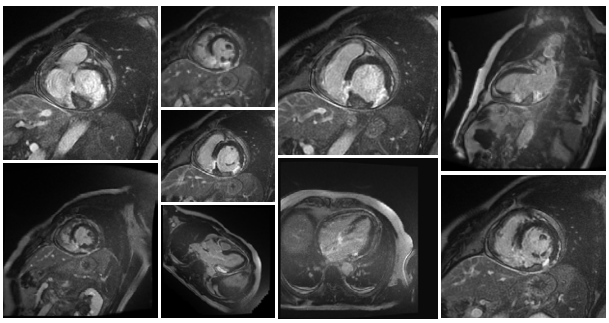
Appropriate for determining viability prior to revascularization*

Circulation. 2010;121:2462-2508

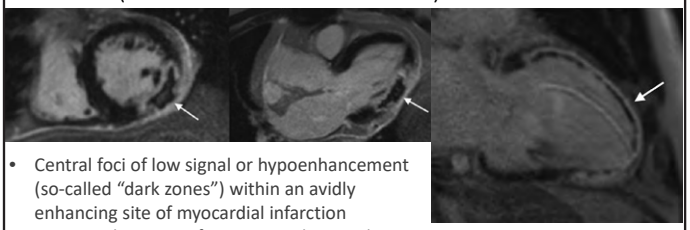
Case 3

- 72-year M presents with chest pain. ACS status post RCA PCI
- CMR prior to discharge





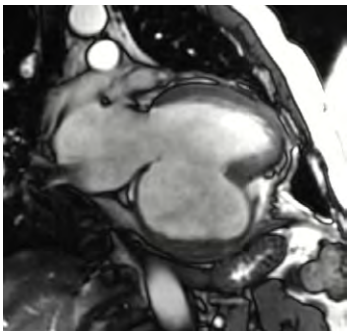
MVO (Microvascular occlusion) on LGE



- Central foci of low signal or hypoenhancement (so-called "dark zones") within an avidly enhancing site of myocardial infarction
- MVO predicts more frequent cardiovascular complications including adverse LV remodeling, HF, reinfarction, cardiac death and stroke

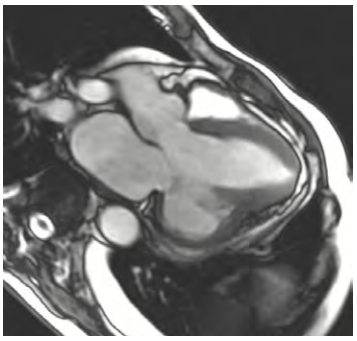


- 72-year-old veteran presents with chest pain. ACS status post PCI RCA
- CMR prior to discharge



72-year-old M. ACS status post RCA PCI

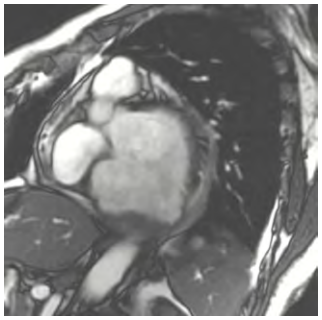
CMR 2 months after discharge

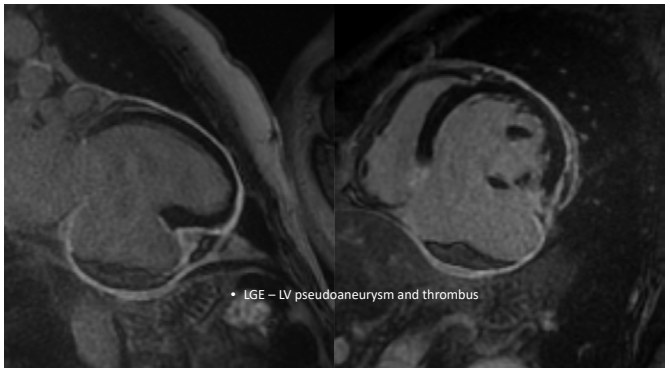


72-year-old vet ACS status post RCA PCI

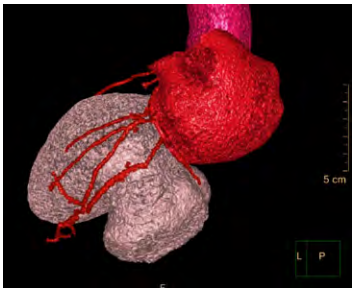
CMR 2 months after discharge

- 72 vet presented with chest pain.
- 2 months post inferior wall MI treated by PCI





- LGE – LV pseudoaneurysm and thrombus





70 M. Post MI returned with inf wall large pseudoaneurysm on CT

LV True aneurysm vs pseudoaneurysm

Pseudoaneurysms have a higher risk of rupture leading to cardiac tamponade, shock, and death, compared with a more benign natural history for true aneurysms. Accurate diagnosis of these conditions is clinically important

- True aneurysms

Location

More common in an apical, anterior, or anterolateral location

Morphology

Wide neck and smooth transition from normal myocardium to thinned myocardium.

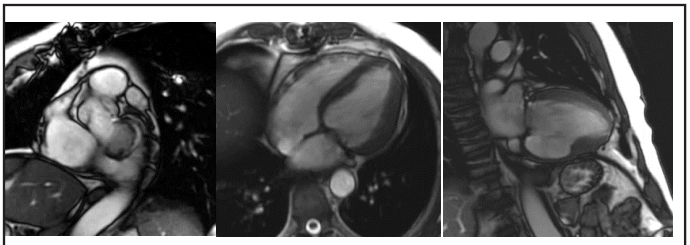
- Pseudoaneurysm

Location

More commonly involve posterior or inferior walls

Morphology

Narrow-necked channel that connects the large aneurysmal sac with the ventricle.

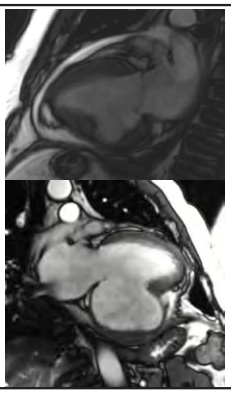


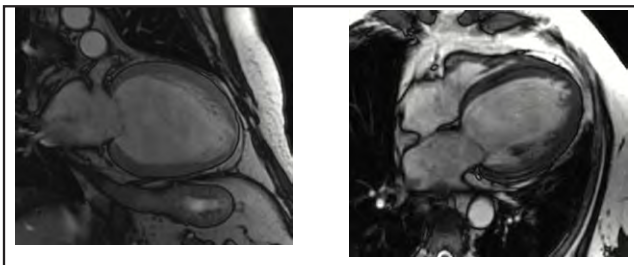
Interval resection of the left ventricular inferior wall pseudoaneurysm and patch repair

CMR 11/2016- Full-thickness myocardial infarction likely acute within the inferior wall, inferior septum and inferior lateral wall. MVO. Small dyskinetic focal aneurysmal region in the inferior wall at the mid ventricular region measuring 13 mm x 12 mm. LV ejection fraction is 35%. Small pericardial effusion with pericardial enhancement consistent with an acute pericarditis. RV inferior wall infarction. RV ejection fraction is 44%.

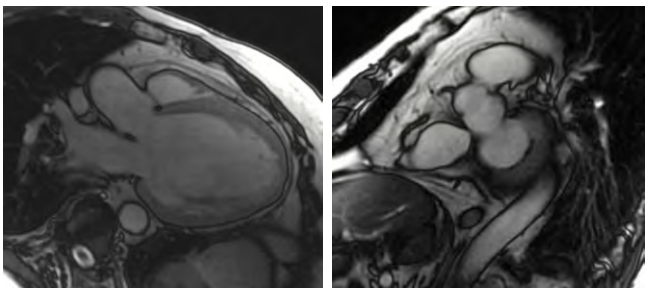
CMR 1/2017- Large 7 cm x 5 cm x 5 cm pseudoaneurysm arising from the inferior wall of the left ventricle from the base to the apical regions. There is layering adherent thrombus along the inferior wall of the aneurysm which is formed by the pericardium. LV EF 17%.

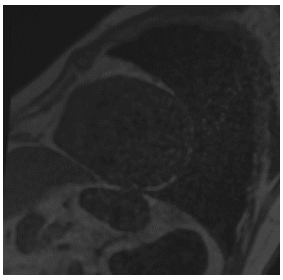
CMR 6/2017 - Interval resection of the left ventricular inferior wall pseudoaneurysm and patch repair. The inferior wall of the left ventricle at the site of the repair is akinetic from the base through to the apical segments. Overall left ventricular ejection fraction and systolic function is however improved from 17% on the presurgical study to 39% on the current examination

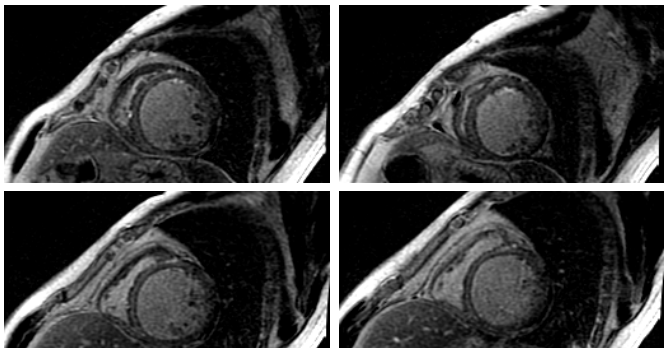


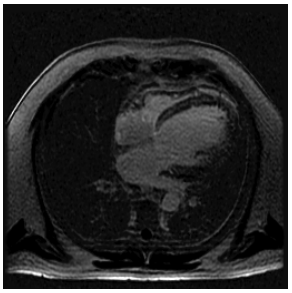


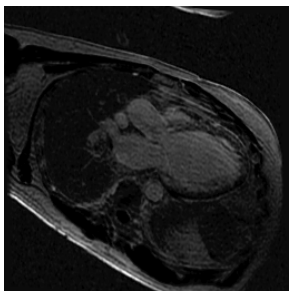
Case 4





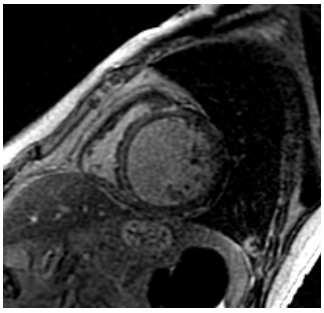






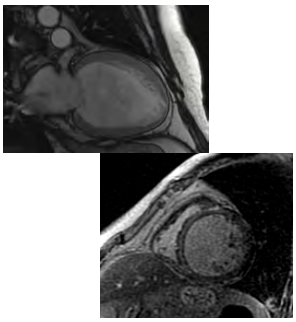
MRI report

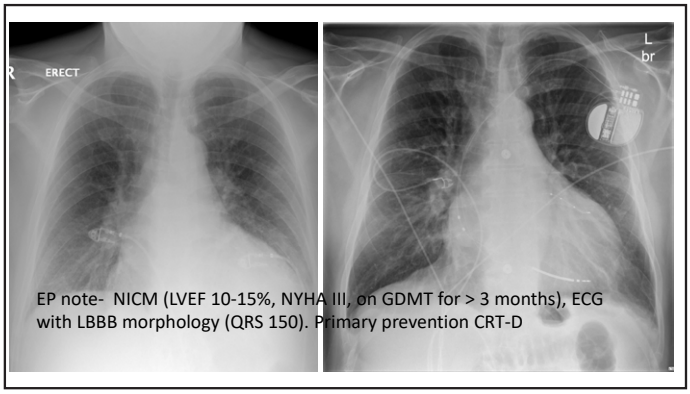
- Severely decreased left ventricular ejection fraction of 14%. Left ventricular cavity is severely dilated and globally hypokinetic.
- No vasodilator stress induced perfusion defects, specifically no inducible ischemia.
- Extensive nonischemic mid wall late gadolinium enhancement/scar in the interventricular septum, anterior and inferior walls of the left ventricle base through to the apical segments.
- RV EF 33%



Non-Ischemic Dilated Cardiomyopathy (DCM) Familial

- 60 M first diagnosed with HF in 2016 in San Diego. He states he underwent a LHC via his wrist at that time but was told no stents were placed. He was told he had a dilated cardiomyopathy.
- Endorsing DOE, orthopnea, and PND. Feels breathless and is not able to take a deep breath because he feels "full". He denies chest pain but feels pressure after he ambulates a few yards and becomes severely winded prior.
- States strong family history of HF. Dad has ICD and two brothers with heart failure. No genetic testing ever done.

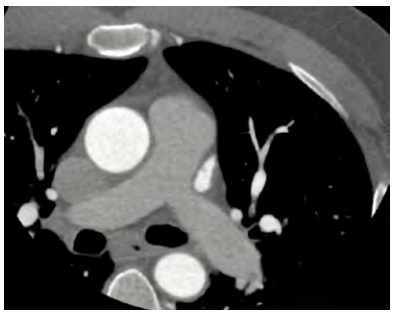


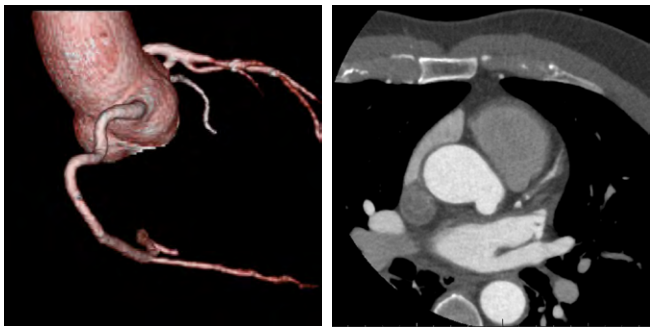


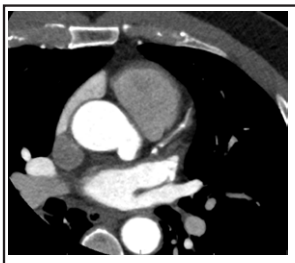
EP note- NICM (LVEF 10-15%, NYHA III, on GDMT for > 3 months), ECG with LBBB morphology (QRS 150). Primary prevention CRT-D

Case 5

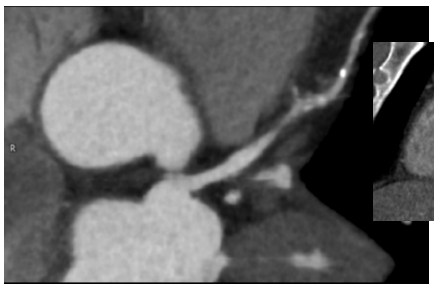
60 veteran with chest pain on exertion.

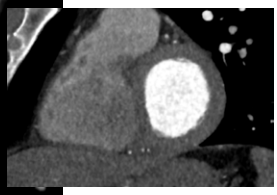










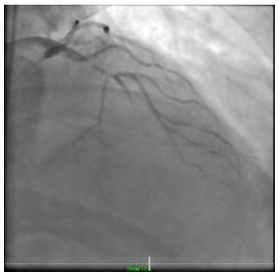


What features on CT suggest a high-risk coronary plaque?

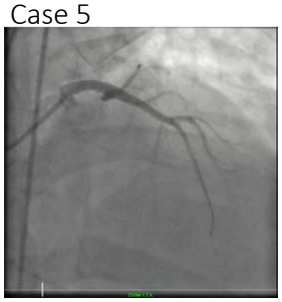
- Positive remodelling
- Napkin ring sign
- Spotty calcification
- Low attenuation center

Case 5. Severe Mid LAD stenosis



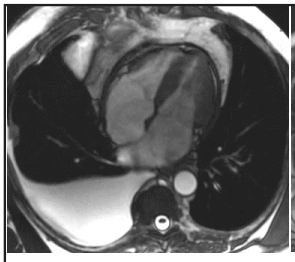


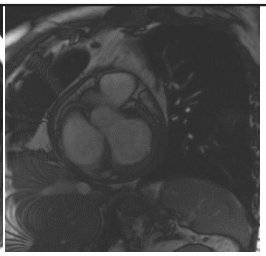
Case 5





Successful PCI of culprit lesion in mid LAD with implantation of Resolute Onyx 3.0 x 26mm drug-eluting stent

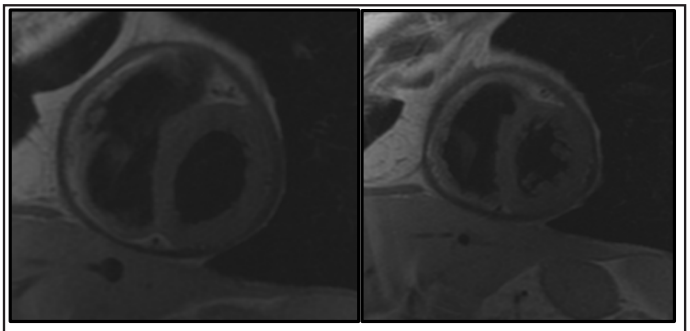




Case 6

CMR 2016. **CMR findings are consistent with constrictive pericarditis.** Circumferential thickening of the pericardium up to 6 mm. Relatively narrow tubular ventricles. Dilated atria and IVC. Paradoxical septal motion, septal flattening and diastolic septal bounce accentuated in inspiration. No pericardial enhancement.

65 M. Bilateral lower extremity edema, DOE, abnormal LFTs. Pleural effusions. Liver biopsy on hold

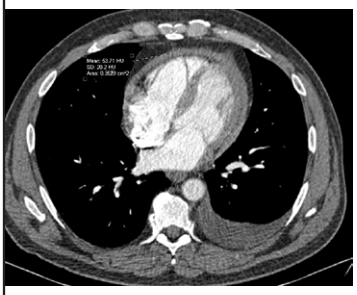


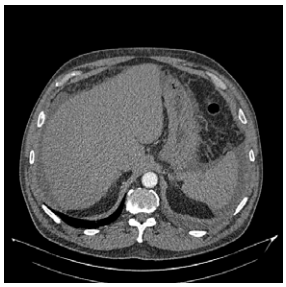
Black Blood Imaging- Spin Echo with a DIR pre pulse



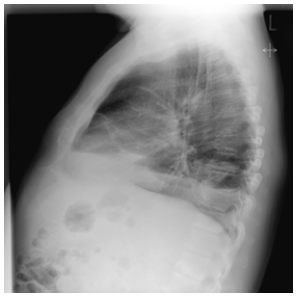


PE CT 2013 for Dyspnea-No evidence of PE or dissection.
Pericardial effusion areas measuring up to 12 mm thick.
Partially seen peritoneal free fluid.
Small to moderate left pleural effusion.



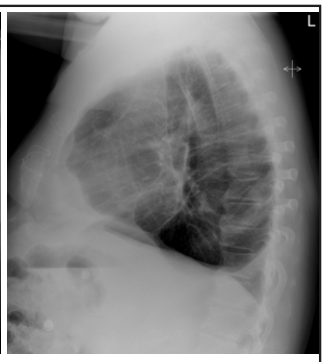




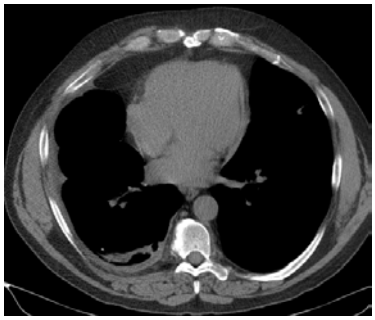


CXR Pre MRI

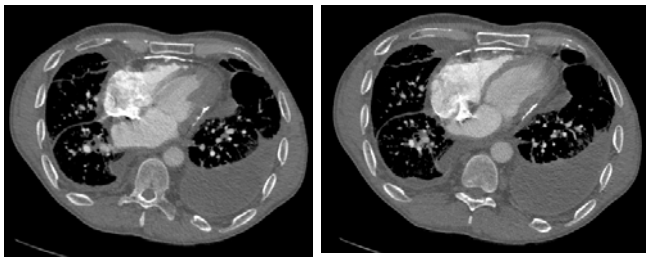


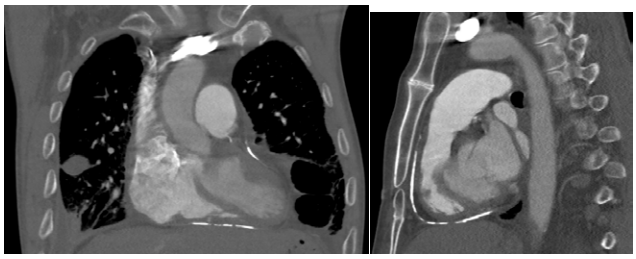


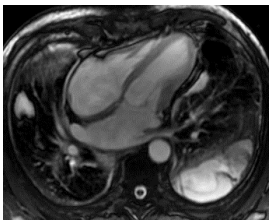
Post MRI CXR

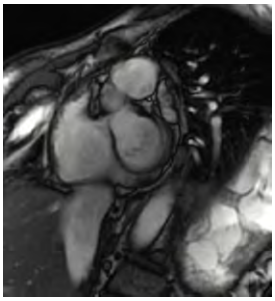


Constrictive Pericarditis status post Pericardial resection



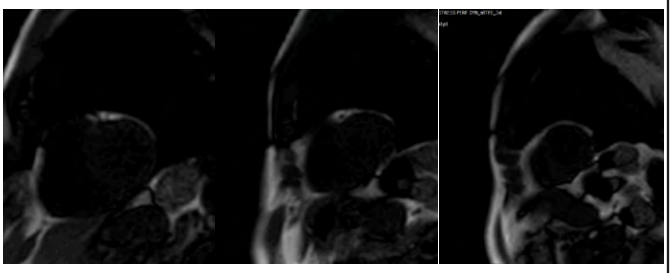




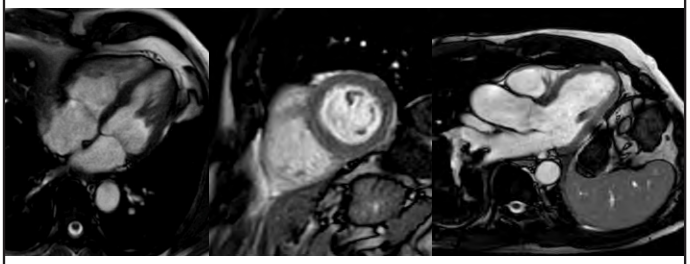


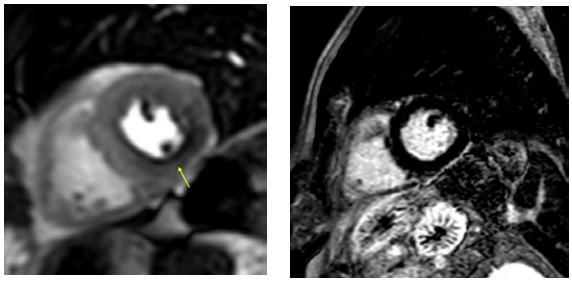
61 M. Dyspnea, PND, edema and HF admissions

Case 7

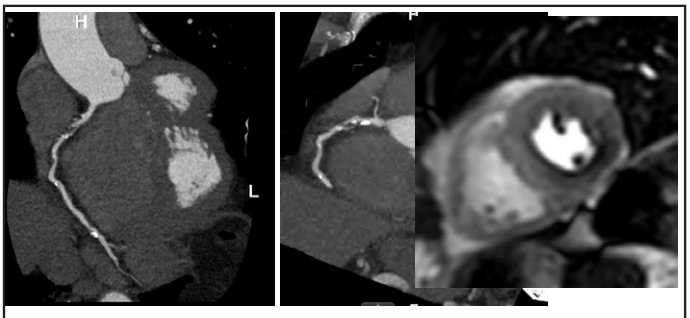


Regadenoson 1st pass stress perfusion in 3 short axis slices

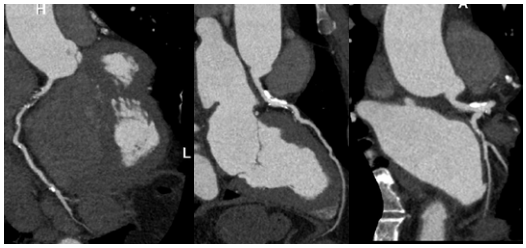




Mild to Moderate sized inducible perfusion defect on CMR. Normal wall motion and LV EF. No MI or scar



RCA > 70% stenosis



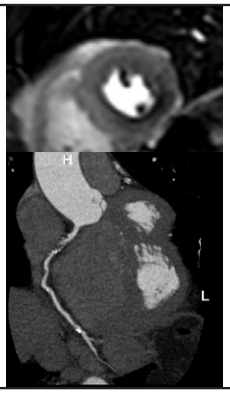
RCA > 70% stenosis

LAD < 50% stenosis

LCX non obstructive disease

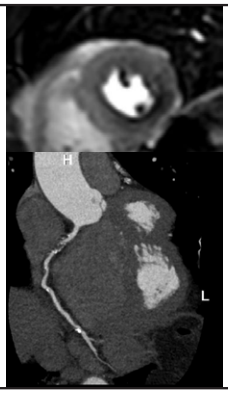
Case 7

- 70 M. Asymptomatic. Extremely physically active with no angina. Hyperlipidemia
- Being evaluated for inguinal hernia repair in CA ,which led to a stress ECG, echo and a CTA
- Stress ECG – 2-3 mm flat to upsloping ST depression in II, III, aVF, V4, V5, V6 and 1 mm ST elevation at peak exercise. No chest pain
- Stress Echo - Bruce protocol,13 minutes, 99% MPHR, 2 mm horizontal STD inferior leads and V4-V6 during stress. Baseline LV function normal. Stress induced mid-basal inferior wall and posterior wall HK. No chest pain
- CTA- CAC 1200. Obstructive CAD RCA
- Sought a 2nd opinion at MM. Declined cath. Offered Nuc med perfusion or MRI and preferred MRI



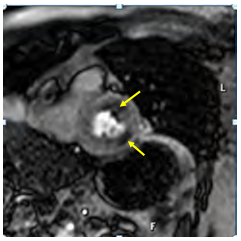
Case 7

- 70 M. Asymptomatic. Extremely physically active with no angina. Hyperlipidemia
- CMR (12/20/2019): Mild- Moderate inducible ischemia RCA distribution. LV EF 54% . No scar
- Deferred LHC due to his lack of symptoms
- Underwent successful laparascopic bilateral inguinal hernia repair (9/30/2019)
- High intensity statins (atorvastatin 40mg qhs) and ASA 81mg daily



Stress CMR Evidence

- **MR-IMPACT II (** 533 patients): Compared the accuracy of perfusion CMR, SPECT against the gold standard coronary angiography. Perfusion CMR was non-inferior compared to SPECT.
- **CE-MARC Study** (752 patients): Stress CMR could safely be performed in all participants and had a better sensitivity and specificity (86.5/83.4%) than SPECT (66.5/82.6%) for detecting significant coronary artery stenosis.
- **MR-INFORM Study** (918 patients): Stress CMR had a similar outcome as invasive FFR for guiding the indication for revascularization, but was associated with a significant reduction of invasive revascularization procedures





2021 AHA/ACC/ASE/CHEST/SAEM/SCCT/SCMR Guideline for the Evaluation and Diagnosis of Chest Pain: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines

J Am Coll Cardiol. Oct 28, 2021. Epublished DOI: 10.1016/j.jacc.2021.07.053

2021 The American Heart Association, Inc., and the American College of Cardiology Foundation

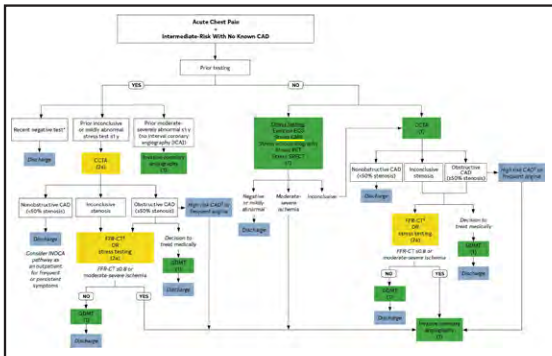
The choice of imaging depends on the clinical question of importance, to either a) ascertain the diagnosis of CAD and define coronary anatomy or b) assess ischemia severity among patients with an expected higher likelihood of ischemia with an abnormal resting ECG or those incapable of performing maximal exercise.

Testing choice will be influenced by site expertise and availability, but knowledge regarding which test may be preferable is useful when selecting between different modalities.

Cost should also be considered, when known by the ordering clinician and there is equipoise between available modalities

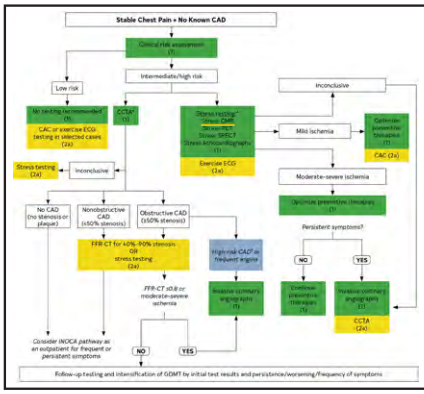
Exercise ECG is the lowest cost procedure used in the diagnostic evaluation when compared with stress imaging or anatomic procedures, with the exception of coronary artery calcium (CAC) scoring . For all imaging procedures, costs vary by payer and site of services.

JACC



CMR stress testing a Class 1 indication

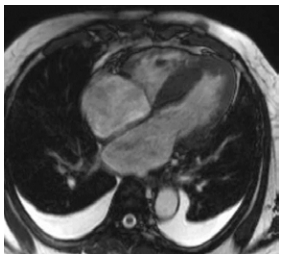
2021 AHA/ACC/ASE/CHEST/SAEM/SCCT/SCMR Guideline for the Evaluation and Diagnosis of Chest Pain: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines

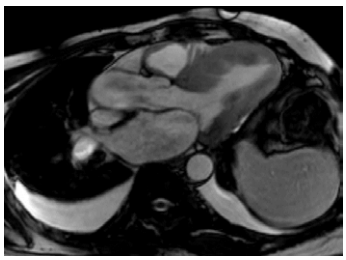


CMR stress testing a Class 1 indication

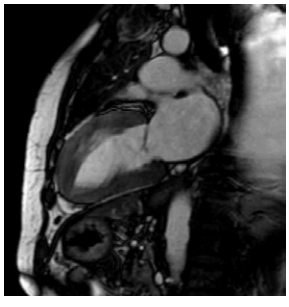
2021 AHA/ACC/ASE/CHEST/SAEM/SCCT/SCMR Guideline for the Evaluation and Diagnosis of Chest Pain: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines

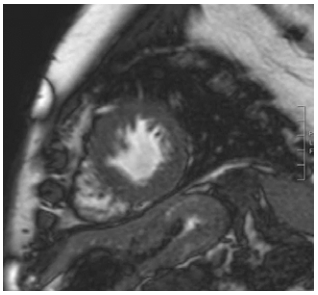
Case 8



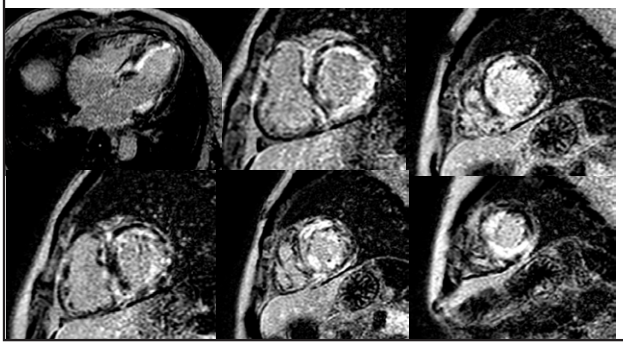


Case 8

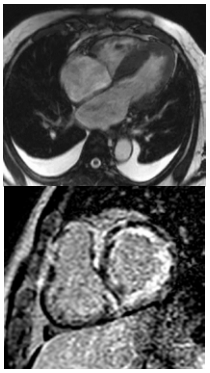




Case 8



Case 8 . CMR 8/3/2016



1.Patchy delayed enhancement involving the majority of the left ventricular myocardium with subendocardial, transmural and patchy midwall patterns, with associated asymmetric left ventricular wall affecting predominantly the interventricular septum. These findings are most compatible with a infiltrative cardiomyopathy, with ischemia considered very unlikely given that areas of delayed enhancement are colocalized with areas of wall thickening. Additionally, there is suggestion of patchy delayed enhancement within the right ventricle and delayed enhancement within the left atrial wall. **Findings are considered most compatible with cardiac amyloidosis,** with cardiac sarcoid considered a less likely possibility.

2. Borderline enlarged left ventricle with mildly reduced global systolic function (LVEF 42%).

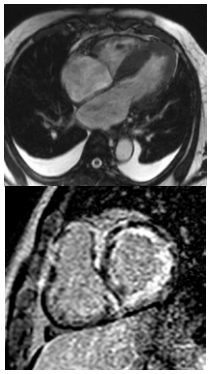
3. Normal left right ventricular size with moderately reduced global systolic function (RVEF 26%).

4. Small to moderate sized jet of mitral regurgitation with associated left atrial enlargement.

5. Small bilateral pleural effusions.

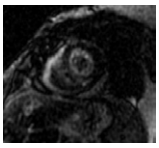
Case 8

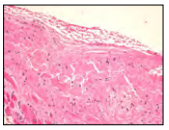
- 74-year-old African American with a history of HF with mildly reduced EF. History of primary hyperaldosteronism with secondary hypertension, hyperlipidemia, diabetes mellitus
- CMR 8/3/2016. Cardiac cath 3/9/2017 showed mild non-obstructive CAD and biventricular pressure overload. He had an EMB at the time which revealed ATTR amyloidosis (Val122Ile mutation)
- Dual chamber ICD implanted for primary prevention (NSVT). On a Diuretic regimen (Toresemide) Started on Doxycycline. Diflunisal was considered
- Multiple HF admission since 2016 and deceased 12/2/2018
- ATTR can result from mutant TTR protein with one of the most common mutations in the United States, V122I, present in 3.43% of African Americans. ATTRm V122I amyloidosis carries significant morbidity and mortality



CMR Cardiac Amyloidosis

- In patients with biopsy-proven cardiac amyloidosis, LGE frequently occurs in a peculiar pattern.
- Global transmural or subendocardial LGE is most common, but suboptimal myocardial nulling and focal patchy LGE are also observed
- On the basis of the gold standard EMB, CMR can be used to diagnose or rule out cardiac amyloidosis with good sensitivity (80-88%) and excellent specificity in a clinical routine setting.

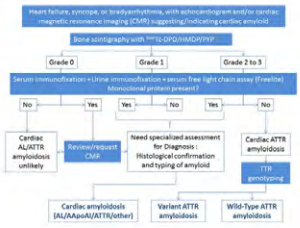




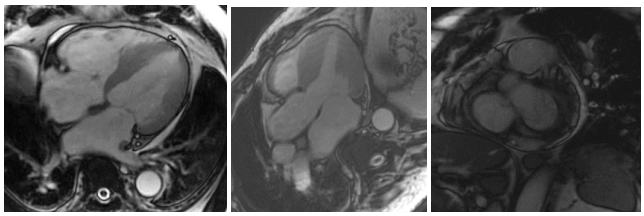
Role of cardiac magnetic resonance imaging in the detection of cardiac amyloidosis. JACC Cardiovascular imaging 2010 Feb ; 39(2) 155-64

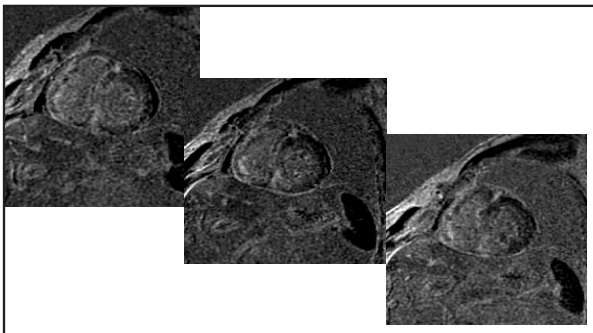
Cardiac Amyloidosis Imaging

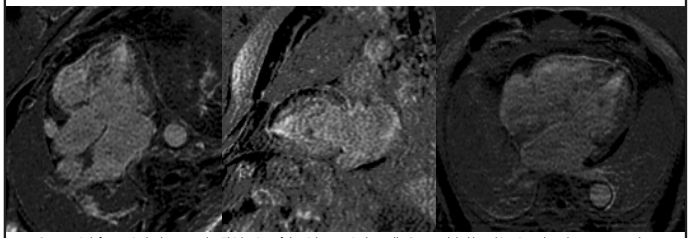
- The advent of bone scintigraphy has enabled noninvasive diagnosis of ATTR, limiting the need for EMB
- Differentiating ATTR from other types of amyloidosis, especially AL, is critical. Emerging targeted ATTR therapies (Tafamidis FDA approved May 2019) offer the potential to improve outcomes of these patients previously treated only palliatively
- CMR is unable to definitely distinguish between ATTR and AL amyloid



Darbola et al. Multimodality imaging in cardiac amyloidosis. Journal of Nuclear Cardiology. 2019 Dec;26 (6): 2065-2123

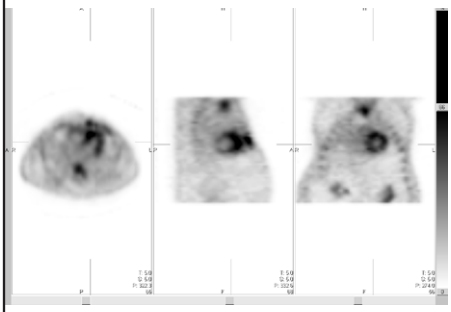






Concentric left ventricular hypertrophy. Thickening of the right ventricular walls. Severe global hypokinesis and moderate to severely decreased ejection fractions. LV ejection fraction is 38% and RV ejection fraction 34%. Dilated atria.
Diffuse myocardial enhancement and difficulty nulling the myocardium. Diffuse patchy enhancement throughout the left ventricular walls including areas of global subendocardial enhancement as well as enhancement of the thickened right ventricular walls.
Small pericardial effusion.

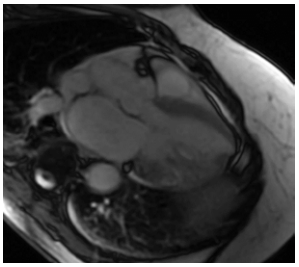
Cardiac MRI findings consistent with amyloid infiltration.



The Tc99M PYP myocardial scan is highly suggestive of ATTR cardiac amyloidosis

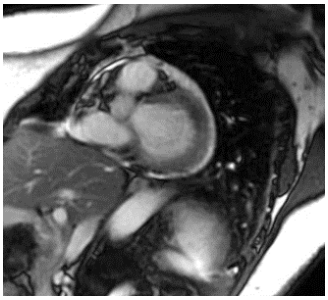
The patient was injected with 14.5 mCi of Tc99M PYP. Planar images were obtained in the Anterior, LAO 45 degrees and Left Lateral position one hour after injection of the radiotracer. Following plantar images, SPECT imaging was acquired.

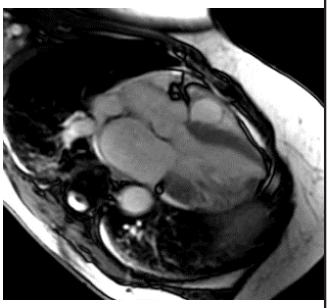
Findings: The quality of the study is adequate. Visually, semiquantitative myocardial 99mTc-PYP radiotracer uptake in the cardiac region of interest was estimated at Grade 2 (uptake equal to than rib uptake).

