CT Imaging: The Benefits are Worth the Responsibilities

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Acknowledgement

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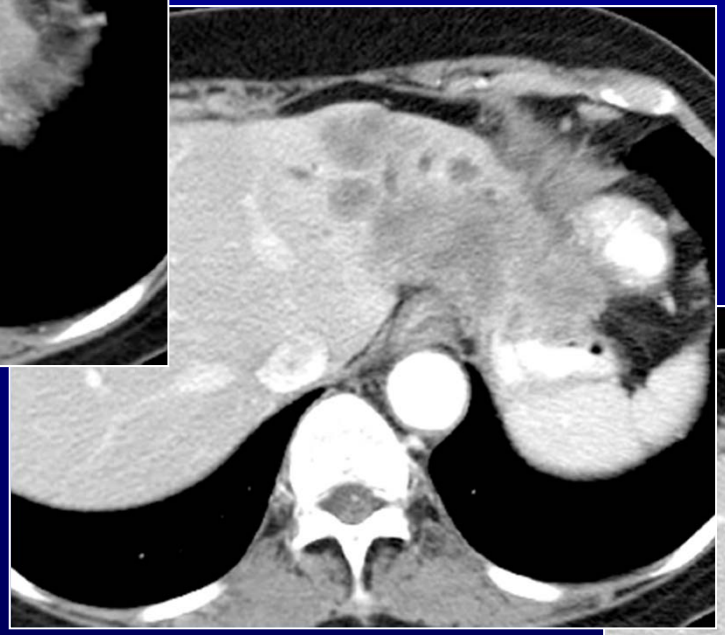
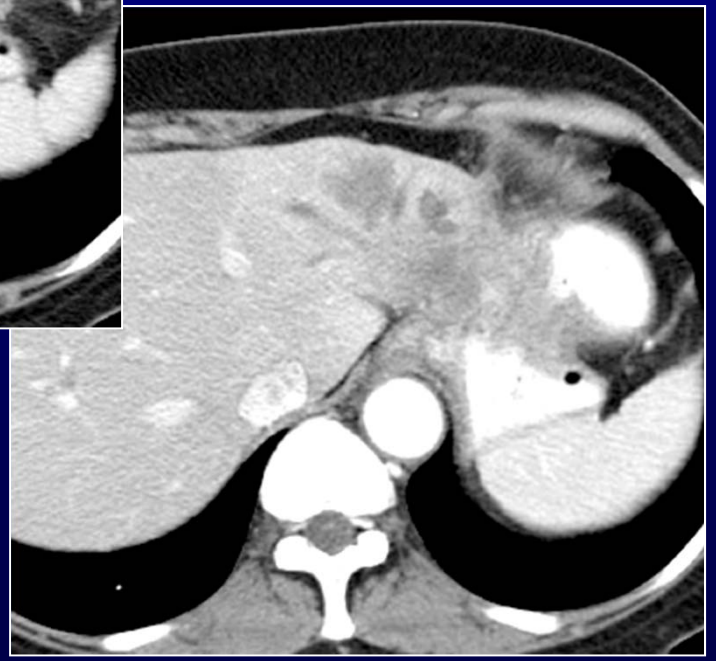
Yale University School of Medicine

'Benefits' of CT

- Standard Axial Imaging
  - Superb Anatomic Depiction
    - Head to toe
  - Innumerable Diagnoses
    - Confirmed
    - Excluded

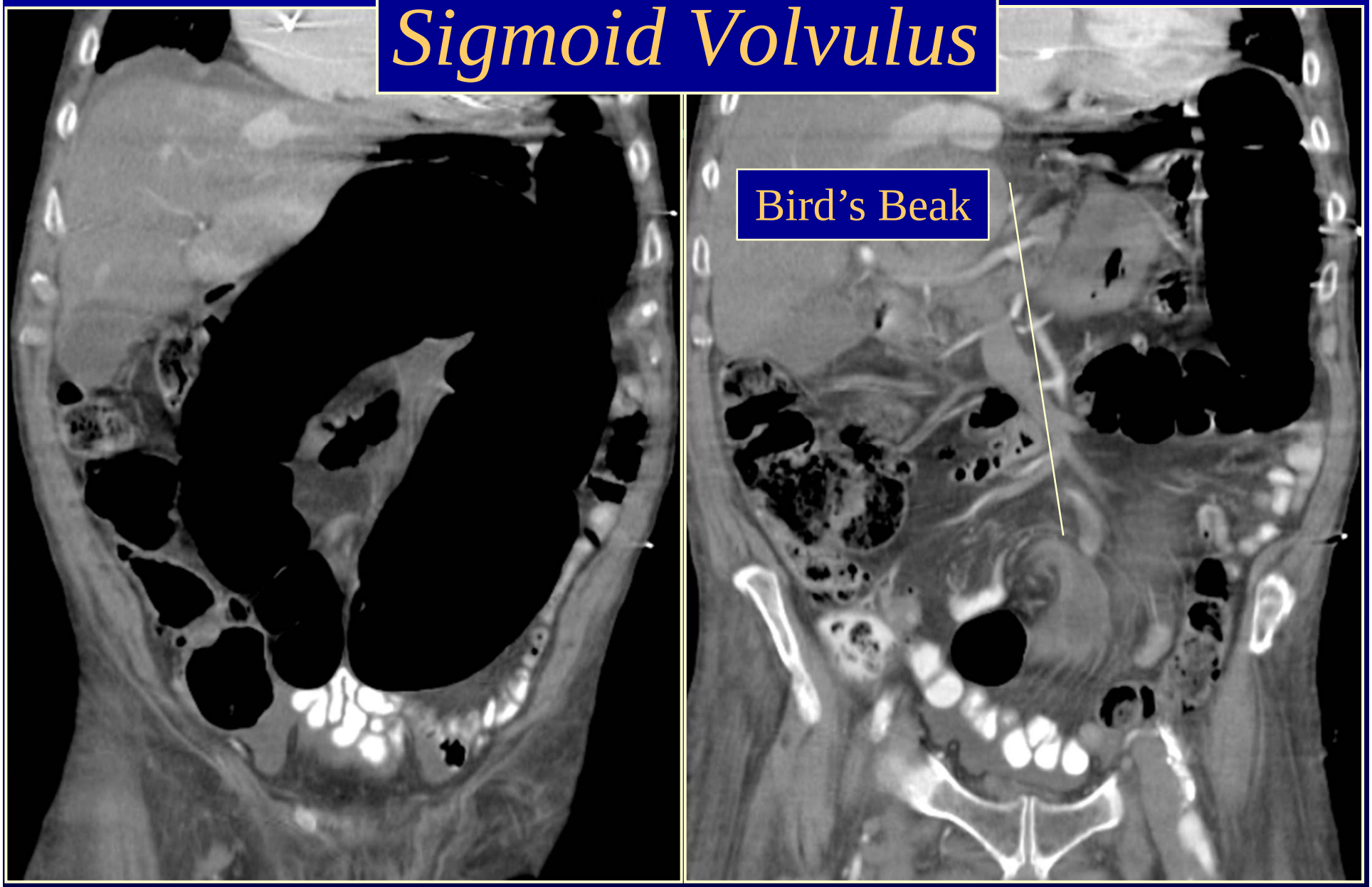
Hepatoma





Invasion of Gastrohepatic Ligament, Stomach

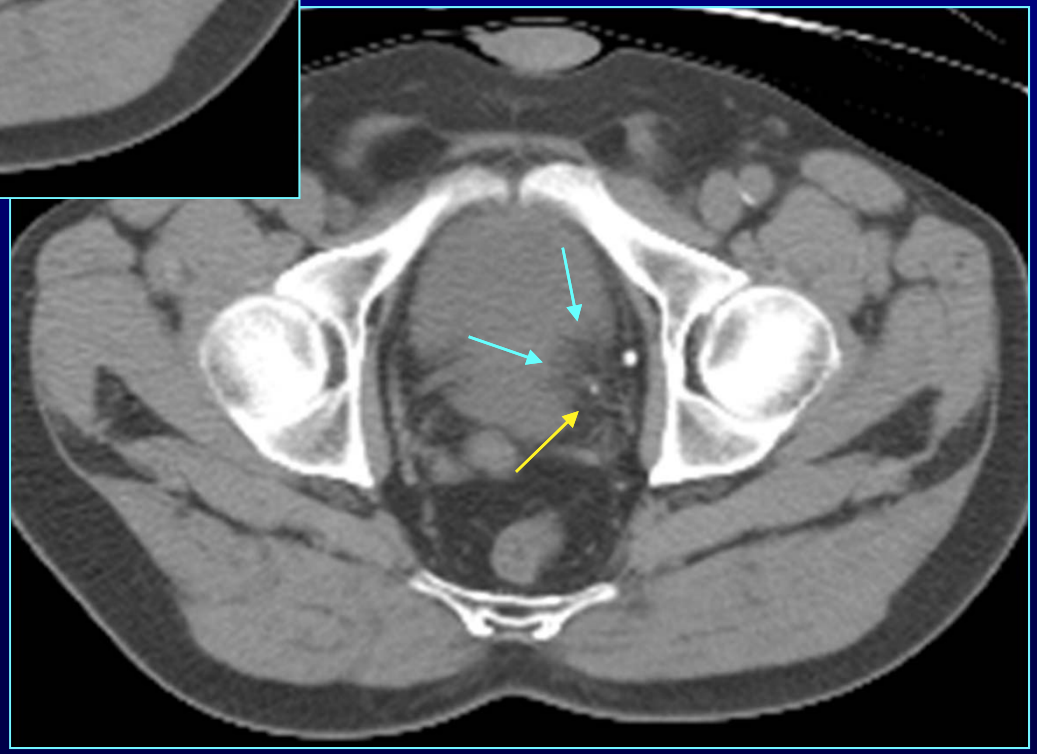
Sigmoid Volvulus



'Benefits' of MDCT

- New uses of CT imaging
  - Renal/Ureteral Stone CT
  - CT "Virtual" Colonoscopy
  - CT Angiography of Head, Pulmonary Vessels, Aorta and Extremities
  - Coronary CT Angiography