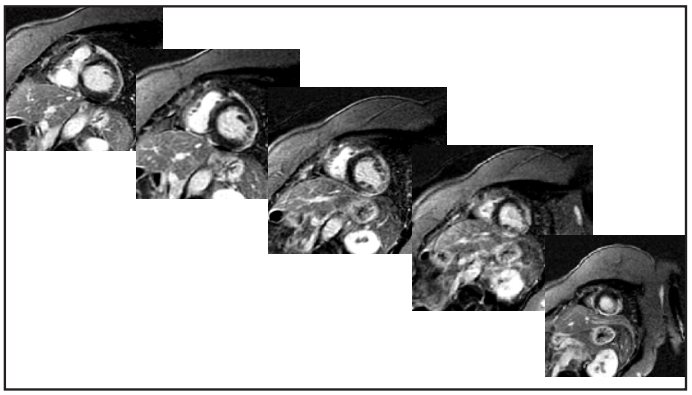


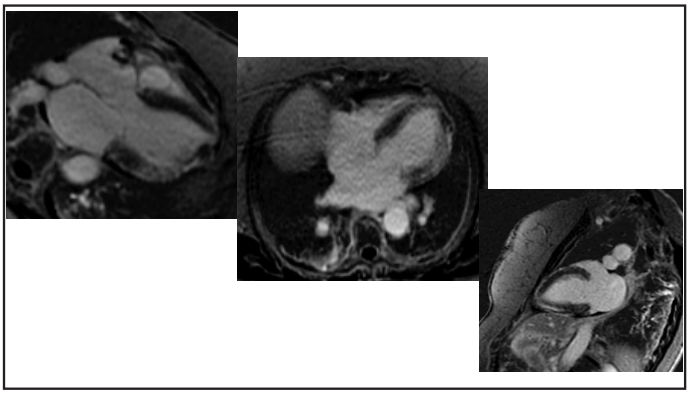


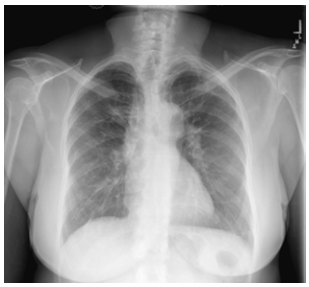
Case 9

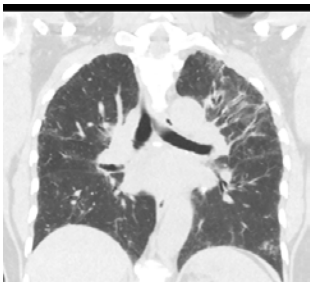


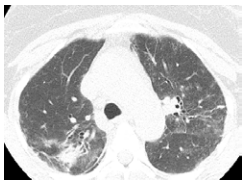








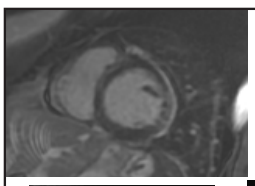


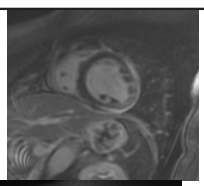


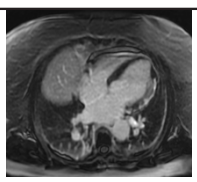
Diagnosed with pulmonary sarcoid by her report in the 1980s after presenting with night sweats and undergoing a bronchoscopic biopsy. Does not recall ever receiving any specific treatment for sarcoidosis. Initially seen in consultation in pulmonology clinic in 2017 with chronic cough.

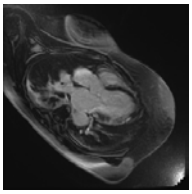
August 2020, she reported NYHA class II symptoms with some shortness of breath after climbing a flight of stairs as well as her chronic cough with clear sputum production. The cough was attributed to postnasal drip and bronchospasm. At her last pulmonology appointment in April 2021 her PFTs had improved slightly, and her symptoms remained stable.

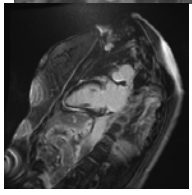
An echocardiogram was obtained to determine if there were any cardiac contributors to her dyspnea. This demonstrated low ejection fraction of 30% with several areas of hypokinesis.









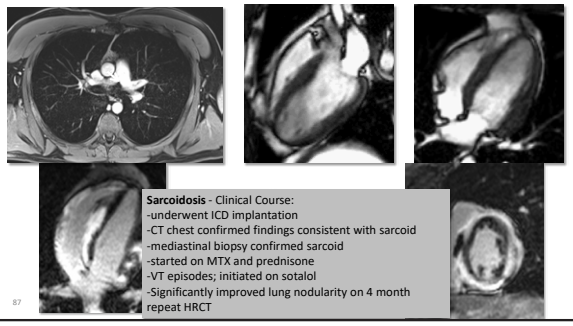


CMR July 2021 . Fairly extensive nonischemic pattern of enhancement involving the subepicardial region of the lateral wall and inferior wall base through to the apical segments. LV ejection fraction is moderately decreased at 40%.

MRI findings are highly suggestive of sarcoid myocarditis.

No vasodilator ischemic perfusion defects i.e. no inducible ischemia or evidence for obstructive coronary artery disease..

Case: 42yo man with no prior PMH admitted with syncope. "High degree AV block" on telemetry in ED. TTE showed mildly reduced LVEF otherwise no abnormalities.



Sarcoidosis - Clinical Course:
-underwent ICD implantation
-CT chest confirmed findings consistent with sarcoid
-mediastinal biopsy confirmed sarcoid
-started on MTX and prednisone
-VT episodes; initiated on sotalol
-Significantly improved lung nodularity on 4 month repeat HRCT

87

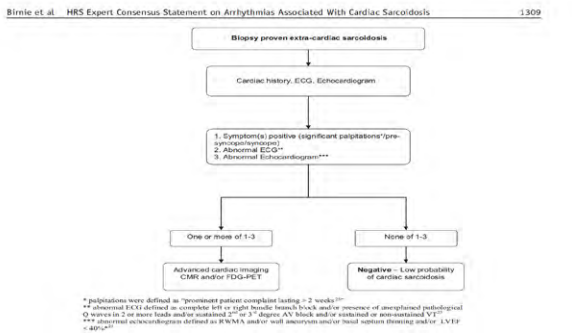
Expert Consensus Recommendations on ***Criteria for the Diagnosis of CS***

There are 2 pathways to a diagnosis of Cardiac Sarcoidosis:

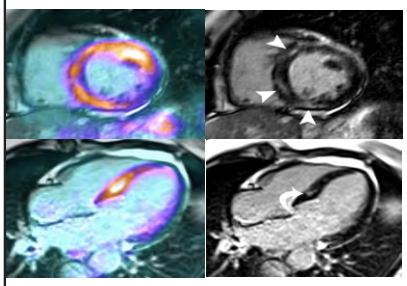
1. Histological Diagnosis from Myocardial Tissue
   CS is diagnosed in the presence of non-caseating granuloma on histological examination of myocardial tissue with no alternative cause identified (including negative organismal stains if applicable).
2. Clinical Diagnosis from Invasive and Non-Invasive Studies:
   It is probable* that there is CS if:
   a) There is a histological diagnosis of extra-cardiac sarcoidosis
   and
   b) One or more of following is present
   - Steroid +/- immunosuppressant responsive cardiomyopathy or heart block
   - Unexplained reduced LVEF (< 40%)
   - Unexplained sustained (spontaneous or induced) VT
   - Mobitz type II 2nd degree heart block or 3rd degree heart block
   - Patchy uptake on dedicated cardiac PET (in a pattern consistent with CS)
   - Late Gadolinium Enhancement on CMR (in a pattern consistent with CS)
   - Positive gallium uptake (in a pattern consistent with CS)
   and
   c) Other causes for the cardiac manifestation(s) have been reasonably excluded

*In general, 'probable involvement' is considered adequate to establish a clinical diagnosis of CS.[17]

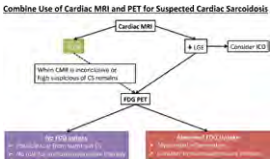
Heart Rhythm. 2014 Jul;11(7):1305-23. **HRS expert consensus statement on the diagnosis and management of arrhythmias associated with cardiac sarcoidosis.**



Heart Rhythm. 2014 Jul;11(7):1305-23. **HRS expert consensus statement on the diagnosis and management of arrhythmias associated with cardiac sarcoidosis.**



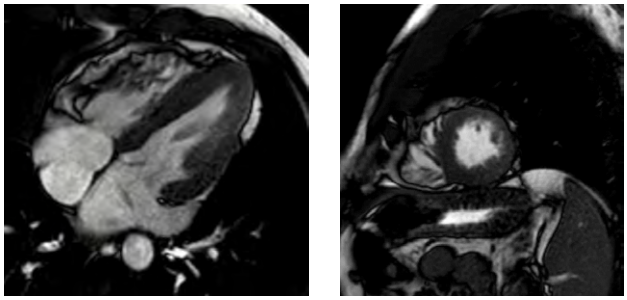
*Among patients with suspected CS, combining CMR and PET provides complementary value for estimating the likelihood of CS and guiding patient management.

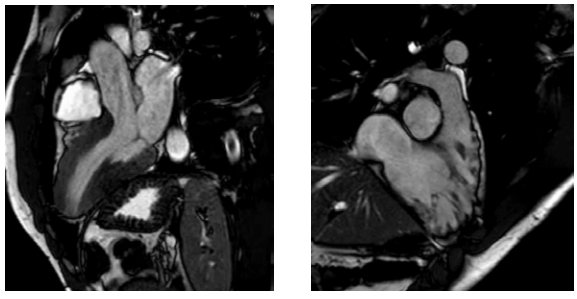


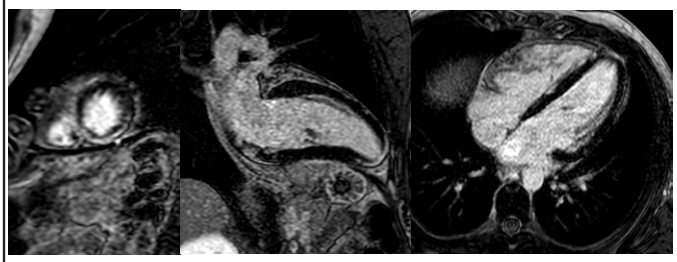
***Tomas Vita et al. Circ Cardiovasc Imaging. 2018;11:e007030**

Case courtesy Kavitha Yaddanapudi, MD. Stonybook University

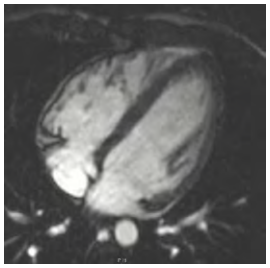
Case 10



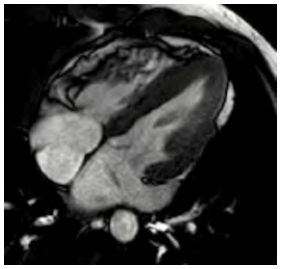




Case 10



2009



2018

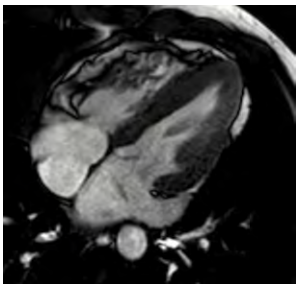
Case 10 (CMR 2018)

1. Mildly dilated right ventricle with indexed end-diastolic volume of120 mL/sq m. Moderately to severely depressed right ventricular systolic function (ejection fraction of 38%). Delay contraction and dyskinesia within the right ventricular outflow tract and anterior free wall of the RV. In this case, MRI findings fulfill one major MRI criteria for ARVD diagnosis (proposed modification of task force criteria are given below). Please note that MRI findings constitute only part of the diagnosis of ARVD which requires the presence of major and minor criteria encompassing structural, histologic, electrocardiographic, arrhythmic, and genetic factors

2. Normal size left ventricle with low-normal left ventricular systolic function

3. Subendocardial delayed enhancement within the right ventricular outflow tract and the basal septum of the right ventricle. These are new compared to the prior study.

4. Transmural and subepicardial delayed enhancement within the inferior wall of the left ventricle at the apical level along with thinning of the inferior wall consistent with chronic nonischemic scarring. These are new compared to the prior study



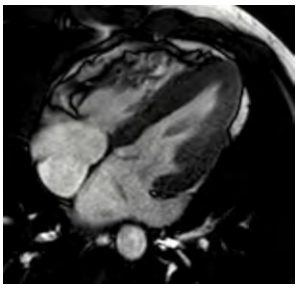
Case 10

30-year-old Male. Palpitations. Syncope . VT. Initial presentation at age 16 with palpitations

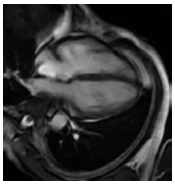
Genetic testing negative for pathogenic variants. FH negative

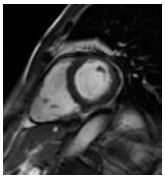
ARVC diagnosed by task force criteria. T wave inversions in leads V1-V4 and late potentials on a signal average ECG. LBBB VT patterns

Dual chamber ICD inserted 2019 . Recurrent VT. Multiple ablations pre and post ICD. On Flecanide and Sotalol



Arrhythmogenic RV Cardiomyopathy (ARVC)





Regional RV akinesia or dyskinesia

•Major Criteria
-RV EDV ≥ 110ml/m2 (males) or ≥ 100ml/m (female)
-RV EF ≤ 40%

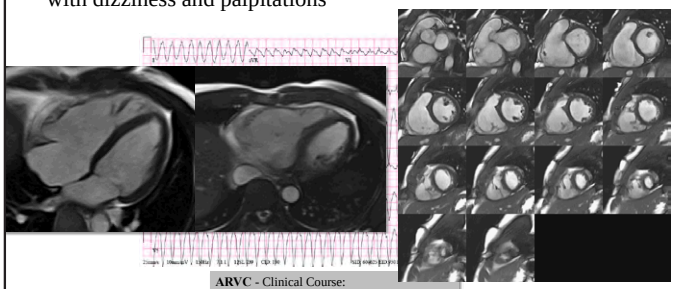
•Minor Criteria
-RV EDV 100-110ml/m2 (males) or 90-100 (females)
-RV EF 40-45%

35-year-old female. Syncope. T wave inversion in right precordial leads and epsilon waves. Dilated RV. Focal dyskinetic areas in the anterior free RV wall.

- CMR is the test of choice for imaging evaluation of RV structure and function in suspected ARVC
- Diagnosis of ARVD requires a combination of criteria derived from structural , histological, ECG, arrhythmic features and family history

Marcus FI et al. Circulation 2010; 131 (13): 1533-1541

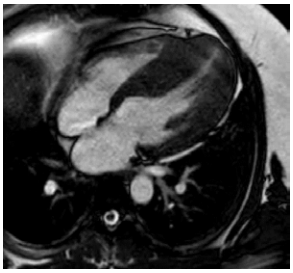
Case: 35yo firefighter with no PMH presents to the ED with dizziness and palpitations

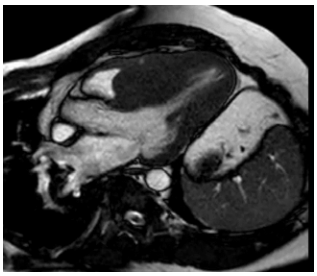


ARVC - Clinical Course:
-underwent ICD implantation
-VT episode; started on sotalol

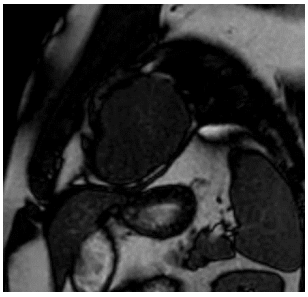
98

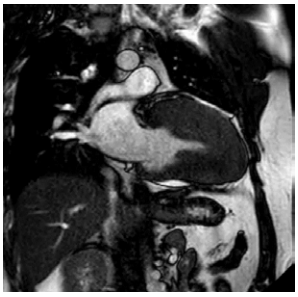
Case 11



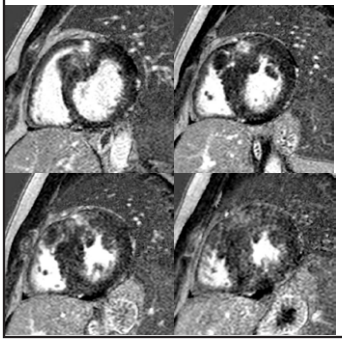


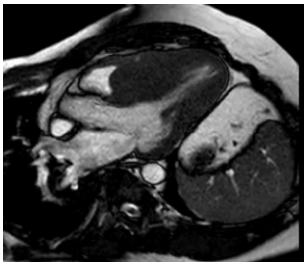
Case 11



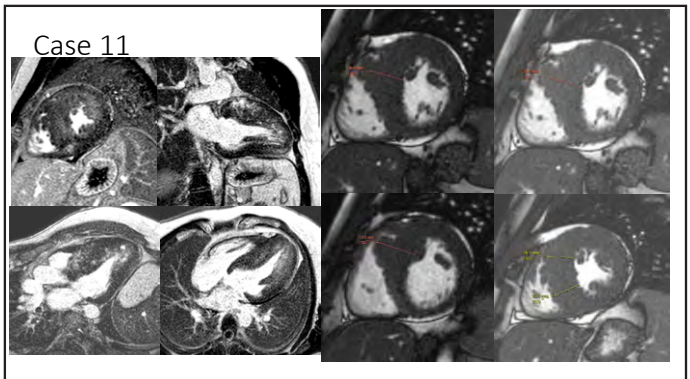


Case 11



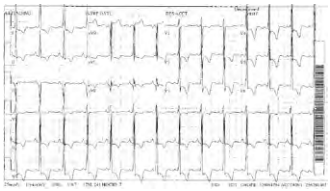


Case 11



Case 11

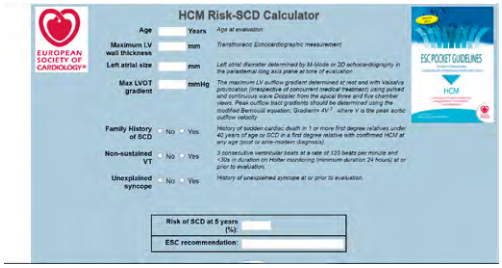
- 32-year-old man
- Came to cardiovascular attention at the time of a pre-operative primary care appointment prior to removal of a Morton's neuroma. ECG done at that time demonstrated diffuse T-wave inversions thus he was referred to an outside cardiologist
- Echocardiogram revealed evidence of HCM with asymmetric septal hypertrophy with provocable mid-cavity obstruction with valsalva and with exercise (IVSD 21mm and 42mm mid cavitary peak gradient with Valsalva)
- 5-year SCD risk was estimated to be intermediate at 4.45% so CMR was recommended for further risk stratification



Case 11

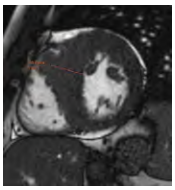
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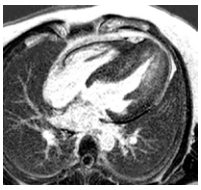
Year of Diagnosis	2018
Morphology	Asymmetric septal hypertropic with extension to mid/apical cavity
Obstruction	Provocable, mid-cavitary obstruction
NYHA Class	I
VO2 stress test	pVO2 27.1 ml/kg/min (72% predicted)
Arrhythmias/ ICD	None
HCM Associated Interventions	None
SCD risk factors:	
Max hypertrophy	21 mm
Holter/event monitoring	No NSVT event monitor 1/2019
Syncope (non-vasovagal)	None
FMH of sudden death	No
MRI delayed enhancement	Moderate to large amount of DE - 15% total myocardial mass
Left atrial size	43 mm
ESC-HCM 5yr SCD risk score	4.45 %
Genetics	2 variants of unknown significance in MYH7 and RIT1



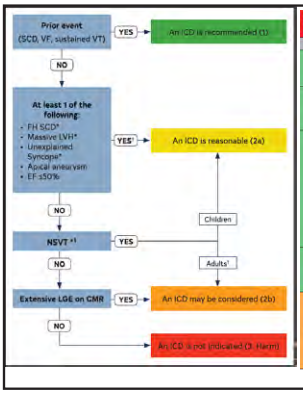
Acccording to ESC Guidelines, in patients with a 5-year risk of SCD <4%, an ICD is generally not indicated, in patients with a risk of 4 to less than 6%, an ICD may be considered and in patients with a 5-year risk ≥6%, an ICD should be considered.

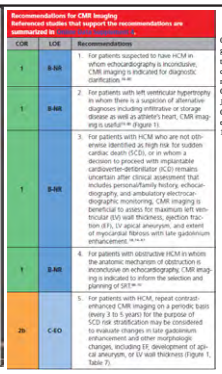
Case 11 . HCM



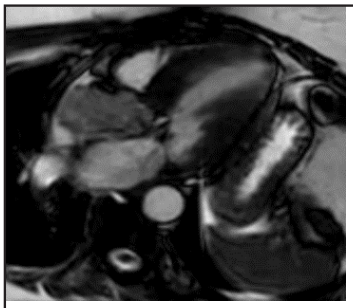


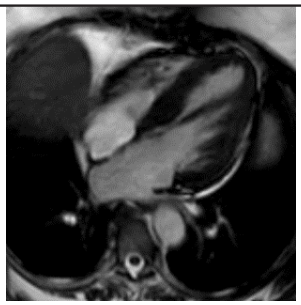
- Cardiac MRI identified massive septal thickening with extensive LGE and he was referred for ICD due to his young age, hypertrophy and scar burden
- Both the subcutaneous and intravenous ICD discussed and proceeded with subcutaneous ICD given his age and lack of ventricular tachycardia





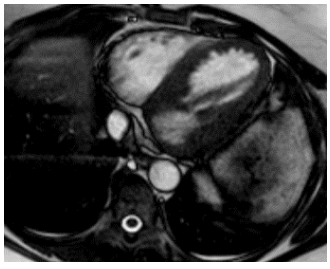
Ommen SR et al. 2020 AHA/ACC guideline for the diagnosis and treatment of patients with hypertrophic cardiomyopathy: executive summary: a report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. *Circulation*. 2020;142:e533–e557. doi:: 10.1161/CIR.0000000000000938



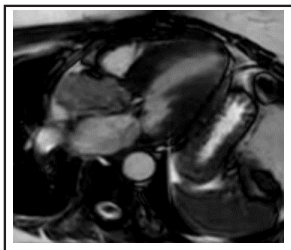


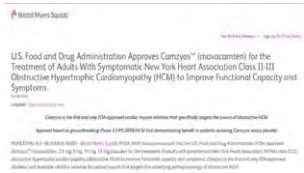
HOCM





HOCM





HOCM- Hypertrophic Obstructive Cardiomyopathy

LVOT obstruction caused by a combination of factors in HCM including basal septal hypertrophy, abnormal mitral valve and subvavlular apparatus and SAM

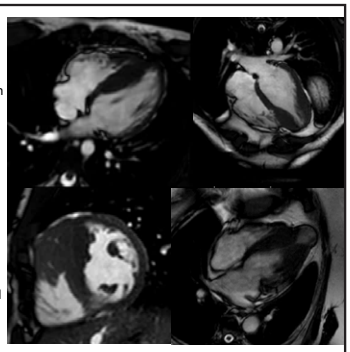
Diagnosis – Resting echo or provocation maneuvers eg Valsalva

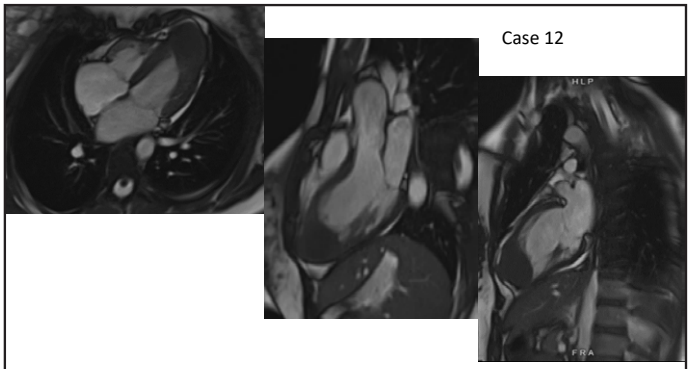
Management- Medical (Beta blockers, Calcium channel blockers, Mavacamten; Surgical – Myectomy ; alcohol septal ablation

Good hydration is important!

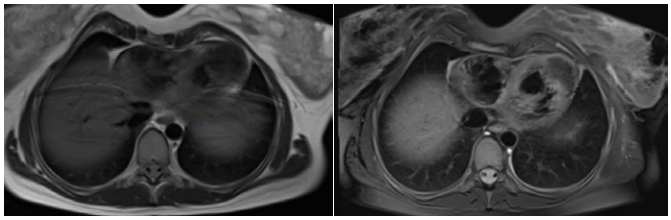
Role of CMR in HCM

- Identification of the phenotype of HCM (especially basal anterior wall and apical regions) particularly when echo windows are poor
- Differentiation from phenocopies e.g. Athletes heart, Hypertensive cardiomyopathy, Amyloid, Fabrys and other storage disorders
- Accurate measurement of wall thickness (15mm for diagnosis and 30 mm for massive hypertrophy)
- Identification of fibrosis (LGE) and its extent
- Other high risk features e.g Apical aneurysms and LV EF < 50%
- Evaluation of the anatomy of the LVOT and mitral valve apparatus when septal reduction therapies are planned

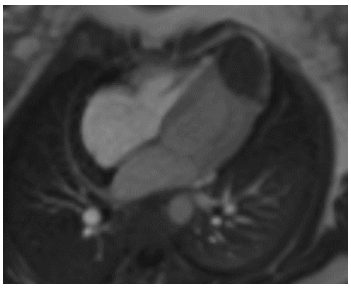




Case 12



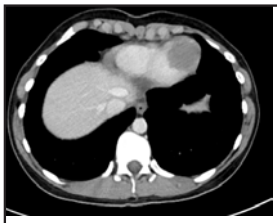
T2 TSE T2 TSE FAT SAT







Cardiac fibroma- Low signal on T1 and T2 imaging and intense enhancement post gad



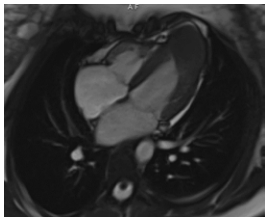


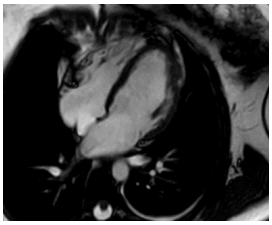


cardiac mass initially discovered on abdominopelvic CT

Case 12

- 21 F. Golin-Geltz syndrome . Incidental discovery of a cardiac mass while undergoing abdominal pelvic CT for pain. Cardiac Fibroma resected

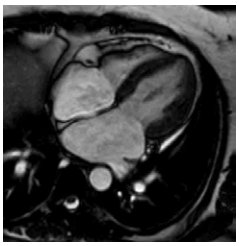
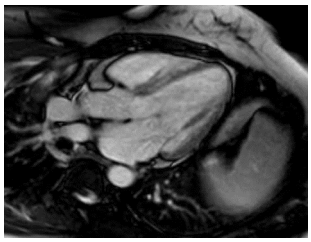


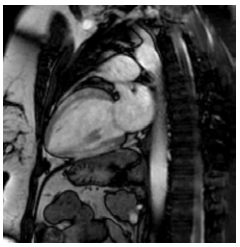
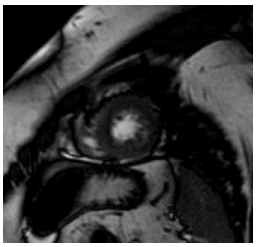


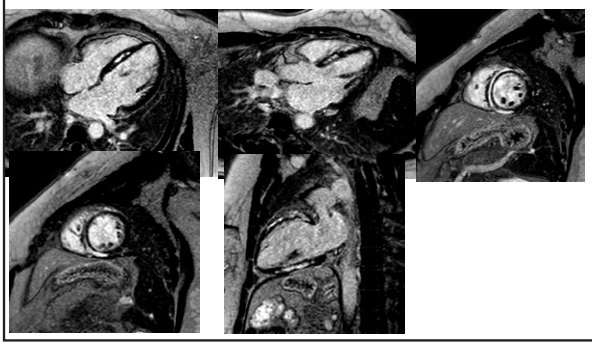
Incidental Cardiac findings that may be identified and reported *or missed* on routine Chest CT

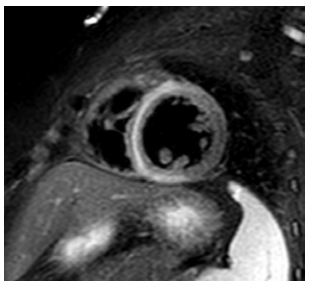
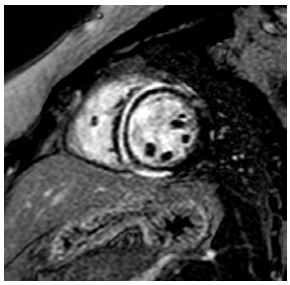
- Holes in the heart- Atrial septal defects specially Sinus venosus type ASD. Clue right heart dilatation
- Anomalous pulmonary venous return
- Cardiac chamber dilatation
- Valvular calcification especially aortic (when severe may indicate AS)
- Cardiac masses specially thrombi in the LV or LAA
- LV wall thinning or LVH
- LV wall non enhancement or calcification in chronic MI
- Pericardial thickening and calcification
- Coronary calcification specially when severe or involves the left main, proximal LAD or any coronary ostia

Case 13



T2 Black blood with fat sat (STIR)

LGE

Case 13

- Mid wall liner LGE septum and inferior wall with corresponding T2 high signal
- WMA inferior wall
- LV EF 54%
- Small pericardial effusion

CMR findings fulfill diagnostic criteria for acute myocarditis



CMR 2017

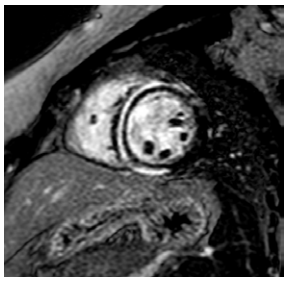
Case 13

33 F. ED presentation with chest pain and shortness of breath. Peak Troponin 123. CTA coronaries normal (prior to CMR)

CMR (2017) at admission with findings fulfilling diagnostic criteria for acute myocarditis

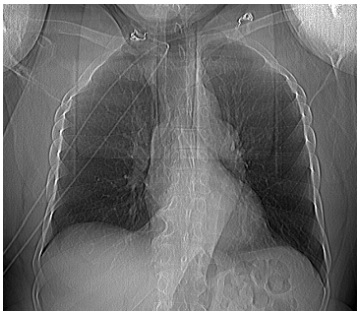
Presents with palpitations 2018 and 2019. Telemetry and EKG no arrhythmia. EP consult. No loop recorder thought needed. Symptoms did not correlate with arrhythmia

? Repeat CMR now to assess residual fibrosis



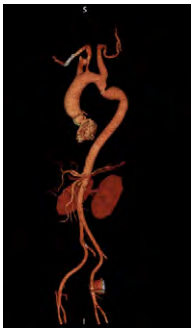
Acute Myocarditis

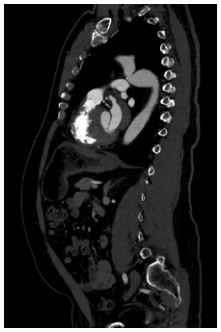
- Frequent etiology in patients with ACS yet normal coronary arteries.
- CMR is the diagnostic tool of choice in tertiary care centers for patients with evidence for acute nonischemic myocardial injury. Suspected myocarditis is one of the most frequent indications for CMR scans and, in Europe, represents about one third of CMR referrals
- CMR allows for targeting several features of myocarditis: inflammatory hyperemia and edema, necrosis/scar, contractile dysfunction, and accompanying pericardial effusion (Lake Louis criteria)
- The presence of LGE is an independent predictor of all-cause mortality and of cardiac mortality. Patients with normal CMR have a good prognosis



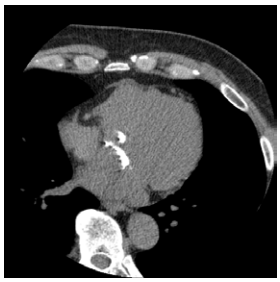
Case 14

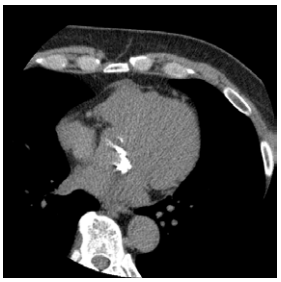
72 M

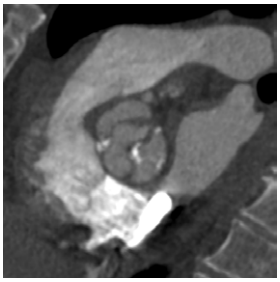




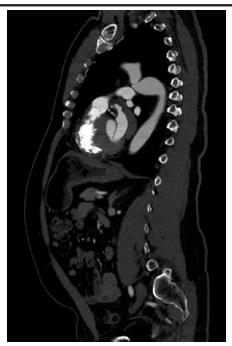
CoA peak to peak gradient 8-12mm on cath







72 M. Coarctation of the aorta with a Bicuspid Aortic valve. AS TAVR CT



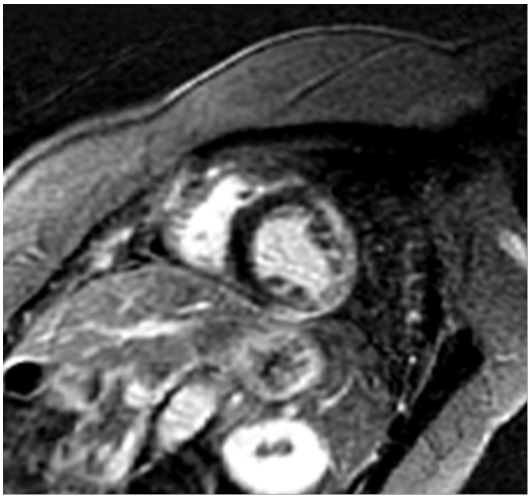
Thank you !

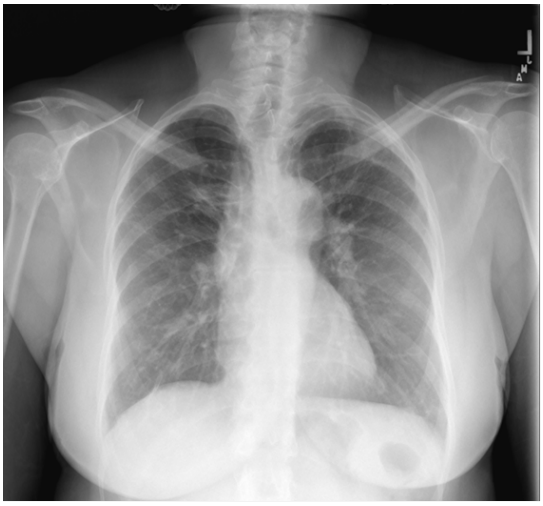
Anil Attili, MD
aattili@umich.edu

SELF EVALUATION

Cardiac MR and CT Case Reviews

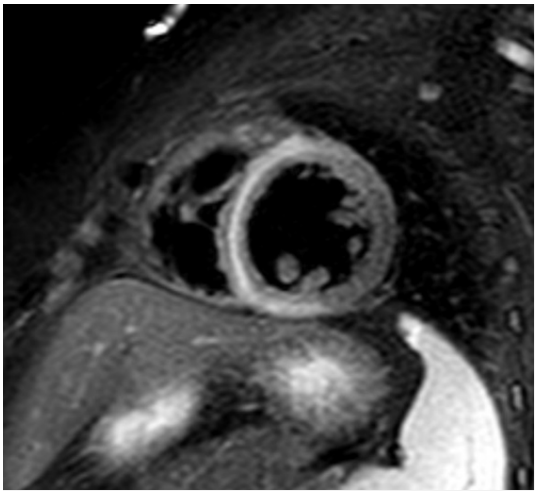
1. Late gadolinium enhancement and a CXR from a 50 year old woman with shortness of breath and palpitations are presented below. Which of the following is the most likely diagnosis?

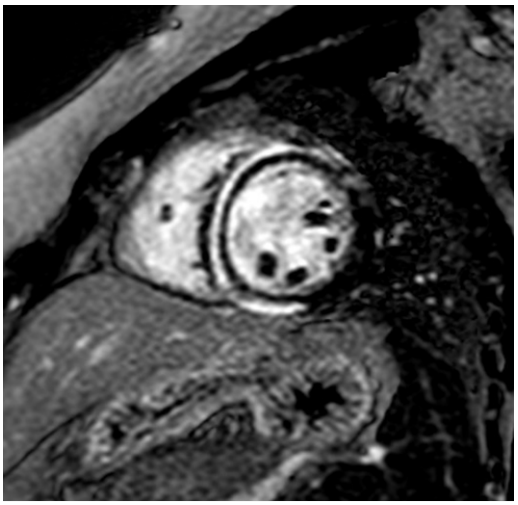




a. Myocardial infarction in the circumflex coronary artery distribution
b. Cardiac amyloidosis
c. Histoplasmosis affecting the heart
d. Cardiac sarcoidosis
e. Acute viral myocarditis

2. T2 fat suppressed short axis and short axis late gadolinium enhancement images are shown below in a 30 year old woman presenting to the ED with chest pain. What is the most likely diagnosis?

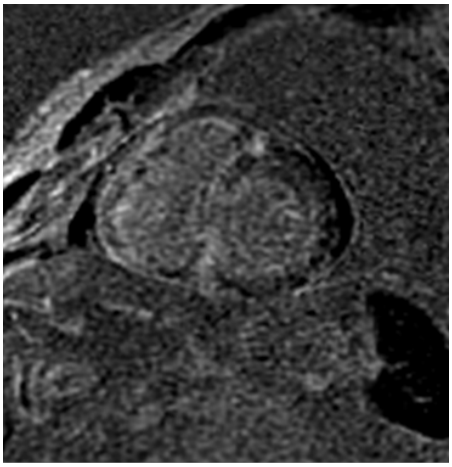


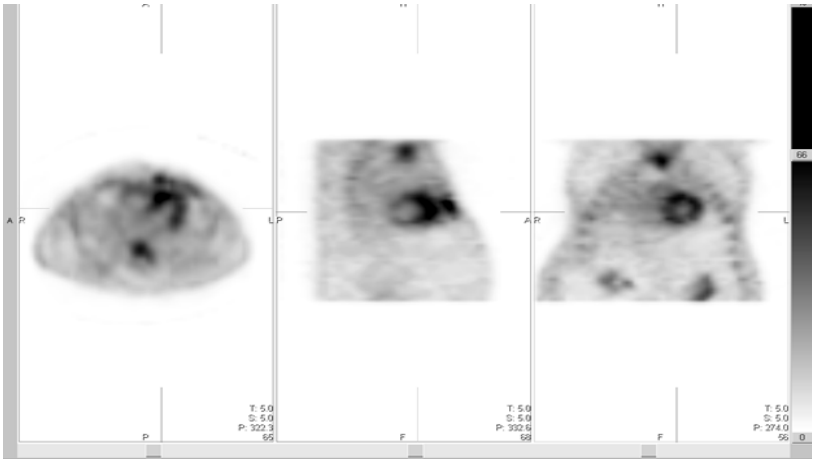


a. Myocardial infarction
b. Cardiac Sarcoidosis
c. Acute viral myocarditis
d. Cardiac Amyloidosis
e. Arrhythmogenic right ventricular cardiomyopathy

Cardiac MR and CT Case Reviews (cont.)

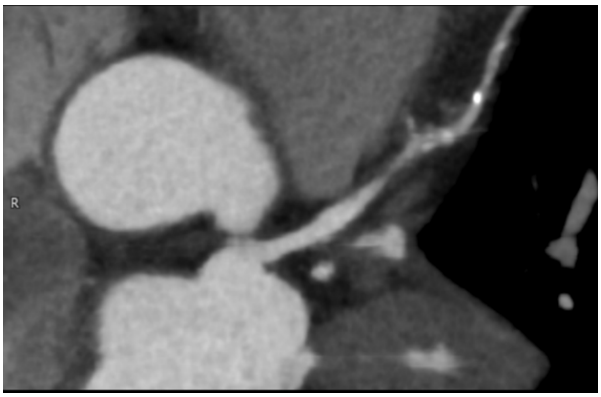
3. Late gadolinium enhanced images and results of a Tc99M PYP bone scan are presented below in a patient with heart failure. Which of the following is the most likely diagnosis?

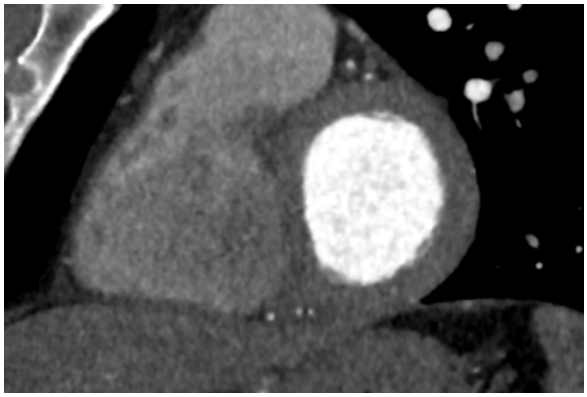




a. AL Amyloid
b. Idiopathic non ischemic dilated cardiomyopathy
c. Constrictive pericarditis
d. ATTR Amyloid
e. Multivessel coronary artery disease

4. CTA reconstructions in a 50 M with chest pain on exertion are presented. What would be the correct CAD- RADS score to be reported if the remainder of the CTA examination showed no abnormalities?