Impacted Stone
Lt. UVJ



Edema in
Lt. Trigone

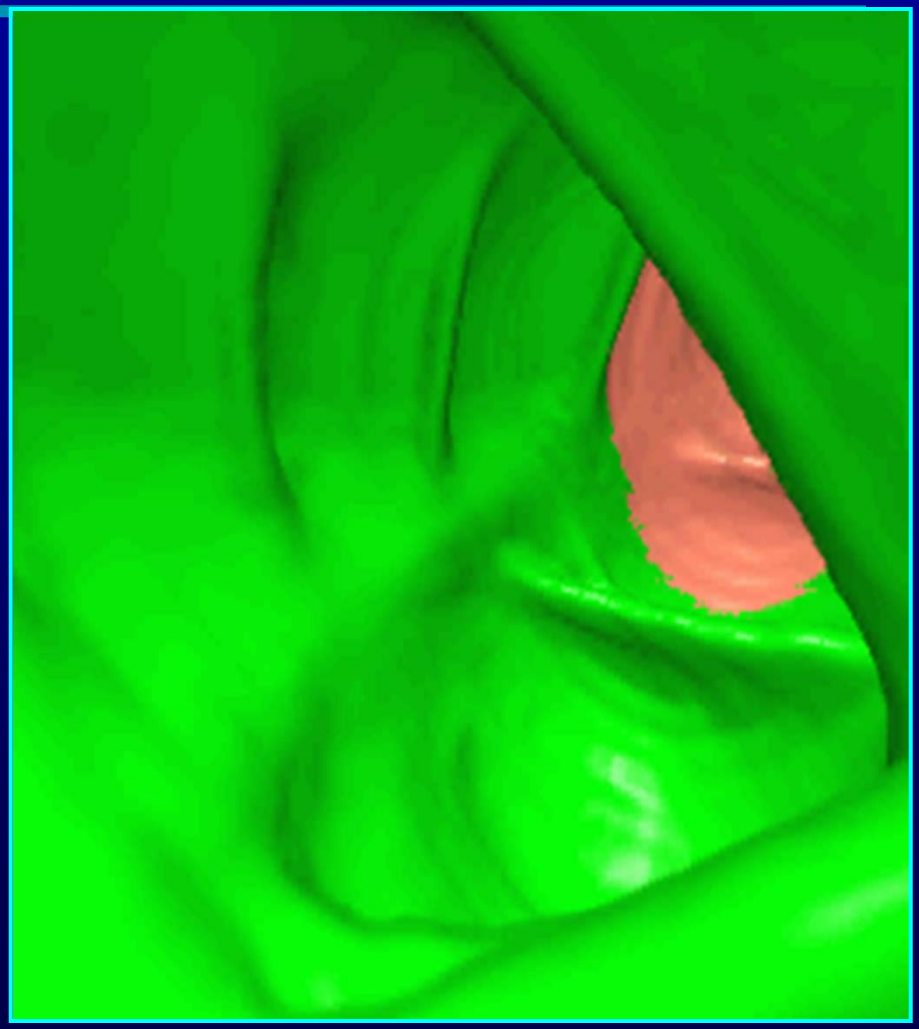
9 mm Tubular Adenoma: Asc Colon

ACRIN

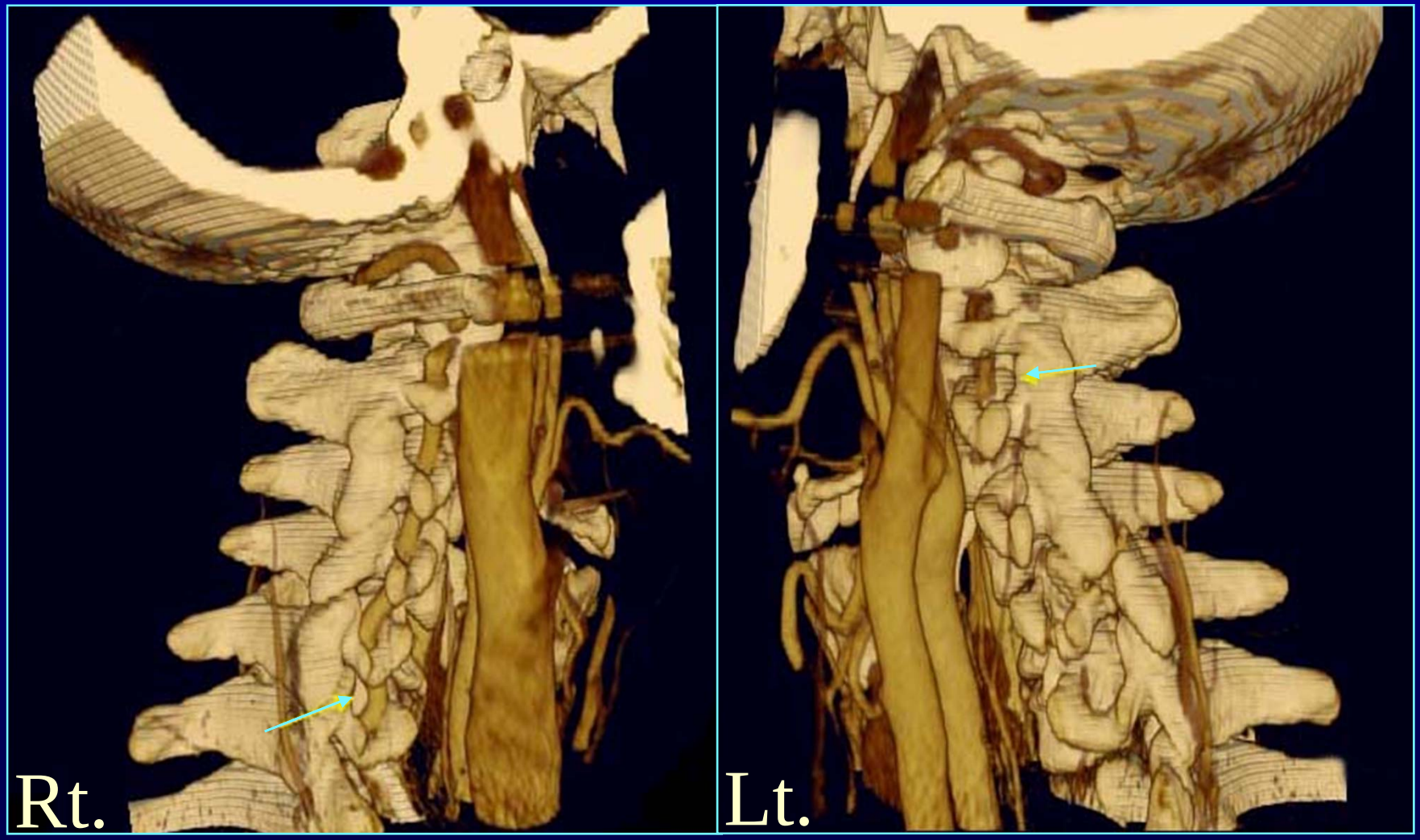
Mucosal Labeling

"Missed patch" tool

- Shows colonic wall not displayed w/ auto-centerline
- Useful in cases w/ limited distention



Courtesy of Perry Pickhardt, M.D.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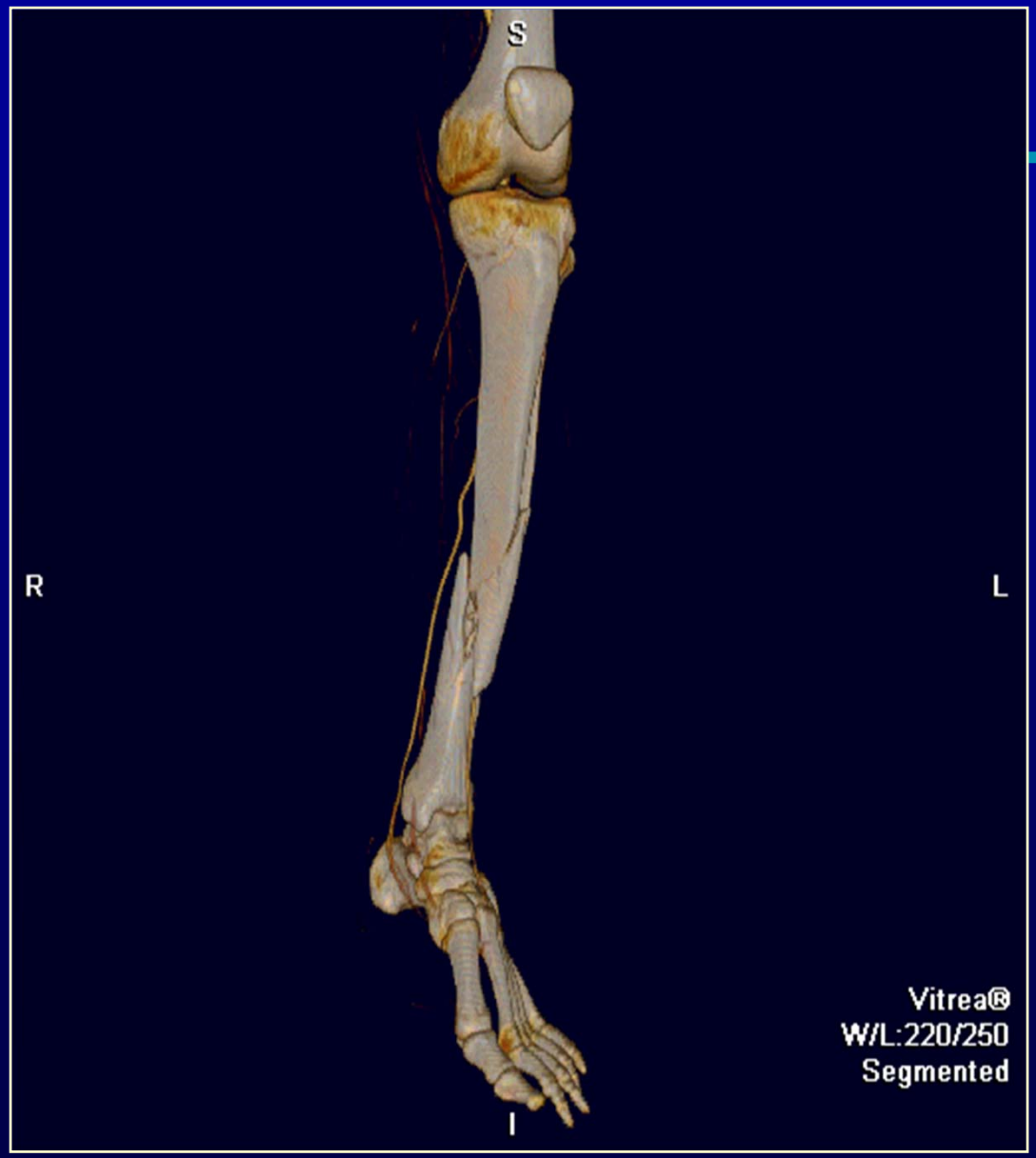
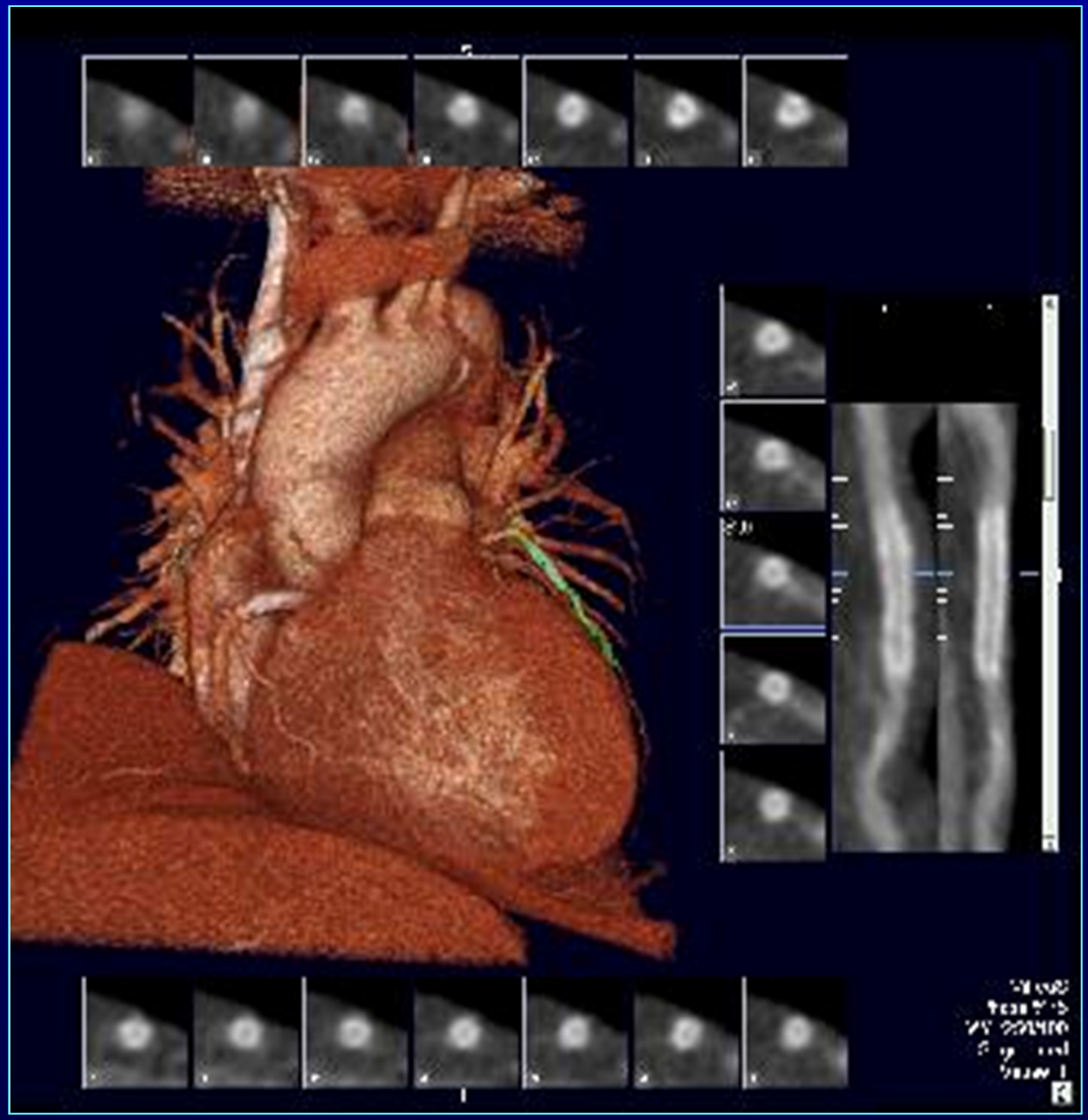


Motorcycle Accident

? Arterial Injury

Motorcycle Accident

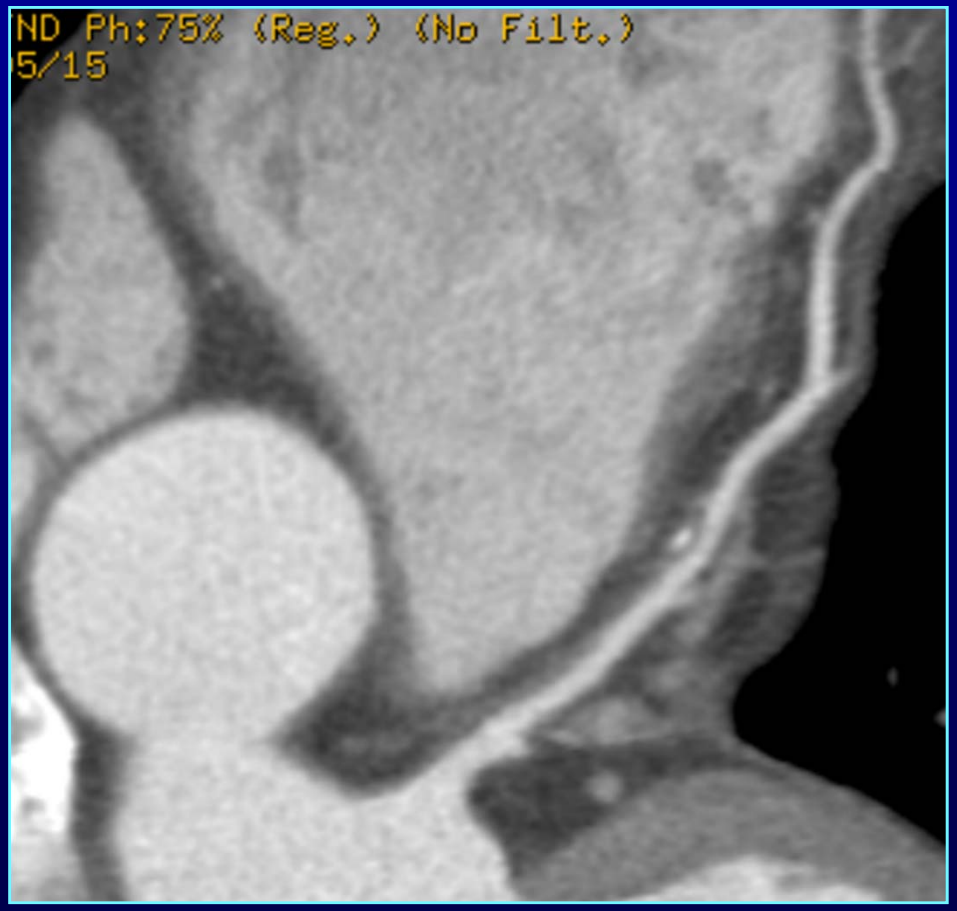
Occluded Left Anterior Tibial Artery

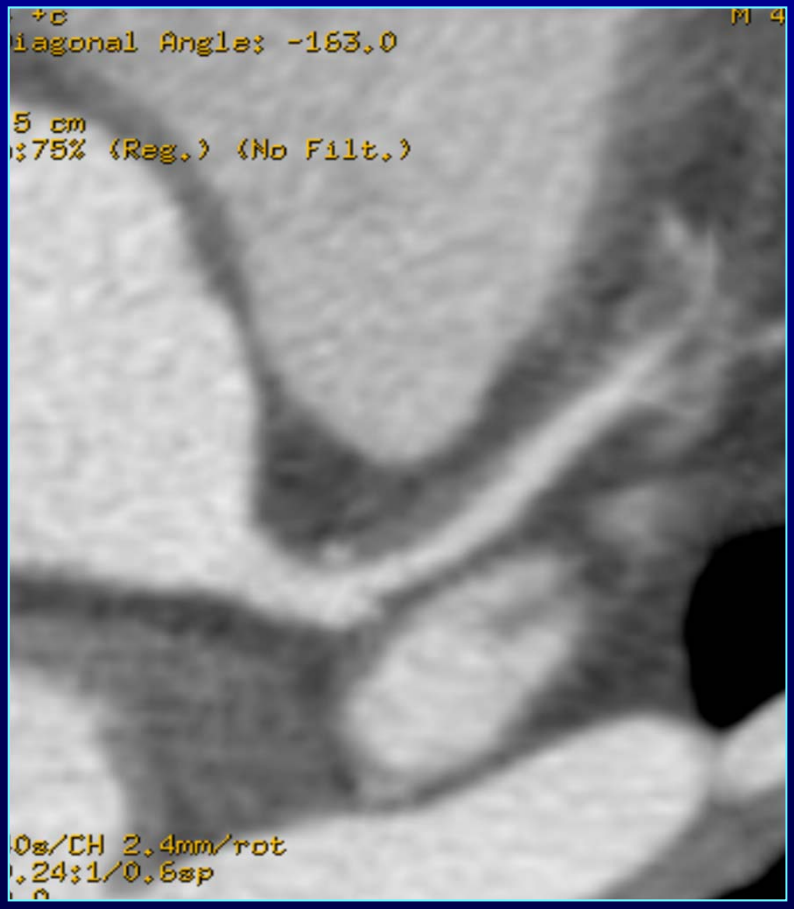


Courtesy of Kevin Johnson,

Courtesy of Kevin Johnson,

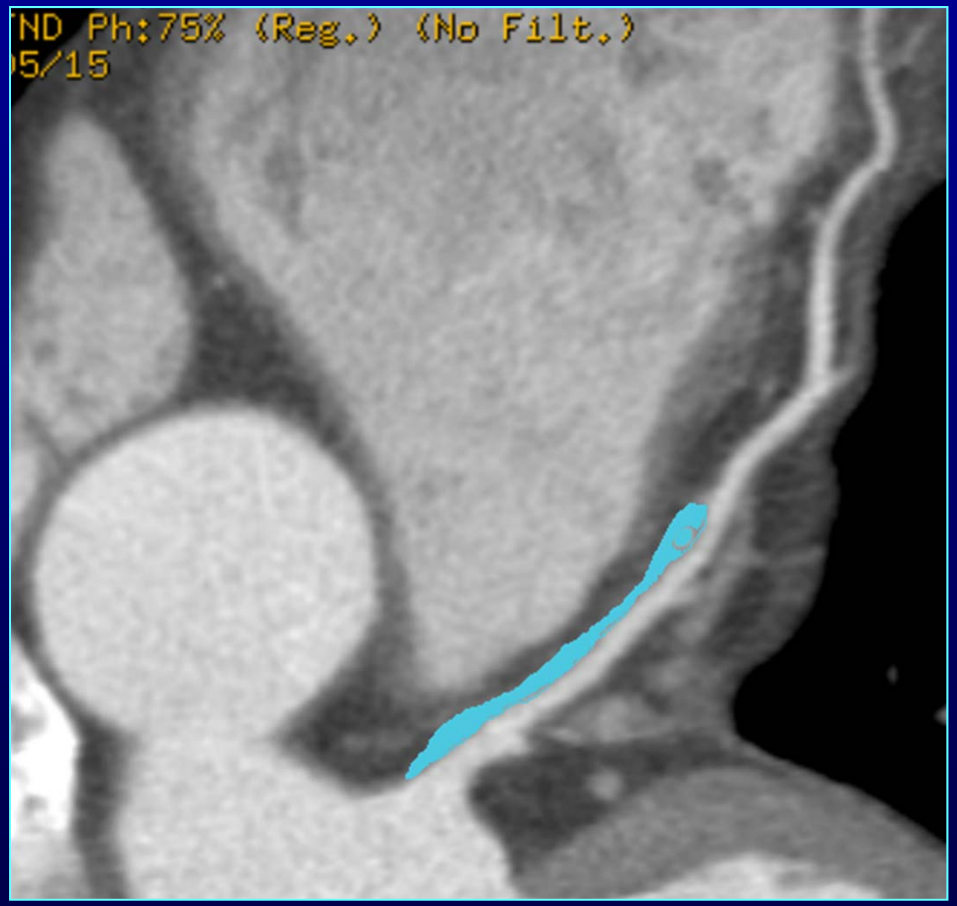
Diffuse Plaque in Proximal LAD

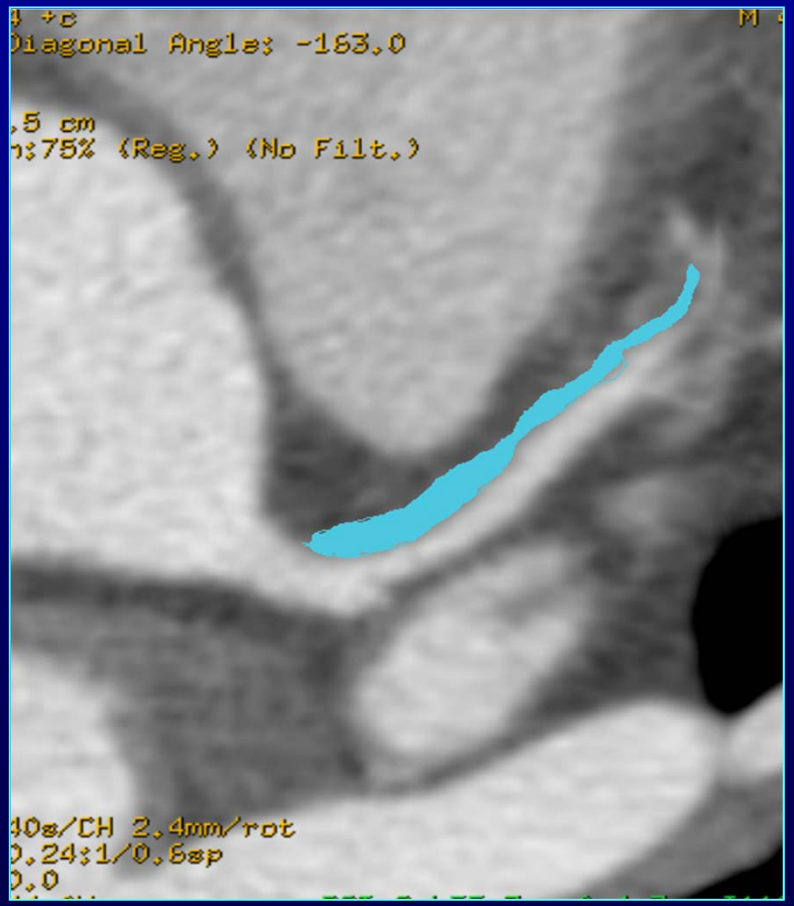




Courtesy of Kevin Johnson, M.D.

Diffuse Plaque in Proximal LAD





Courtesy of Kevin Johnson, M.D.

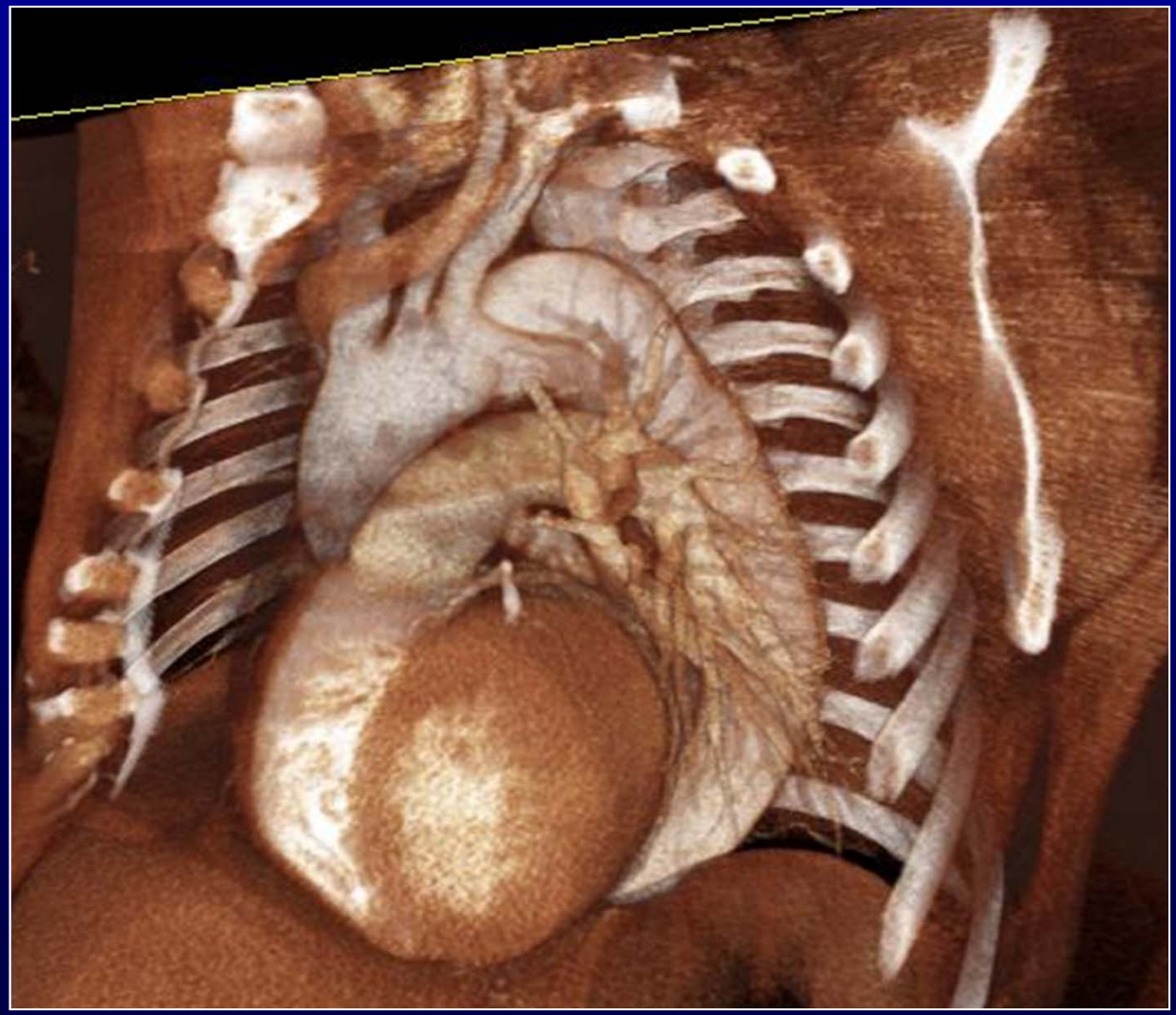
Triple Rule-Out:

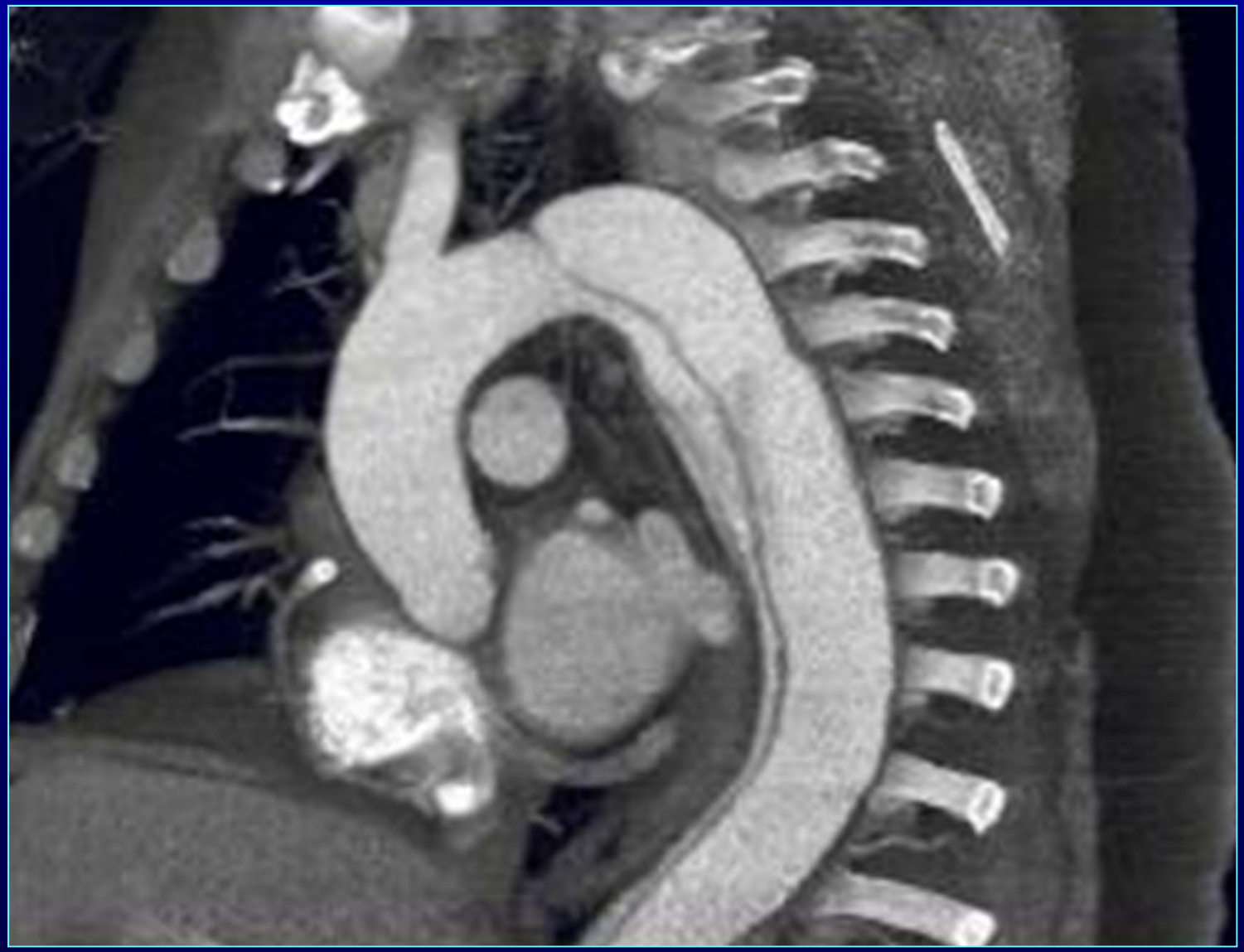
Aortic Dissection

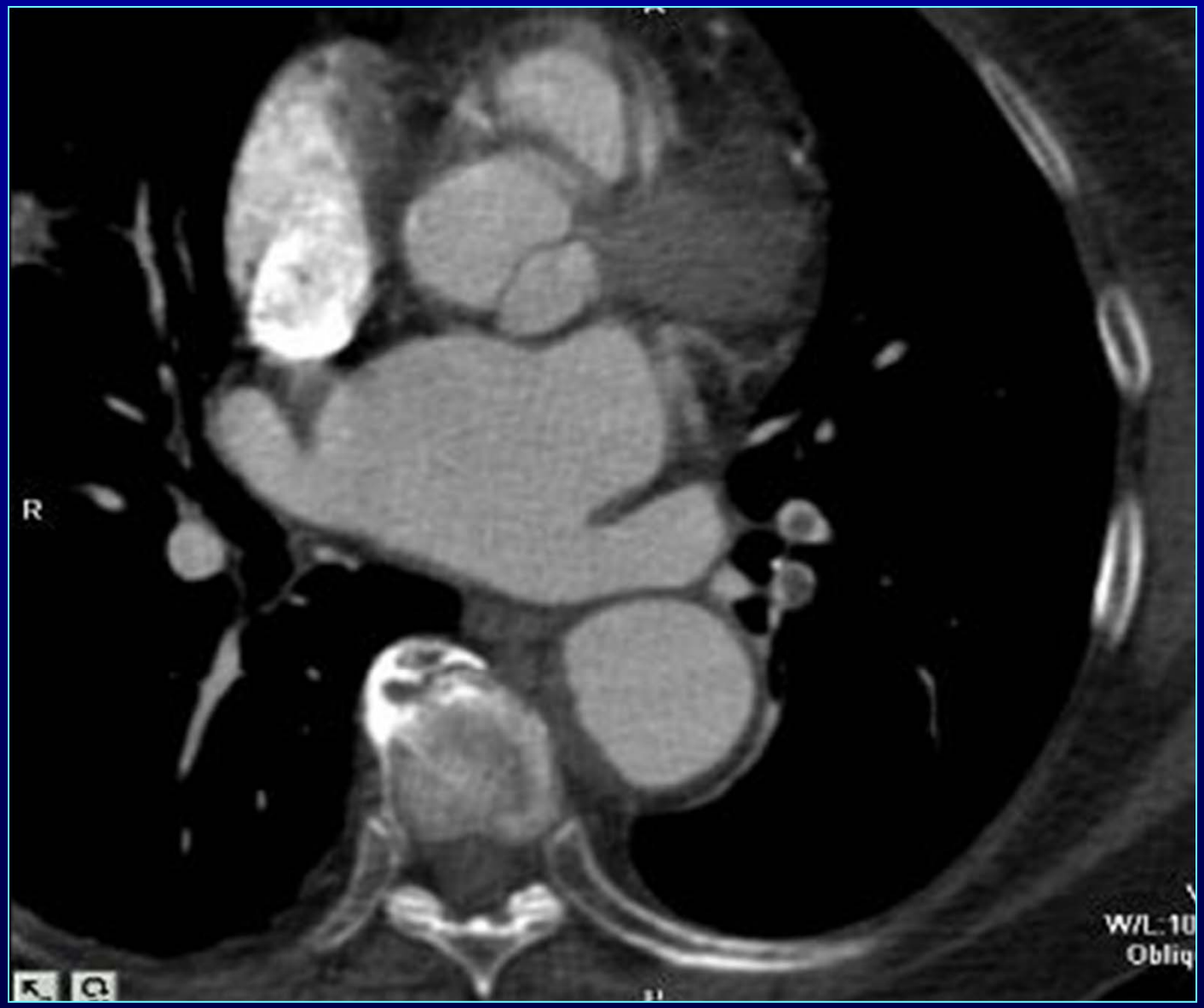
Pulmonary Emboli

Coronary Artery Disease

Acute Chest Pain: Gated CTA