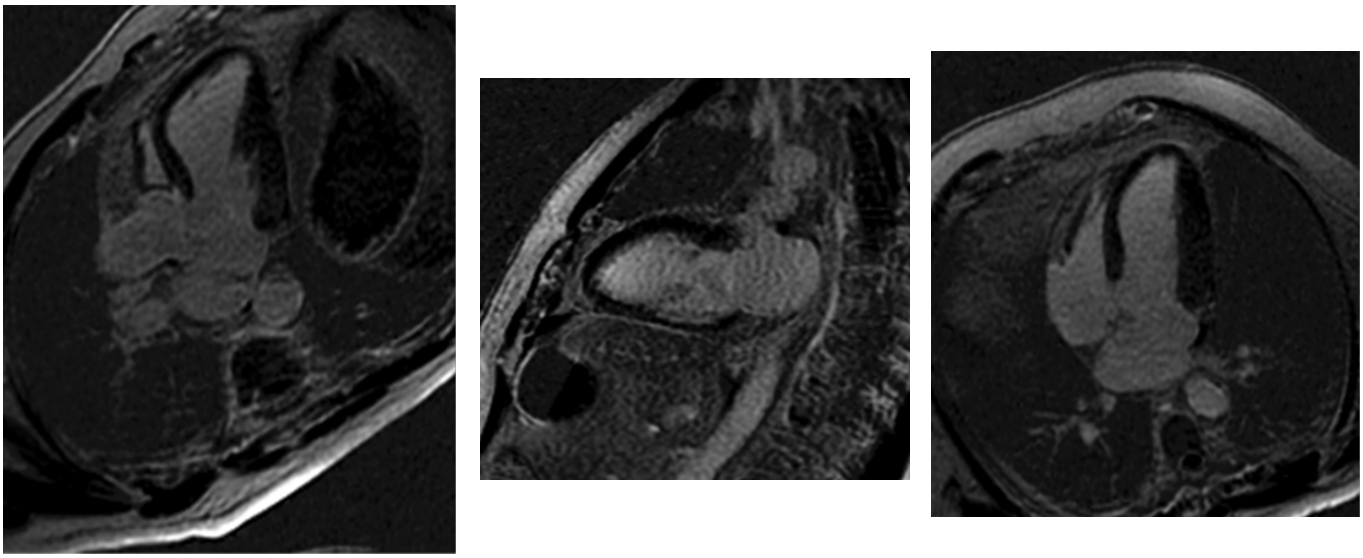




a. CAD-RADS 0
b. CAD-RADS 1
c. CAD-RADS 2
d. CAD-RADS 4A
e. CAD-RADS 5

Cardiac MR and CT Case Reviews (cont.)

5. Late gadolinium enhanced images from a patient with chest pain and a severely decreased ejection fraction. Which of the following is the most likely diagnosis?



a. Non viable infarct in the RCA territory
b. Viable infarct in the RCA territory
c. Viable infarct in the LAD territory
d. Non viable infarct in the LCX territory
e. Acute myocarditis

6. Mark the FALSE statement regarding the benefits and applications of CCTA.

a. Coronary artery calcium (CAC) scoring may be used for risk stratification and reclassification in asymptomatic patients with intermediate probability of coronary artery disease (CAD).
b. The use of CCTA is appropriate for detection of obstructive CAD in symptomatic patients when functional stress testing cannot be performed or is nondiagnostic
c. The use of CCTA in the emergency department in patients with chest pain and negative cardiac enzymes allows safe discharge, reduces length of stay, and is cost saving.
d. The use of CCTA is appropriate for preoperative evaluation in patients undergoing heart surgery for noncoronary indications when the risk of CAD is low to intermediate.
e. A major advantage of CCTA is its high positive predictive value for detection of obstructive CAD

Cardiac MR and CT Case Reviews (cont.)

7. Which of the following statements is FALSE regarding the applications of CMR in ischemic heart disease (IHD)?

a. Late gadolinium enhancement (LGE) has a higher spatial resolution and accuracy than cardiac single-photon emission computed tomography (SPECT) for detection of MI and viability.
b. CMR myocardial stress perfusion imaging has a higher sensitivity and specificity than cardiac SPECT for detection of obstructive coronary artery disease.
c. CMR is appropriate for evaluation of ventricular size and function in IHD when echo windows are unsatisfactory.
d. CMR is the test of choice for direct anatomical evaluation of coronary stenosis.
e. The identification of microvascular obstruction on CMR is an adverse prognostic finding in IHD.

8. The most common area of scarring/late gadolinium enhancement in CS is at which of the following locations?

a. Basal interventricular septum
b. Inferior wall left ventricle
c. Lateral wall left ventricle
d. Anterior wall left ventricle
e. Anterior wall right ventricle

Answer Key: 1. D, 2. C, 3. D, 4. D, 5. B, 6. E, 7. D, 8. A

FACULTY

Gary J. Whitman, MD

Dr. Gary J. Whitman is a Professor of Breast Imaging and Breast Radiation Oncology at The University of Texas MD Anderson Cancer Center, where he serves as Director of Breast Imaging Research and Medical Director of the Mobile Mammography Program. A national leader in breast imaging, he has held major leadership roles including President of the American Roentgen Ray Society and currently serves as Vice President of the Society of Breast Imaging. His work focuses on advancing breast imaging, particularly in high-risk screening and mobile mammography.

You may contact Dr. Whitman with any questions or comments at gwhitman@mdanderson.org.

Breast Biopsy Techniques

Gary J. Whitman, MD

Breast Biopsy Techniques

Gary J. Whitman, MD
The University of Texas
MD Anderson Cancer Center

Disclosures

- Consultant, Siemens
- Editor, UpToDate
- Vice President, Society of Breast Imaging

Objectives

- Discuss strengths and limitations of US-guided core biopsy
- Identify challenges associated with US-guided core biopsy procedures and discuss solutions
- Discuss imaging-pathology concordance
  - Explore ways to improve concordance

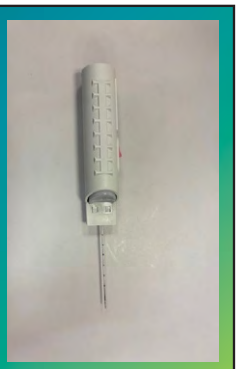
Breast Biopsies

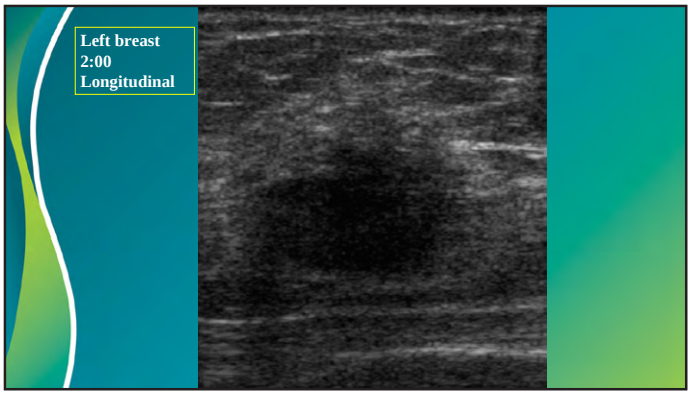
- Nearly all breast biopsies performed with percutaneous techniques
- Nearly all biopsies of masses are US-guided
  - Core biopsy
  - Vacuum-assisted biopsy
  - Fine needle aspiration (FNA)

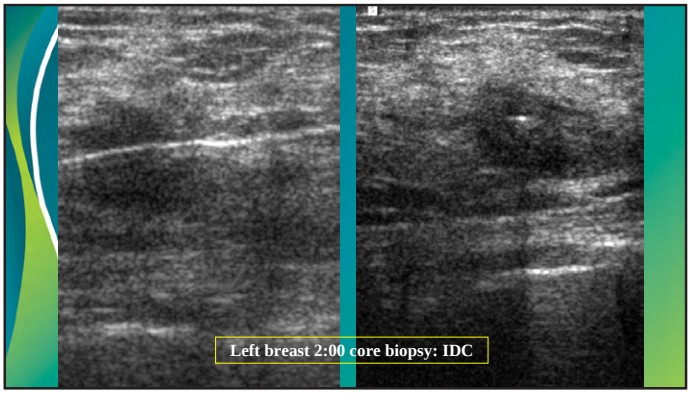


Rather than surgery….

US-guided percutaneous core biopsy







Plan

- Review US-guided core biopsy procedures
- Advantages and disadvantages
- Pre-procedural preparations
- Biopsy techniques
- Imaging-pathologic correlation

US-Guided Biopsies

- Can be performed **quickly**
- Less expensive than stereotactic and surgical procedures
  - Decreased cost of diagnosis by 56% (compared to surgical biopsy)

Liberman et al. Radiology 1998;208:717-23

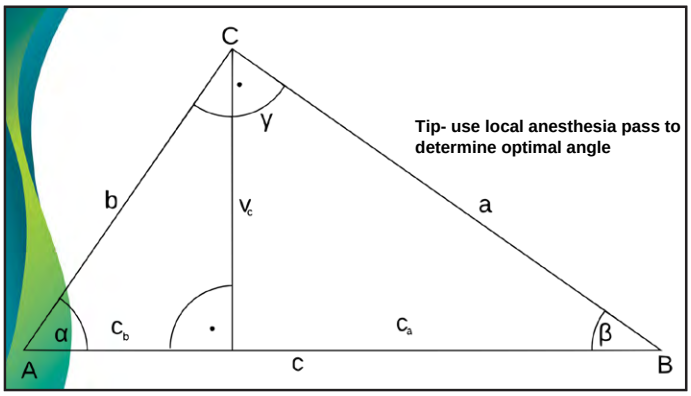
US-Guided Procedures

- US does not use ionizing radiation
- US – **access to all areas of the breast and the regional lymph nodes**
  - Axillary (core or FNA)
  - Infraclavicular (FNA)
  - Internal mammary (FNA)
  - Supraclavicular (FNA)

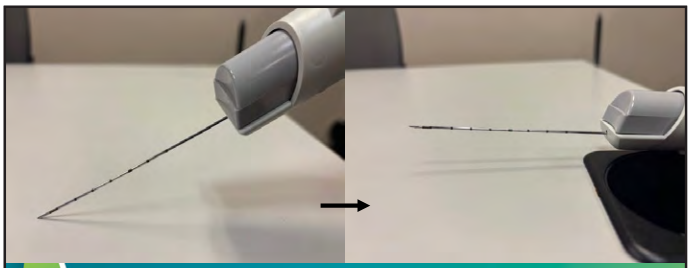
US-Guided Procedures

- Requires operator skill
- Hand-eye coordination
- One hand holding the probe; one hand holding the biopsy device

Applied geometry



Tip- use local anesthesia pass to determine optimal angle



See needle better with less angle
Aim for needle to be parallel to chest wall

Real-Time Monitoring

- See needle tip in the lesion
- Document needle in the lesion
  - Orthogonal views

Visualization with US

- If a lesion can be seen with US, it should be amenable to an US-guided biopsy
  - Depending on location
    - Near chest wall
    - Near implant

US-Guided Core Biopsy

- Review images (mammograms, US, MRI)
- Discuss case with sonographer and/or assistant
- Position patient (wedge)
- Position proceduralist (stool)
- Perform the biopsy
- Inspect the cores
- Place a clip
- Post-procedure mammography

Patient Positioning

- Positioning with US
  - Patient supine (medial lesions)
    - Supine oblique (lateral lesions)
- More comfortable than:
  - Mammography (patient seated)
  - Stereotactic bx (patient prone or seated)
  - MRI-guided bx (patient prone)

Wedge



Wedge



The wedge flattens the outer breast

US Procedure Room

- Patient bed with wheels
- Patient bed with adjustable height
- Chair/stool for operator
- Control room lighting
  - Dimmer switch

Two Monitors



Skin Cleaning

- Skin cleaned with Betadine, chlorhexidine, and/or alcohol
- Sterile probe cover
- Alcohol or sterile gel used for transducer contact

Local Anesthesia

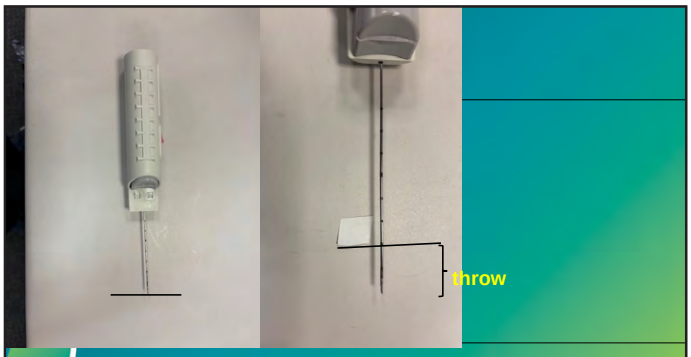
- Lidocaine (mixed with sodium bicarbonate)
  - 10 lidocaine: 1 sodium bicarbonate
- Lidocaine with epinephrine (deeper anesthesia)
  - Scan with color Doppler or power Doppler to identify vessels or vascular components

US-Guided Core Biopsy

- Most frequently performed US-guided procedure in breast imaging
- Automated needles
- Vacuum-assisted devices

Automated Core Needles

- 14 g
- 16 g
- 18 g
- Most commonly used: 14 g with long throw (2.2 cm)



Short Throw Needles

- Short throw (1 cm)
- May be useful:
  - Axilla
  - Axillary tail
  - Chest wall
  - Implant

What Gauge Needle?

- 14 g > 16 g > 18 g
- 14 g: larger specimens
- 14 g: better in terms of:
  - Tissue fragmentation
  - Crush artifact
  - Adequacy of tissue for diagnosis

Helbich et al. AJR 1998;171:59-63

US-Guided Core Biopsy

- 181 breast lesions
- 14 g core biopsies
- 49 lesions□ surgery
  - 100% correlation between US bx diagnoses and surgical diagnoses

Parker et al. Radiology 1993;187:507-11

US-Guided Core Biopsy

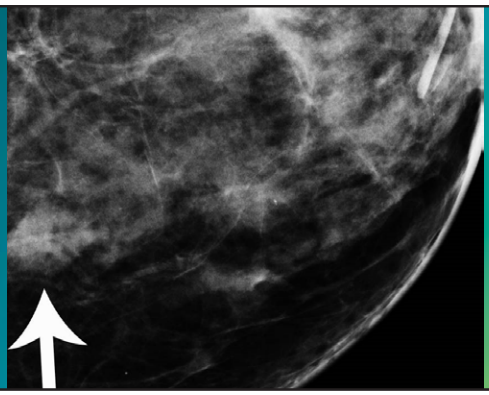
- US bx: 132 benign lesions
- 12-36 month follow-up
  - No cancers identified

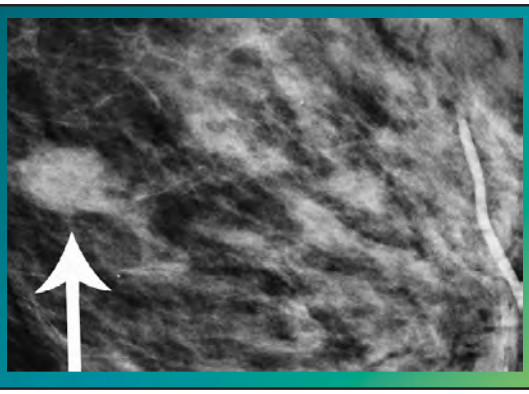
Parker et al. Radiology 1993;187:507-11

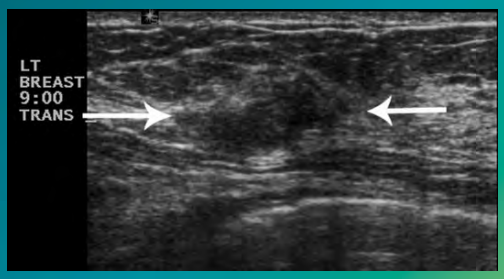
Over 30 yrs later, US-guided core biopsy has been firmly established as the best way to sample masses seen on US

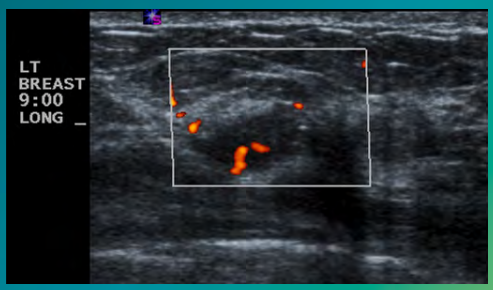
65-Year-Old Woman

- Left breast 9:00 mass
- Identified on screening mammography







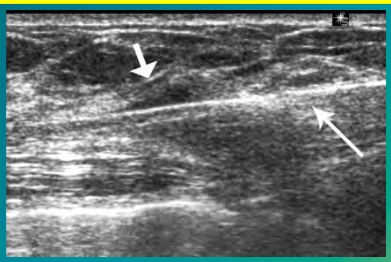


Power

US-Guided Core Biopsy

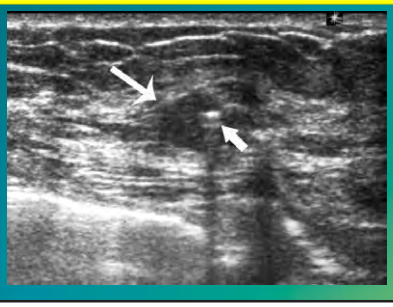


US-Guided Core Biopsy



Long arrow = core biopsy needle

Orthogonal View

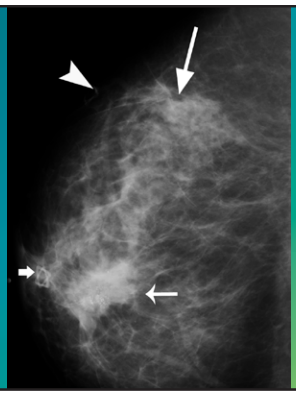


Pathology

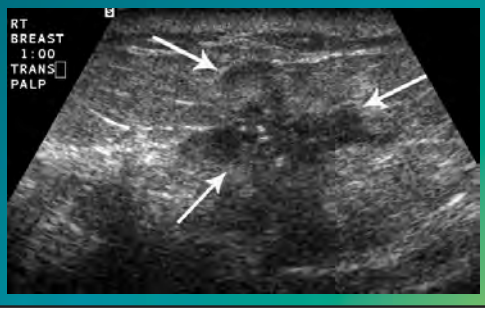
- Core biopsy: invasive ductal carcinoma
- Segmental resection: invasive ductal carcinoma with DCIS close to margins
- Mastectomy: DCIS

52 Year-Old Woman

Two palpable abnormalities (triangular markers) on CC mammogram



Right Breast 1:00



Right Breast 1:00 Core



Right Breast 1:00 Core



Bayonet artifact

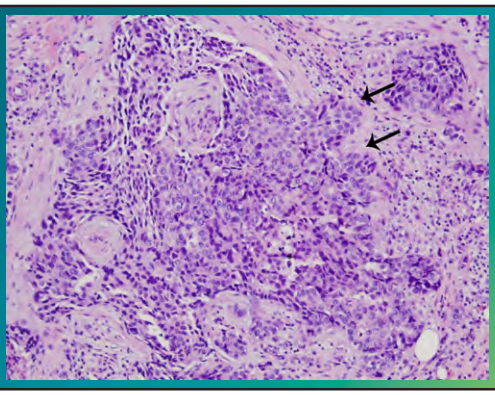
(due to differences in speed of sound)

Orthogonal View

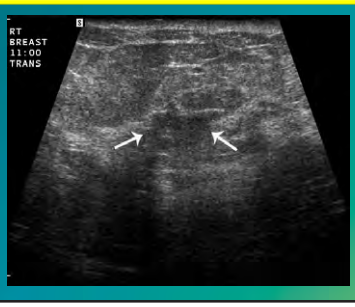


Right Breast 1:00 Core

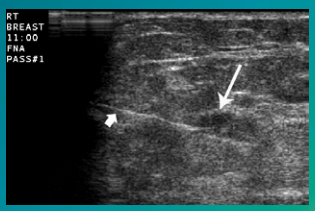
- Pathology: invasive ductal carcinoma
  - High grade



Right Breast 11:00

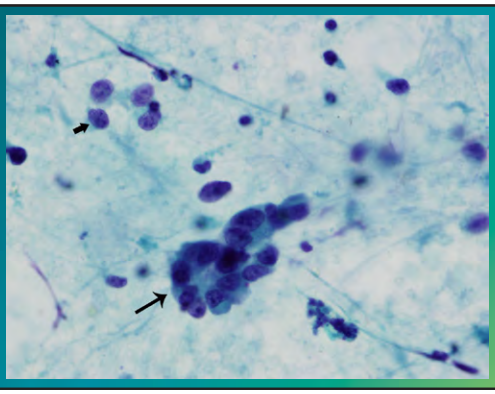


Right Breast 11:00 FNA



Right Breast 11:00 FNA

- Cytology: ductal carcinoma



Expert Cytology Support

- ESSENTIAL component of a successful FNA program

715 US-Guided Core Biopsies

- 652 patients
- 14 g needle
- Sensitivity of core biopsy: 96.3%
- False negative rate: 3.7%

Crystal et al. JCU 2005;33:47-52

31 Additional Biopsies

- Original core biopsy: benign
- 31 lesions □ additional sampling
  - Indeterminate pathologic findings (5)
  - Disagreement between imaging and pathology (14)
  - Patient or surgeon preference (12)

Crystal et al. JCU 2005;33:47-52

31 Additional Biopsies

- 25 open excisional biopsies
- 4 prone vacuum-assisted stereotactic biopsies
- 2 repeat ultrasound-guided core biopsies

Crystal et al. JCU 2005;33:47-52

31 Additional Biopsies

- 9 additional cancers were found
- Imaging-pathologic discordance → repeat biopsy in 14 lesions and 7 lesions were malignant
- 5 lesions excised because of indeterminate pathologic findings and 2 were malignant

Crystal et al. JCU 2005;33:47-52

Imaging Follow-Up

- Fatty breasts → mammography
- Dense breasts → mammography and US
- Follow-up on 373 lesions with benign US-guided core biopsy results
  - Range: 27-60 months
  - Median: 39 months

Crystal et al. JCU 2005;33:47-52

Imaging Follow-Up

- During follow-up, 3 carcinomas were discovered at the site of a prior core biopsy which showed benign results
- Size range of carcinomas: 9-13 mm
- 2 of the 3 malignancies were invasive lobular carcinomas

Crystal et al. JCU 2005;33:47-52

Discordant Benign Diagnoses

- 26/828 (3.14%) – discordant benign diagnoses
  - Stereotactic and ultrasound-guided core biopsies
- 20 biopsies repeated
- 10/20 (50%) of repeated biopsies – malignancy

- Rjoop et al. BMC Women's Health. 2025, 25:47

Discordant Benign Diagnoses

- Oval shape more common in benign pathology
  - p = 0.035
- Posterior shadowing less common in benign lesions
  - p = 0.050

- Rjoop et al. BMC Women's Health. 2025, 25:47

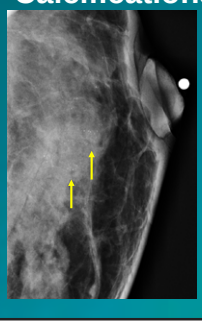
Discordant Benign Diagnoses

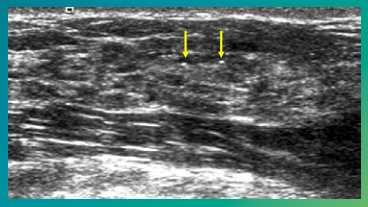
- Carefully review cases with non-specific benign diagnoses
  - Fibrosis
  - Fibrocystic changes

US-Guided Core Biopsy of Calcifications

- Calcifications within masses
- Calcifications without an associated mass
- US-guided biopsy of calcifications
  - Calcifications close to nipple or skin
  - Thin breast
  - Heavy patient
    - Beyond weight limit for stereotactic table

Calcifications





Biopsy: benign calcifications

Vacuum-Assisted Biopsy

- Conventional core biopsy may be suboptimal for sampling:
  - Calcifications
  - Small (< 1.5 cm) masses
  - Papillary lesions

Vacuum-assisted biopsy may be helpful for avoidance of surgical excision
- Radial scars with no atypia

Vacuum-Assisted Biopsies

- Some advantages compared to core needles
- Firing not required
- Tissue can be acquired at a distance from the probe
  - Not only in the line of fire
  - Tissue can be pulled into the sampling chamber

Vacuum-Assisted Biopsy

- 1 insertion
- Multiple samples
- Larger cores
  - Larger than cores from 14 g core needles

Vacuum-Assisted Biopsy

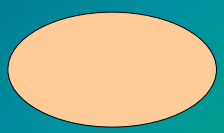
- Fewer underestimates compared to core biopsy
  - ADH □ DCIS
  - DCIS □ invasive ductal carcinoma
    - Major issue in stereotactic biopsy
    - Less of an issue in US-guided biopsy

Vacuum-Assisted Biopsy

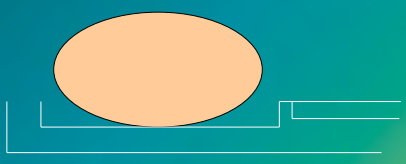
- Less epithelial displacement compared to core biopsies
- Epithelial displacement = displacement of benign or malignant epithelium away from targeted lesion
- Displaced DCIS may mimic invasive ductal carcinoma

Parker et al. AJR 2001;177:405-8

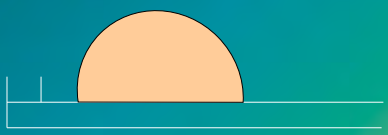
Targeted Mass



Vacuum-Assisted Biopsy



Vacuum-Assisted Biopsy



Vacuum-Assisted Biopsy



US-Guided Core Biopsy

- Advantages and disadvantages
- Pre-procedural preparations
- Biopsy techniques
- Imaging-pathology correlation

US-Guided Procedures

- Core biopsy
- Vacuum-assisted biopsy
- FNA
- Marker placement
- Needle localization

Basic concepts are similar for all US-guided procedures

US-Guided Core Biopsies

- Most core biopsies of masses with US guidance
  - Easily tolerated by patients
  - Quick
  - Reliable
- US-guided core biopsies □ accurate diagnoses
  - Single surgical procedure
  - With adequate margins

STEREOTACTIC BREAST BIOPSY

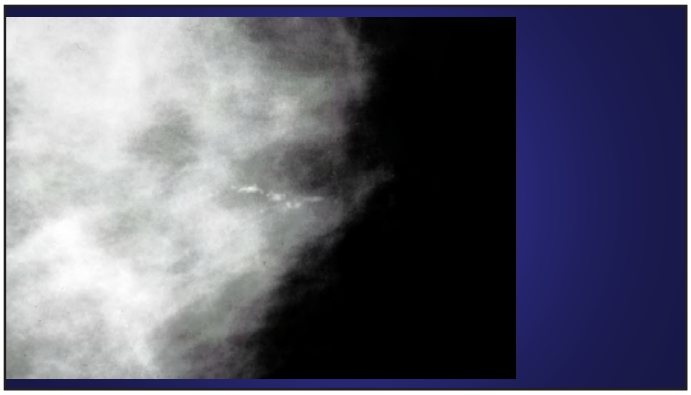
Gary J. Whitman, M.D.
The University of Texas
MD Anderson Cancer Center

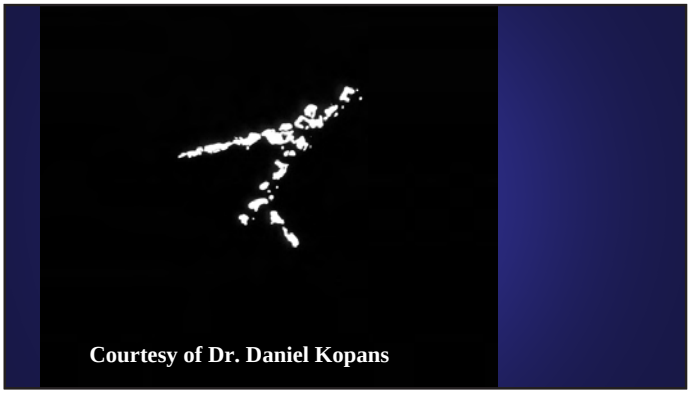
Special Thanks

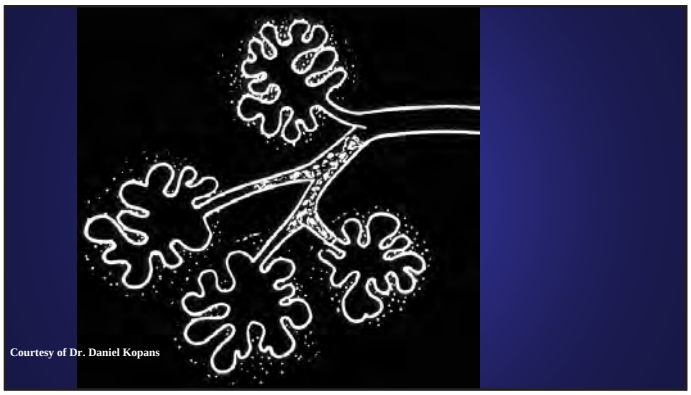
- Deborah Davis and Debra Dawson
- Helped to prepare this presentation

Breast Cancer

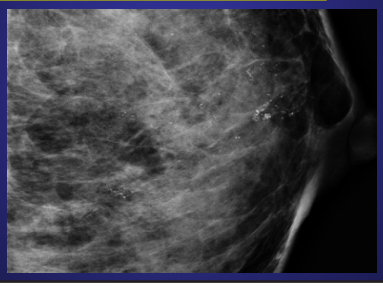
- 90% originate in ductal epithelial cells
  - ductal carcinoma in situ (DCIS)
  - infiltrating ductal carcinoma







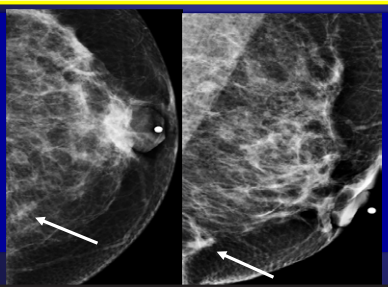
Invasive Ductal Carcinoma



Breast Cancer

- 10% originate in lobular epithelium
  - invasive lobular carcinoma

Invasive Lobular Carcinoma

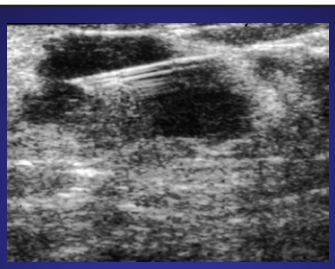


Decreasing Breast Cancer Morbidity

- Detection of early intraductal carcinomas and node-negative invasive carcinomas
- Identification and biopsy of small (early) cancers

Stereotactic Biopsy

- Precise method for biopsy of:
  - Calcifications
  - Architectural distortions (DBT)
  - Small masses (DBT)
- Larger masses usually biopsied with sonographic guidance



IDC

- US guidance quicker and cheaper than stereotactic or MRI guidance
- US guidance – better tolerated by patients

Stereotactic Biopsy

- Accurate method to biopsy:
  - Benign lesions
  - High risk lesions (ADH, ALH, LCIS)
    - Appropriate percutaneous sampling may avert surgical excision
      - Especially with focal (minimal) ADH
        - » Careful multidisciplinary review
  - Malignant lesions

Stereotactic Biopsy

- Accurate
- Safe
- Quick
- Little pain
- Short learning curve
- Cheaper than surgical biopsy
  - Surgical biopsy > MR biopsy > stereotactic biopsy > US biopsy

Calcifications

- Most frequently targeted lesions
- Most frequently missed lesions
- Require precise targeting
  - Target on distinctive component of calcification cluster (especially in large clusters)
  - May use DBT for targeting
  - Be alert for patient motion

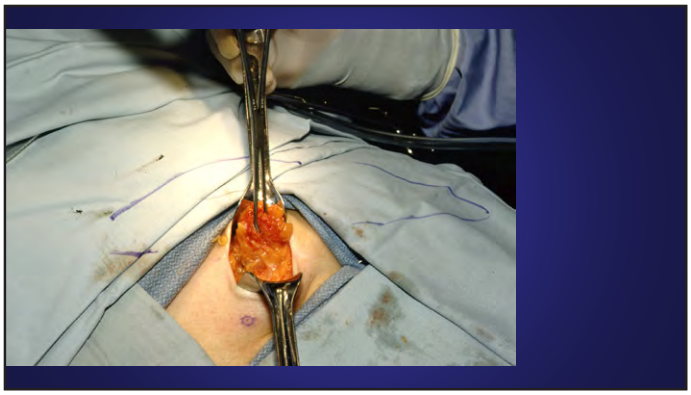
Stereotactic Biopsy

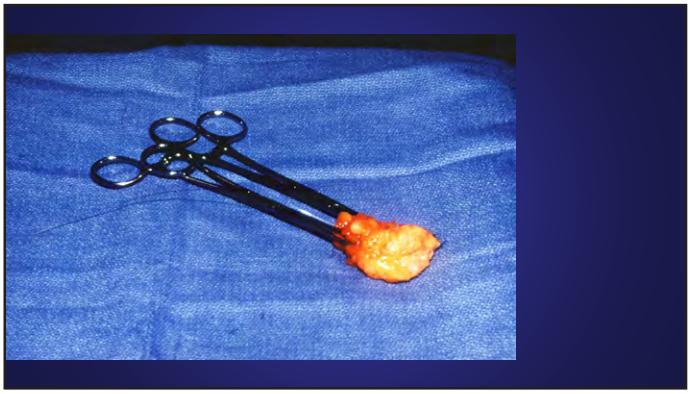
- Malignant lesions: allows for one definitive surgical procedure
- Benign lesions: nearly eliminates surgical biopsy of all benign lesions

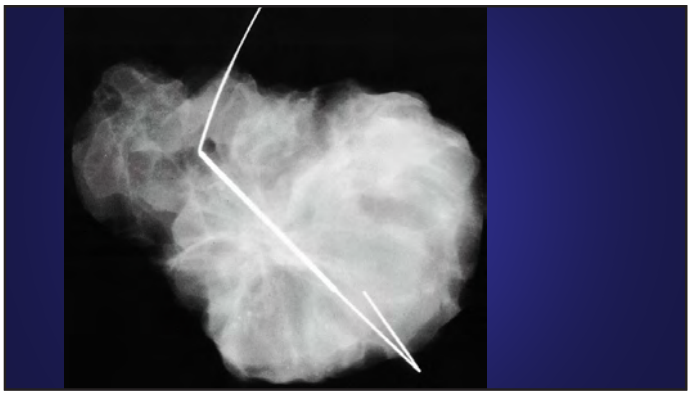


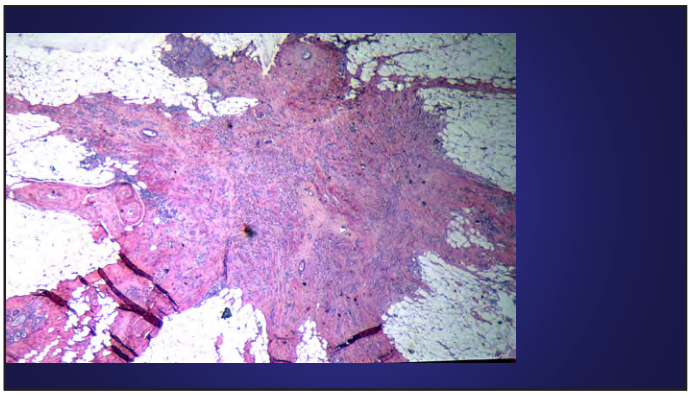


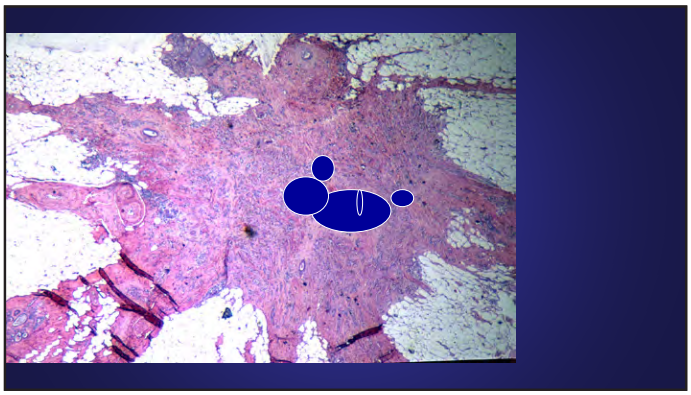


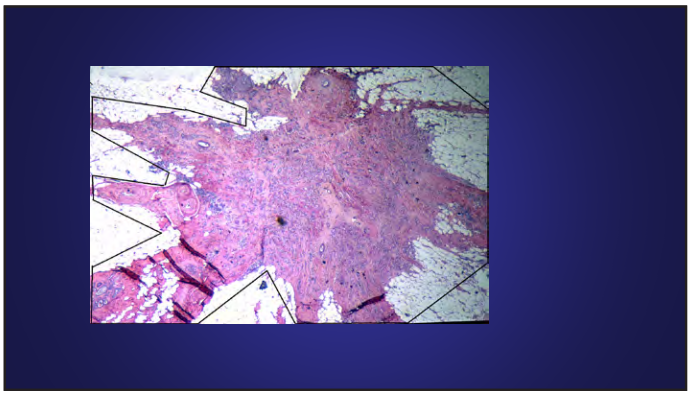


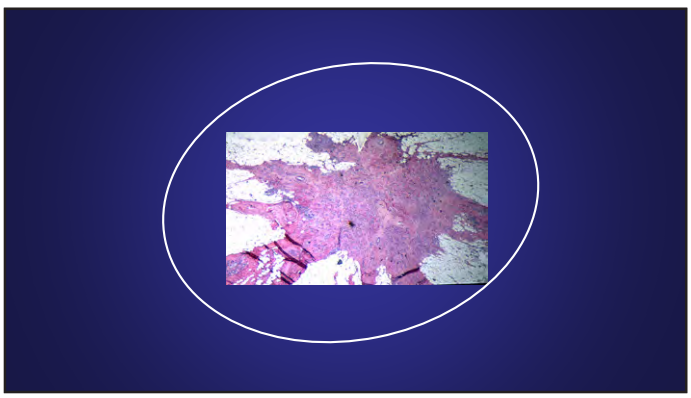












Stereotactic Biopsy

- Should not be used instead of six month follow-up mammography for probably benign lesions
- Probably benign = BI-RADS 3
  - Less than 2% probability of malignancy
  - Follow-up imaging in 6 months
  - To document stability

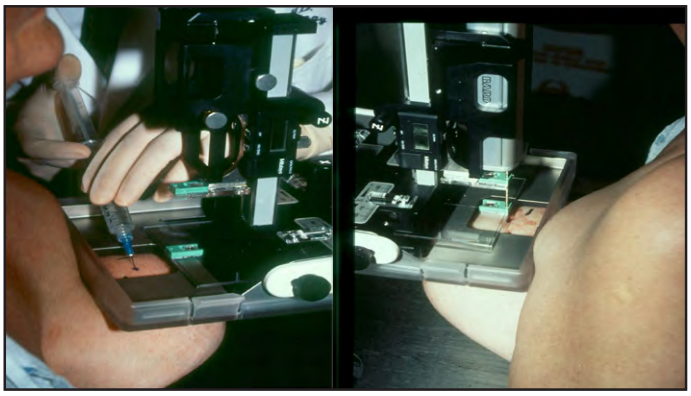
Stereotactic Equipment

- Add-on devices (upright)
  - Can position patient on side on stretcher
  - More efficient use of equipment
- Prone tables
  - Dedicated for biopsies/localizations

Stereotactic Biopsy







Positioning the Patient



Positioning the Patient



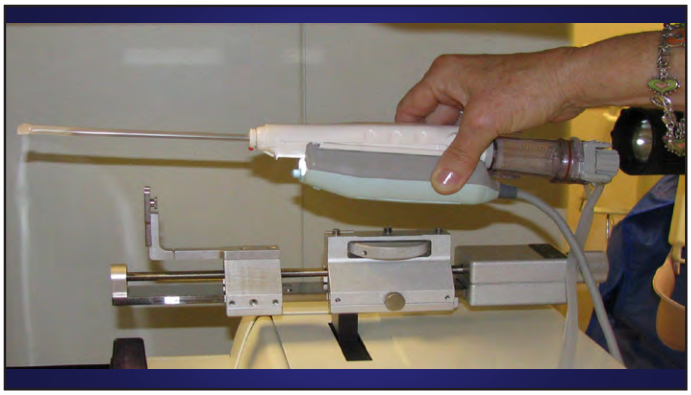


Try to make the patient comfortable (especially head/neck)



Improved Accuracy

- 18g ☐ 16g ☐ 14g ☐ 9g ☐ 8g ☐ 7g
- Core ☐ vacuum-assisted



Biopsy Devices

- Core needles
- Vacuum-assisted biopsy devices
  - Necessary for biopsies of calcifications
  - Single insertion
  - Contiguous sampling
  - Directional capability

Digital Detectors

- Decrease procedure time
- Allow for post-processing
  - Contrast
  - Brightness
  - Edge enhancement
  - Inversion of gray scale
  - Magnification

Stereotactic Biopsy

- Careful mammographic interpretation
- Scheduling the procedure
- Informed consent
- Performing the biopsy
- Specimen radiography
- Clip placement
- Post-procedural mammography

Stereotactic Biopsy

- Post-procedural care
- Assessment of histopathologic concordance
- Communication of results to patient and doctor
- Follow-up imaging

Limitations

- Very small breasts (3 cm > compressed thickness)
  - Lateral arm approach
- Periareolar lesions and lesions very close to skin
- Posterior lesions
  - Arm through the hole approach



Arm through the hole

Scout Examination

- Target on lesions
- Obtain coordinates
- Determine if stereotactic biopsy is feasible