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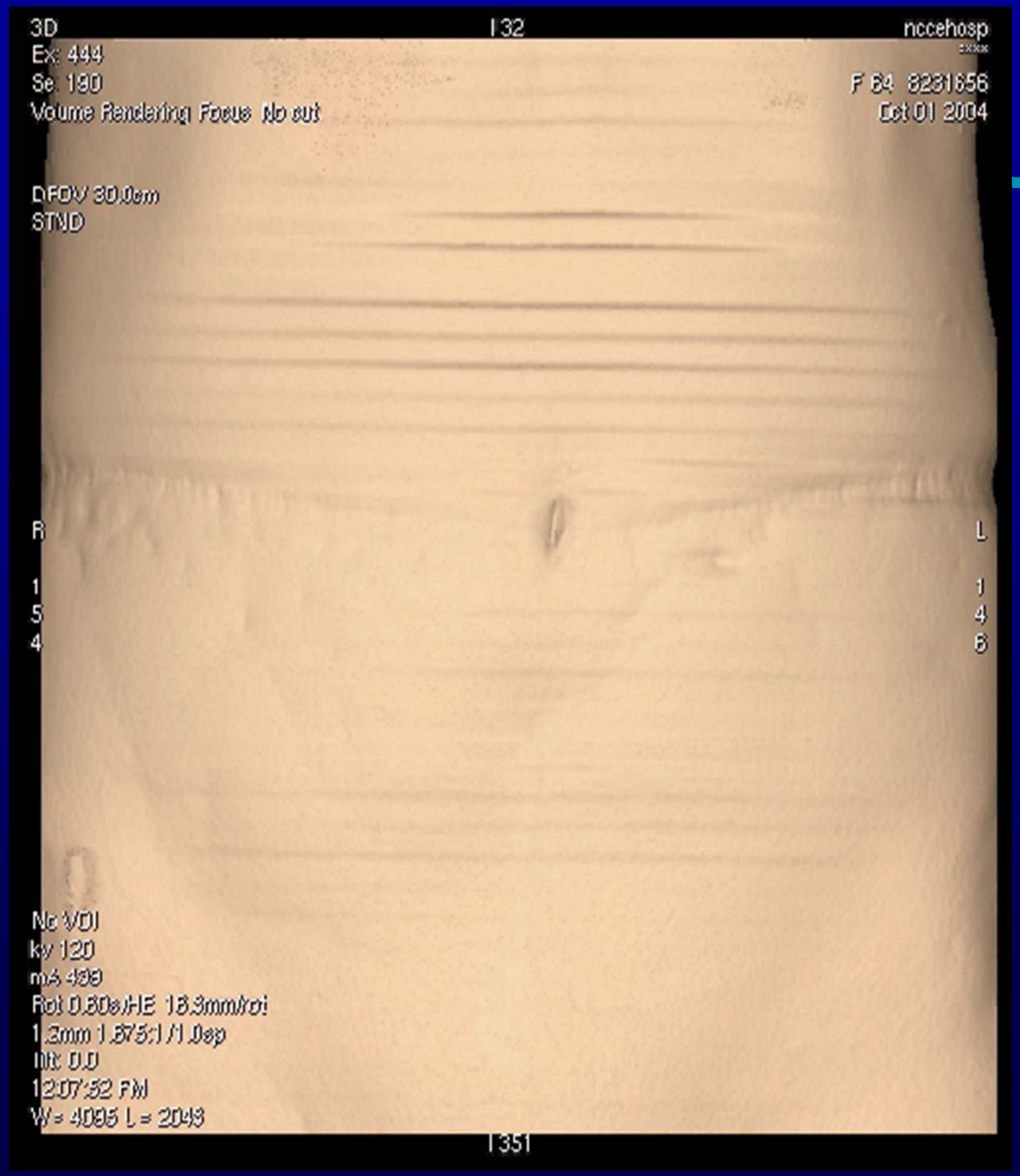


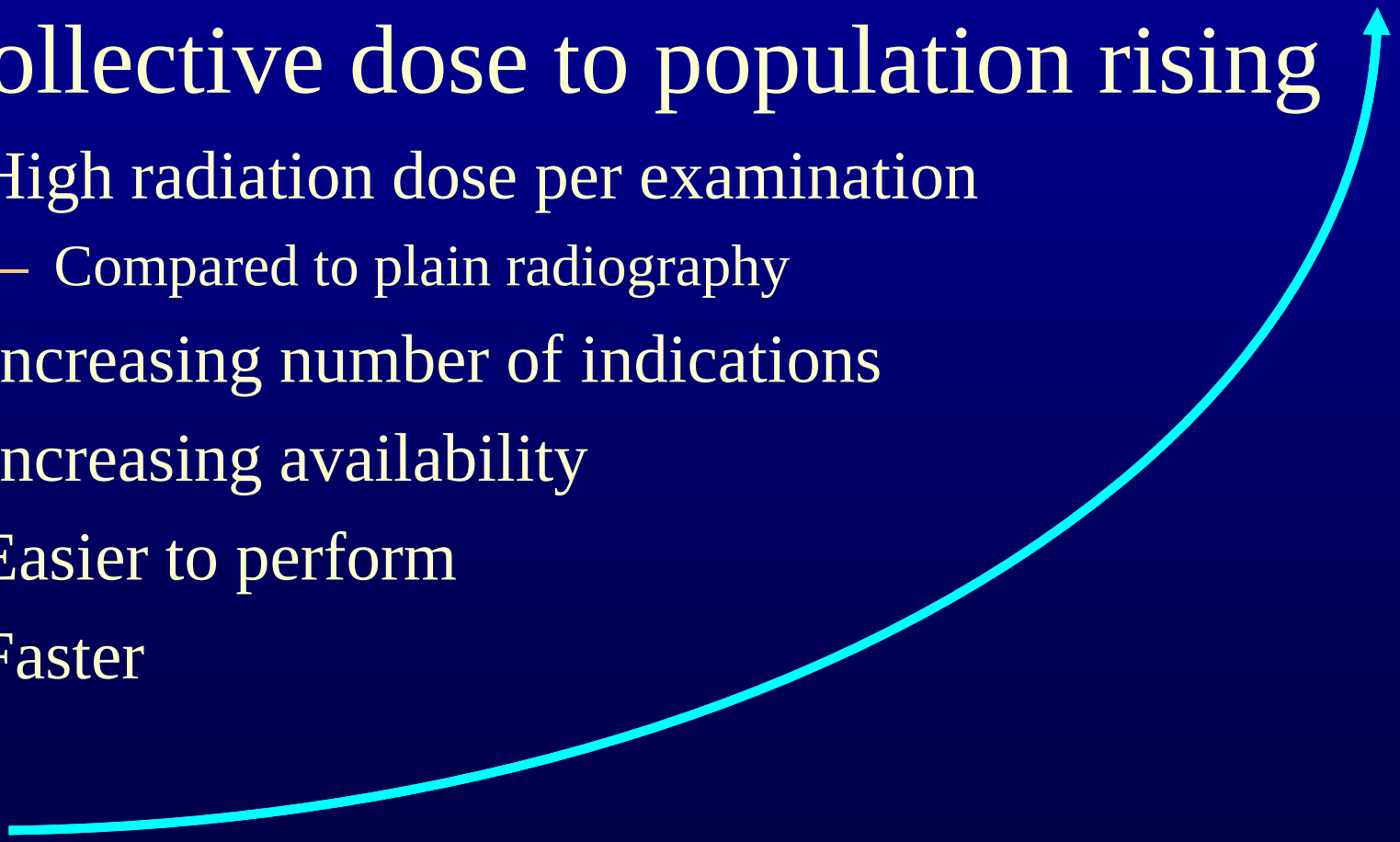
Hybrid Imaging:

- PET/CT
- CT Colon
- CT Angio

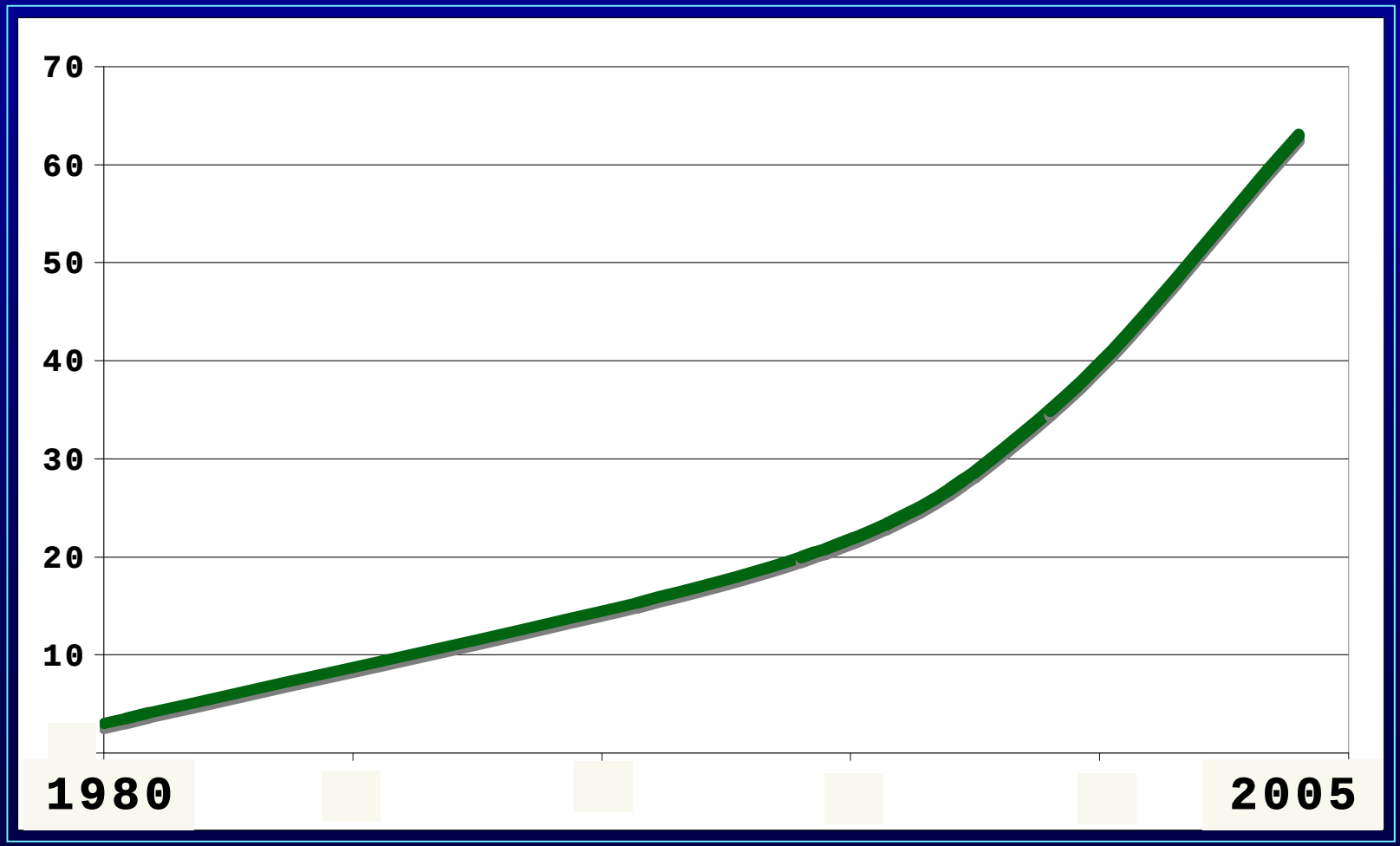
Radiation Exposure from CT

Collective dose to population rising

- High radiation dose per examination
  - Compared to plain radiography
- Increasing number of indications
- Increasing availability
- Easier to perform
- Faster



Millions of CT Exams



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FINAL SCORES
USA TODAY
NO. 1 IN THE USA
Thursday, November 29, 2007

By Robert Deutsch, USA TODAY

Johan Santana: Twins ace may be trade fodder.

What your AL team wants

■ Teams gather in Nashville for annual winter meetings, 10C

Unnecessary CT scans exposing patients to excessive radiation

Study: Cancer cases could spike as result

By Steve Sternberg
USA TODAY

Overuse of diagnostic CT scans may cause as many as 3 million excess cancers in the USA over the next two to three decades, doctors report today.

Researchers say they're not trying to discourage all use of CT scans — CT stands for computed tomography — which superimpose multiple X-ray images to make 3-D pictures. Rather, they say, CT scanning is an invaluable tool in many cases. The problem is that doctors too often overlook its risks.

"About one-third of all CT scans that are done right now are medically unnecessary," says David Brenner of Columbia University, lead author of the study reported in today's *New England Journal of Medicine*.

CT scans offer an unparalleled window into the human body, and their use has grown dramatically in recent decades as doctors use them to identify ailments in the head, abdomen and heart.

Today, about 62 million CT scans are performed nationwide every year, up from 3 million in 1980, the authors say. Medical exposure to radiation, mainly through CT scans, has replaced environmental radon as the dominant source of radiation exposure for the U.S. population, the doctors say.

"On average, we now get double the radiation exposure we got in 1980 because of increased CT scans," Brenner says. "Virtually anyone who presents in the emergency room with pain in the belly or a chronic headache will automatically get a CT scan. Is that justified?"

University of New Mexico radiologist Fred Mettler, who was not part of the study, agrees that CT scans are overused. "We're always behind on CT scans because of demand from clinicians," he says.

As many as 5 million scans are now done in children, who are 10 times more sensitive to radiation than adults. The increase was driven by technical advances that allow doctors to capture images in less than a second, eliminating the need for anesthesia to keep a child from moving.

And the use of the scans continues to grow, Brenner says. Doctors are scanning smokers and ex-smokers for early-stage lung cancer, a highly controversial practice; they're using non-invasive "virtual" colonoscopies to check for colon cancer; and CT angiography is now being tested as a possible complement to ordinary angiography as a way to diagnose blockages in arteries leading to the heart.

In critiquing a study on CT angiography at an American Heart Association meeting in Orlando last month, Michael Lauer of the National Heart, Lung and Blood Institute called that practice into question. He said there is no evidence of benefit from the technology, and a real concern for harm.

New machines being developed by Philips and Toshiba for CT angiograms, however, may be safer because they emit 80% less radiation than standard CT scanners, Brenner says.

Brenner and his co-author, Eric Hall, also of Columbia, say many doctors don't realize that just a scan or two can bathe a patient in roughly the same amount of radiation as the atomic bomb delivered to the Japanese survivors of Hiroshima and Nagasaki standing a mile or two from ground zero. And many people receive multiple scans over a lifetime.

The amount of radiation delivered during a single CT scan can range from 1,000 to 10,000 millirems, depending on the machine and the protocol. Japanese survivors a mile or two from ground zero received about 3,000 millirems on average.

The cancer rates in the new study were drawn directly from a joint $1 billion study of the bomb survivors financed by the United States and Japan.

Radiation risk

An ordinary CT scan delivers roughly the same average amount of radiation, 3,000 millirems, as Japanese survivors of the atomic bombs in World War II received a mile or two from ground zero.

Studies of those survivors showed that a person's individual risk is low but that excess cancers slowly accumulate in a large population. The following risk estimates are based on scans delivering 1,000 millirems, the lowest likely dose:

Age	Gender	Lifetime odds of getting cancer
Infant	female	5 in 1,000
10	female	2.5 in 1,000
30	female	1 in 1,000
Infant	male	2.5 in 1,000
10	male	2 in 1,000
30	male	7 in 10,000

Source: Owen Hoffman, SENES, Oak Ridge Inc.

Utilization

Steps to Control Radiation Exposure

Appropriate Utilization

- Tailor exam to the patient/application
  - Reduce dose as much as possible
- CT vs. other imaging tests
- Avoid un-necessary / repetitive studies

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ACR Appropriateness Criteria

Topic	Variant	Test	AC
Hematemesis	No history of alcoholism or liver disease.	Arteriography visceral	8
Hematemesis	No history of alcoholism or liver disease.	X-ray chest	8
Hematemesis	No history of alcoholism or liver disease.	Tc-99m labeled RBC scan liver	6
Hematemesis	No history of alcoholism or liver disease.	Tc-99m sulfur colloid scan liver	6
Hematemesis	No history of alcoholism or liver disease.	X-ray barium swallow and upper GI seri	4
Hematemesis	No history of alcoholism or liver disease.	US liver with Doppler	4
Hematemesis	No history of alcoholism or liver disease.	CT abdomen	4
Hematemesis	No history of alcoholism or liver disease.	CT chest	4
Hematemesis	No history of alcoholism or liver disease.	MRI with or without MRA/MRV abdomei	4
Hematemesis	No history of alcoholism or liver disease.	Wedge venography liver	4
Hematemesis	No history of alcoholism or liver disease.	Slenoportography	2

- 167 Topics, > 800 Variants
- 7578 Topics / Variants / Tests:
- CT is listed as a possible test in 931 / 7578 (12%)

ACR Appropriateness Criteria - Hematemesis

Variant 2: No history of alcoholism or liver disease.

Radiologic Procedure	Rating	Comments	RRL*
Arteriography visceral	8		Med
X-ray chest			Min
Tc-99m labeled RBC s			Med
Tc-99m sulfur colloid			Med
X-ray barium swallow			Med
US liver with Doppler			None
CT abdomen			Med
CT chest			Med
MRI with or without M abdomen			None
Wedge venography liver	4		NS
Splenoportography	2		NS

Rating Scale: 1=Least appropriate, 9=Most appropriate

*Relative Radiation Level

Relative Radiation Level Designations	
Relative Radiation Level*	**Effective Dose Estimate Range**
None	0
Minimal	< 0.1 mSv
Low	0.1-1 mSv
Medium	1-10 mSv
High	10-100 mSv

Blunt Abdominal Trauma

Unstable Patient

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	8	To evaluate for fracture and abnormal air collection. Patient condition permitting.	Min
US chest abdomen and pelvis (FAST scan)	8	Rapid assessment of free fluid. Patient condition permitting.	None
X-ray abdomen and pelvis	8	To evaluate for fracture and abnormal air collection. Patient condition permitting	Med
CT chest abdomen and pelvis with contrast	7		High
Arteriography with possible embolization abdomen and pelvis	5		NS
US abdomen and pelvis	3		None
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Blunt Abdominal Trauma

Stable Patient -- Hematuria

Radiologic Procedure	Rating	Comments	RRL*
CT chest abdomen and pelvis with contrast	9		High
X-ray chest	8		Min
X-ray abdomen and pelvis	7	To identify pelvic or spinal fracture.	Med
CT pelvis with bladder contrast (CT cystography)	6	Refer to text for indications.	High
X-ray retrograde urethrography	6	Refer to text for indications.	Med
Arteriography with possible embolization kidney	5	If CT identifies active site of bleed or arterial injury.	NS
X-ray cystography	4	CT cystography preferred.	Med
X-ray intravenous urography	3		Med
US abdomen and pelvis	3		None
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Blunt Abdominal Trauma

Stable Patient – No Hematuria

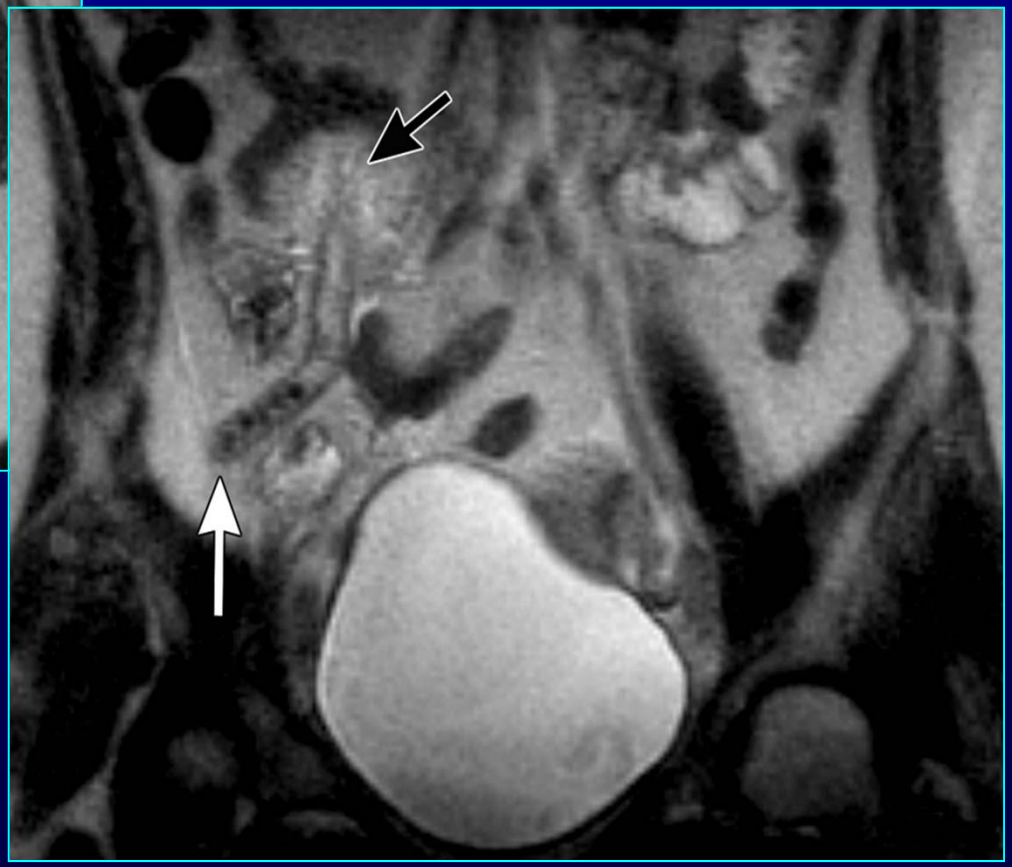
Radiologic Procedure	Rating	Comments	RRL*
CT chest abdomen and pelvis with contrast	9		High
X-ray chest	8		Min
Arteriography with possible embolization abdomen and pelvis	5		NS
US chest abdomen and pelvis (FAST scan)	5		None
X-ray abdomen and pelvis	4	Information provided by CT.	Med
US abdomen and pelvis	3		None
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

- CT is listed as “7, 8, or 9” in 285 / 931 (31%)
- CT is listed as “9” in 115 / 931 (12%)

Appropriate Utilization

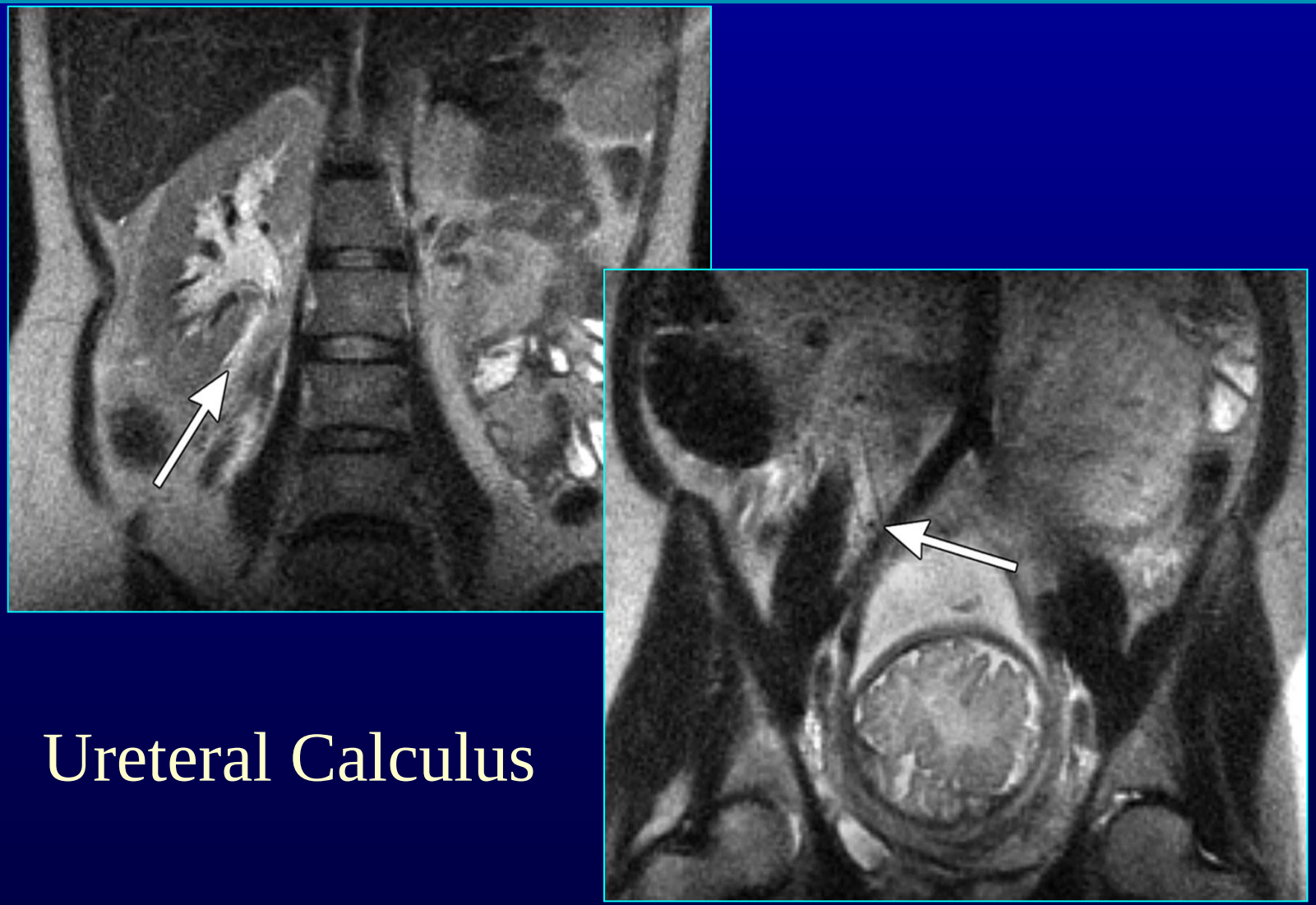
"In high risk patients, CT should be avoided when an ultrasound or MRI is of comparable diagnostic utility"

RLQ Pain: Pregnant (26 wks)



Appendicoliths

RLQ Pain: Pregnant (32 wks)



Ureteral Calculus

RLQ Pain in Pregnancy (w/ Fever, WBCs)

Radiologic Procedure	Rating	Comments	RRL*
US abdomen RLQ	8	With graded compression. Better in first and early second trimester.	None
MRI abdomen and pelvis without contrast	7		None
US pelvis	6		None
CT abdomen and pelvis with contrast	6	Use of oral or rectal contrast depends on institutional preference.	High
CT abdomen and pelvis without contrast	5	Use of oral or rectal contrast depends on institutional preference	High
X-ray abdomen	2		Med
X-ray contrast enema	2		Med
Tc-99m WBC scan abdomen and pelvis	2		Med
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

- US and MR are more appropriate than CT for RLQ pain in pregnant women

Asymptomatic Patients

- CT Colonography
  - American Cancer Society endorsed CTC as screening test for colorectal cancer in 2008
  - Anticipated life-time risk of colorectal cancer = 5 – 6%
  - Potential risk of radiation-induced cancer from CTC*

    50 years 0.14%

    70 years 0.07%

    (Benefit >> Risk)

**Brenner DJ, Georgsson MA. Mass screening with CT colonography: should the radiation exposure be of concern? Gastroenterology 2005:129;328-337*

Steps to Control Radiation Exposure

Appropriate Utilization

- Tailor exam to the patient/application
  - Reduce dose as much as possible
- CT vs. other imaging tests
- Avoid un-necessary / repetitive studies

Appropriate Utilization

"I am an adult and a physician! I don't need your approval for CT scans that are necessary for my patients"

Anon – ER Physician

NCRP

Computed Tomography in Emergency Medicine – Ensuring Appropriate Use

September 23-24, 2009
Bethesda-Chevy Chase Rescue Squad Building
Anastasi Conference Room
Bethesda, Maryland

Journal of the American College of Radiology
Volume 8, Issue 5 , Pages 325-329, May 2011

Physician Education

- Adult CT patients for abdominal pain
- Questioned about consent, radiation risk and CXR equivalents
- Same questions asked of ED physicians and radiologists

Lee CI, Haims AH, Monico EP, Brink JA, Forman HP. Diagnostic CT scans: assessment of patient, physician, and radiologist awareness of radiation dose and possible risks. Radiology 2004; 231:393-398.