Planning the Procedure

- What to target?
- What approach?
  - In general — shortest distance between skin and lesion
  - In small breasts — may use longer distance

Images for Documentation

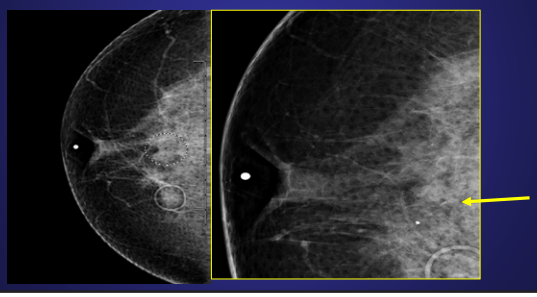
- Scout (straight on)
- Scout (stereotactic pair)
- Pre-fire (stereotactic pair)
- Post-fire (stereotactic pair)
- Specimen radiograph
- Post-clip (one stereotactic view)
- Post-procedure mammogram (two views)

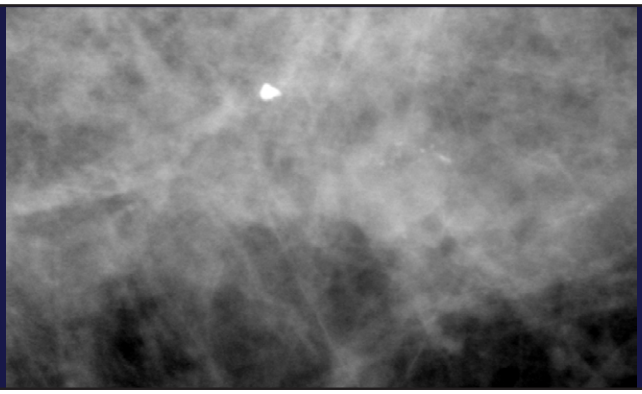
- OR COULD TARGET WITH DBT

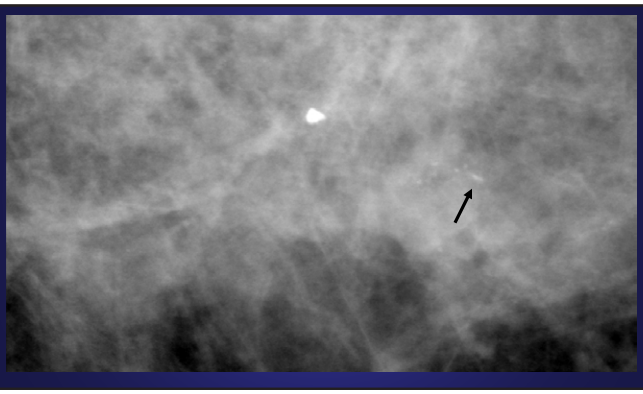
Informed Consent

- Meaningful discussion
- What to expect
- Possible complications
- When results will be available

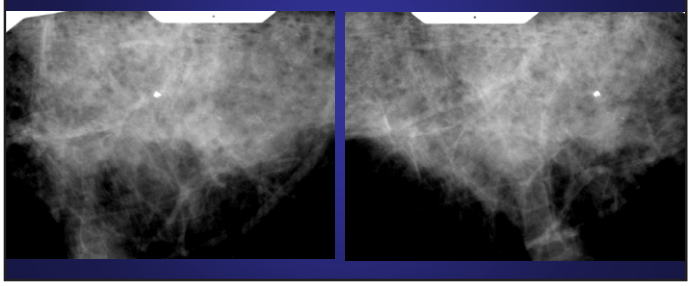
72-Year-Old Woman



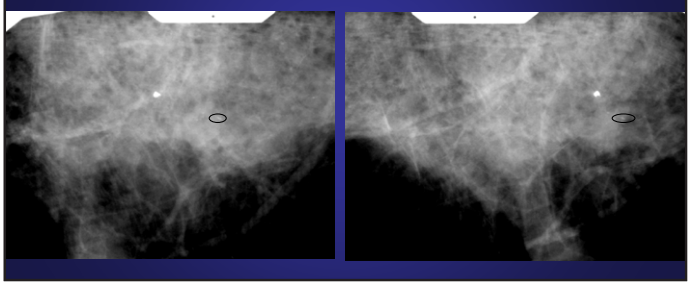




Stereotactic Pair



Stereotactic Pair



Targeting

- X (horizontal)
- Y (vertical)
- Z (depth)



Targeting

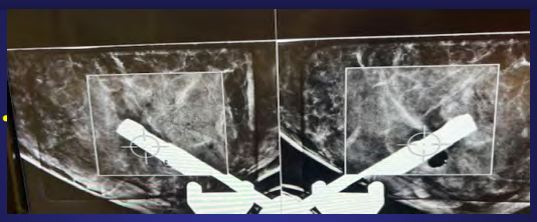
- Central (on lesion)
- Below lesion
  - Lesion will be @ 12:00
  - May not be "on" lesion

Targeting



Circle = target

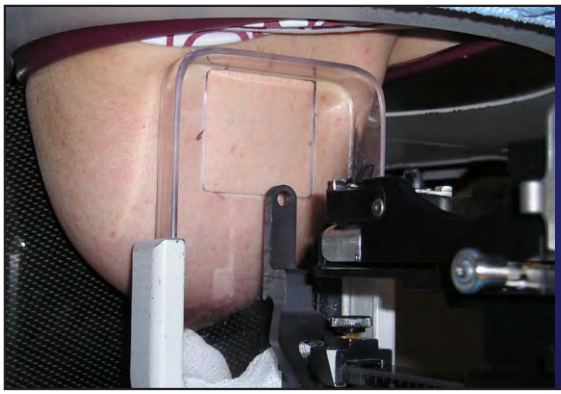
Targeting

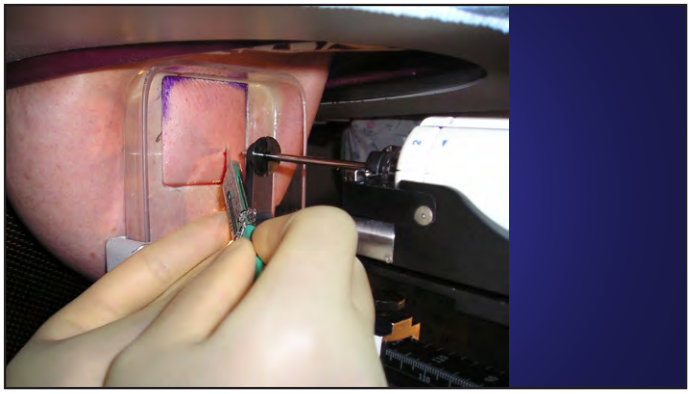


Target =

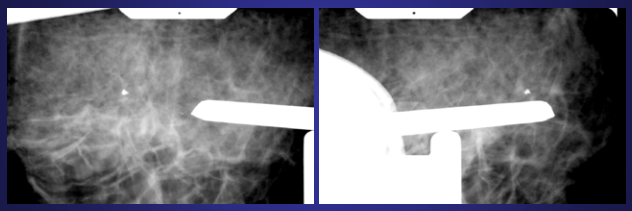




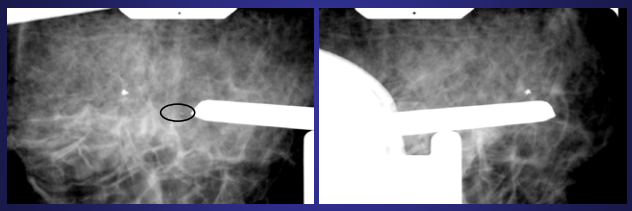




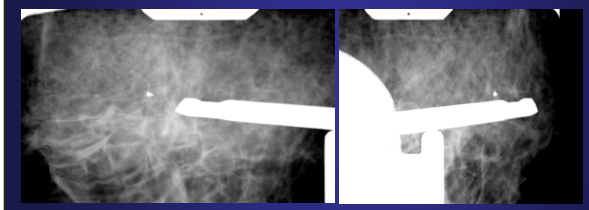
Stereotactic Pair Pre-Fire



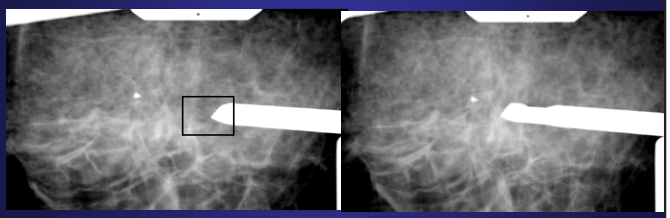
Stereotactic Pair Pre-Fire



Stereotactic Pair Post-Fire

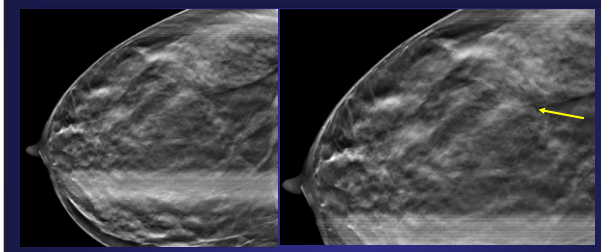


Targeting Pre and Post



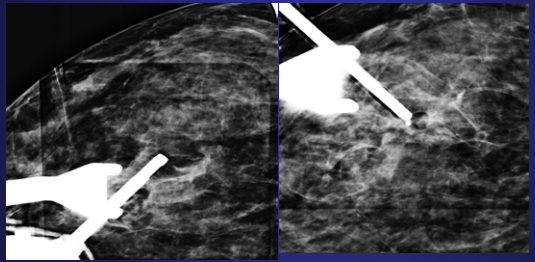
Pre-Fire Post-Fire

51-Year-Old Woman



Right CC tomosynthesis Right CC tomosynthesis

51-Year-Old Woman



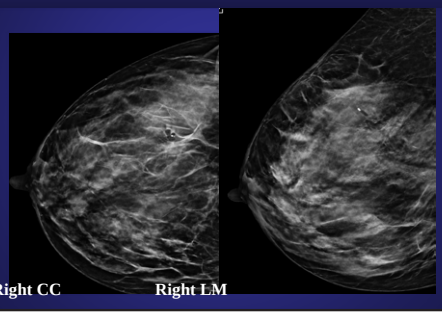
Right CC pre-fire Right CC post-clip

51-Year-Old Woman



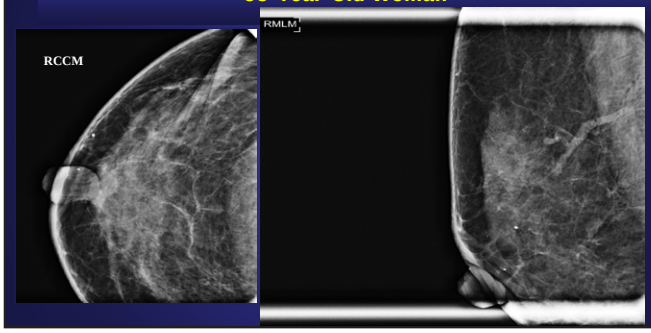
Sclerosing adenosis with usual ductal hyperplasia, breast tissue with dense stromal fibrosis, and cysts

Post-Procedure Mammograms

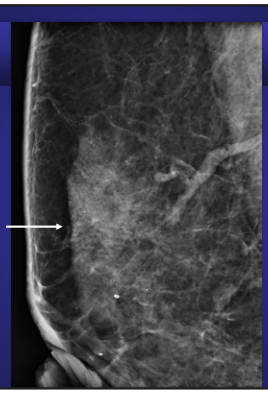


Right CC Right LM

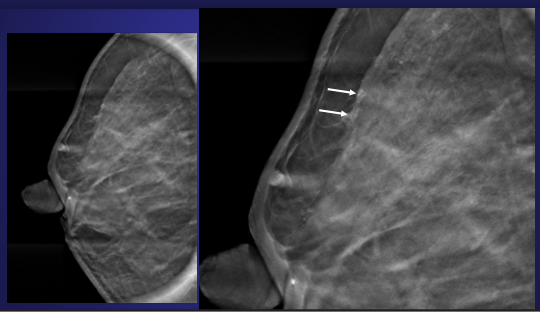
53-Year-Old Woman



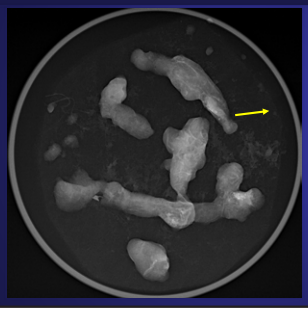
Right LM Magnified



Right LM Tomosynthesis



Specimen Radiography



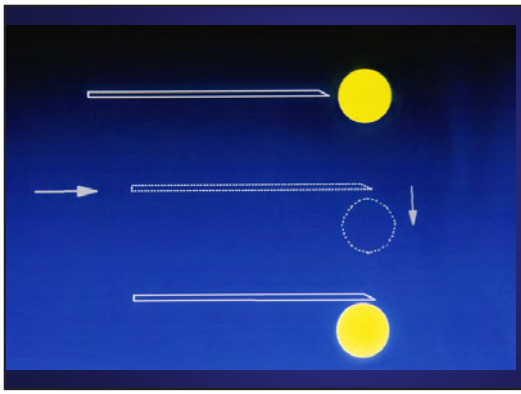
Atrophic glands. sclerosing adenosis, stromal fibrosis

Throw of Needle

- Distance needle travels through breast at time of biopsy

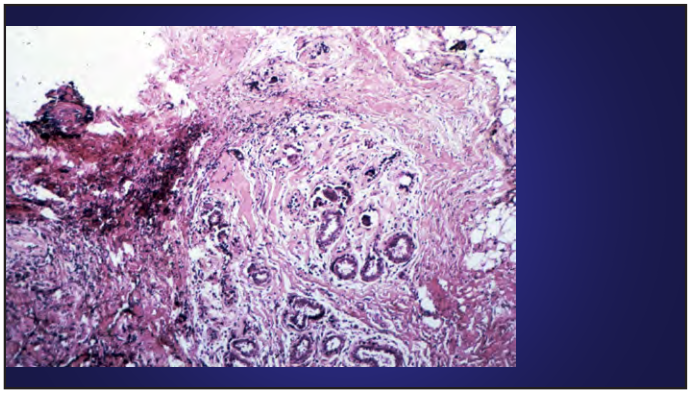
Sampling error

- Needle tip may displace lesion
  - Firm (calcified) lesion
    - Fibroadenoma



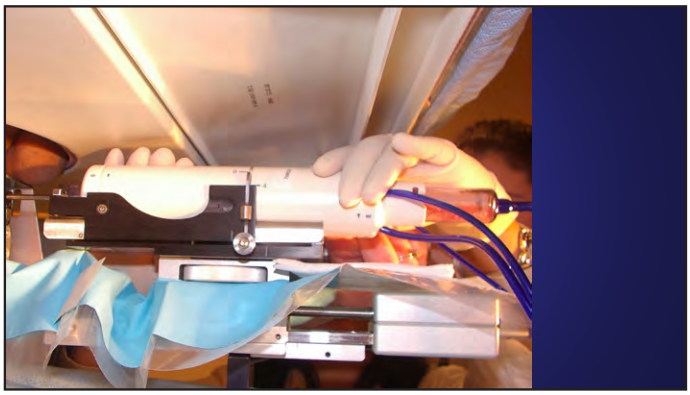
Errors in Targeting

- Minor deviations from the expected target may lead to sampling outside the lesion
  - especially with small (1 cm > x) lesions and calcifications



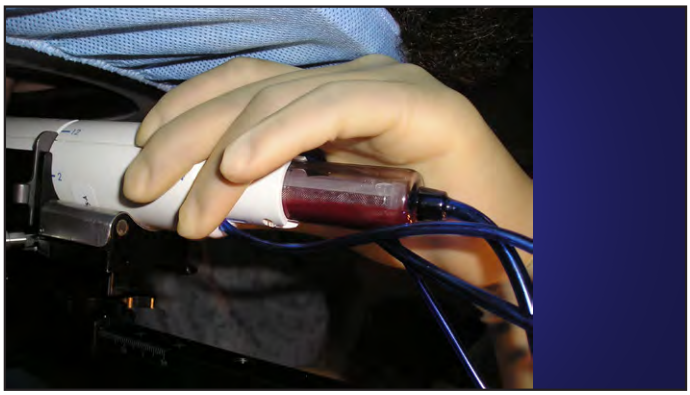
Sampling

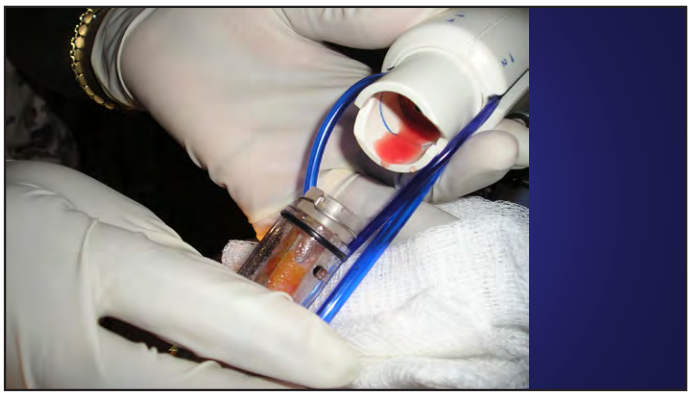
- Where is the target?
- Sample at:
  - 2, 4, 6, 8, 10, 12 o'clock
  - 1, 2, 3, 4, 5.... o'clock
  - Start biopsy where most likely obtain a good sample of the lesion
    - See the lesion best at 6:00 ☐ start at 6:00

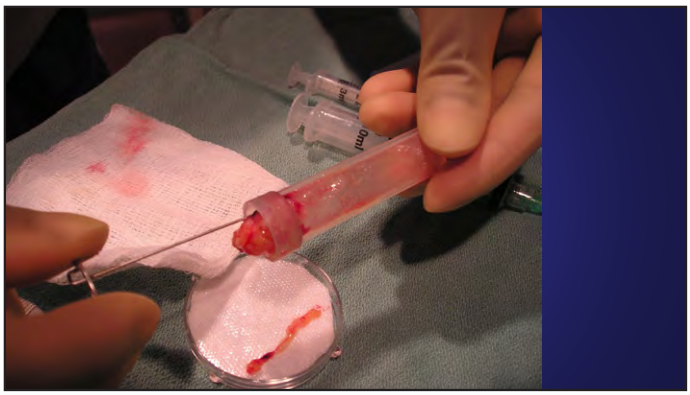


Goal of Biopsy

- Accurately sample the lesion
- Upgrades reduced when most / all of the lesion removed
  - ADH ☐ DCIS
  - DCIS ☐ invasive ductal carcinoma
    - Upgrades affect management / treatment









Specimen Radiography

- Was the targeted lesion sampled in an adequate manner?
  - Were most of the calcifications removed?
  - For non-calcified lesions-
    - Was the lesion sampled appropriately?

Specimen Radiography

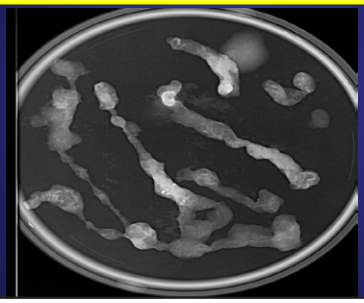


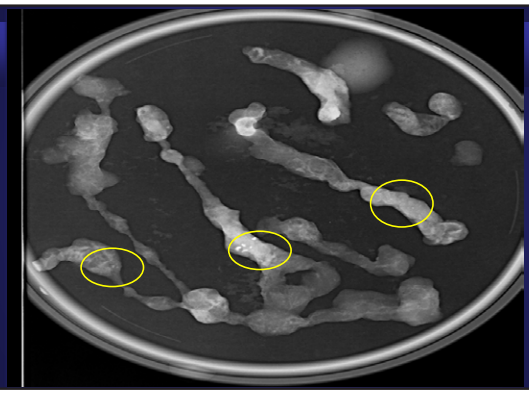


Specimen Radiography



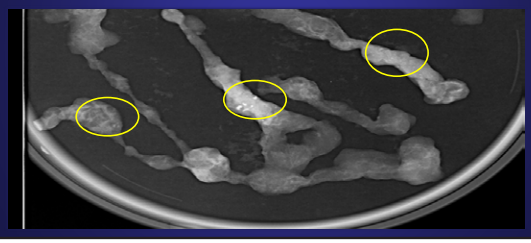
Specimen Radiography





Specimen Radiography

Our practice – separate calcified from non-calcified cores



Samples Placed in Formalin



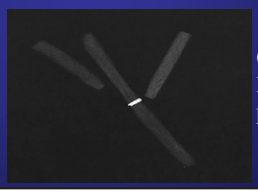
Clip Placement

- To mark biopsy site when lesion is completely removed
- To mark location of lesions that disappear or shrink with preoperative chemotherapy

Clip Marker







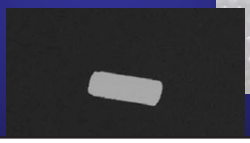
Clip with Microfiber pad

Clip Marker

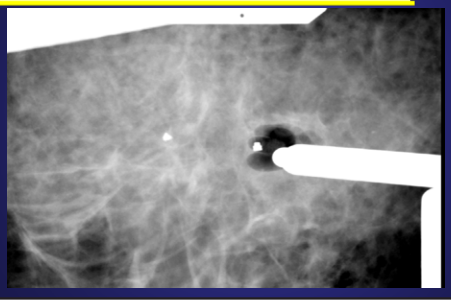


- Titanium marker



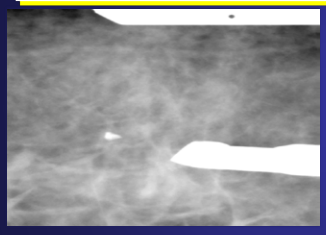


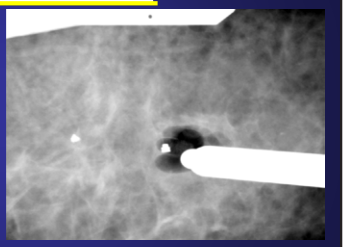
Post-Clip Stereo View



Single stereo image

Post-Fire vs Post-Clip

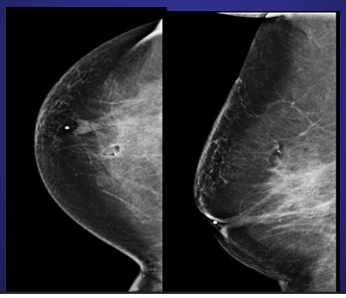




Post-Fire

Post-Clip

Post-Clip Mammograms



Complications

- Hematomas
- Infections
- Pain
  - Local anesthesia
    - Lidocaine with sodium bicarbonate
    - With and without epinephrine

Post-Procedure

- Ice and pressure dressing (x 48 hrs)
- Acetaminophen
- No aspirin, non-steroidals
- No strenuous activity x 48 hrs
- Warm compresses for bluish discoloration on skin

Biopsy Results

- Malignancy ☐ surgical excision
- ADH ☐ surgical excision
  - 15% upgraded at surgery to DCIS or invasive cancer
  - Focal (minimal) ADH
    - May elect imaging follow-up after multidisciplinary review
      - Review of imaging
      - Review of pathology

Consultation

- Pathologist
- Other radiologists
- Multidisciplinary conference
  - High risk lesions
  - ADH, ALH, LCIS

Upgrades

- ADH with significant atypia and/or necrosis ☐ likely to be associated with malignancy ☐ should be excised
- ADH without atypia and/or necrosis
  - Associated with minimal risk of carcinoma (3%)
  - Mammographic and clinical follow-up may be appropriate

Discordant Results

- Expect malignancy and diagnosis is benign
- Consider repeat percutaneous biopsy or surgical excision

Notification

- Patient
- Doctor
  - ACR standards: direct communication

Follow-up Imaging

- Concordant benign (specific diagnosis) ☐ 1 year
- Likely concordant benign or non-specific benign diagnosis ☐ 6 months

Follow-Up Imaging

- Calcifications may change SLOWLY
- False negatives may be discovered > 24 months post-biopsy

Seeding Needle Track

- Reported
- Unlikely to be a clinical problem

Stereotactic Biopsy

- Careful mammographic interpretation
- Scheduling the procedure
- Informed consent
- Performing the biopsy
- Specimen radiography
- Clip placement
- Post-procedural mammography

Stereotactic Biopsy

- Post-procedural care
- Assessment of histopathologic concordance
- Communication of results to patient and doctor
- Follow-up imaging

THANK YOU!



gwhitman@mdanderson.org



SELF EVALUATION

Breast Biopsy Techniques

1. What is the most commonly used needle size for ultrasound-guided core breast biopsy?

a. 18-gauge
b. 16-gauge
c. 14-gauge with a long throw (2.2 cm)
d. 9-gauge vacuum-assisted needle

2. T/F - Ultrasound-guided breast biopsies are generally less expensive and better tolerated by patients than stereotactic breast biopsies.

3. Which lesion type is most commonly targeted during stereotactic breast biopsy?

a. Palpable masses
b. Axillary lymph nodes
c. Calcifications
d. Breast implants

4. T/F - Imaging-pathology discordance following a benign core biopsy result should prompt consideration of repeat biopsy or surgical excision.

5. Which of the following is an indication for surgical excision after biopsy?

a. Concordant benign lesion with a specific diagnosis
b. BI-RADS 3 lesion with stable imaging
c. Atypical ductal hyperplasia (ADH)
d. Simple breast cyst

Answer Key: 1. C, 2. T, 3. C, 4. T, 5. C

Inflammatory Demyelinating Lesions: MRI Patterns, Diagnostic Criteria, and Key Mimics
David M. Yousem, MD, MBA

Inflammatory Demyelinating Lesions: MRI Patterns, Diagnostic Criteria, and Key Mimics

David M. Yousem MD, MBA
Johns Hopkins Medical Institution

Disclosures

- **None specific to this talk**
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- Consulting (medicolegal)
- MRIOnline.com/Medality/TrueLearn: consultant fees, speakers' fees, board member, stockowner

Objectives

- Review the classics and how to distinguish them: MS, NMOSD, MOGAD and variants
- Describe less common entities that are in specialized scenarios: IRIS, PRES, ARA

The Age of MyChart in Epic

- "Age appropriate white matter changes"
- "Small vessel ischemic changes ("leukoaraiosis") greater than expected for age"
- Non-specific white matter changes possibly related to migraines, vasculopathy including accelerated atherosclerosis, previous trauma or inflammation

2024 Recommendations

- In patients who are being considered for a diagnosis of multiple sclerosis presenting at age 50 years and older or with significant vascular risk factors (eg, hypertension, smoking, diabetes, hyperlipidaemia, or known macrovascular disease), additional features are strongly recommended to confirm the diagnosis:
- A spinal cord lesion
- CSF positivity by demonstration of intrathecal antibody production with oligoclonal bands or kappa free-light chain index
- Central vein sign positivity



Multiple Sclerosis

- A CLINICAL DIAGNOSIS
  MR is paraclinical evidence
- 15%>50 y/o, 13% < 20 y/o
- Sibs at 20X, kids at 12x risk
- Temperate climates

Multiple Sclerosis

- Sites: classically on periventricular location, optic nerve in 80%, brainstem in 50%
- 5% in "gray matter"
- DDx: ADEM, Lyme, vasculitis, sarcoid, lupus, SAE, toxins

McDonald Criteria 2017

- DIS definition:
  - At least one T2 lesion in at least two of the following four areas: periventricular, juxtacortical, infratentorial, and spinal cord
- DIT definition:
  - Appearance of a new lesion on a second scan, regardless of the timing in relation to the initial scan or simultaneous presence of asymptomatic gad-enhancing and nonenhancing lesions on a single scan

2024 McDonald DIS Revisions

- Optic nerve serves as a fifth anatomical location (in addition to the periventricular, cortical or juxtacortical, infratentorial brain, and the spinal cord)
- Optic nerve involvement can be documented using OCT, VEPs, or MRI

2024 McDonald DIS Revisions

- In patients with typical clinical presentations and typical lesions in one region, a positive central vein sign or presence of one or more paramagnetic rim lesions plus DIT or CSF positivity is sufficient to diagnose multiple sclerosis
- In patients with progressive disease, two spinal cord lesions are enough to identify DIS



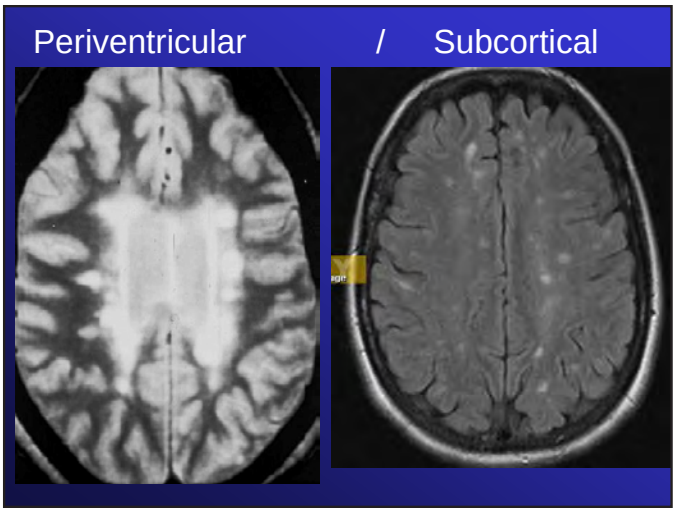


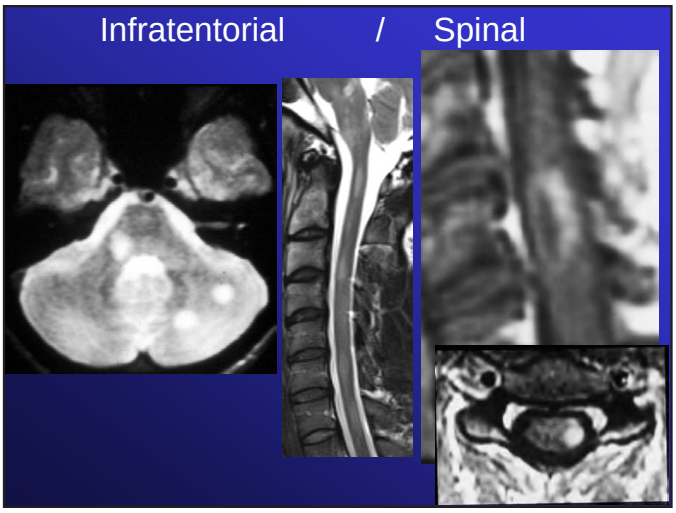


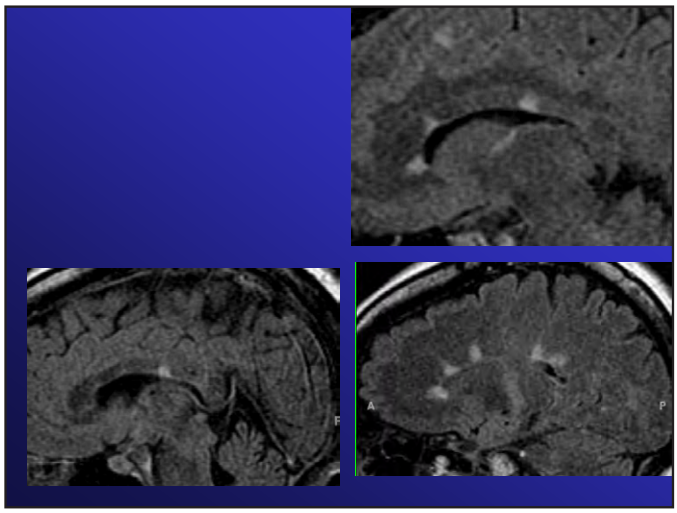
- The select 6 method is considered positive when six or more white matter lesions are CVS positive; if fewer than ten white matter lesions are detected on MRI, the number of CVS positive lesions should be the majority
- In people with clinically isolated syndrome and abnormal MRI showing typical lesions in only one anatomical location and who have either DIT on MRI or CSF-restricted oligoclonal bands, the presence of one or more PRL is sufficient to diagnose MS

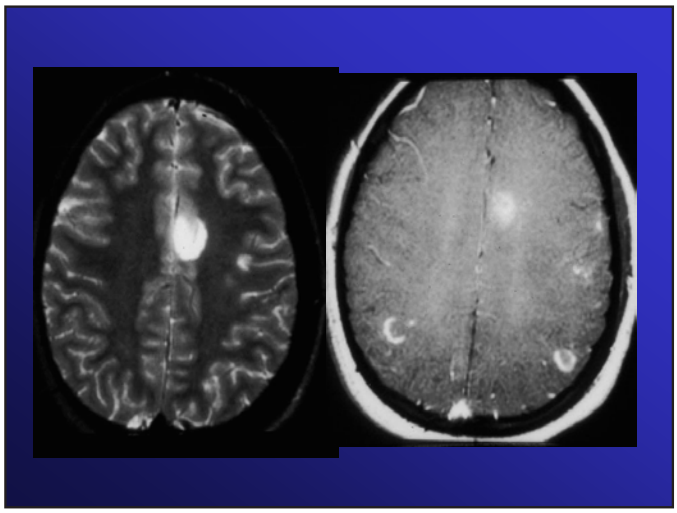
2024 McDonald DIT Revisions

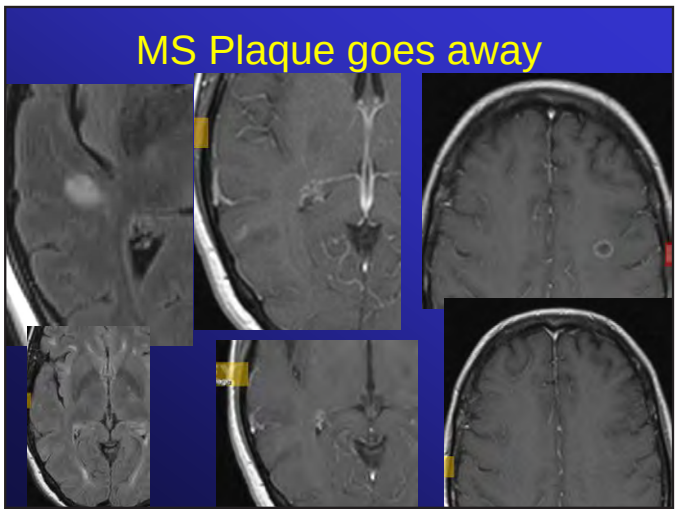
- The presence of new or simultaneous gadolinium-enhancing and non-enhancing typical lesions on MRI increases the specificity of the diagnostic criteria and, together with relapses, should be retained in the diagnostic process of multiple sclerosis, but not as a mandatory additional requirement to DIS. DIT is now considered not essential.

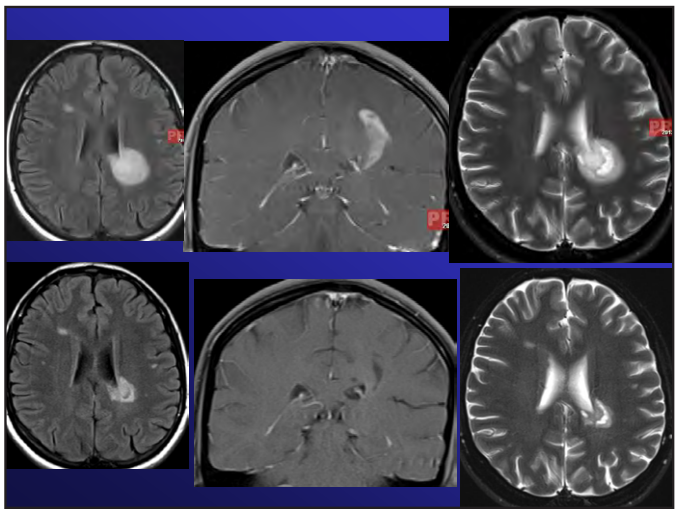

Periventricular / Subcortical


Infratentorial / Spinal






MS Plaque goes away



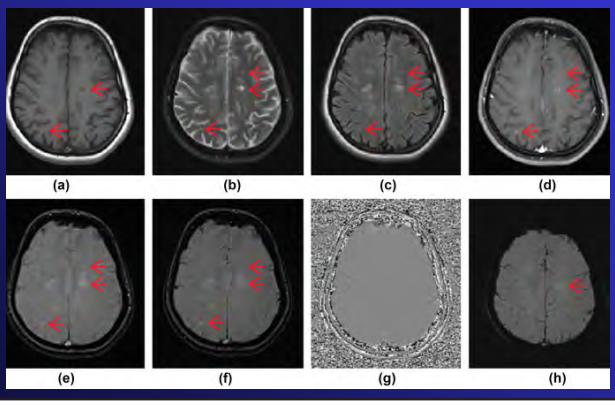
MAGNIMS Consensus 2016
(Magnetic Resonance Imaging in MS: European)

- Optic neuritis added to 4 locations
- ≥3 periventricular lesions
- Cortical and juxtacortical
- DIT need not be (a)symptomatic
  - New lesion
  - Enhancing/non-enhancing on same study

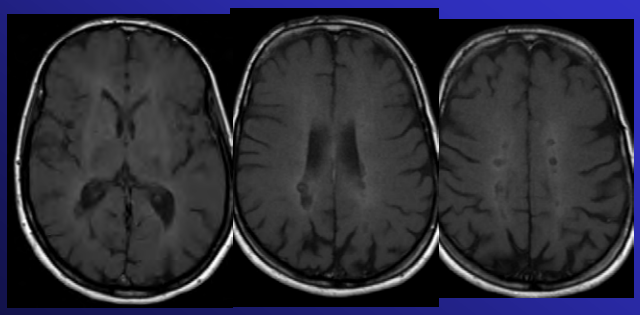
MAGNIMS Consensus 2024
(Magnetic Resonance Imaging in MS: European)

- Implement 2024 McDonald criteria
  - Optic nerve added to 4 locations for DIS
  - CVS and PRL useful if inconclusive
- Scanning recommendations:
  - Brain and C-T spine, SWI, Orbit sequences, 3D FLAIR, T1 pre/post

Detection of multiple sclerosis lesions by susceptibility-weighted imaging—A systematic review and meta-analyses
Afkandeh, R. et al.
Clinical Radiology, Volume 79, Issue 12, e1522 - e1529



Black Holes and EDSS (Expanded Disability Status Scale)



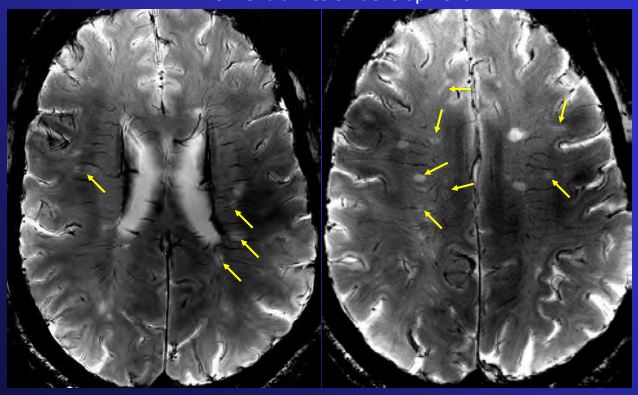
And Brain Volume! And Brain Iron!

MS and Disability (Fisher E et al, 2008 ANA Maghzi et al. MS Rel Dis 2014)

- GM atrophy related to disability
  - CIS to 2*ProgMS by 14 fold
- Baseline T2 lesion volume and atrophy predicted deficits
- Over time brain volume decreases corresponded with worse deficits, worse outcomes

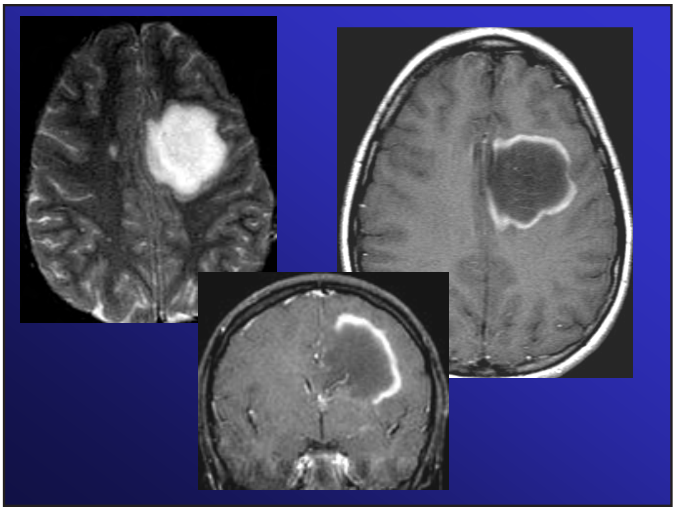
Multiple Sclerosis @ 7T

Perivenular Lesion development



Tumefactive Sclerosis: > 2 cm

- Single Lesion
  - Often with less mass effect than expected with tumor of same size, BUT
  - Often with surrounding edema, ring enhancement
  - If not much edema, mass effect, watch expectantly
- **CBV Estimation (*Radiology, 4/2002*)**
  - **MS lesions, in general, show lower CBV than do tumors**
- **MRS - MS lesions often show higher NAA than do tumors (choline often high in either), but can look similarly**



Clinically Isolated Syndrome

- Monophasic presentation with suspected underlying inflammatory demyelination
- Symptoms are typically of rapid onset, and last for more than 24 hours

Clinically isolated syndromes (CIS)

- Type 1 CIS: clinically monofocal, at least one asymptomatic MRI lesion
- Type 2 CIS: clinically multifocal, at least one asymptomatic MRI lesion
- Type 3 CIS: clinically monofocal, MRI may appear normal; no asymptomatic MRI lesions
- Type 4 CIS: clinically multifocal, MRI may appear normal; no asymptomatic MRI lesions
- Type 5 CIS: no clinical presentation to suggest demyelinating disease, but MRI is suggestive (RIS)

Clinically Isolated Syndrome

- Impact of MRI
  - 82% with abnl, 21% with normal MRI converted to MS in 20 years (Fisniku)
  - 88% with abnormal, 19% with normal MRI at 14 years (Brex)
- Increased risk with single Gad enhancing lesion
  - Increased disability with T1 load, enhancement, T2 volume

Clinically Isolated Syndrome

- Kuhle J et al. Mult Scler 2015 (July) 21: 1013-24
  - 623/1047 converted from CIS to CDMS in 2 years
  - Highest rate in those with > 9 WM lesions, 2-9 WM lesions, oligoclonal bands, younger age
- 2024 revision
  - In people with CIS and abnormal MRI showing typical lesions in only one anatomical location and who have either DIT on MRI or CSF-restricted oligoclonal bands, the presence of one or more paramagnetic rim lesion is sufficient to diagnose MS

Radiologically Isolated Syndrome (RIS)

- Subjects with incidental brain MR imaging WM lesions suggestive of MS and who fulfill 2005 McDonald criteria for dissemination in space (DIS) but have no signs or symptoms of the disease.
  - 8.8% of the healthy relatives of patients with MS and 4.9% of non-familial healthy control subjects show > 9 WM signal abnormalities

2024 RIS Criteria

- RIS is identified by the incidental discovery of CNS white matter T2-weighted hyperintense foci on MRI, which are highly typical of multiple sclerosis in the absence of typical clinical symptoms related to inflammatory demyelination or findings on clinical examination
- In patients with RIS, fulfilling dissemination in space (DIS) and dissemination in time is sufficient for diagnosing multiple sclerosis
- In patients with RIS, fulfilling DIS and positive CSF is sufficient for diagnosing multiple sclerosis
- In patients with RIS fulfilling DIS, the presence of the select 6 central vein sign (CVS) is sufficient for diagnosing MS

Radiologically Isolated Syndrome

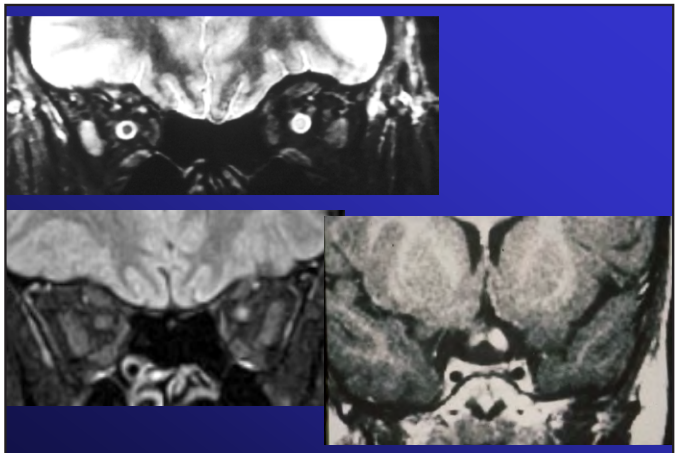
- MS pattern in a patient with symptoms other than MS-like
- 33% progress to MS diagnosis in 3 years
  - If enhancing lesions risk increased by 3.4X
  - 59% had progressive MR findings
    - Neurology. 2009 Apr 7;72(14):1284

Pakpoor J….Yousem DM. Follow-Up of EDMRI Scans Suggesting New Diagnosis of CNS Demyelination. AJR Am J Roentgenol 209 (1), 171-175. 2017

- "Where a demyelinating disorder was placed as the only, first, second, or third (or later) differential diagnosis, the final diagnosis was concordant with demyelination in 84.3% (43/51), 37.5% (3/8), 18.2% (2/11), and 0% (0/22) of cases, respectively ($p < 0.01$)."

Optic Neuritis and Brain MRI

- 5 year cumulative prob of MS was 30%
  - –16% with no brain lesions
  - –51% with 3 or more brain lesions
    - **Neurology 1997; 49: 1404-13**
- 30 year risk of 22% with childhood optic neuritis
  - **Lucchinetti et al. Neurology 1997; 49: 1413-18**
- 49% at 8-10 years, 59% with brain lesions
  - **Ghezzi et al. Neurol Sci 2000; 21: 865-869**



Neuromyelitis Optic Spectrum Disorder (NMOSD) Major Criteria

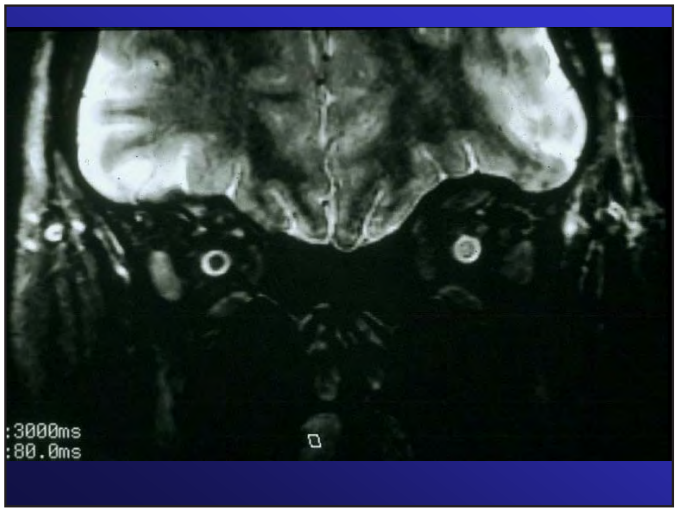
- Optic neuritis in one or more eyes
- Transverse myelitis, clinically complete or incomplete, but associated with radiological evidence of spinal cord lesion extending over
- Three or more spinal segments on T2-weighted MRI images and hypointensity on T1-weighted images when obtained during acute episode of myelitis
- No evidence for sarcoidosis, vasculitis, clinically manifest systemic lupus erythematosus or Sjögren's syndrome, or other explanation

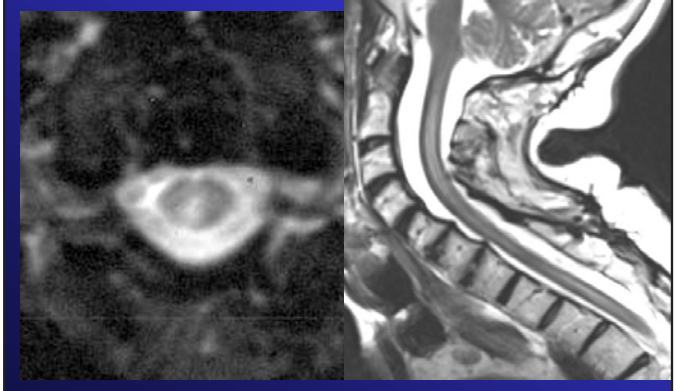
NMO Minor Criteria

- Most recent brain MRI scan of the head must be normal or may show abnormalities not fulfilling Barkhof criteria used for McDonald diagnostic criteria, including:
- Non-specific brain T2 signal abnormalities not satisfying Barkhof criteria as outlined in McDonald criteria
- Lesions in the dorsal medulla, either in contiguity or not in contiguity with a spinal cord lesion, Hypothalamic and/or brainstem lesions, "Linear" periventricular/corpus callosum signal abnormality, but not ovoid, and not extending into the parenchyma of the cerebral hemispheres in Dawson finger configuration
- Positive test in serum or CSF for NMO-IgG/aquaporin-4 antibodies

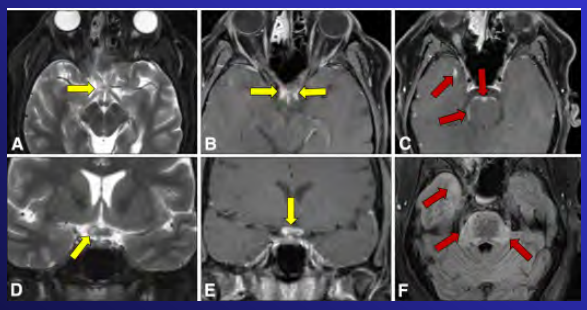
NMO-SD

- Leukopathy vs Astrocytopathy
  - Against astrocytic foot processes
  - Transmembrane water flow
- AQP4- myelin oligodendrocyte glycoprotein (MOG IgG) antibodies + in 5-7%
  - ON, TM, brainstem ds / BS encephalitis
  - More fulminant





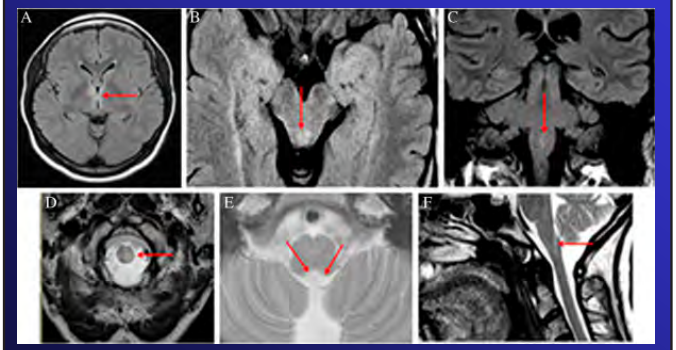
NMOSD



NMO Brain Lesions
Pekcevik Y…Izbudak I. MS. 2016 March ; 22(3): 302–311

- 14/27 patients had typical brain NMO lesions
  - Located in the hypothalamus, around the third and the fourth ventricle, or the cerebral aqueduct;
  - Located in the dorsal medulla, area postrema (may be linear and continuous with cervical LETM);
  - Located in the corticospinal tract; and
  - When 'Dawson's finger'-type periventricular lesions and juxtacortical lesions were not present

Asgari et al. BMC Neurology 2013
NMO Brain Lesions (28% HT-81% BS)

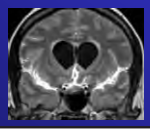


Who Cares: MS vs NMO

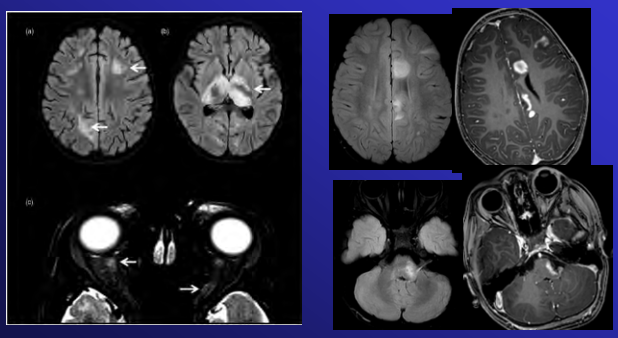
- Current drugs for MS [interferon, fingolimod (Gilenya), natalizumab (Tysabri)] may exacerbate NMO
- Early effective NMO treatment can prevent disability
  - IV steroids, plasma exchange acutely
  - Rituximab, CellCept, Imuran long term

MOG Antibody Associated Demyelination = MOGAD

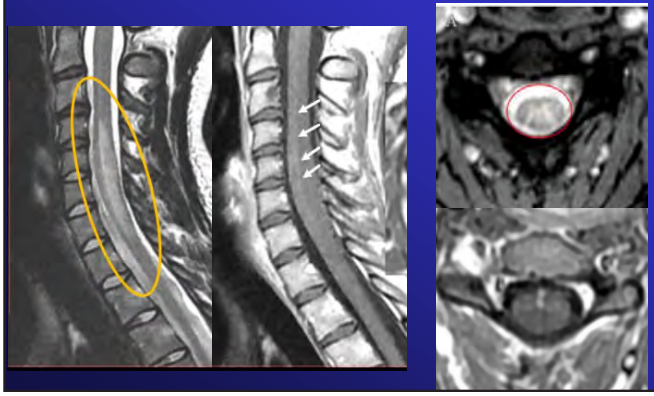
- Myelin Oligodendrocyte Glycoprotein-IgG
- Outcome favorable despite recurrent attacks and severe symptoms
- Ddx: ADEM, MS, TM, NMOSD with overlapping anti N-methyl-D-aspartate receptor encephalitis (anti NMDAR)
- Optic neuritis Bilat. (up to 50%) or unilateral in 70%+
- Encephalitis in ¼ of cases
  - Brain stem, Cortical
- Myelitis in 1/5 of cases
- ADEM-Like in peds
- Optico-spinal phenotype in adolescent/adults
- Rare MOGAD aseptic meningitis



MOGAD

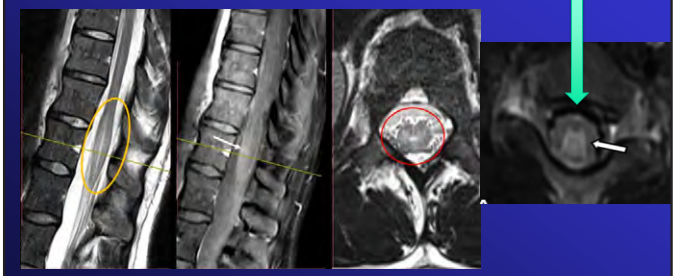


MOGAD:LETM-type
(often conus, bilateral)



MOGAD

Pseudodilatation of central canal--H sign



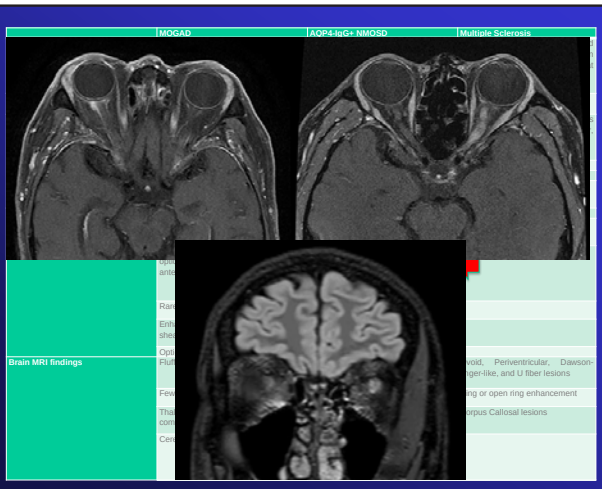
FLAIR hyperintense cortical lesions in MOG-associated Encephalitis with Seizures (FLAMES) + Unilateral Cerebral Cortical Encephalitis(UCCE)

- Unilateral cortical FLAIR hyperintensity +/- DWI
- Sulcal hyperintensity +/- meningeal GdEn
- Hyperperfusion



FIG 8. MRI brain of a 7-year-old patient presenting with seizures showing FLAIR-hyperintense cortical lesions in FLAMES. Axial diffusion-weighted, ADC, and T2-FLAIR images show restricted diffusion (*white arrow, A* and *B*) and T2-FLAIR hyperintensities with edema (*white arrow, C*) in the right frontoparietal cortex. Corresponding areas show increased CBF on arterial spin-labeling (*white arrow, D*). Follow-up Axial T2-FLAIR image after 3 months reveals right frontoparietal atrophy (*white arrow, E*).

Kankara SR et al. Neurographics; 15(4) 296-309



	Central cord location with >50% of cord involvement	Central cord location with >50% of cord involvement	Peripheral location usually in dorsolateral tracts
Spine MRI findings	Usually LETM (~75%)	Usually LETM (~85%)	Short segment
	Conus medullaris involvement (~40%)		
	Axial "H sign" and Sagittal T2 hyperintense line	Bright spotty lesions and T1 dark lesions	
	Less cord edema and enhancement compared to AQP4+ NMOSD		
Relapse	Monophasic or relapsing	Relapsing	Typically presents with relapsing disease (~90%) and can transition to a progressive course (secondary progressive MS); alternatively may present with progressive disease at onset (10-15%; primary progressive MS)
	Commonly as ON followed by TM	ON LETM	Lesions commonly enhance
	Persistence of IgG seropositivity may be predictive of a relapsing course		
	Less cord necrosis or atrophy as a sequela of TM		
	Myelitis lesions are frequently non-enhancing		
Predictors of long-term outcome	Residual disability in 50–80% of patients, with transverse myelitis at onset being the most significant predictor of long-term outcome	25% of long-term disability related to initial onset attack	Infratentorial lesions, "Black holes" on MRI, sphincter symptoms at onset, incomplete recovery from the first attack, short interval between the first and second attack are predictors of long-time disability
	Higher relapse frequency might be associated with worsening disability	Worse visual and motor outcome compared to MOGAD	Gadolinium-enhancing lesions on IFNβ therapy strongly correlates with severe disability
CSF findings	Pleocytosis variable (present in over 50%)	Commonly ≥ 50 WBC/mm	Commonly < 50 WBC/mm
	OCB 5-15%	OCB 10-25%	OCB in up to 95% of RRMS

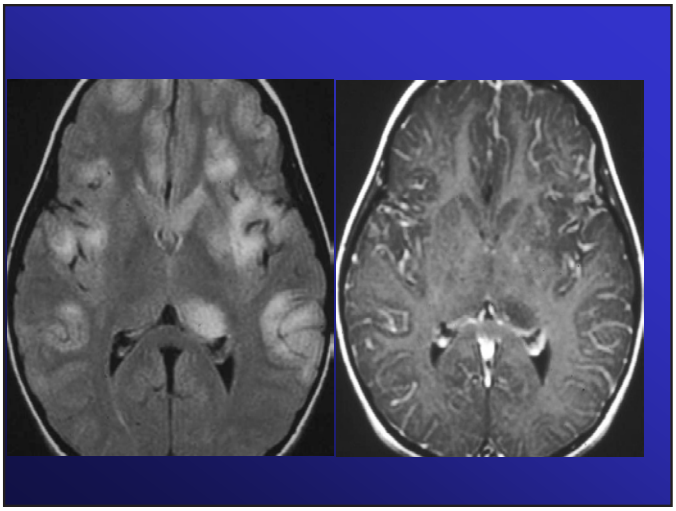
ADEM

- Monophasic…..or recurrent
- Classically 2-4 weeks after viral infection/immunization
- DTH to myelin basic protein
- Brain and spine can be seen
- Hemorrhagic aggressive form

ADEM Sites of Involvement

- Subcortical white matter in 93%p
- Cerebral cortex in 80%p vs 10%a
- Periventricular white matter in 25-60%p vs 67-88%a
- Deep gray matter in 47-80%p, 44-57%a
- Brainstem in 47-67%p, 22-52%a
- Cerebellum 50%p vs 14%a
- Cord 50%p vs 10%a

- Murthy SN et al. Pediatrics 2002; 110.e21
- Lin et al. JNNP 2007; 78: 162-167

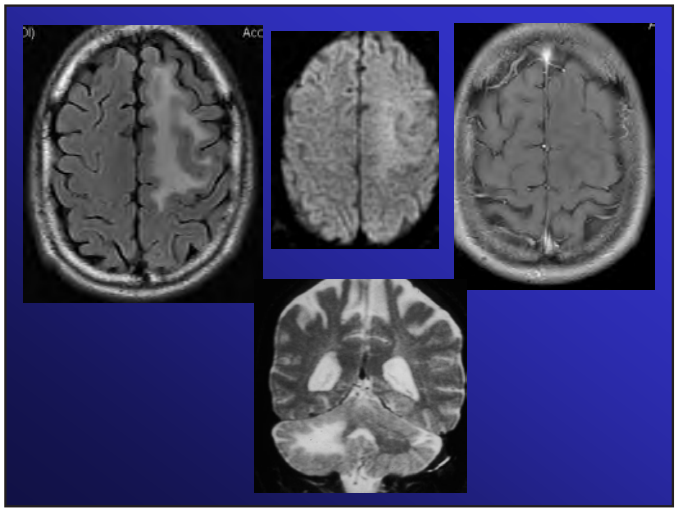


Multiphasic DEM (MDEM)

- Recurrences/relapse can occur after steroid withdrawal or further infection
  - 24% of cases > 1 month after onset
  - Usually at original site
    - Cohen et al. Arch Neurol 2001; 58: 797-801
- Can see new lesions during therapeutic stage
- ? Late progression to MS

PML

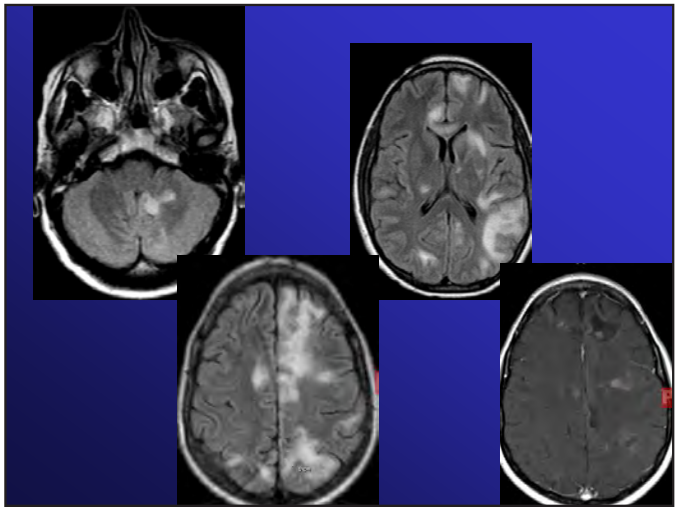
- Papovavirus-JC virus destroys oligodendrocytes-WM (polymerase chain reaction positive)
- Immune-compromised host
  - Tysabri Natalizumab & Rituximab induced
- MTRs strikingly low
- No to little enhancement, U fibers, posterior predilection



IRIS

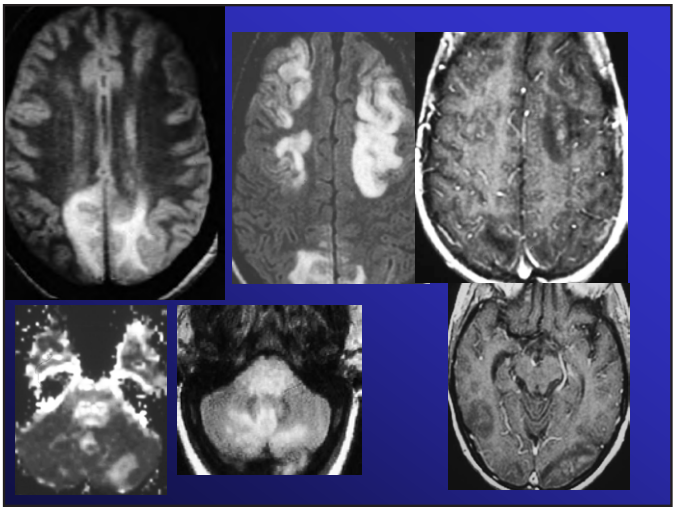
Neurology. 2009 April 28; 72(17): 1458–1464

- The use of combined antiretroviral therapy markedly improves immune function and prognosis in HIV-infected patients; however, PML may develop or worsen with antiretroviral therapy, despite a recovery of the immune system. This manifestation is believed to be a result of immune reconstitution inflammatory syndrome (IRIS).
  - Higher rate of CE, mass effect, FLAIR in IRIS



Hypertension/PRES

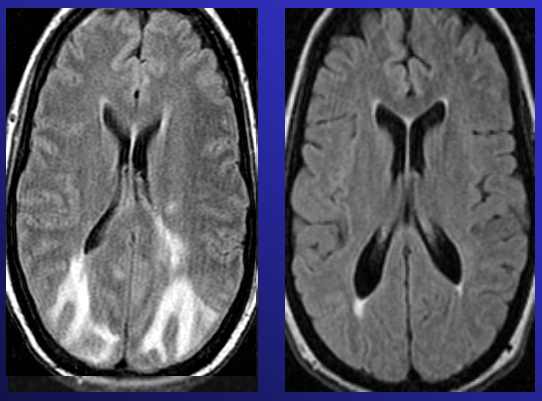
- 1. HTN, 2. Eclampsia, 3. Cyclosporine
  - All mediated through overwhelmed or dysfunctional vasoregulation
    - ?2^0 to regionally different adrenergic innervation
    - Effect in (3) may be related to HTN induced by drug
  - Fluid extravasation hydrostatic edema
  - Typically, occipital lobe WM
  - Mild mass effect



PRES

- CE in up to 1/3-1/2: BBB breakdown
  - Leptomeningeal in 76%, cortical and LM in 35%, 24% other
  - Marker of endothelial injury
  - Women > men 3:1
- 10% hemorrhage
- 3% permanent moderate deficit, 15% minimal or mild
- Beware DDX RCVS Thunderclap H/A

Initial 2 month follow-up



c/o Peter Barker, JHH

Amyloid-=Related Imaging Abnormalities (ARIA)

Table 2: ARIA Grading Criteria

ARIA Type	Mild	Moderate	Severe
ARIA-E	FLAIR hyperintensity confined to sulcus and cortex/subcortical white matter in one location <5 cm	FLAIR hyperintensity 5–10 cm, or more than one site of involvement each measuring <10 cm	FLAIR hyperintensity >10 cm, often with sulcal involvement, may involve one or more sites
ARIA-H microhemorrhage	Four or more new microhemorrhages	Five to nine new microhemorrhages	10 or more new microhemorrhages
ARIA-H superficial siderosis	One focal area of superficial siderosis	Two focal areas of superficial siderosis	More than two focal areas of superficial siderosis

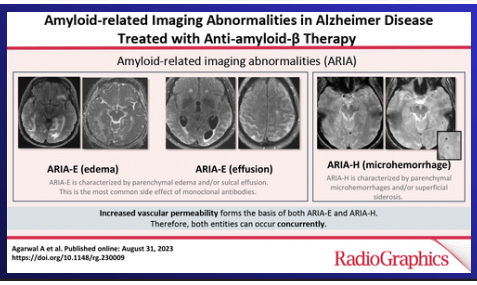


Table 3: Management of ARIA-E

Clinical Severity of ARIA-E	ARIA-E Severity at MRI: Mild	Moderate	Severe
Asymptomatic	Continue dosing at current dose and schedule	Suspend dosing; once imaging findings resolve, resume dose	Suspend dosing; once imaging findings resolve, resume dose
Mild, moderate, severe, serious ("other medically important event" only)	Suspend dosing; once ARIA-E resolves, same dose treatment can resume	Suspend dosing; once ARIA-E resolves, same dose treatment can resume	Suspend dosing; once ARIA-E resolves, same dose treatment can resume
Serious, except for "other medically important event"	Discontinue dosing	Discontinue dosing	Discontinue dosing

Source.—Reference 48.

Table 4: Management of ARIA-H

Clinical Severity of ARIA-H	ARIA-H Severity at MRI: Mild	Moderate	Severe
Asymptomatic	Continue dosing at current dose and schedule	Suspend dosing; once imaging findings resolve, resume dose	Discontinue
Mild, moderate, severe, serious ("other medically important event" only)	Suspend dosing; once ARIA-H resolves, same dose treatment can resume	Suspend dosing; once ARIA-H resolves, same dose treatment can resume	Suspend dosing; once ARIA-H resolves, same dose treatment can resume
Serious, except for "other medically important event"	Discontinue dosing	Discontinue dosing	Discontinue dosing

Source.—Reference 48.

Take Home Messages

- Manifold manifestations of Multiple Sclerosis and its variants
- DDx of high intensity foci in young
- Clinical Hx for PML, CPM, ADEM

Take Home Messages

- Iatrogenic causes of WM Ds
- Metachromatic Leukodystrophy as the most common of dysmyelinating disorders
- Pearls for the rest of the eponyms

SELF EVALUATION

Inflammatory Demyelinating Lesions: MRI Patterns, Diagnostic Criteria, and Key Mimics

1. The new 2024 McDonald criteria added:

a. Central vein sign and paramagnetic rim lesions to the DIS criteria
b. Lack of enhancement as a DIT criterion
c. 5 or more periventricular lesiosn to the criteria
d. The optic nerve as a 5th location criterion
e. None of the above

2. RIS refers to:

a. Remyelination in space
b. Clinical findings suggestive of MS but a negative MR
c. Imaging findings of MS without meeting clinical criteria
d. Refractory immunosuppression demyelination
e. All of the above

3. NMOSD findings in the brain are more likely to see what location involved more than with traditional MS?

a. Periventricular white matter
b. Cortical plaque
c. Dorsal medulla
d. Corpus callosum
e. None of the above

4. The spinal “H-sign” implicates:

a. MS
b. CIS
c. NMOSD
d. PRES
e. None of the above

5. You see a new large confluent white matter lesion in a patient with MS receiving natalizumab for her disease. The differential diagnosis favors:

a. Tumefactive MS
b. ADEM
c. PML
d. IRIS
e. All of the above

Answer Key: 1. D, 2. C, 3. C, 4. E, 5. C

Thoracic Imaging: Case Review
Anil Kumar Attili, MD

Thoracic Imaging: Case Review

Anil Attili, MD

Professor of Radiology

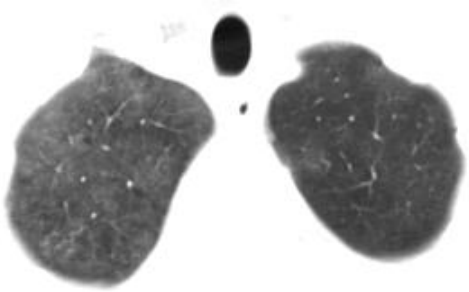
University of Michigan

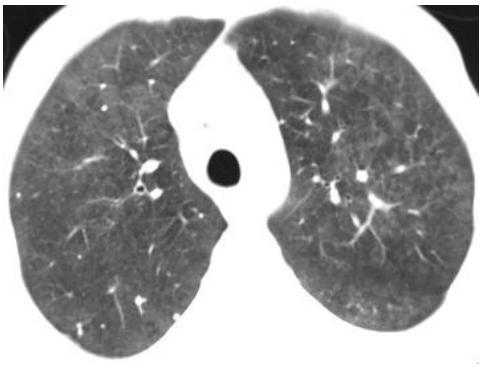
Case 1

- 40 yr. M .HIV positive
- Cough ,Dyspnea on exertion
- CD4 =169/mm

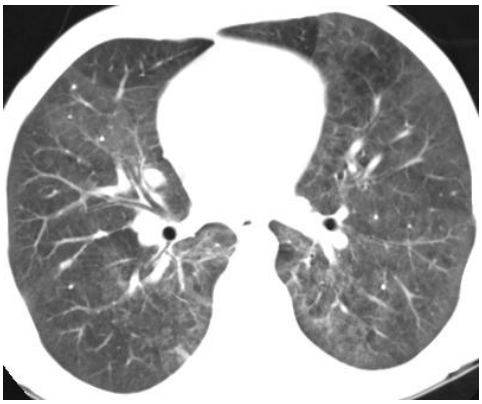
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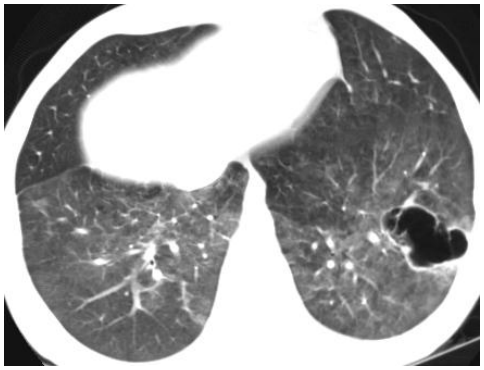
- Selected sections from a HRCT Imaged on lung and soft tissue windows,

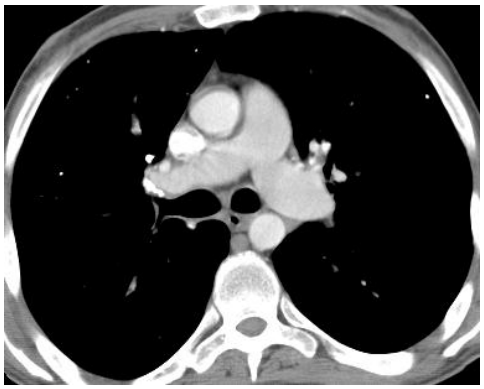
















Case 1

Pneumocystis Carinii Pneumonia

- **HRCT** -Extensive diffuse ***GGO***.
  - Calcified Nodules in the lungs
  - Cavitary lesion LLL
  - Splenic calcification.

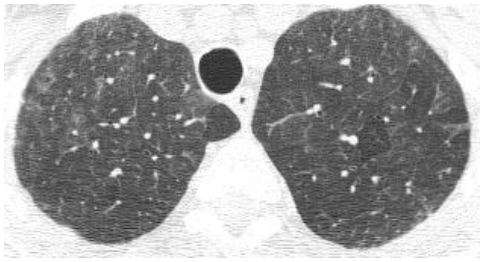
  Diagnosis -PCP , possible coexistent Bacterial/fungal cavity, old histoplasmosis.
- **Sputum** PCP PCR Positive
- **Bronchoscopy with BAL** -PCP PCR positive

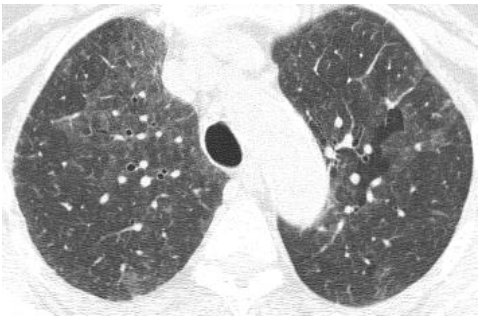
Case 2

- 67 yr. F
- Progressive Dyspnea on exertion

Imaging Provided

- Selected sections from a HRCT.(Inspiratory images and single expiratory image)

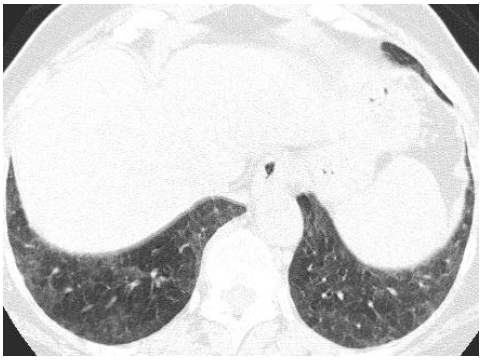












Expiratory scan.



Case 2
Hypersensitivity Pneumonitis

- HRCT- Extensive diffuse ***GGO***
  Centrilobular nodules
  Air trapping on expiration
  Diagnosis -Hypersensitivity Pneumonitis.
- Transbronchial Biopsy- Interstitial lymphocytic infiltration and granulomatous inflammation suggestive of Hypersensitivity pneumonitis.

Case 3

- 37 yr.F
- Relatively asymptomatic
- High Hemoglobin
- Restrictive pattern of Pulmonary function tests.

Imaging provided

- Selected Slices from a HRCT(Lung and Soft tissue windows)

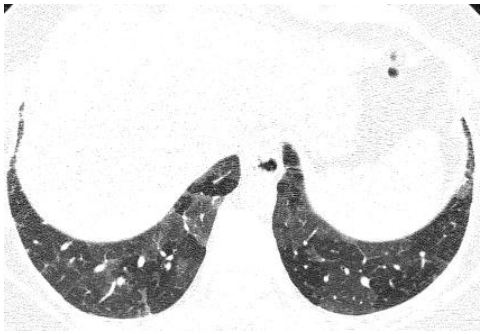






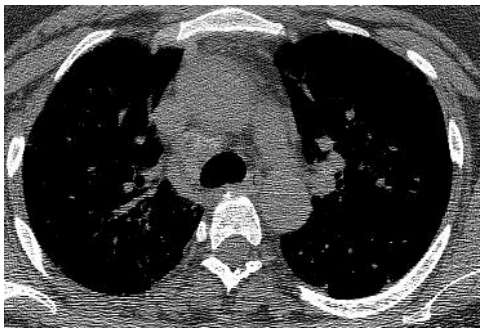






Expiratory Scan





Case 3
Sarcoidosis

- **HRCT**-Extensive Mosaic pattern of ***GGO***
  - Air trapping on expiration
  - Right paratracheal and Subcarinal L.N Enlargement

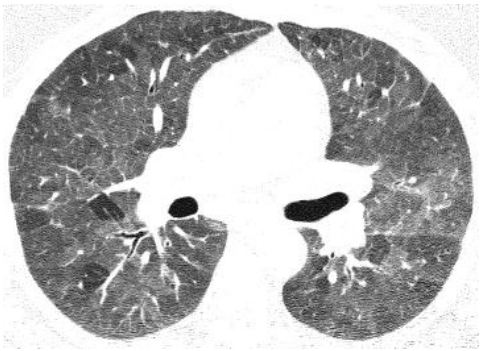
  D.D - Hypersensitivity. P, Sarcoidosis
- **Path**- open lung biopsy specimen; extensive non necrotizing granulomatous inflammation, prominent interstitial inflammation, favoring sarcoidosis

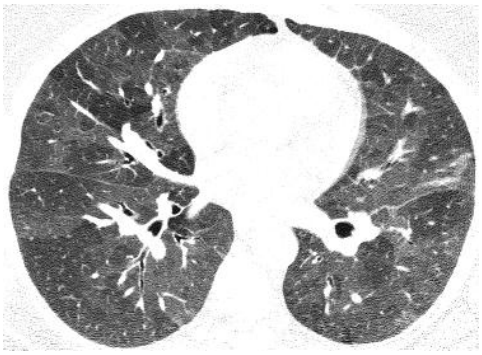
Case 4

- 46 yr. F.
- Dyspnea on exertion
  Imaging provided
- Chest Radiograph
- Selected sections from a HRCT.









Case 4
Nonspecific Interstitial Pneumonitis

- **CXR**-Haznonspecificopacity in the mid and lower lungs. Recommend HRCT.
- **HRCT**-Bilateral geographic areas of ***GGO***.No Honeycombing No significant air trapping on expiration. Subpleural sparing

  DD-Non-specific interstitial pneumonitis, Hypersensitivity pneumonitis.
- **Pathology**-Lingula and left lower lobe wedge biopsies: Interstitial inflammation and focal interstitial fibrosis, features most consistent with nonspecific interstitial pneumonitis.

Nonspecific Interstitial Pneumonits (NSIP)

HRCT findings in NSIP

- Patchy ground glass opacity
- Airspace consolidation
- Irregular reticular opacities
- Traction bronchiectasis
- Honeycombing uncommon
- Peripheral and lower zone predominance
- Subpleural sparing

Ground Glass Pattern

Hazy increased attenuation of lung, with preservation of bronchial and vascular margins; caused by partial filling of airspaces, interstitial thickening, partial collapse of alveoli, normal expiration, or increased blood volume.

Ground Glass Opacity

Results from the volume averaging of morphological abnormalities too small to be clearly resolved by HRCT.

Significance?

A highly significant finding, as it often indicates the presence of an ongoing, active, and potentially treatable process.

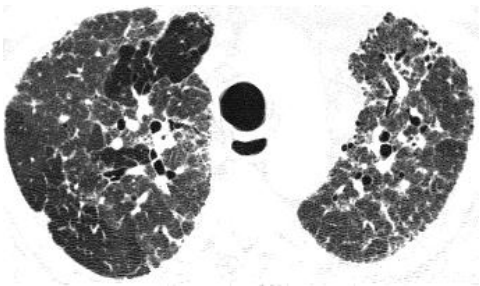
Conditions characterized by GGO as the dominant abnormality

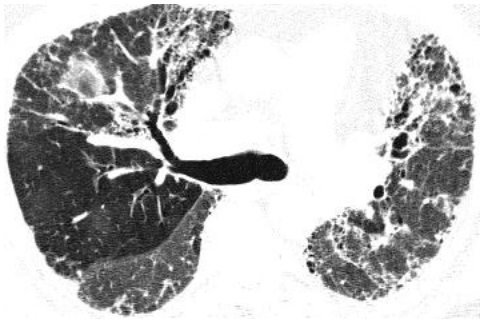
- Hypersensitivity Pneumonitis (subacute)
- Pulmonary edema
- *Pneumocystis carinii* or CMV pneumonia
- Nonspecific interstitial pneumonia
- Bronchioalveolar .Ca
- ARDS and AIP
- Respiratory bronchiolitis-interstitial lung disease
- Alveolar proteinosis
- Desquamative interstitial pneumonia
- Lymphocitic interstitial pneumonia

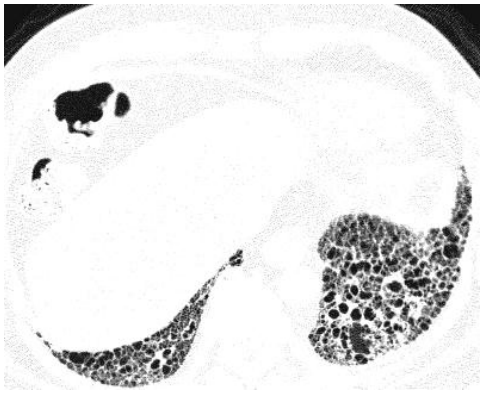
Case 5

- 68 yr.M
- Insidious onset of Dyspnea

  Imaging Provided
- Selected images from a HRCT







Case 6
Usual Interstitial Pneumonia

HRCT- Patchy ***GGO*** in the upper lobes Interlobular and interlobar septal thickening, Traction bronchiectasis and extensive honey combing at the bases.

Diagnosis: UIP(morphological pattern),IPF(clinical syndrome)

D.D: Collagen vascular disease
Asbestosis
Chronic Hypersensitivity pneumonitis

Usual Interstitial Pneumonitis (UIP)

HRCT findings in UIP

- Irregular septal thickening
- Traction bronchiectasis
- Honeycombing
- Ground glass opacity in areas of fibrosis
- Lower lung subpleural and peripheral predominance of abnormalities

Honeycomb Pattern

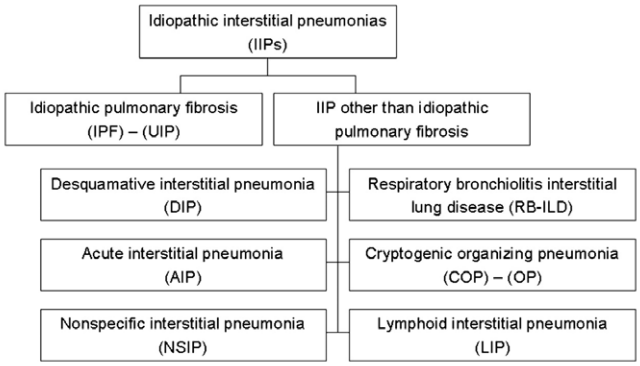
- Process characterized by the presence of cystic airspaces, ranging from several millimeters to centimeters in diameter and characterized by thick, clearly definable fibrous walls lined with bronchiolar epithelium. The cystic airspaces are clustered and share walls and are predominantly subpleural.
- Results from destruction of alveoli and loss of acinar architecture and is associated with fibrosis.

Honeycomb Pattern

Causes:

- Usual interstitial pneumonia
- Collagen Vascular disease
- Asbestosis
- Chronic Hypersensitivity Pneumonitis
- Drug related Fibrosis.

Terminology for the IIPs with the various subentities according to the ATS-ERS classification

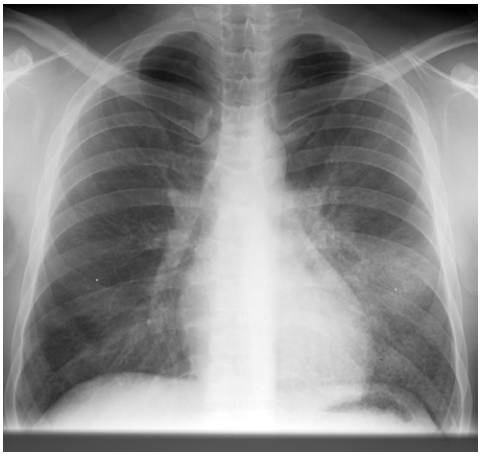


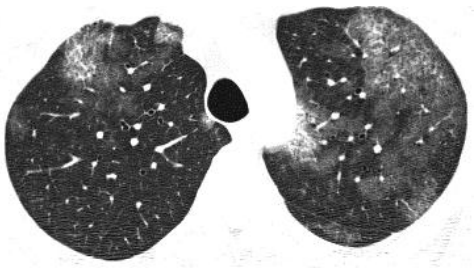
Case 6

- 34 yr.M .
- Dyspnea

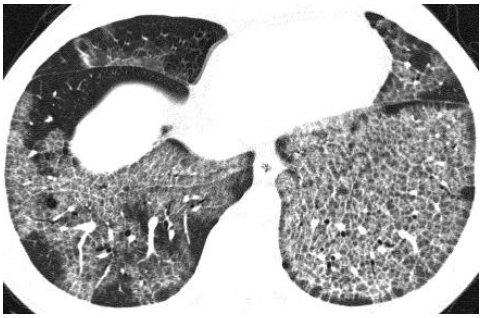
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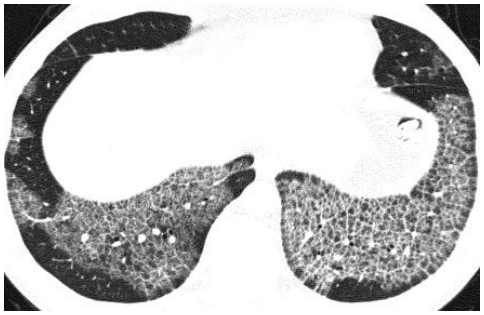
- Chest Radiograph
- Selected sections from a HRCT











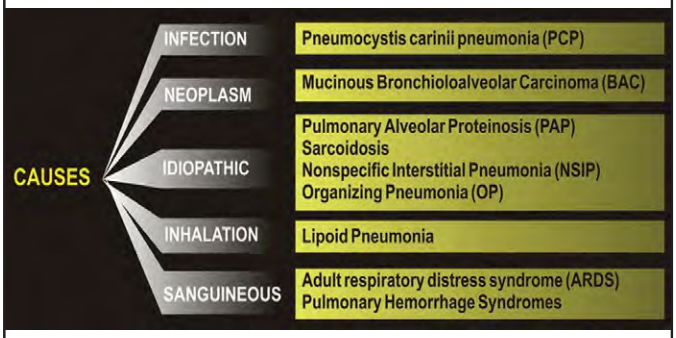
Case 6
Alveolar Proteinosis

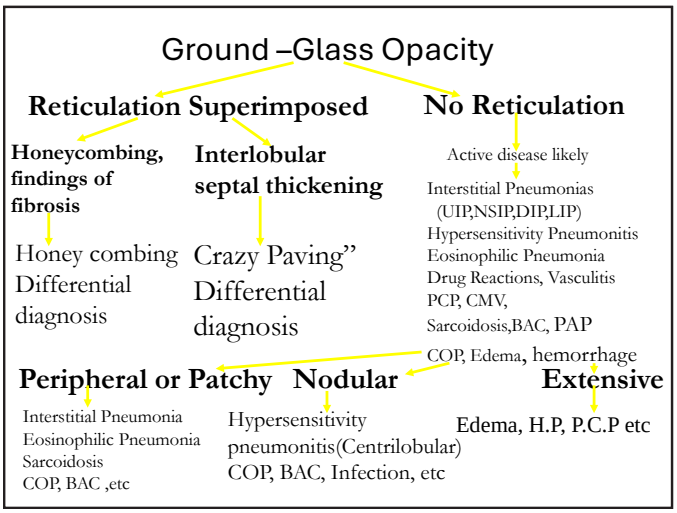
- **CXR**-Left mid lung airspace opacity.Bilateral perihilar and lower lung interstitial opacities
- **HRCT**- Extensive crazy paving appearance .
  Diagnosis-Pulmonary alveolar Proteinosis
- **Path**-Trans bronchial biopsy:alveolar spaces contain eosinophilic granular material.Histological features favor the diagnosis of alveolar proteinosis.

Crazy Paving Pattern

Ground glass opacity in combination with interlobular septal thickening.

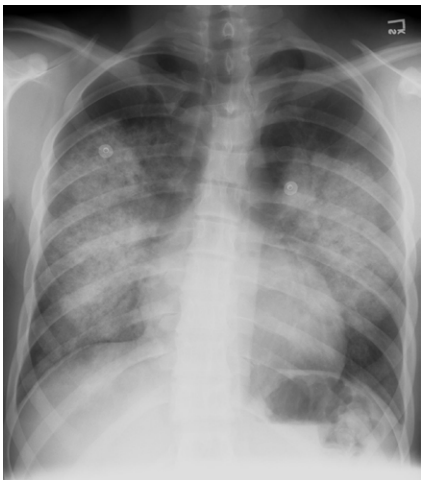
Crazy Paving Pattern -Causes

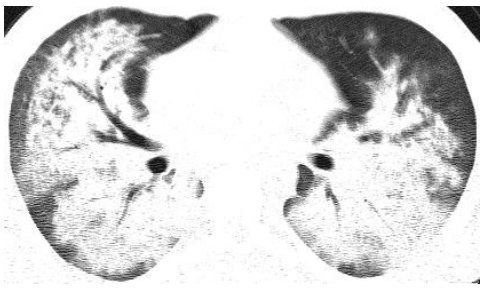


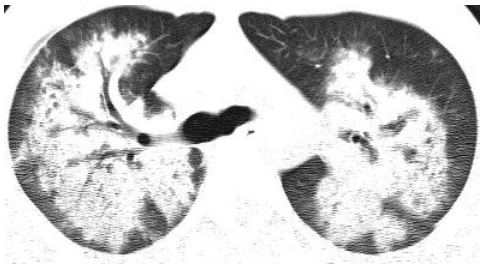


Case 7

- 18 yr. Male
- Previously well
- Progressive cough and hemoptysis over a 3-week period.
- C-ANCA Highly positive Imaging Provided
- Chest Radiograph
- Selected slices from a HRCT







Case 7
Wegener's Granulomatosis

- CXR-Bilateral Perihilar ***consolidation***
- HRCT-Extensive Bilateral Perihilar ***Consolidation***.

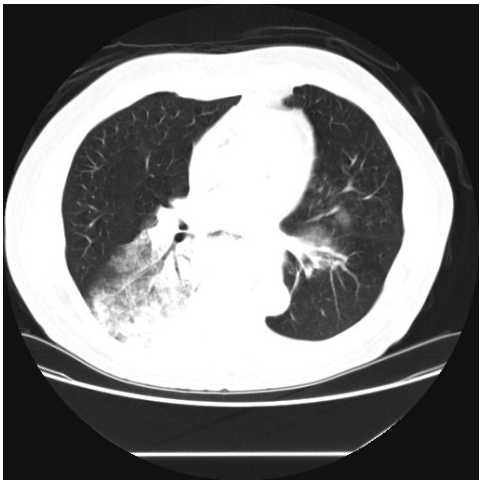
Diagnosis- Wegener's granulomatosis

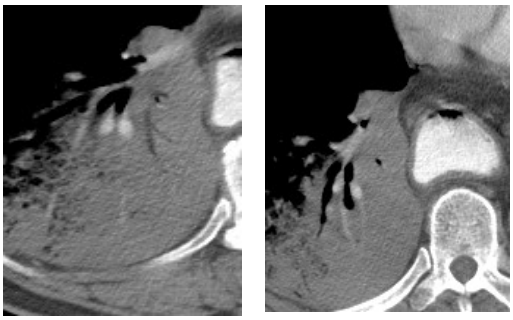
Case 8

- 67 yr. Male
- Non resolving pneumonia

Imaging Provided

- Selected slices from a Conventional CT imaged on lung and soft tissue windows





Case 8
Adenocarcinoma

- CT- Right lower lobe ***consolidation***
  Foci of GGO in the left lung
  CT Angiogram Sign

Diagnosis- Adenocarcinoma

CT Pulmonary Angiogram Sign

- **Branching enhancing vessels within consolidated low attenuation lung.**
- **First described with Bronchoalveolar carcinoma, but is seen in a variety of other conditions including lymphoma, obstructive pneumonitis,bacterial pneumonia, lipoid pneumonia and pulmonary edema**

Case 9

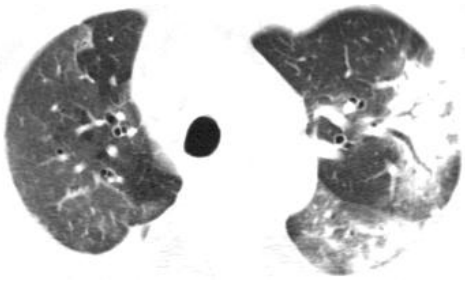
- 79 yr.Male
- Presented to an outside institute with Pyrexia , Chills and Sweats
- Improved slowly with antibiotics
- Continues to have persistent low-grade fever.

Imaging provided

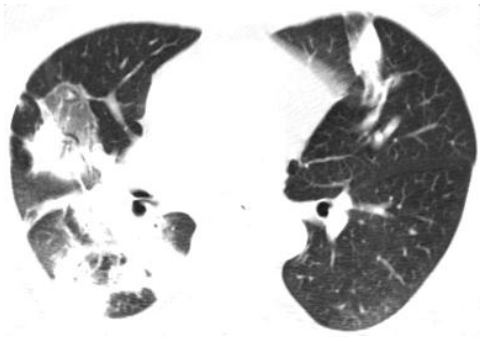
- Chest Radiograph
- Selected slices from CT pre and post treatment



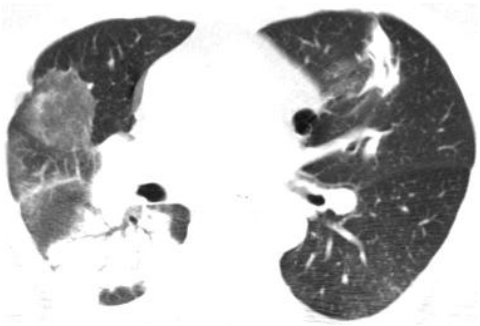
Pretreatment CT



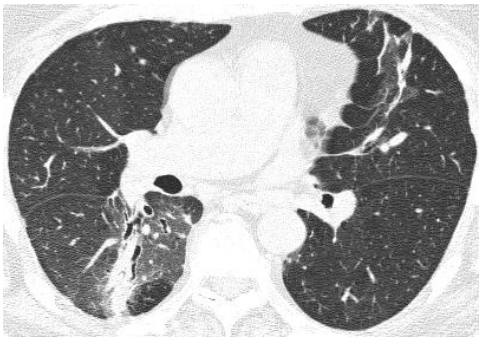
Pretreatment CT



Pretreatment



Post treatment



Case 9
Cryptogenic Organizing Pneumonia

- **Chest Radiograph**- Left upper lobe peripheral ***consolidation*** and patchy foci of consolidation in the Right lower lobe.
- **CT-Pretreatment**-BilateralPeribronchovascular and Peripheral areas of ***consolidation***.
- **CT-Post treatment**- Interval resolution of dense ***consolidation*** ,GGO in some areas.

Imaging Diagnosis- Organizing Pneumonia.Eosinophilic Pneumonia.

- Thoracoscopic Wedge resection ,left upper lobe and left lower lobe
- Path -Organizing Pneumonia

Consolidation

- In contrast to GGO, consolidation obscures underlying vasculature and frequently is associated with air bronchograms
- Diseases that produce consolidation are characterized by a replacement of alveolar air by fluid, cells, tissue or some other substance

Consolidation

Chronic

Tuberculosis
Chronic eosinophilic pneumonia
Cryptogenic organizing pneumonia
Bronchioalveolar Ca
Lymphoma
Sarcoidosis
Lipoid pneumonia

Acute

Infectious pneumonia
Pulmonary edema
Pulmonary hemorrhage
Acute eosinophilic pneumonia
Acute extrinsic allergic alveolitis
Radiation pneumonitis
Pulmonary infarction

Consolidation

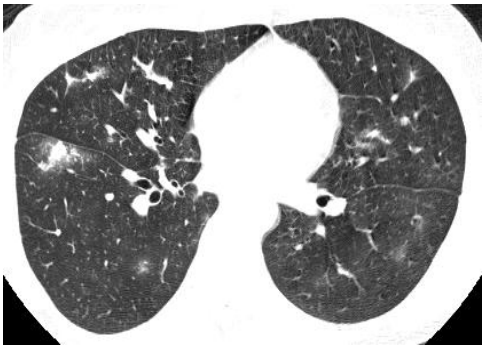
Lobar	Diffuse	Subpleural	Patchy, nodular
Pneumonia BAC COP	Pneumonia BAC ARDS,AIP Edema, Hemorrhage	Eosinophilic Pneumonia COP Interstitial pneumonia (UIP,NSIP,DIP)	Eosinophilic Pneumonia COP BAC Bronco .P

Case 10

- 40 yr.F
- AML, 591 days post BMT .
- Shortness of Breath

Imaging Provided

Selected section from a HRCT



Case 10
Angioinvasive Aspergillosis

- HRCT -Multiple nodules some with a surrounding area of GGO.

Imaging Diagnosis-Angioinvasive Aspergillosis.

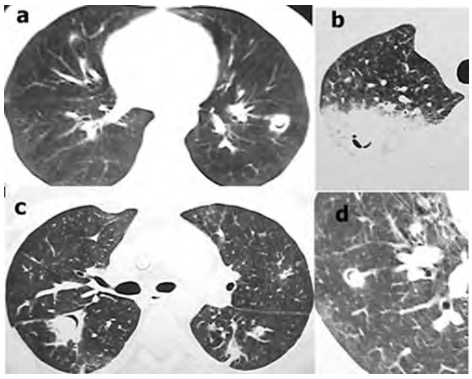
- Trans Bronchial Biopsy -LLB -Non-Diagnostic. Started on Amphotericin for presumed Angioinvasive Aspergillosis.

Follow up CT showed improvement .

Halo Sign

- Refers to GGO surrounding or forming a halo around a denser nodule or focal area of consolidation.
- When seen in patients with acute leukemia, the halo sign is highly suggestive of early angioinvasive aspergillosis.
- This sign may also be seen in Kaposi's sarcoma metastases, metastatic angiosarcoma, Wegener's granulomatosis, and infection from candida species, Mucorales species ,CMV and Herpes simplex.

A *Air Crescent Sign in Angioinvasive aspergillosis*



- Indicates immune function recovery
- Good Prognostic sign

Case 11

- 52 yr. Female
- Increasing shortness of Breath

Imaging Provided
Chest Radiograph
Selected sections from a HRCT







Case 11
Lymphangitis carcinomatosa

- *CXR*-Left Mastectomy. Linear and reticular interstitial opacities.Urgent HRCT recommended
- *HRCT*- Interlobular septal thickening and nodularity.

Diagnosis-Lymphangitis carcinomatosa.
DD- Drug reaction

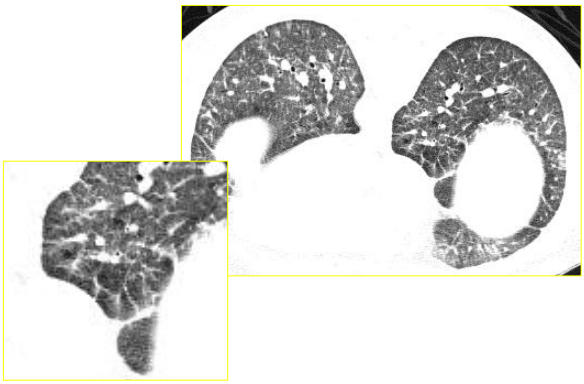
- *Path*-Right lower lobe trans bronchial biopsy:Positive for adenocarcinoma

Case 12

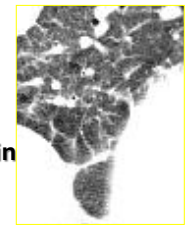
- 28 yr.Female
- SLE
- End Stage Renal Failure

Shortness of Breath
Imaging Provided

- HRCT (selected slices)



Case 12



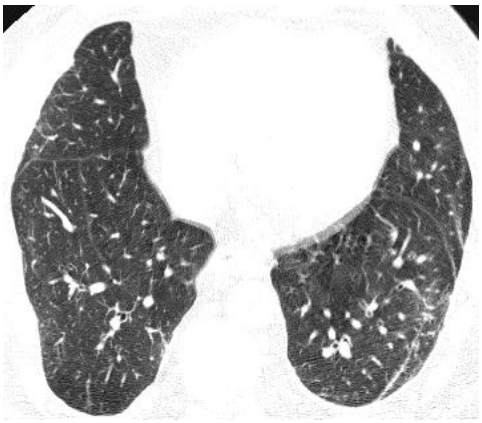
- **Interstitial Pulmonary Edema**
- **Appearance on HRCT:**
  - **smooth interlobular septal thickenin**
  - **Ground glass opacities**
  - **peribronchovascular thickening**
  - **increased vascular diameter**

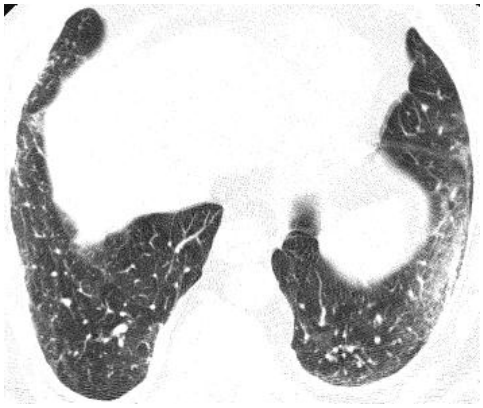
Case 13

- 62 yr.Male
- Exertional Breathlessness subacute onset
- Worked in the shipyards in Jacksonville,Florida

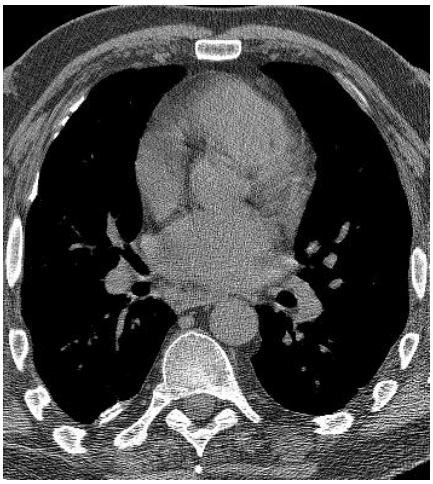
Imaging Provided

Selected images from a HRCT(lung and soft tissue windows)







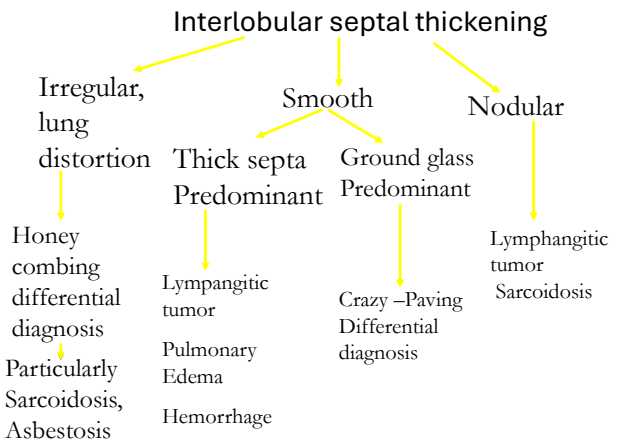


Case 13

Asbestosis

- HRCT:Intra and interlobular septal thickening, parenchymal bands, subpleural bands.
  Pleural thickening and calcification

Diagnosis-Asbestosis



Predominance of Lung disease on CT: Posterior lung versus Anterior lung

Posterior Lung

- UIP; NSIP
- Asbestosis
- Scleroderma
- Silicosis
- Sarcoidosis
- ARDS
- Hypersensitivity Pneumonitis
- Lipoid Pneumonia

Anterior Lung

- Post ARDS fibrosis

Predominance of Lung disease on CT: Central lung versus Peripheral lung

Central lung

- Sarcoidosis
- Silicosis
- Talcosis
- Lympangitic spread of tumor
- Large airway disease i.e bronchiectasis(e.g cystic fibrosis)

Peripheral Lung

- UIP-IPF, Collagen diseases,asbestosis
- NSIP
- Chronic eosinophilic pneumonia
- COP
- AIP, DIP
- Hematogenous metastases

Predominance of Lung Disease on CT: Upper lung vs Lower lung

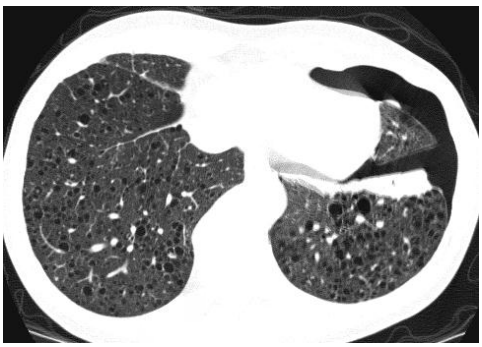
Upper Lung	Lower Lung
Sarcoidosis	Usual interstitial pneumonitis-IPF;Collagen diseases;asbestosis
Langerhans cell Histiocytosis	Nonspecific interstitial Pneumonitis
Tuberculosis	Lipoid pneumonia
Cystic Fibrosis	COP
Silicosis ,CWP	Hematogenous and lymphangitic metastases
Centrilobular Emphysema	
Chronic hypersensitivity pneumonitis	

Case 14

- 40 yr F.
- Acute exacerbation of chronic shortness of breath
- Previous history of resection of a renal and adrenal mass



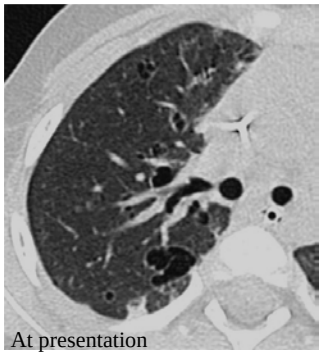




Case 14
Lymphangioleiomyomatosis

- Females of Childbearing age
- Uniform distribution of thin-walled cysts
- Pneumothorax
- Chylous pleural effusions
- Angiomyolipomas

Cystic Lung Disease
Langerhans cell Histiocytosis





Cystic Pattern

• Definition:

A nonspecific term describing the presence of a thin walled (usually less than 3 mm thick), well defined and circumscribed, air-or –fluid –containing lesion,1cm or more in diameter that has an epithelial or fibrous wall.

Cystic Pattern

Differential diagnosis of Cystic Lung Disease

• Lymphangiomyomatosis/Tuberose sclerosis
• Langerhans cell Histiocytosis

Pseudocystic patterns

• Emphysema
• Pneumatocele
• Honeycombing
• Cystic bronchiectasis

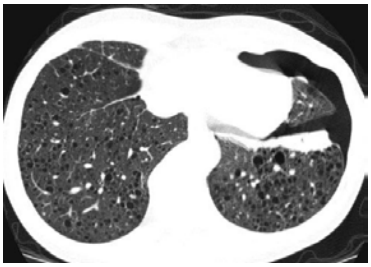
Thank you !

Anil Attili, MD
aattili@umich.edu

SELF EVALUATION

Thoracic Imaging: Case Review

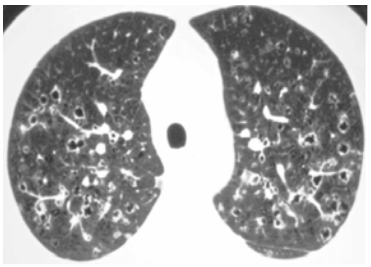
1. CT images from a 35 year old woman with chest pain and shortness of breath are presented. What is the most likely diagnosis?

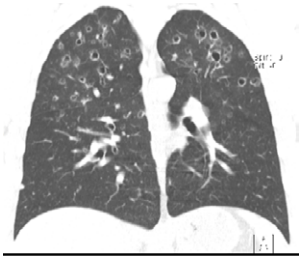




a. Emphysema
b. Cystic Bronchiectasis
c. Lymphangioleiomyomatosis
d. Langerhans cell histiocytosis
e. Birt Hogg Dube disease

2. CT images from a 40 year old male patient with a 20 pack year history of smoking are presented. What is the most likely diagnosis?





a. Lymphangioleiomyomatosis
b. Pulmonary Langerhans cell histiocytosis
c. Cystic bronchiectasis
d. Emphysema
e. Lung cancer

3. A representative CT section from a 35 year old Male smoker with non resolving CXR opacities and shortness of breath is presented below. What is the most likely diagnosis?



a. Idiopathic Pulmonary Fibrosis
b. Hypersensitivity Pneumonitis
c. Non specific interstitial Pneumonitis
d. Pulmonary Alveolar Proteinosis
e. Organizing Pneumonia

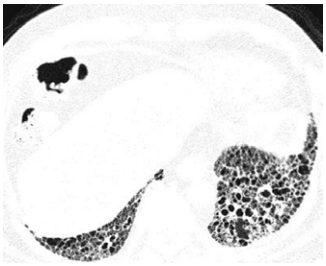
4. Centrilobular ground glass nodules are a key HRCT feature of which of the following condition?

a. Sarcoidosis
b. Miliary TB
c. Hematogenous metastases
d. Respiratory Bronbhiolitis Interstitial Lung Disease
e. Lymphangitis Carcinomatosa

5. Which of the following conditions has an upper lung distribution of abnormalities on CT?

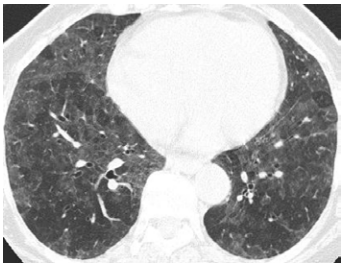
a. IPF
b. NSIP
c. Sarcoidosis
d. Organizing Pneumonia (OP)
e. Desquamative Interstitial Pneumonitis (DSIP)

6. A HRCT section from a 75 year old male patient with shortness of breath and restrictive PFTs is shown below. What is the most likely diagnosis?



a. Idiopathic Pulmonary Fibrosis (IPF)
b. Non specific Interstitial Pneumonitis (NSIP)
c. Organizing Pneumonia
d. Connective Tissue Disease related ILD
e. Emphysema

7. Inspiratory and Expiratory images from the CT of a 40 year old woman with chronic shortness of breath and cough are presented. What is the most likely diagnosis?





a. Sarcoidosis
b. Hypersensitivity Pneumonitis
c. Alveolar Proteinosis
d. Organizing Pneumonia
e. Idiopathic Pulmonary Fibrosis

8. Which of the following HRCT patterns and clinical scenarios does not require a lung biopsy for diagnosis after multidisciplinary discussion?

a. A typical UIP pattern with basal lung honey combing as the predominant abnormality in a 70 year old male
b. An indeterminate UIP pattern in a 50 year old female
c. Ground glass opacity as the predominant finding with expiratory air trapping in a 40 year old man
d. A crazy paving pattern in a 40 year old male smoker
e. Peribronchovascular and lower lung persistent consolidation and ground glass opacity in a 50 year old woman

Answer Key: 1. C, 2. B, 3. D, 4. D, 5. C, 6. A, 7. B, 8. A

Axillary Staging and Breast Localization

Gary J. Whitman, MD



THE UNIVERSITY OF TEXAS MD Anderson Cancer Center
Making Cancer History®

Axillary Staging and Breast Localization



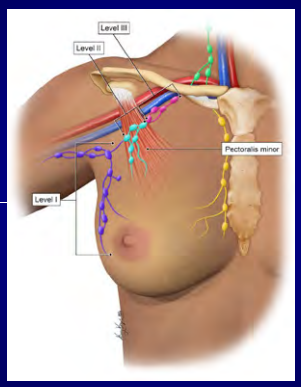
Gary J. Whitman, MD
The University of Texas
MD Anderson Cancer Center

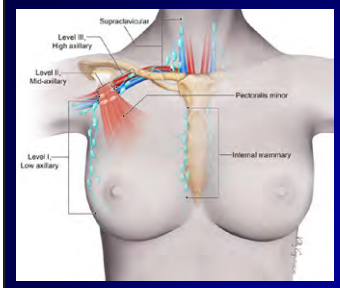
Disclosures

- Gary J. Whitman, MD
- Editor, UpToDate
- Consultant, Siemens
- Vice President, Society of Breast Imaging

Objectives

- To review management of the axilla using the MD Anderson approach
  - Ultrasound
    - All patients with known/suspected invasive disease
  - FNA
  - Sentinel lymph node biopsy
    - Targeted axillary dissection





Level I – lateral to pectoralis minor

Level II – between medial and lateral margins of pectoralis minor (include interpectoral (Rotter) nodes

Level III – medial to medial margin of pectoralis minor

Teichgraeber DC et al. AJR 2021;217:278-290

Regional Nodes (N)

- N0 = no regional nodes
- N1 = metastasis to movable ipsilateral axillary LN
- N2 = metastasis to fixed ipsilateral axillary LN
- N2 = metastasis to ipsilateral internal mammary LN without axillary node metastasis

AJCC Cancer Staging Manual 2002: 257-281.

Regional Nodes (N) continued

- N3 = metastasis to ipsilateral internal mammary LN with axillary LN metastasis
- N3 = metastasis to ipsilateral infraclavicular LN
- N3 = metastasis to supraclavicular LN

AJCC Cancer Staging Manual 2002: 257-281.

Staging

Stage	T	N	M
0	Tis	N0	M0
I	T1	N0	M0
IIA	T0	N1	M0
	T1	N1	M0
	T2	N0	M0
IIB	T2	N1	M0
	T3	N0	M0

AJCC Cancer Staging Manual 2002: 257-281.

Staging

Stage	T	N	M
IIIA	T0	N2	M0
	T1	N2	M0
	T2	N2	M0
	T3	N1	M0
	T3	N2	M0
IIIB	T4	N0	M0
	T4	N1	M0
	T4	N2	M0
IIIC	any T	N3	M0
IV	any T	any N	M1

AJCC Cancer Staging Manual 2002: 257-281.

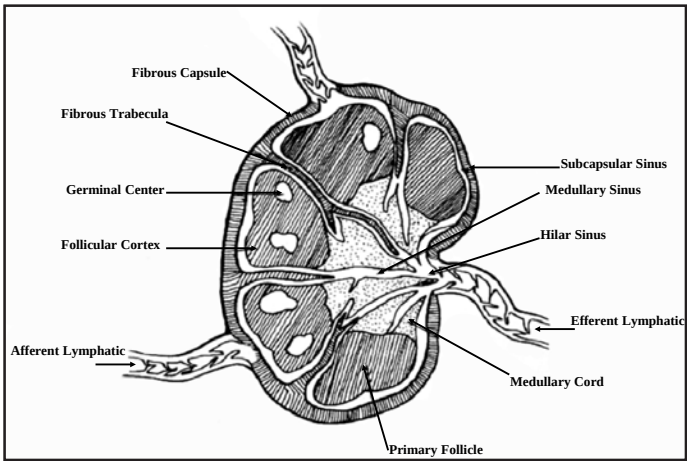
Staging

- Lymph node basins
  - Axillary
  - Infraclavicular
  - Supraclavicular
  - Internal mammary

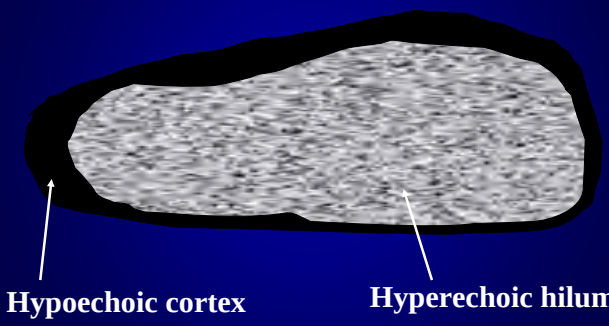
Nodal Status

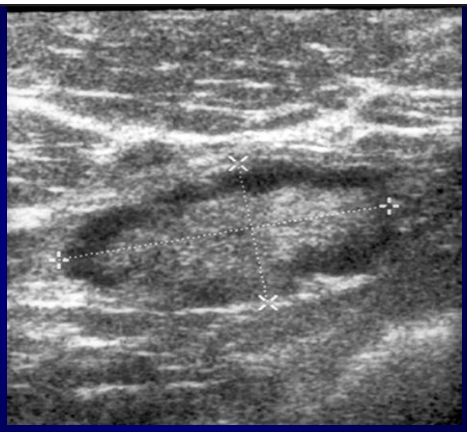
- Axillary nodal status
  - Associated with relapse free survival
  - Associated with overall survival
- Local therapy
- Systemic therapy
  - Chemotherapy
    - Often – If LN+ □ chemotherapy

Glynne-Jones et al. Clinical Oncology 1990; 2:35-38.



Normal Benign Lymph Node





Metastatic Lymph Nodes

- Absence or deformity of the echogenic hilum
- Eccentric cortical hypertrophy

Lymph Node Size

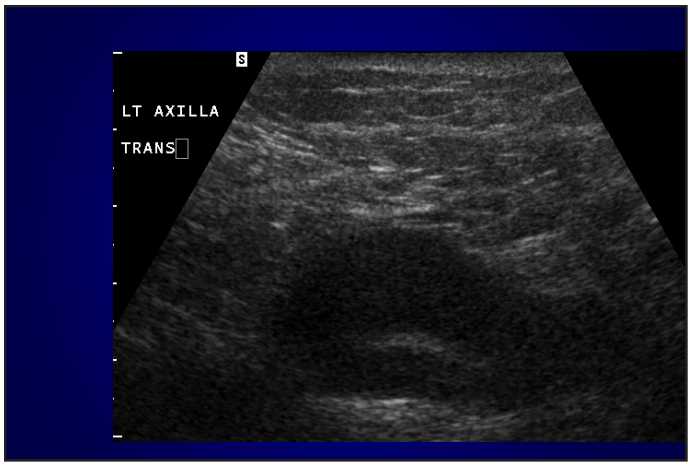
- Useful measurements
  - short axis measurement
  - ratio of long-to-short axis

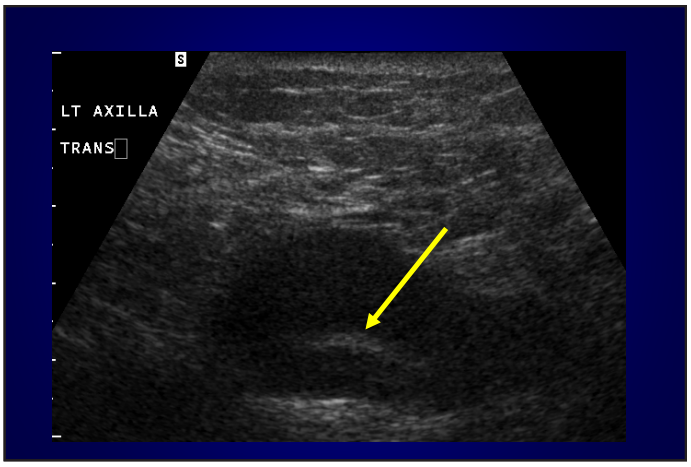
Malignant Lymph Node



- Increased short axis dimension
- Cortical prominence
- Hilar compression







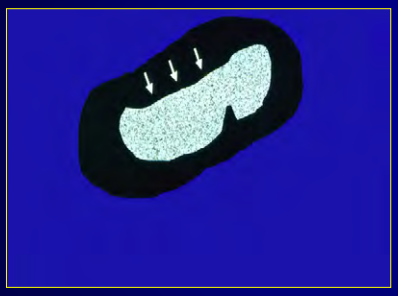
Malignant Lymph Node: Shape



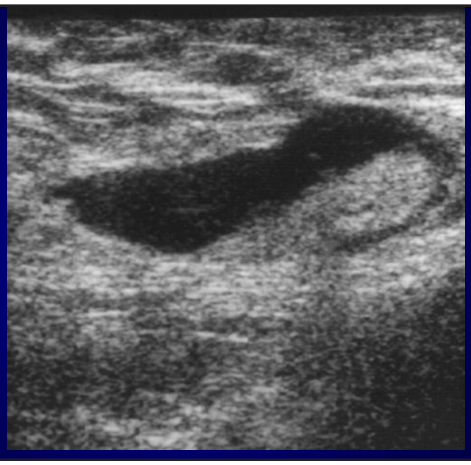


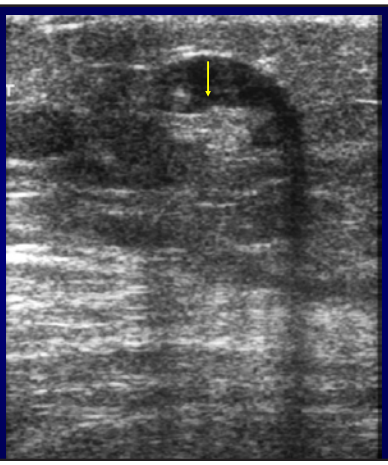
- No evidence of an echogenic hilar region
- Malignant lymph nodes tend to become more rounded

Malignant Lymph Node: Hilar Compression

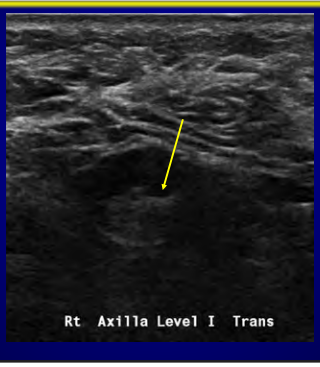


Additional feature favoring malignancy: eccentric cortical rim thickening





Metastatic Right Axillary LN



Physical Examination of the Axilla

- Palpable, suspicious nodes - 70% metastatic
- Nonpalpable nodes - 30% metastatic

Vlastos et al. Am J Surg 2000; 179:446-452.

Lymph Node Sonography

- More sensitive than palpation
- Can identify suspicious nonpalpable lymph nodes
- Can be used to help guide biopsy
  - FNA
  - Core biopsy

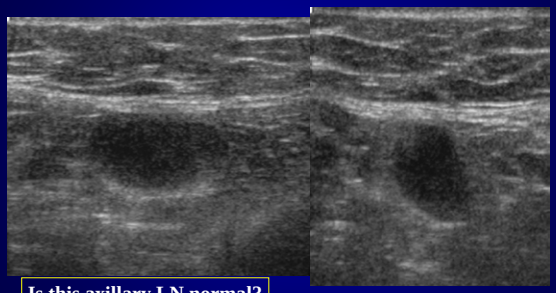
US: Value Added

- Determination of morphology
  - Likely benign
  - Likely malignant
- Guide biopsy
  - FNA
  - Core biopsy
    - If cytology support not available





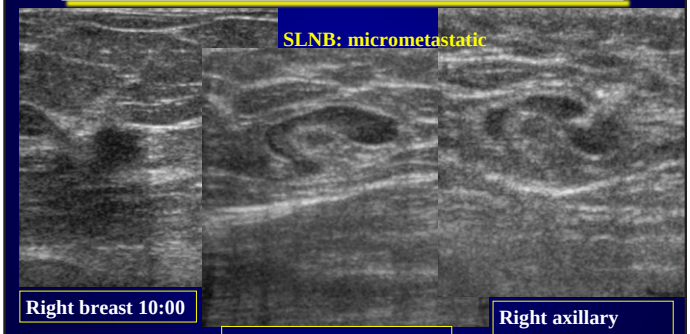
Limitations of Nodal US



Is this axillary LN normal?

FNA/ SLNB- no evidence of malignancy

Limitations of Axillary FNA: Micrometastatic Disease



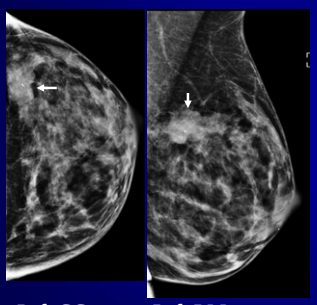
SLNB: micrometastatic

Right breast 10:00

Right axillary LN

Right axillary FNA: negative

Left Breast Triple Negative

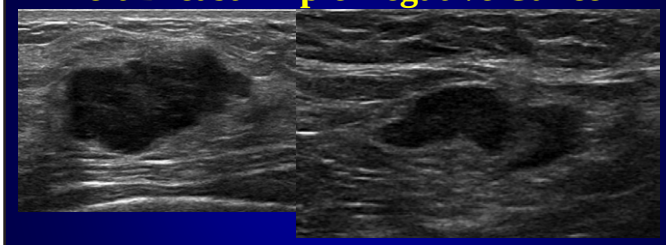


32 Year-Old Woman

Left CC

Left LM

Left Breast Triple Negative Cancer



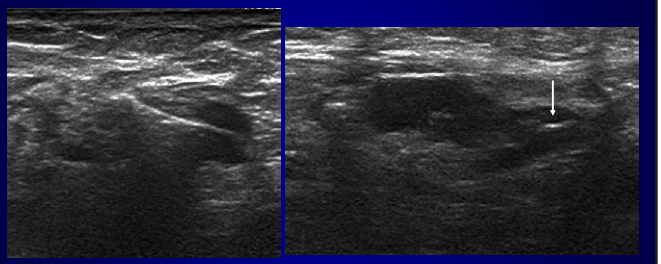
Left breast 1:00-2:00 radial

Left axillary level I longitudinal

Prior left axillary lymph node biopsy was benign

WHAT NEXT?

Left Axillary Core Biopsy



Left axillary core (transverse)

Left axillary longitudinal post-clip

Pathology: no evidence of malignancy

Detection of Metastases by Sonography

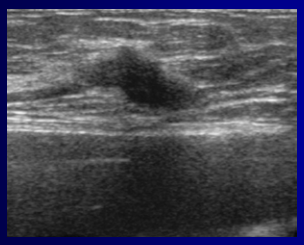
- Limitations
- Sensitivity (56 - 73%)
- Specificity (70 - 90%)

Vlastos et al. Am J Surg 2000; 179:446-452.

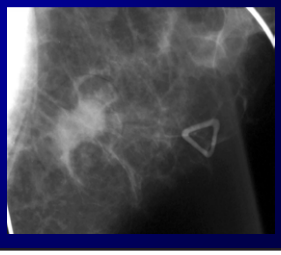
Ultrasound Evaluation of the Axilla

- US to determine if patient undergoes sentinel lymph node biopsy
  - Negative US → sentinel lymph node biopsy or no axillary surgery
  - Positive US → axillary lymph node dissection or targeted axillary dissection (with sentinel lymph node biopsy)

Sentinel Lymph Node Mapping



Known cancer



Are the axillary LN involved?

Rationale

- Accurate assessment of axillary lymph nodes without complications of axillary lymph node dissection
  - Potential morbidity
  - Sampling error

Glass et al. Semin Nuc Med 1999; 29:57-68.

Axillary Lymph Node Dissection

- Previously known for:
  - Surgical control of axillary disease
  - Accurate assessment of metastatic involvement of axillary lymph nodes
  - Prognostic information

Vlastos et al. Am J Surg 2000; 179:446-452.

Potential Complications of ALND

- Lymphedema
  - Disfiguring
  - Debilitating
- Additional complications
  - Wound infection
  - Seromas
  - Paresthesias



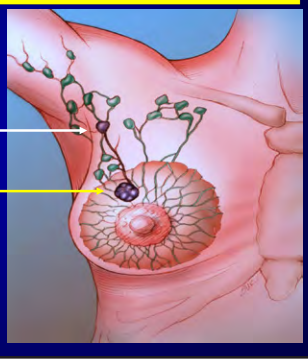
Lymph Node Mapping

- Careful histopathologic evaluation
  - Identification of micrometastases
- Markedly reduced risk of complications

Canavese et al. Semin Nuc Oncol 1998; 15:272-277.

Sentinel Lymph Node Concept

- Sentinel LN

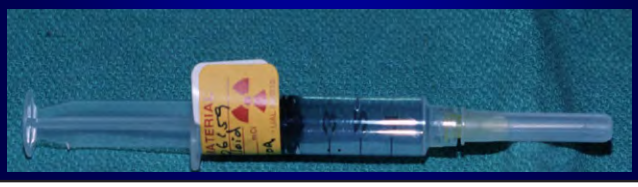


Radiopharmaceutical

- Technetium - 99m sulfur colloid
  - Filtered
  - 0.5 mCi (2.5 mCi if injected the day before surgery)
  - Mixed with saline (4 cc)

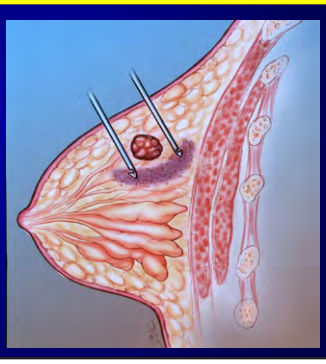
Sentinel LN Mapping

- Peritumoral
  - US or mammographic guidance
- Subdermal
- Periareolar

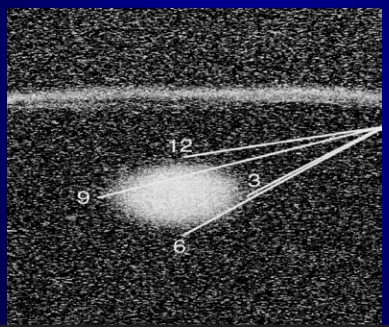


Mammographic Guidance

- Peritumoral

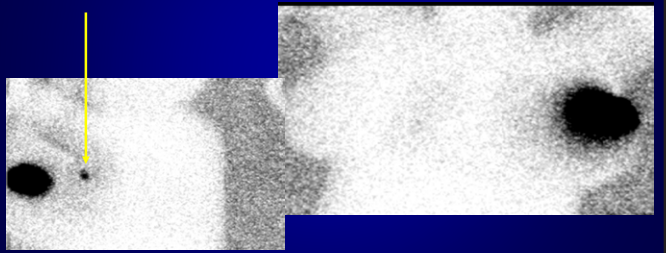


Sonographic Guidance



Nuclear Medicine

- Sentinel LN

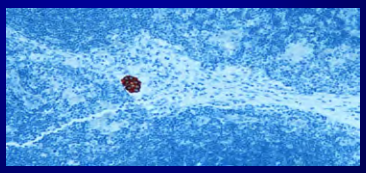


Lymph Node Mapping



Pathology

- Thin sections
- Immunohistochemistry



Targeted Axillary Dissection in Addition to Sentinel Lymph Node Biopsy

- Clip placed in metastatic LN with US guidance
- Clipped node targeted for localization with US
- Clipped node removed surgically
- Historically – TAD for 3 or fewer abnormal LN on US
  - Challenged in recent literature
  - No significant difference in false negative rates for 3 < LN or LN > 3 on US
  - Loveland-Jones et al. Eur J Surg Onc 2024 50 108245

ACOSOG Z11

- Z11 Conclusion: In patients with limited SLN metastatic breast cancer treated with BCT and systemic therapy, SLN compared to ALND did not result in inferior survival

- Giuliano et al. Axillary Dissection vs No Axillary Dissection in Women With Invasive Breast Cancer and Sentinel Node Metastasis. A Randomized Clinical Trial. JAMA 2011;305:569-575.

WHAT WE LEARNED FROM Z11

- Z11: Early stage breast cancer with a low nodal burden can be treated with less extensive surgery
  - SLNB instead of ALND
  - Without compromising survival

Giuliano et al. Axillary Dissection vs No Axillary Dissection in Women With Invasive Breast Cancer and Sentinel Node Metastasis. A Randomized Clinical Trial. JAMA 2011;305:569-575.

ACOSOG Z11

Z11 TRIAL □□□

SHOULD EVERY PATIENT WITH KNOWN OR SUSPECTED INVASIVE BREAST CANCER UNDERGO AXILLARY US?

- Giuliano et al. Axillary Dissection vs No Axillary Dissection in Women With Invasive Breast Cancer and Sentinel Node Metastasis. A Randomized Clinical Trial. JAMA 2011;305:569-575.

ACOSOG Z0011 ELIGIBILITY

INVASIVE CARCINOMA

5 CM OR LESS

SLN WITH METASTATIC BREAST CANCER (FROZEN SECTION, TOUCH PREP, H AND E)

NOT ELIGIBLE IF:

3 OR MORE POSITIVE SLN, MATTED LN, GROSS EXTRANODAL DISEASE

NEOADJUVANT CHEMOTHERAPY

NOT ELIGIBLE IF:

PALPABLE AXILLARY LYMPHADENOPATHY

- Giuliano et al. Axillary Dissection vs No Axillary Dissection in Women With Invasive Breast Cancer and Sentinel Node Metastasis. A Randomized Clinical Trial. JAMA 2011;305:569-575.

ACOSOG Z0011 ELIGIBILITY

NO MENTION OF AXILLARY US IN METHODS

SOME Z11 PATIENTS HAD AXILLARY US

POSITIVE AXILLARY BIOPSY → NOT ELIGIBLE FOR Z11

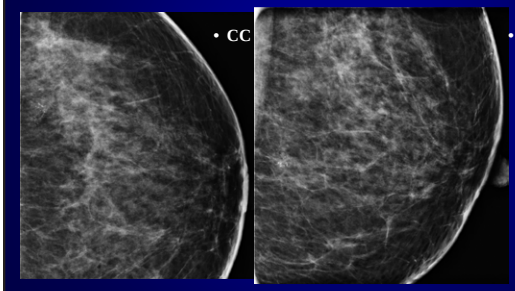
POST Z11:

ROLE OF AXILLARY US

AXILLARY US → FIND METASTATIC LN AND INITIATE NEOADJUVANT CHEMOTHERAPY

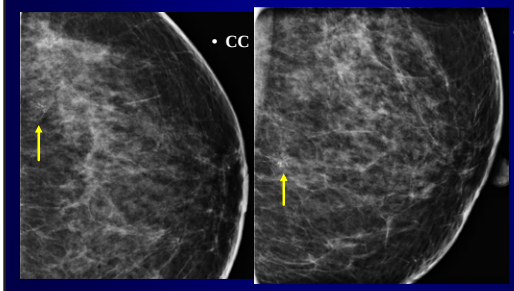
Giuliano et al. Axillary Dissection vs No Axillary Dissection in Women With Invasive Breast Cancer and Sentinel Node Metastasis. A Randomized Clinical Trial. JAMA 2011;305:569-575.

41-Year-Old Woman with New Calcifications in the Left Breast



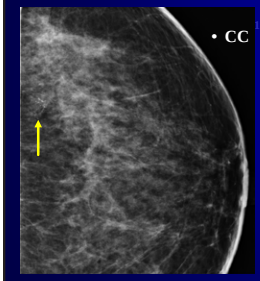
- CC
- ML
- PATIENT WOULD LIKELY QUALIFY FOR Z11

41-Year-Old Woman with New Calcifications in the Left Breast



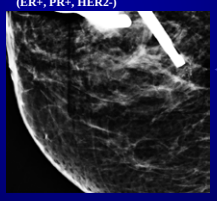
- CC
- ML

41-Year-Old Woman with New Calcifications in the Left Breast



- CC

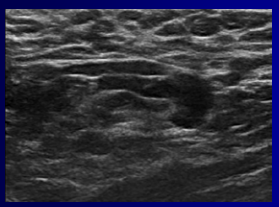
STEREOTACTIC BIOPSY: INVASIVE DUCTAL CARCINOMA AND DCIS (ER+, PR+, HER2-)



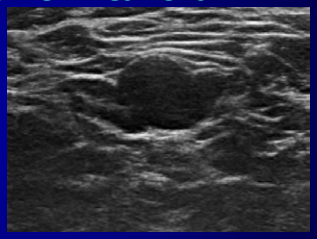
SHE WOULD QUALIFY AS A Z11 PATIENT

SHOULD AXILLARY US BE PERFORMED?

Left Axillary Ultrasound
No palpable LN on clinical exam

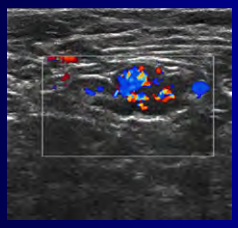


Longitudinal

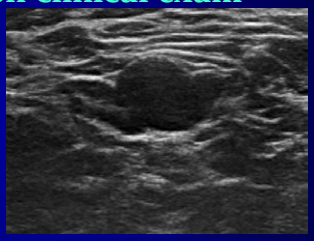


Transverse

Left Axillary Ultrasound
No palpable LN on clinical exam

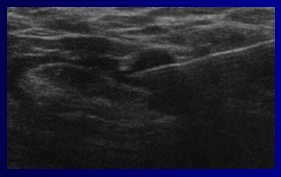


Transverse Power Doppler

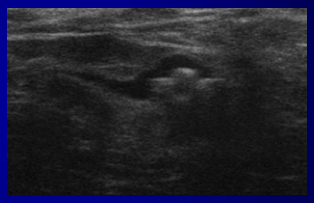


Transverse

Left Axillary Ultrasound FNA and Clip Placement
No palpable LN on clinical exam

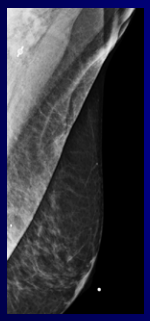


Left axillary FNA: metastatic carcinoma



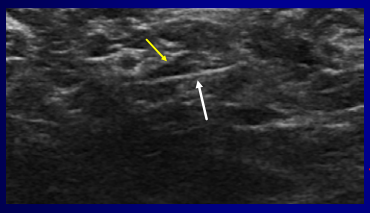
Left axillary clip

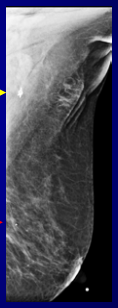
Post-Clip Placement Mammogram



- Clip within targeted lymph node
  - IDC with axillary metastatic disease → preoperative chemotherapy
  - Taxol followed by FAC

Ultrasound-Guided I-125 Seed Placement





Pathology

- Left breast nipple sparing mastectomy: extensive treatment effects, no residual carcinoma
- Left axillary sentinel lymph node biopsy: 0/4 (including clipped node)
- 2 year follow-up: no locoregional or distant recurrence

POST-Z11 – WHAT IS THE ROLE OF AXILLARY US?

One point of view: Biopsy proven + axillary LN → ALND

However, ALND may be obviated with targeted axillary dissection (TAD)

- TAD decreases the false negative rate of SLNB
- False negative rate of 2% (SLNB + TAD)
  - *Caudle et al. J Clin Oncol 2016;34:1072-1078*

Giuliano et al. Axillary Dissection vs No Axillary Dissection in Women With Invasive Breast Cancer and Sentinel Node Metastasis. A Randomized Clinical Trial. JAMA 2011;305:569-575.

Caudle et al. Selective Surgical Localization of Axillary Lymph Nodes Containing Metastases in Patients With Breast Cancer. A Prospective Feasibility Trial. JAMA Surg 2015;150:137-143

Targeted Axillary Dissection

65-year-old woman with right breast poorly differentiated invasive cancer



Suspicious lymph node



FNA was positive for malignancy

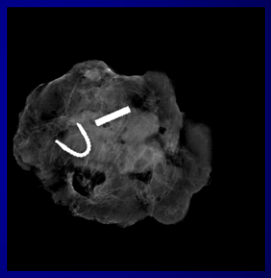


Clip placed in node

Targeted Axillary Dissection



Magnetic seeds placed with US guidance



4 sentinel LN removed and no residual tumor in breast or axillary LN

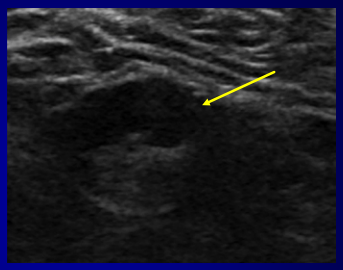
Clip Placement

- 81-year old woman with IDC
- Axillary FNA: metastatic LN
  - Clip placed in metastatic LN
- Mastectomy: no residual disease
- ALND: 1/15 LN +
  - Clipped LN: post-treatment changes



Axillary US

Sensitivity: 35-65%
Specificity: 68-78%
NPV: 79-97%
PPV: 58-94%



Hieken et al. Preoperative axillary imaging with percutaneous lymph node biopsy is valuable in the contemporary management of patients with breast cancer. Surgery 2013; 154:831-840.

Post-Z11– What is the Role of Axillary US?

Axillary US is more sensitive than clinical examination and mammography for detecting axillary metastases

--US can be helpful in clinically node negative patients
  Triage
  "Personalized medicine"
--Accuracy of US enhanced with FNA or core biopsy

Hieken et al. Preoperative axillary imaging with percutaneous lymph node biopsy is valuable in the contemporary management of patients with breast cancer. Surgery 2013; 154:831-840.

Axillary US: Study of 310 Patients

Axillary US	Axillary US-guided biopsy (FNA/core)
Sensitivity: 93%	Sensitivity: 86%
Specificity: 48%	Specificity: 100%

Joh et al. Indications for Axillary Ultrasound Use in Breast Cancer Patients. Clinical Breast Cancer 2012;12:433-437

Post-Z11– What is the Role of Axillary US?

Axillary US (with biopsy) identifies patients with a higher tumor burden

2/3 of T1/T2 patients with multiple suspicious lymph nodes on US had > 2 positive lymph nodes on pathology

- -Axillary US as a triage tool
- -ALND without SLNB appropriate for some patients with extensive nodal disease

Hieken et al. Preoperative axillary imaging with percutaneous lymph node biopsy is valuable in the contemporary management of patients with breast cancer. Surgery 2013; 154:831-840.

Post-Z11– What is the Role of Axillary US?

Axillary US in Patients with T1 and T2 Tumors:

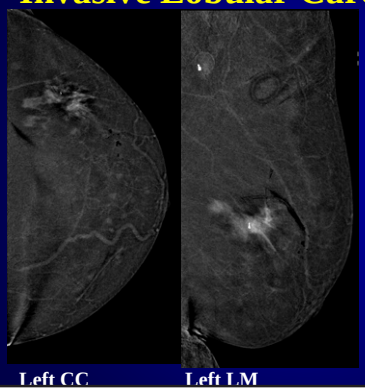
1 abnormal LN on US 30.7% had > 3 + LN on pathology

Multiple abnormal LN on US 68.6% had 3+ LN on pathology

(P = 0.0008)

US: PREDICTIVE VALUE FOR DETERMINING NODAL BURDEN

Invasive Lobular Carcinoma

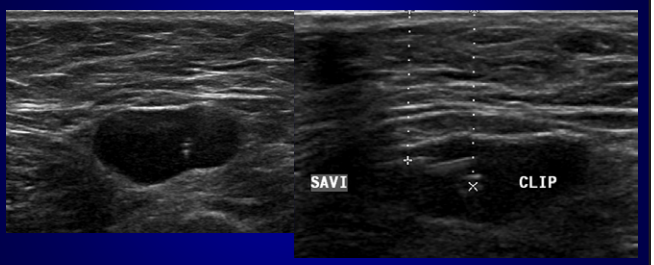


Left CC Left LM

Left axillary biopsy showed metastatic disease

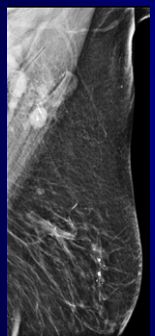
81-years old

Ultrasound-Guided Scout Placement

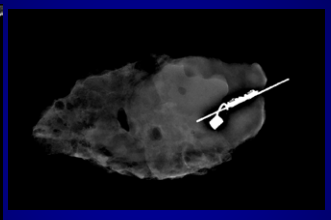


Left axillary clip (transverse) Left axillary scout and clip (transverse)

Verification of Removal of Targeted Node



Left MLO



Specimen radiograph

Clipped lymph node +
3/3 sentinel lymph nodes +
4/10 lymph nodes + (dissection)

Axillary US

Allowed for accurate treatment planning:
-Planned ALND without SLNB in 28.6% of node + patients
(Cost savings, decreased morbidity, avoid false negative SLNB)

+ Axillary LN on needle biopsy associated with:
Greater # of metastatic LN
Larger metastases
More extranodal extension

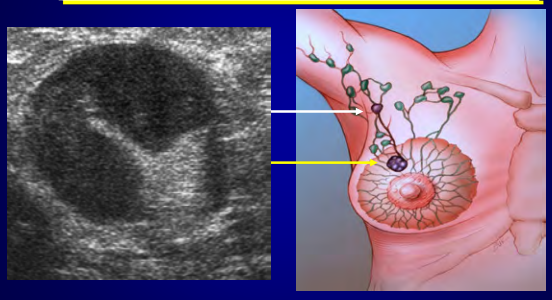
Hieken et al. Preoperative axillary imaging with percutaneous lymph node biopsy is valuable in the contemporary management of patients with breast cancer. Surgery 2013; 154:831-840.

Post-Z11:

3-5% of ax needle biopsy+ T1/T2 patients met Z11 criteria
-May have avoided ALND

Hieken et al. Preoperative axillary imaging with percutaneous lymph node biopsy is valuable in the contemporary management of patients with breast cancer. Surgery 2013; 154:831-840.

Axillary US with Biopsy vs Sentinel Lymph Node Biopsy



US-Guided Biopsy of the Axilla vs. SLNB

- 139 Axillary US-guided biopsy +
- 163 SLNB +
- US-guided Ax LN biopsy + more likely:
  - Older ($p < 0.001$)
  - Palpable LN ($p < 0.001$)
  - Underwent mastectomy ($p < 0.001$)
  - Larger tumors ($p < 0.001$)
  - Lymphovascular invasion ($p = 0.035$)
  - HER2neu positive ($p = 0.006$)
  - Negative hormone receptors ($p = 0.003$)

Verheuval et al. The Role of Ultrasound-Guided Lymph Node Biopsy in Axillary Staging of Invasive Breast Cancer in the Post-ACOSOG Z0011 Trial Era. Ann Surg Oncol 2015;22:409-415

US-Guided Biopsy of the Axilla vs. SLNB

- 139 Axillary US-guided biopsy +
- 163 SLNB +
- US-guided Ax LN biopsy + more likely:
  - More LN with macrometastatic disease ($p < 0.001$)
  - Extranodal extension ($p < 0.001$)
  - Involvement of axillary level III LN ($p < 0.001$)
  - Worse disease-free survival (hazard ratio = 2.71)
  - Worse overall survival (hazard ratio = 2.67)

Verheuval et al. The Role of Ultrasound-Guided Lymph Node Biopsy in Axillary Staging of Invasive Breast Cancer in the Post-ACOSOG Z0011 Trial Era. Ann Surg Oncol 2015;22:409-415

Post-Z11: Comparison of Axillary Node Positive Patients (Biopsy Proven) and Sentinel Lymph Node Positive Patients

Axillary LN positive patients have:
-Less favorable disease characteristics…
-Worse prognosis…
when compared to SLN positive patients

Patients with positive axillary LN seen on US are substantially different than patients with positive axillary SLN

Verheuval et al. The Role of Ultrasound-Guided Lymph Node Biopsy in Axillary Staging of Invasive Breast Cancer in the Post-ACOSOG Z011 Trial Era. Ann Surg Oncol 2015;22:409-415

Post-Z11: Comparison of Axillary Node Positive Patients (Biopsy Proven) and Sentinel Lymph Node Positive Patients

Patients with positive axillary LN seen on US are not equivalent to those with positive SLN
The results of the Z11 trial should only be applied to the SLN+ group
-Not to the axillary US LN+ group

Verheuval et al. The Role of Ultrasound-Guided Lymph Node Biopsy in Axillary Staging of Invasive Breast Cancer in the Post-ACOSOG Z011 Trial Era. Ann Surg Oncol 2015;22:409-415

Post-Z11: What is the Role of Axillary US in Patients with T2 or Greater Tumors?

Axillary US	Axillary US with Needle Biopsy
Sensitivity = 86.2%	Sensitivity = 89.3%
Specificity = 40.5%	Specificity = 100%

Neoadjuvant chemotherapy given in 49.7% of patients

Save health care $ by doing axillary US
-Save > $ 4000/patient
-Axillary US reduced use of SLNB

Lee et al. Consequences of Axillary Ultrasound in Patients with T2 or Greater Invasive Breast Cancers. Ann Surg Oncol 2011; 18:72-22

Conclusion– There is a Role for Axillary US

Axillary US post-Z11:
Axillary US+ LN patients are different from SLN+ patients
Axillary US+ LN associated with more extensive nodal disease and worse survival compared to SLN+

Axillary US: Cost-effective role in triage
Identifies those with more extensive nodal disease
Identifies patients who may benefit from neoadjuvant therapy

Hieken et al. Preoperative axillary imaging with percutaneous lymph node biopsy is valuable in the contemporary management of patients with breast cancer. Surgery 2013; 154:831-840.

Conclusion

- US plays a critical role in staging the axilla
- FNA and core biopsy are valuable tools in sampling the regional lymph nodes
  - FNA requires optimal cytology support
  - If cytology support is not available core biopsy

Conclusion

- Sentinel lymph node biopsy plays an important role in staging the axilla
- Targeted axillary dissection is an evolving technique in axillary staging
  - Targeted axillary dissection decreases the false negative rate associated with sentinel lymph node biopsy

NON-WIRE LOCALIZATIONS

Gary J. Whitman, M.D.
The University of Texas
MD Anderson Cancer Center

Special Thanks

- Piyanoot Woodtichartpreecha, MD, helped to prepare this presentation

Localization Techniques

- Needles/wires
- Radioactive seeds
- Magnetic seeds
- Radar localizers

Non-Wire Localization Techniques

- Radioactive seeds
- Magnetic seeds
- Radar localizers

- Decouple breast imaging procedure from surgical procedure

Non-Wire Localization Techniques

- Radioactive seeds
- Magnetic seeds
- Radar localizers

- Scheduling flexibility
  - Do not have NPO patients coming for breast imaging procedures on the day of surgery
- More comfortable for patients

Starting a Radioactive Seed Program

- Involve multidisciplinary coordination
  - Radiation safety officer (RSO)
  - Nuclear medicine physicians
  - Radiologists
  - Surgeons
  - Pathologists

Radioactive Seed Localization (RSL)

- Introduced in 1999
- An alternative method to standard wire localization (WL) for preoperative localization of nonpalpable breast lesions

Radioactive Seed Localization

- Implantation of an Iodine-125 seed in the tumor under mammographic or ultrasound guidance
- Intraoperative transcutaneous tracking of Iodine-125 counts using a gamma probe

Radioactive Seed Program

Regulatory compliance

- Investigate state-specific nuclear regulatory compliance (NRC) issues and gain approval for use
- Train involved personnel in radiation safety and handling
- Develop a written protocol
- Design and implement a seed tracking system and recovery procedure

State Regulations

- Guidelines specifically for RSL of breast lesions
  - Limit the length of time to 5 days (Texas) that the seed may remain in the patient before surgical excision
- Proper handling, use, and disposal of the radioactive seed requires the oversight of a RSO and proper facility licensing

Licensing Process

- Applying for radioactive materials (RAM) license if not pre-existing
- Amend RAM license to add use I-125 seed for RSL
- Key members
- Logistics of in-house program

Radiation Safety Officer (RSO)

- Regulatory guidance
- Oversight and radioactive material (RAM) protocol
- Develop policies and procedures for RAM use
- Training based on ALARA principles (time, distance, shielding)

Radioactive Seed

- Iodine-125
  - 60-day half-life
  - 27-keV gamma radiation emission peak

Radioactivity Levels

- Radioactivity levels ranging from 0.1 to 0.3 mCi are considered by the Nuclear Regulatory Commission (NRC) to be safe for human exposure

Radioactive Seeds

Preloaded seed

- 18 g needles in 5, 7, 10, and 15 cm lengths
- With stoppers



Studies Comparing Margin Status for RSL Versus WL

Margin status

References	Wire (*N*)	First intraop margin +	Final margin positive	Seed (*N*)	First intraop margin +	Final margin positive
Gray [7]	26	57 %	N/A	35	26 %	N/A
Gray [3]	79	46 %	24 %	83	26 %	10 %
Hughes [4]	99	46 %	25 %	383	27 %	8 %
Rao [16]	33	N/A	54 %	50	N/A	42 %
Lovrics [8]	153	N/A	22 %	152	N/A	19 %
Murphy [9]	256	N/A	22 %	431	N/A	23 %
Chiu [14]	44	N/A	55 %	59	N/A	17 %
Sharek [15]	118	21 %	11 %	114	31 %	13 %

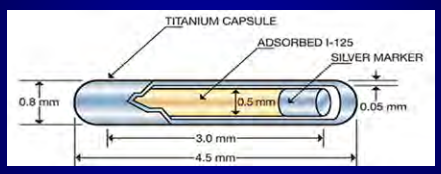
Jakub et al. Ann Surg Oncol. 2015; 22:3197-3202

Preloaded Radioactive Seeds

Stopper

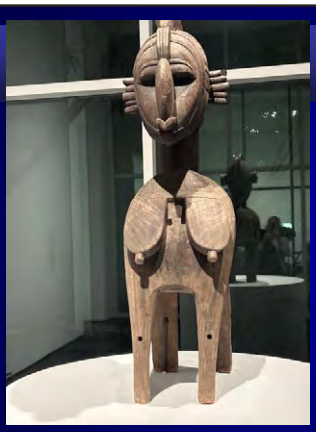


Seed size: 4.5-mm x 0.8-mm



Gamma Detection Probe

- Handheld probe
- Can select either Tc-99m (used for lymph node mapping) or I-125 (used for seed localization)

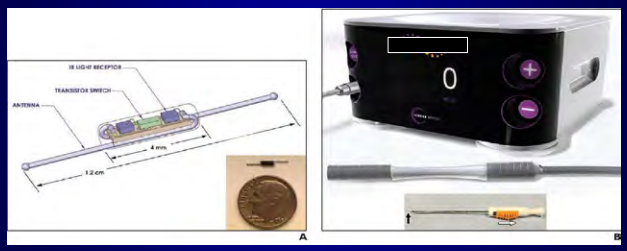


Magnetic Seed



Delivery system identical to radioactive seeds

Radar Device



Mango V et al. AJR 2015;207(4):W69-W72.

Non-Wire Localizations: Advantages

- Improved scheduling
- Decouples surgical schedule from breast imaging procedure schedule
  - Can place seed in breast on a day prior to surgery
    - Usual practice at MDACC – 1 day before OR
    - Radioactive seeds can be placed up to 5 days before surgery (in Texas)

Non-Wire Localizations: Advantages

- Results in better patient satisfaction
- Surgeons have found RSL easier to perform than WL
- Radiologists have not reported a difference in difficulty (technique similar to WL)

Sharek et al. AJR 2015; 204:872-877

Goudreau et al. RadioGraphics. 2015;35:1319-1334

Non-Wire Localization: Advantage

- Extremely low likelihood of migration after placement

Sharek et al. AJR 2015; 204:872-877

Goudreau et al. RadioGraphics. 2015;35:1319-1334

RSL: Disadvantage

- The seed is a source of radiation
- The patient receives an extremely low dose of radiation to the tissues immediately adjacent to the seed

Sharek et al. AJR 2015; 204:872-877

Goudreau et al. RadioGraphics. 2015;35:1319-1334

RSL: Disadvantage

- Regulatory considerations
  - Strict oversight by the radiation safety officer (RSO)
  - Need a comprehensive safety plan for tracking, handling, and management of each seed
- Once a seed is deployed within the breast, it cannot be adjusted
  - Must be removed surgically

Studies Comparing Various Aspects: Seed Versus WL

References	Positive margins	Specimen size	Operative time	Patient satisfaction
Gray* [2]	Favor seed	No difference	No difference	No difference
Hughes [4]	Favor seed	N/A	N/A	Favor seed
Lovrics* [8]	No difference	No difference	Favor seed	Favor seed
Murphy [9]	No difference	No difference	No difference	N/A
Chiu [14]	Favor seed	No difference	N/A	N/A
Sharek [15]	No difference	No difference	N/A	N/A

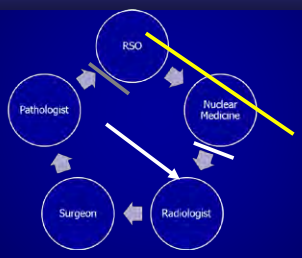
* Randomized, controlled trial

Jakub et al. Ann Surg Oncol. 2015; 22:3197-3202

RSL Workflow



Non-Wire Workflow Without RSL



Seed Workflow in Radiology

Decision making and planning
- Type of seed
  - Determined by surgeon
- Number of seeds per breast
  - Determined by breast imager
- Imaging modality for guidance
  - Mammography or ultrasound
    - Determined by breast imager

Utilization of Multiple Seeds in the Same Breast

Purposes
- Bracketing or localization of multiple lesions
  - Determined by breast imager in conjunction with surgeon
  - Similar to wire localization

Comparison Between RSL versus WL

Advantages

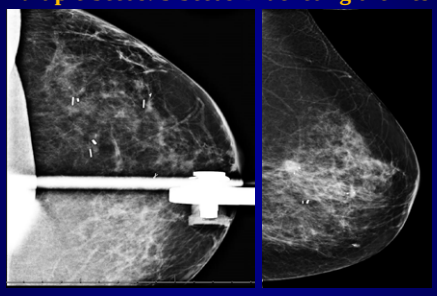
- Can perform 1-5 days before surgery
- Positive margin status is equal or lower in RSL compared to WL
- No difference in specimen size and operative time compared to WL
- Patient satisfaction improved

Disadvantages

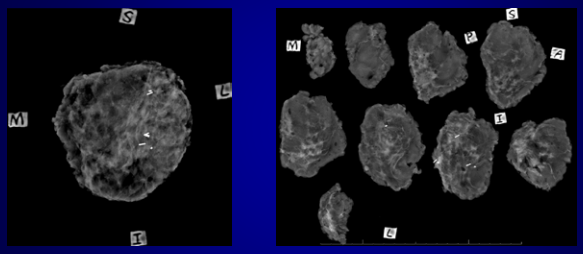
- Cannot be repositioned
- Radiation exposure to patient and staff

Jakub et al. Ann Surg Oncol. 2015; 22:3197-3202

Multiple Seeds: 3 Seeds Bracketing the Lesion



All 3 Seeds are Removed in 1 Specimen



Utilization of Multiple Radioactive Seeds in the Same Breast

- A Geiger counter cannot reliably confirm placement of additional seeds once the first seed has been placed if the seeds are close to one another
- Distance between seeds should be > 2 cm
  - Enable the surgeon to more effectively detect separate radioactive sites

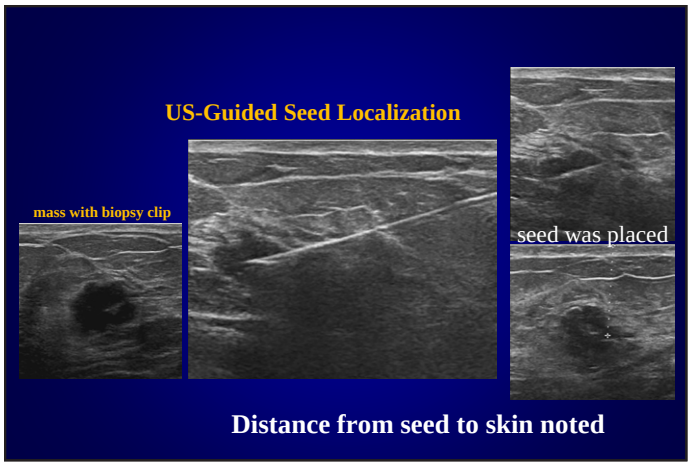
Utilization of Multiple Seeds in the Same Breast is Safe and Feasible

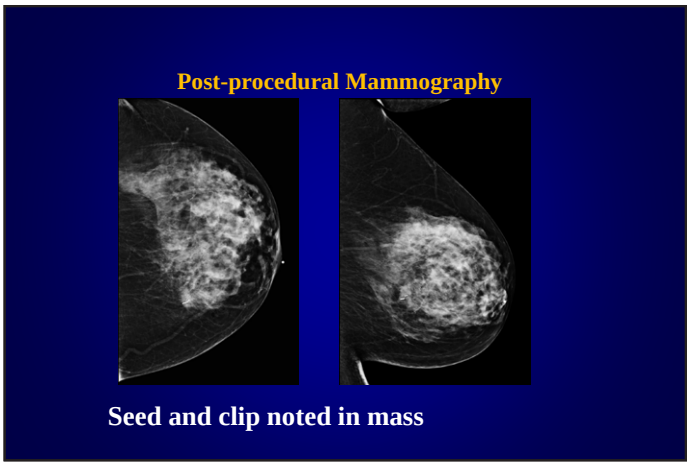
- Overall re-excision rate of 28.2%
  - 18% for re-excision of margins and 10.2% proceeding to mastectomy
  - Patients with multiple lesions in the same breast, multifocal and multicentric cancer, and extensive disease requiring bracketing at a higher likelihood of failing to obtain negative margins

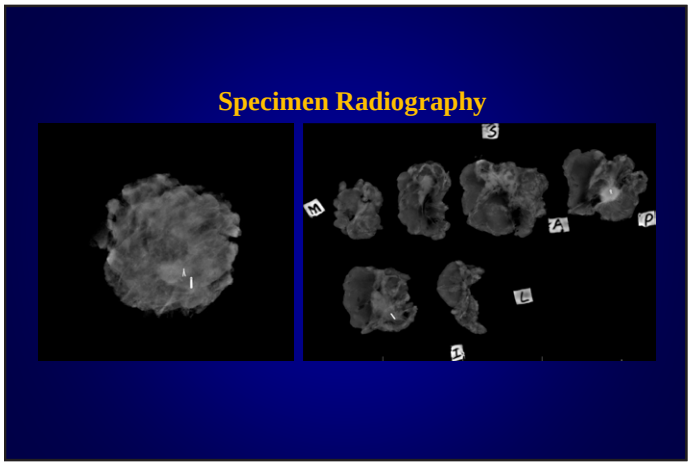
Al-Hilli et al. Ann Surg Oncol. 2015; 22:3350-55

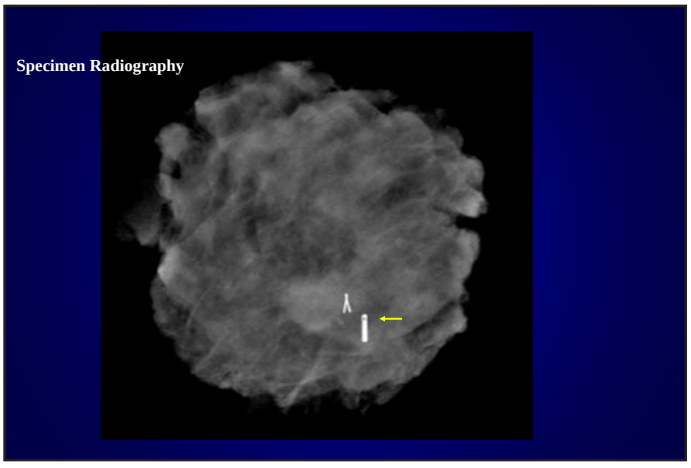
Ultrasound Guidance

- The seed is deployed at the target site during real-time observation, with care taken to avoid any adjacent biopsy clip
- Non-wire localization allows one to use any angle or approach





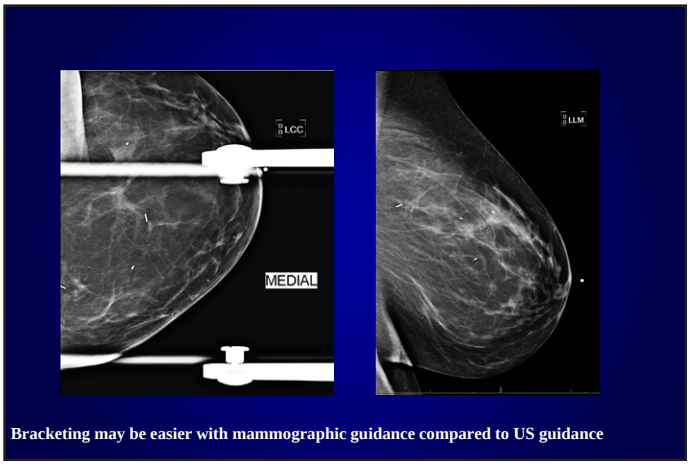


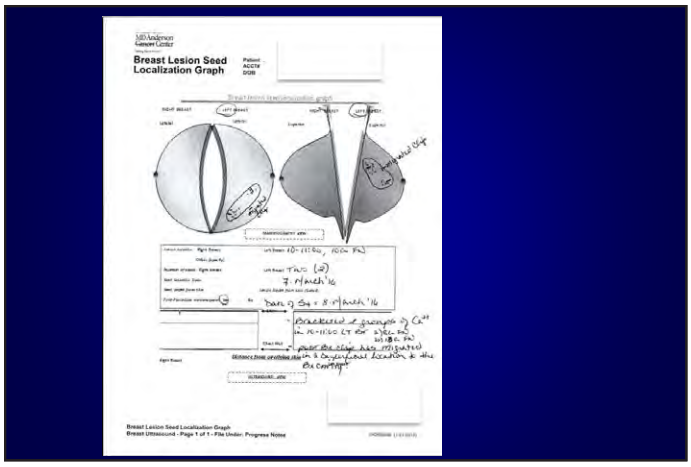


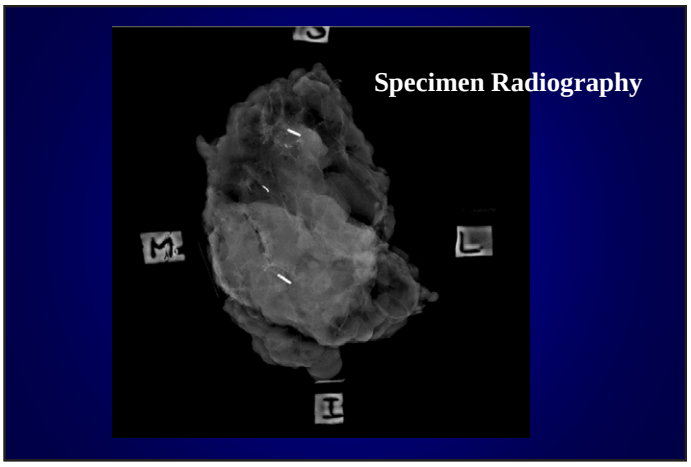
Mammographic Guidance

Digital mammography guidance

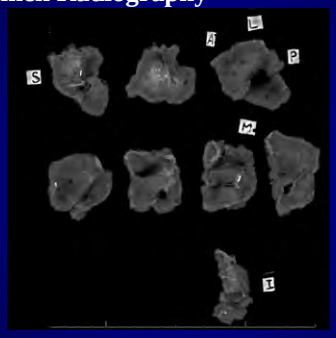
- **Alphanumeric grid in mammography unit or stereotactic guidance**
- **The needle is not completely withdrawn from the patient until the seed is confirmed to be within the breast on at least one image**
  - **If the seed is not successfully deployed, this technique allows for repositioning the needle and attempting to deploy the seed again**



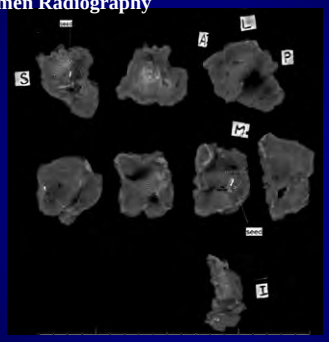


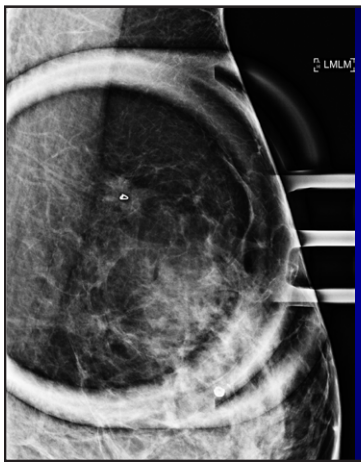


Specimen Radiography



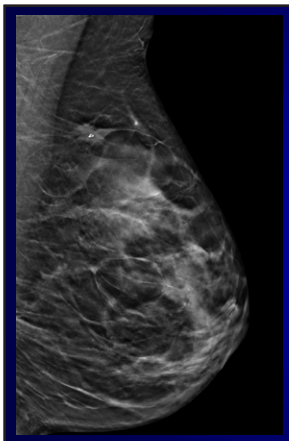
Specimen Radiography





39-year-old woman

IDC with focal lobular features



Left LM tomosynthesis

39-year-old woman

IDC with focal lobular features

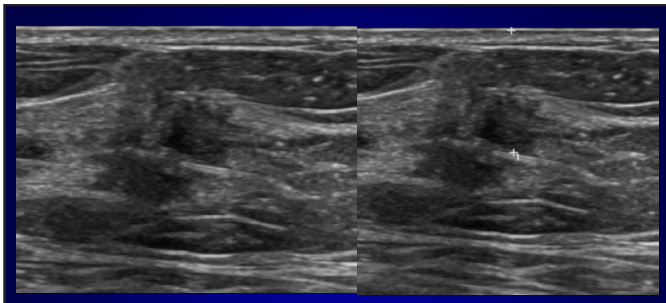
For radar localization



39-year-old woman

IDC with focal lobular features

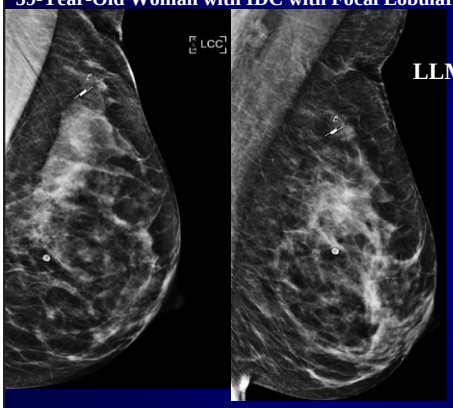
Left breast 2:00 transverse



Left breast 2:00 transverse Left breast 2:00 transverse

Measure distance between radar device and skin

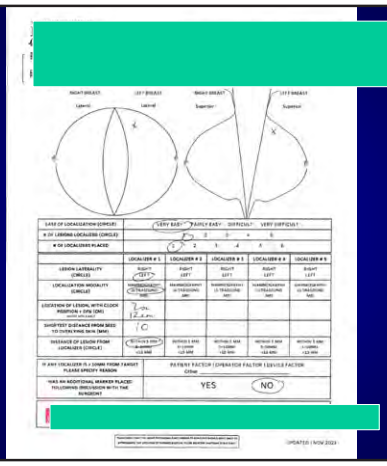
39-Year-Old Woman with IDC with Focal Lobular Features



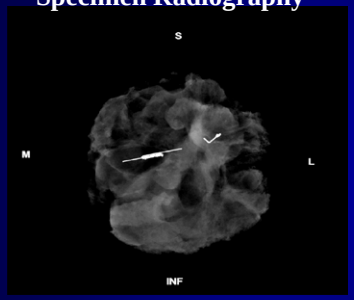
LLM

Radar device placement

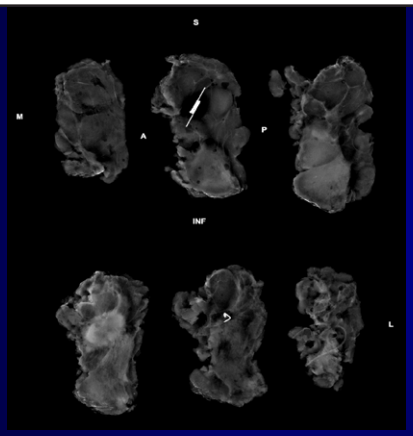
Diagram of the procedure



Specimen Radiography



Verify presence of localization devices and clips



IDC with focal lobular features

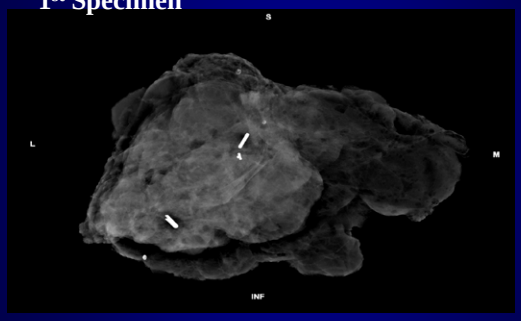
Specimen radiography to verify clips and devices and assess margins

65-Year-Old Woman with DCIS

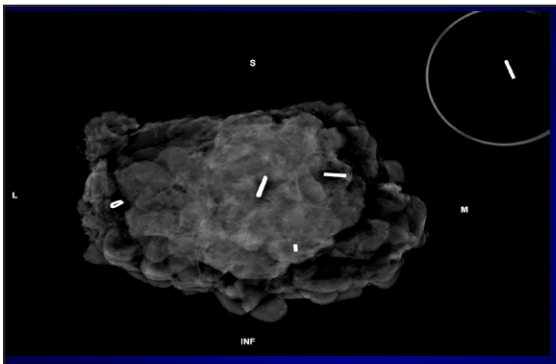


3 magnetic seeds placed

1st Specimen



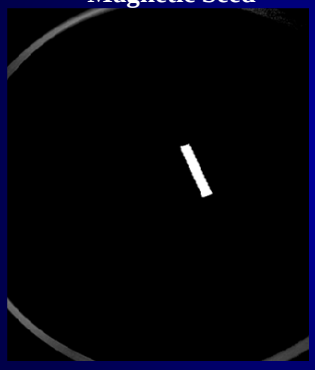
DCIS



DCIS

2nd Specimen

Magnetic Seed



Imaging Guidance

MRI

- Should not be used to guide radioactive or magnetic seed placement
- The gamma detector probe used to locate a lost or dropped seed is not MRI compatible
- MRI can be used for radar placement

Seed Workflow in Radiology

- After radioactive seed deployment, regardless of the guidance method, and before anyone exits the procedure room, the patient is assessed for radioactivity with a Geiger counter to confirm placement of the seed within the breast
- After radar deployment, the signal is verified with a probe
- Post-procedure mammography is then performed

Seed Workflow in Radiology

- Post-procedure mammography with two orthogonal images (regardless of modality used to place the seed)
  - Reconfirms seed placement
  - Evaluation of seed location
  - Successful placement: seed within 1 cm of targeted lesion
    - » If the seed is more than 2 cm from the targeted lesion, the findings should be discussed with the surgeon

Seed Workflow in Radiology

- If the patient has been recently injected with Tc-99m for sentinel lymph node mapping before radioactive seed localization, confirmation of seed placement must be done with imaging
  - Ideally, the radioactive seed placement should be done before Tc-99m is injected

Seed Workflow in Surgery

- Surgery within 1-5 days after radioactive seed implantation
- The surgeon relies on radioactivity counts during excision to recover the seed
- The surgeon must use the gamma probe to:
  - Ensure that the seed is within the excised specimen before passing the specimen off the field
  - Assure no remaining I-125 activity within the breast

Seed Workflow in Surgery

- Some surgeons prefer to avoid suction until the seed is confirmed to be removed and within the specimen
- The surgeon must handle the specimen with care during excision to avoid seed extrusion
- A post-excision specimen radiograph provides confirmation that the seed has been recovered

Specimen Radiography

- A specimen radiograph is obtained to confirm the presence of the seed and the presence of the lesion and/or the marker clip within the specimen
  - Radiologist reviews specimen radiograph and discusses findings with pathologist (and surgeon)

Seed Workflow in Pathology

- Safety equipment includes gloves, tweezers, shielded containers, and caution radioactive material (CRAM) labels
- Survey meter with sodium iodine (NaI) detector

Seed Workflow in Pathology

Handling the specimen

- Specimen radiograph to document seed removal
- Use the specimen radiograph for guidance regarding the seed location
- Retrieval of radioactive seeds
  - The seed should be placed into a lead lined container with a patient identifier denoting which patient's specimen the seed was retrieved from

Safety and Emergency Procedures

- **Written procedures required** for routine monitoring and emergency procedures
  - Radiation levels still present after seed removal
  - Lost seed during placement or removal procedure
  - Transected seed

Safety and Emergency Procedures

- Procedures if the patient does not return for excision of the seed
  - Make every effort to locate the individual
  - A licensed medical physicist should document the calculated radiation dose that the patient would receive from the decay of the radioactive seed

Pitfalls and Potential Issues

- Deployment failure: 0.3-7.2%
  - Seed adheres to the tip of the localization needle due to abundance of bone wax at the needle tip
  - Clinically important seed migration is rare (<1% of cases)

Goudreau et al. Radiographics. 2015; 35:1319-1334

Mishaps and Misplanted Seeds

- Bone wax mimics seed
- Inadvertent deployment of seed
- Problematic seed locations
  - Posterior lesions

Goudreau et al. Radiographics. 2015; 35:1319-1334

Problematic Seed Locations

- Placing a seed within the gelatinous substance of a clip
  - Recovery of the seed difficult at the time of surgery: slippery nature of the bioabsorbable polymer surrounding the metallic clip
  - Aim to place seeds adjacent to, rather than within, biopsy clips

Goudreau et al. Radiographics. 2015; 35:1319-1334

Problematic Seed Locations

- Place the seed adjacent to, rather than within a fluid collection
- Placing seeds into a fluid collection may lead to seed migration, especially in a large collection.

Goudreau et al. Radiographics. 2015; 35:1319-1334

Problematic Seed Locations

- Confirmation of seeds placed in suspicious axillary lymph nodes or in lymph nodes known to contain metastases can be challenging to document mammographically, particularly if the localized nodes are positioned superiorly or deep within the axilla.
  - It is advisable to place a seed in the axilla before any additional seeds are placed in the breast

Goudreau et al. Radiographics. 2015; 35:1319-1334

Bone Wax Mimics Seed

- An abundance of bone wax at the needle tip may mimic the US appearance of the seed
- Nondeployment is more likely to go unrecognized when using US guidance than when performing localizations with mammographic or stereotactic guidance

Goudreau et al. Radiographics. 2015; 35:1319-1334

Inadvertent Deployment of Seeds

- Seeds can be deployed inadvertently
- Preloaded seeds are designed with rubber stoppers to safeguard against premature deployment
  - It is advisable to remove the stopper only after the needle is well-positioned at the target site

Goudreau et al. Radiographics. 2015; 35:1319-1334

Patient Does Not Return for Surgical Excision

- This can almost be completely avoided by:

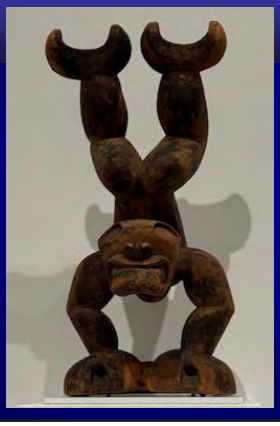
Placing seeds after:

-The patient is seen by the surgeon

-An operation is scheduled

-The patient has committed to surgical excision of the seed

Goudreau et al. Radiographics. 2015; 35:1319-1334



Conclusion

- A non-wire localization program requires collaboration and coordinated planning and workflow

Conclusion

- Non-wire device placement requires planning
  - Coordination with surgeon
  - Protocol system
- US or mammographic guidance
- Type of seed localization device
- Number of seeds

Conclusion: Seed Localization

- Decouples needle localization schedule and surgery schedule
- Seeds can be placed before surgery
- Improved patient satisfaction
- Well accepted by surgeons

gwhitman@mdanderson.org



Thank you!

SELF EVALUATION

Axillary Staging and Breast Localization

1. Which ultrasound feature is most suggestive of a metastatic axillary lymph node?

a. Thin hypoechoic cortex with preserved fatty hilum
b. Oval shape with a prominent echogenic hilum
c. Absence or deformity of the echogenic hilum with cortical thickening
d. Long-to-short axis ratio greater than 3

2. T/F - Sentinel lymph node biopsy was developed to assess axillary nodal status while reducing the complications associated with axillary lymph node dissection.

3. What is a key advantage of targeted axillary dissection (TAD) when combined with sentinel lymph node biopsy?

a. Eliminates the need for pathology evaluation
b. Increases the number of lymph nodes removed
c. Decreases the false-negative rate of sentinel lymph node biopsy
d. Replaces breast surgery entirely

4. T/F - One major advantage of non-wire localization techniques is that they allow the localization procedure to be performed before the day of surgery, improving scheduling flexibility.

5. According to the lecture, which radioactive isotope is used for radioactive seed localization (RSL)?

a. Technetium-99m
b. Iodine-131
c. Iodine-125
d. Gallium-67

Answer Key: 1. C, 2. T, 3. C, 4. T, 5. C

Behavioral Economics and Clinical Decision-Making

Andrew Moriarity, MD, MBA

Behavioral Economics and Clinical Decision-Making

Andrew Moriarity, MD. MBA
Associate Professor, Division of Radiology and Biomedical Imaging, MSU CHM
Quality Director, MSU/Spectrum Radiology Residency
President, Advanced Radiology Services, PC

College of Human Medicine
MICHIGAN STATE UNIVERSITY

Advanced Radiology Services PC

Objectives

- Review methods of economic analysis that apply psychological insights to explain economic decision-making.
- Discuss how human behavioral bias can influence preferences and decisions.
- Develop strategies to optimize decision making during uncertainty.



https://priorprobability.com/2017/12/04/invisible-hand-theories/

Homo economicus

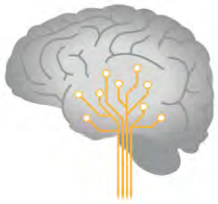
Humans as agents who are consistently rational, narrowly self-interested, and who pursue their subjectively-defined ends optimally.

"The assumption of perfect rationality"

https://en.wikipedia.org/wiki/Homo_economicus

PRINCIPLE 1

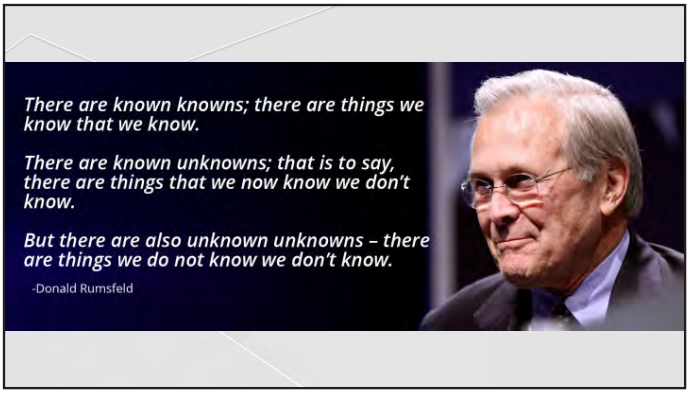
THE HUMAN BRAIN IS NOT A COMPUTER



"Prospect Theory"

A framework for how people view economic outcomes as gains and losses and how this framing affects people's economic decisions and choices.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. Econometrica, 47 , 263-291.



- Anchoring
- Confirmation bias
- Framing effect
- Gambler's fallacy
- Herd behavior
- Loss aversion
- Mental accounting
- Money illusion
- Myopic loss aversion
- Overconfidence
- Paralysis by analysis
- Recency bias
- Regret aversion
- Sunk cost fallacy

...only a partial list!



Behavioral Economics

How your mind can trick/fail you

"The investor's chief problem - and even his worst enemy - is likely to be himself"
— Ben Graham

https://www.bogleheads.org/wiki/Behavioral_pitfalls

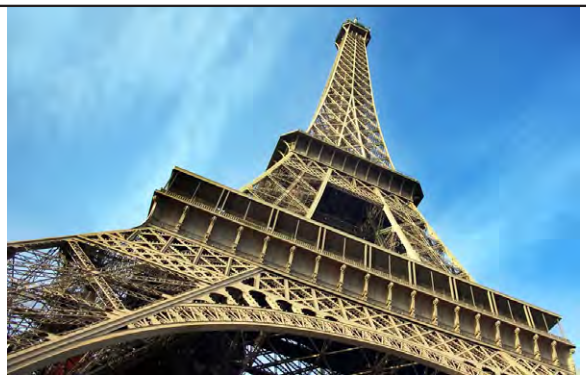




Anchoring

Basing decisions or estimates on events or values already known (the "anchor"), even though these facts may have no bearing on the actual event or value.

https://www.bogleheads.org/wiki/Behavioral_pitfalls



https://www.livescience.com/29391-eiffel-tower.html

Confirmation bias

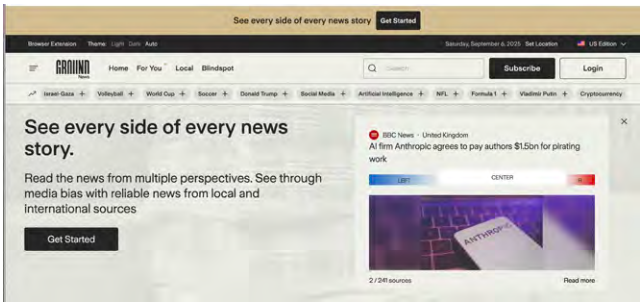
A tendency to seek information that confirms one's existing opinions and overlook or ignore information that refutes them.

https://www.bogleheads.org/wiki/Behavioral_pitfalls



"In short, your own mind acts like a compulsive yes-man who echoes whatever you want to believe,"
- Jason Zweig.

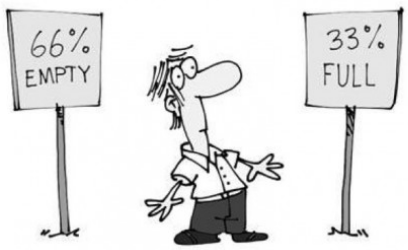




Framing effect

The large changes in preferences that can sometimes be caused by inconsequential variations in the wording of a choice.

https://www.bogleheads.org/wiki/Behavioral_pitfalls



https://www.neurosciencemarketing.com/blog/articles/cognitive-biases-cro.htm

Gambler's fallacy

The belief that heads on a coin flip is more likely after a string of tails, red in roulette is more likely after a string of black, and in general good luck is more likely after a string of bad luck
...and vice versa

https://www.bogleheads.org/wiki/Behavioral_pitfalls



https://www.beginnersbuck.com/hot-hand-fallacy/



***The hot hand appears in free throws… but not in field goals.**

Lantis, R M and E T Nesson (2019), "Hot Shots: An Analysis of the 'Hot Hand' in NBA Field Goal and Free Throw Shooting", NBER Working Paper No. 26510:1-50.

https://voxeu.org/article/basketball-s-hot-hand-myth-or-reality

Herd behavior

A human instinct that causes individuals to mimic the actions of a larger group rather than decide independently based on their own information....
and concludes the majority must be right

https://www.bogleheads.org/wiki/Behavioral_pitfalls

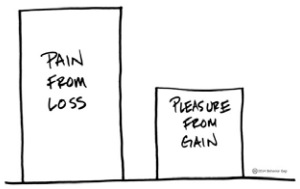


https://www.khouse.org/enews_article/2016/2507/

Loss aversion

The emotional tendency to strongly prefer avoiding losses over acquiring gains

https://www.bogleheads.org/wiki/Behavioral_pitfalls



behaviorgap.com



Google



Google

Mental accounting

The tendency for people to put money into separate accounts based on a variety of subjective criteria, including the source of the money or intent for the account

https://www.bogleheads.org/wiki/Behavioral_pitfalls

$1 = $1*

*but we don't act that way

https://www.moneyhealthsolutions.com/post/mental-accounting

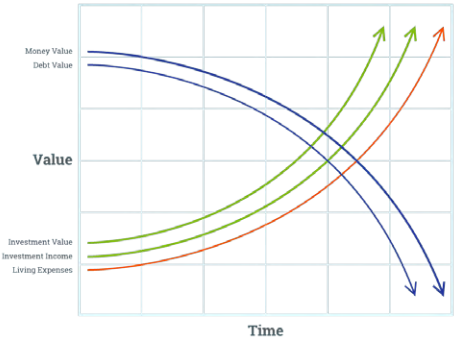


https://www.moneyhealthsolutions.com/post/https://markshirecrypto.com/cryptocurrency/cryptocurrency-and-fungibility/

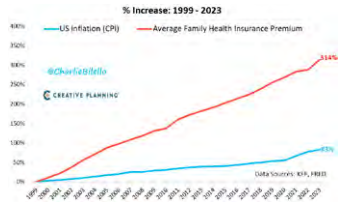
Money illusion

The tendency to think of
money in nominal terms,
instead of inflation-adjusted terms

https://www.bogleheads.org/wiki/Behavioral_pitfalls

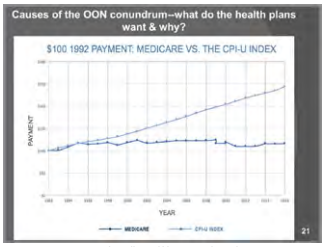


https://emicalculator.net/time-value-money-important-concept-financial-planning/

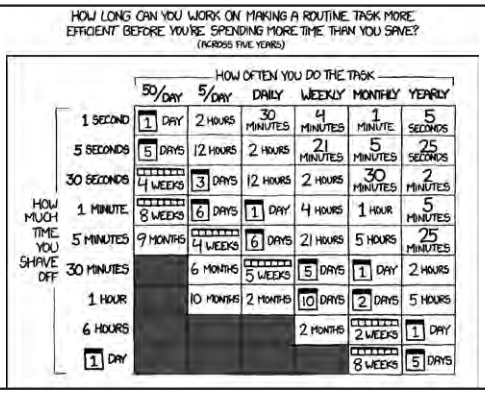


"Physicians are paid less in absolute terms over the last 25 years while insurers are up 314% and inflation is up 83%"

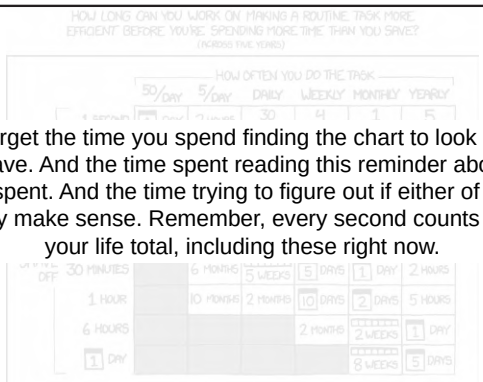
1998 CF- $36.68
2024 CF- $33.29
1999 Insurance premiums - $6k
2024 Insurance premiums - $24k



https://x.com/drbruggeman/status/1833731988945076555



https://xkcd.com/1205/



Don't forget the time you spend finding the chart to look up what you save. And the time spent reading this reminder about the time spent. And the time trying to figure out if either of those actually make sense. Remember, every second counts toward your life total, including these right now.

https://xkcd.com/1205/

Myopic loss aversion

Loss aversion intensified by
constant attention to short-term
portfolio performance

https://www.bogleheads.org/wiki/Behavioral_pitfalls



https://www.quotemaster.org/Plant+A+Tree

Overconfidence

"The only way to achieve everything you're capable of is to accept what you are not capable of"
Jason Zweig

https://www.bogleheads.org/wiki/Behavioral_pitfalls



behaviorgap.com



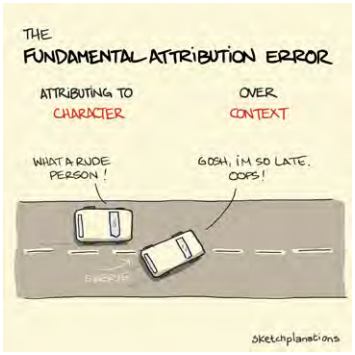
The Big Short (2015) - Prologue & Opening [HD 1080p]

"

Fundamental Attribution Error

"We overestimate the role of personality traits and underestimate the role of situational factors when explaining the behavior of others."

https://www.bogleheads.org/wiki/Behavioral_pitfalls



https://psychsafety.com/the-fundamental-attribution-error/

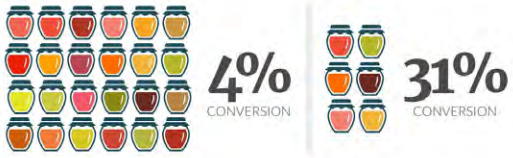


https://www.forbes.com/sites/carltonreid/2018/12/03/you-are-not-stuck-in-traffic-you-are-traffic/

Paralysis by analysis

The more choices available,
the harder it is to choose one,
making no choice the default option
and failing to act

https://www.bogleheads.org/wiki/Behavioral_pitfalls

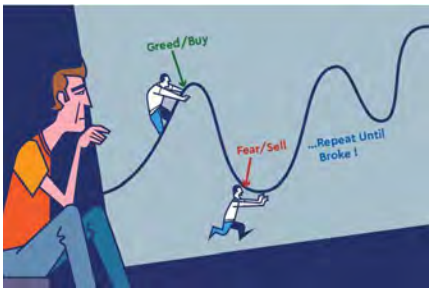


https://boagworld.com/design/analysis-paralysis/

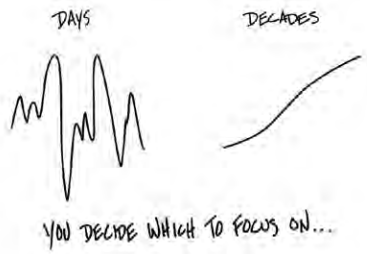
Recency bias

The tendency to draw conclusions about
the future behavior of an investment
from only the recent past

https://www.bogleheads.org/wiki/Behavioral_pitfalls



https://www.financialexpress.com/money/how-individual-investors-succumb-to-performance-chasing-behaviour/1726010/



behaviorgap.com

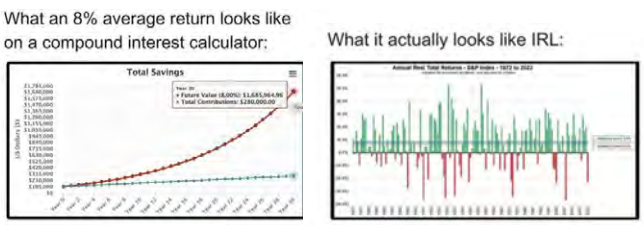
Regret aversion

A theory that says people anticipate
regret if they make a choice that is wrong
in hindsight, and consider this when
making decisions

https://www.bogleheads.org/wiki/Behavioral_pitfalls



https://quicksilver.scoopwhoop.com/unsafe/960x500/center

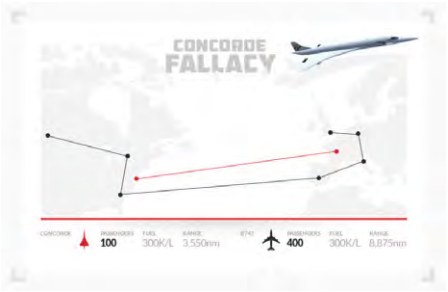


https://hostedimages-cdn.aweber-static.com/NDA2ODg3/original/e5f57f976964eb999ac338f11cc4a7b.png

Sunk Cost Fallacy

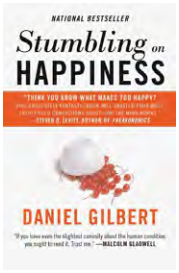
People demonstrate a greater tendency to continue an endeavor once an investment in money, effort, or time has been made

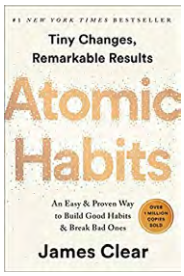
https://en.wikipedia.org/wiki/Sunk_cost

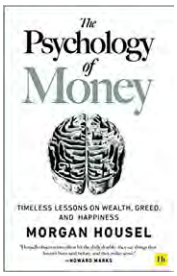


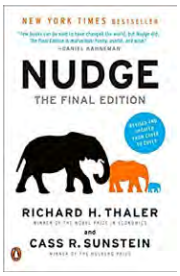
https://www.sportsbettingdime.com/guides/betting-psychology/sunk-cost-fallacy/

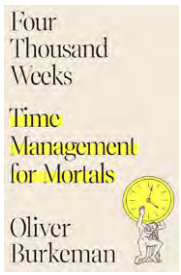
Prepare yourself

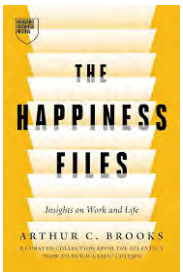














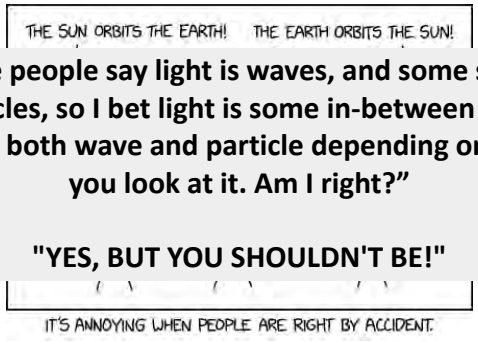








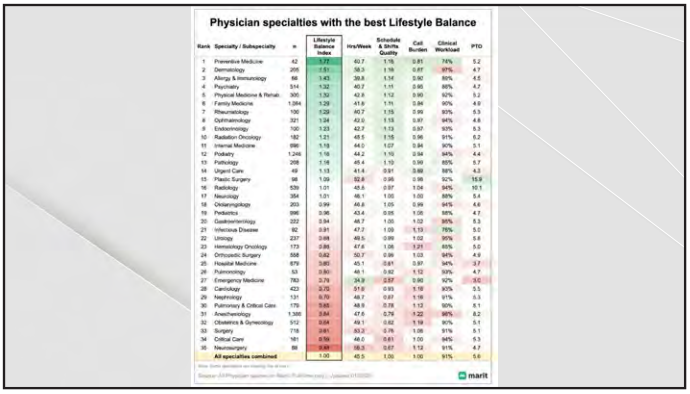




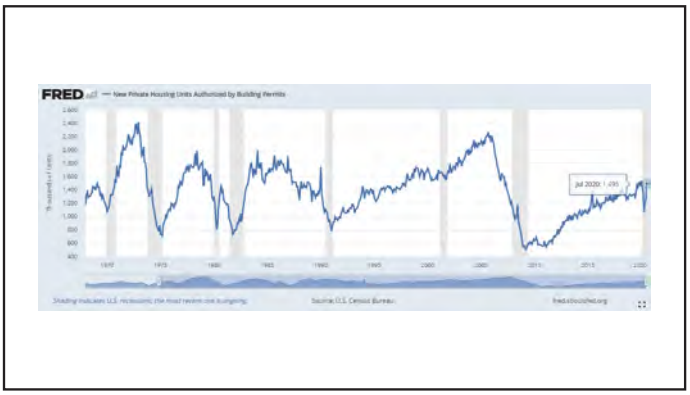
"Some people say light is waves, and some say it's particles, so I bet light is some in-between thing that's both wave and particle depending on how you look at it. Am I right?"

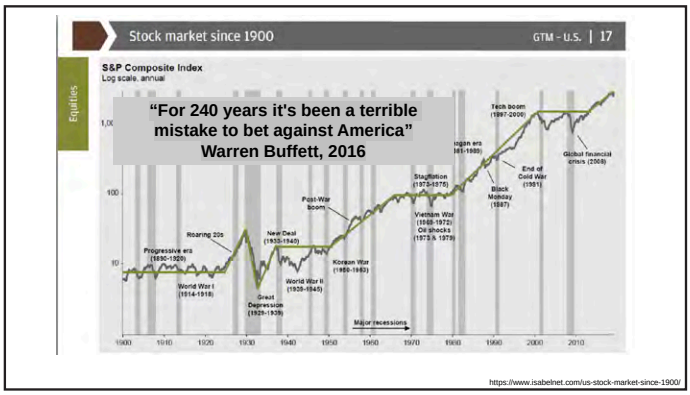
"YES, BUT YOU SHOULDN'T BE!"

Prepare yourself



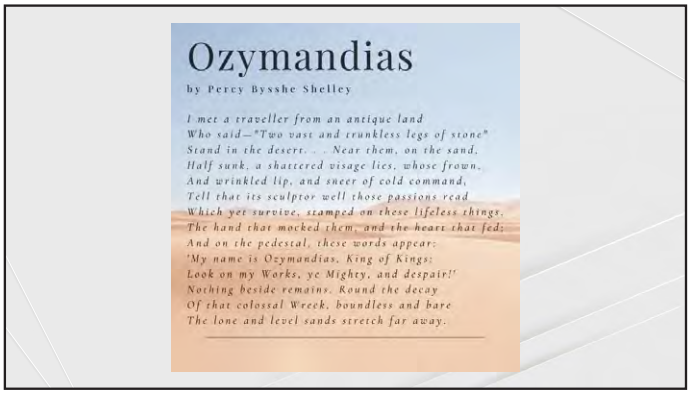
Prepare yourself





It is said an Eastern monarch once charged his wise men to invent him a sentence, to be ever in view, and which should be true and appropriate in all times and situations. They presented him the words

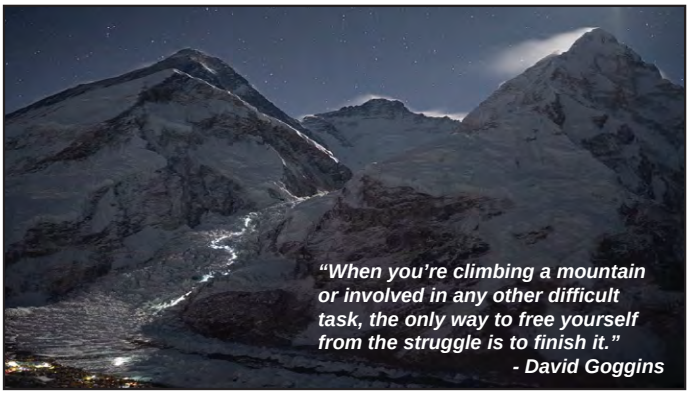
This too, shall pass



Ozymandias

by Percy Bysshe Shelley

I met a traveller from an antique land
Who said—"Two vast and trunkless legs of stone"
Stand in the desert. . . . Near them, on the sand,
Half sunk, a shattered visage lies, whose frown,
And wrinkled lip, and sneer of cold command,
Tell that its sculptor well those passions read
Which yet survive, stamped on these lifeless things,
The hand that mocked them, and the heart that fed;
And on the pedestal, these words appear:
'My name is Ozymandias, King of Kings:
Look on my Works, ye Mighty, and despair!'
Nothing beside remains. Round the decay
Of that colossal Wreck, boundless and bare
The lone and level sands stretch far away.



"We study natural stupidity instead of artificial intelligence."

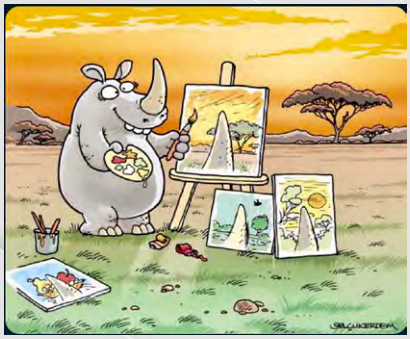
Amos Tversky





"We see the world
not as it is,
but as we are."

Anaïs Nin



SELF EVALUATION

Behavioral Economics and Clinical Decision-Making

1. Prospect Theory, developed by Kahneman and Tversky, primarily explains how people:

a. Always make rational economic decisions
b. View outcomes as gains and losses and make decisions under risk
c. Predict future market returns accurately
d. Avoid all cognitive biases

2. T/F - Anchoring bias occurs when an initial piece of information influences subsequent estimates, even when that information is irrelevant.

3. Which behavioral bias describes the tendency to seek information that supports existing beliefs while ignoring contradictory evidence?

a. Recency bias
b. Gambler's fallacy
c. Confirmation bias
d. Loss aversion

4. Loss aversion refers to the tendency for people to feel the pain of losses more strongly than the pleasure of equivalent gains.

5. Which cognitive bias is illustrated when someone continues investing time or money into a failing project simply because they have already invested heavily in it?

a. Mental accounting
b. Overconfidence
c. Sunk cost fallacy
d. Herd behavior

Answer Key: 1. B, 2. T, 3. C, 4. T, 5. C