Physician Education

- 9% of referring physicians believed that there was an increased cancer risk from CT
- CXR Equivalents (%):

	<1	1-10	10-100	100-250	>500
MDs	7	44	22	22	4
Rads	5	56	15	13	10
Pts	28	64	7	0	0

UK: IRMER (2000)*

- Medical Exposures Directive of Council of the European Union**
  - Strict referral criteria
  - Strict justification criteria
  - Dose optimization requirement
  - Dose exposure reference levels

**Ionizing Radiation (Medical Exposures) Regulations*
***Council Directive 97/43 Euratom*

Appropriate Utilization

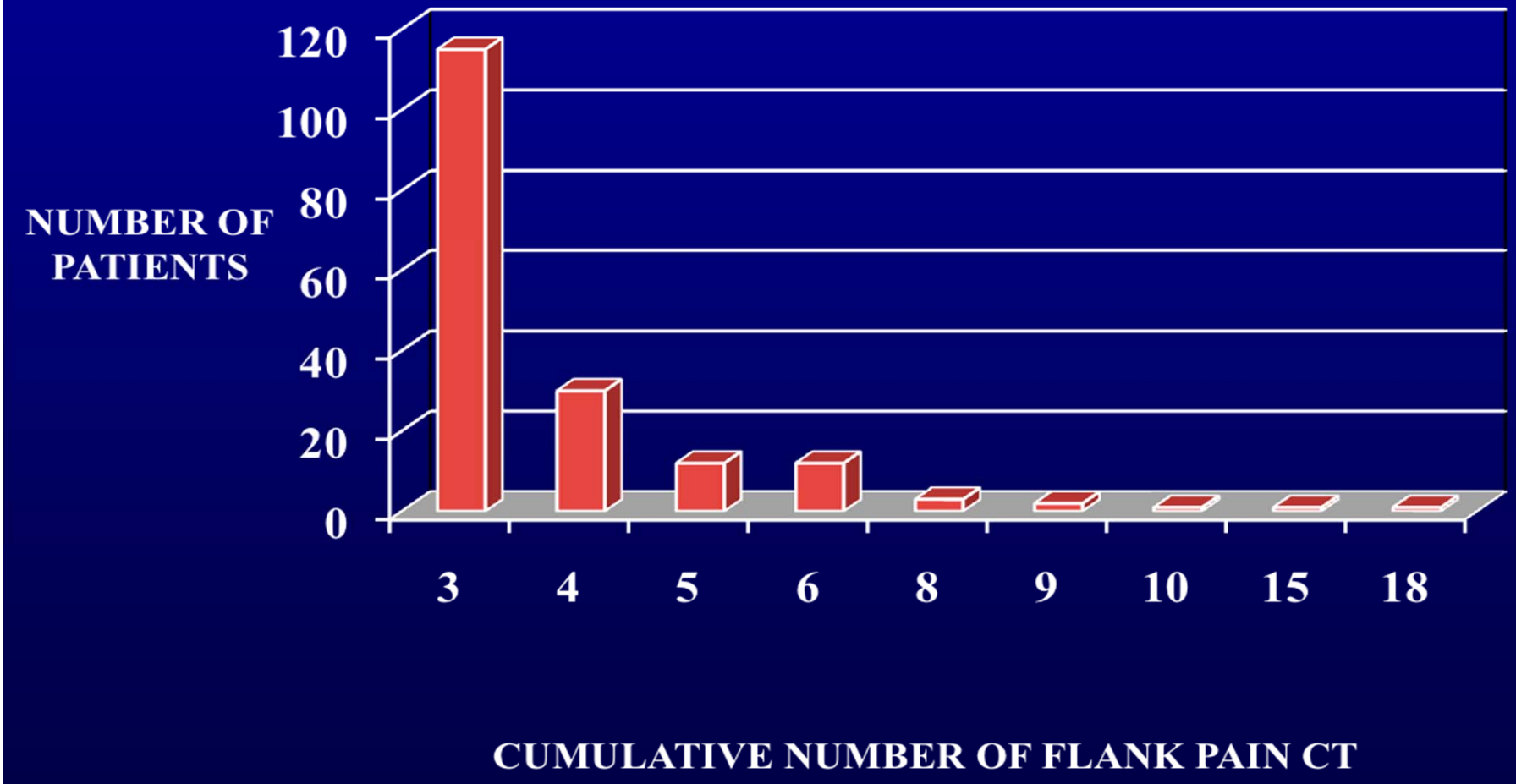
"CT should be avoided when the benefit is marginal"

Repetitive CT for Renal Colic

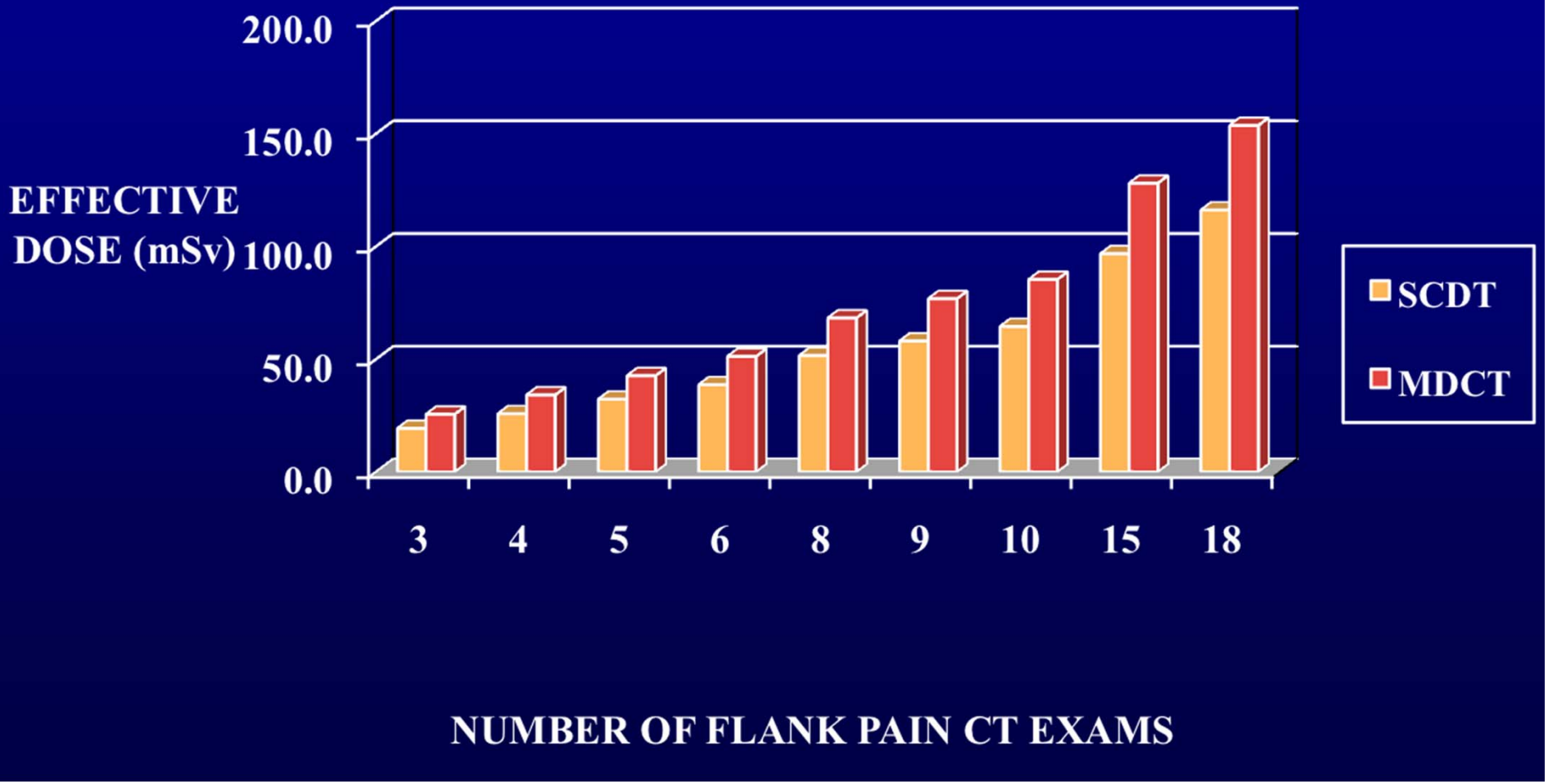
- 6 year period
- 4562 patients
- 5564 CT examinations
- Mean age: 45 years
  - 4% of exams were in children

Katz S, Saluja S, Brink JA, Forman HP. Radiation dose associated with unenhanced CT for suspected renal colic: impact of repetitive studies. AJR 2006;186:1120-1124.

176 Pts (4%) had 3 or more Flank Pain CTs



Estimated Effective Dose



Imaging Pathways / Algorithms

- Practice of radiology is highly variable
  - Need to standardize our practices/processes among institutions across the country
    - Multidisciplinary diagnostic algorithms that go beyond appropriateness criteria

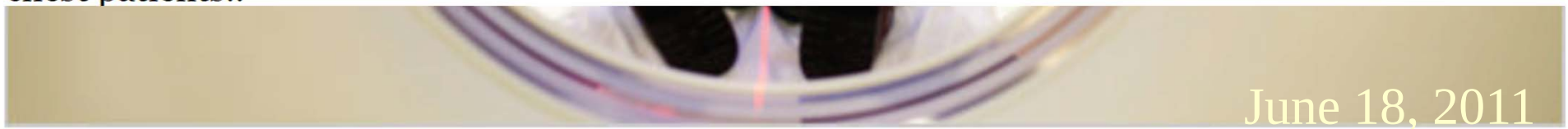
The New York Times

Hospitals Performed Needless Double CT Scans, Records Show

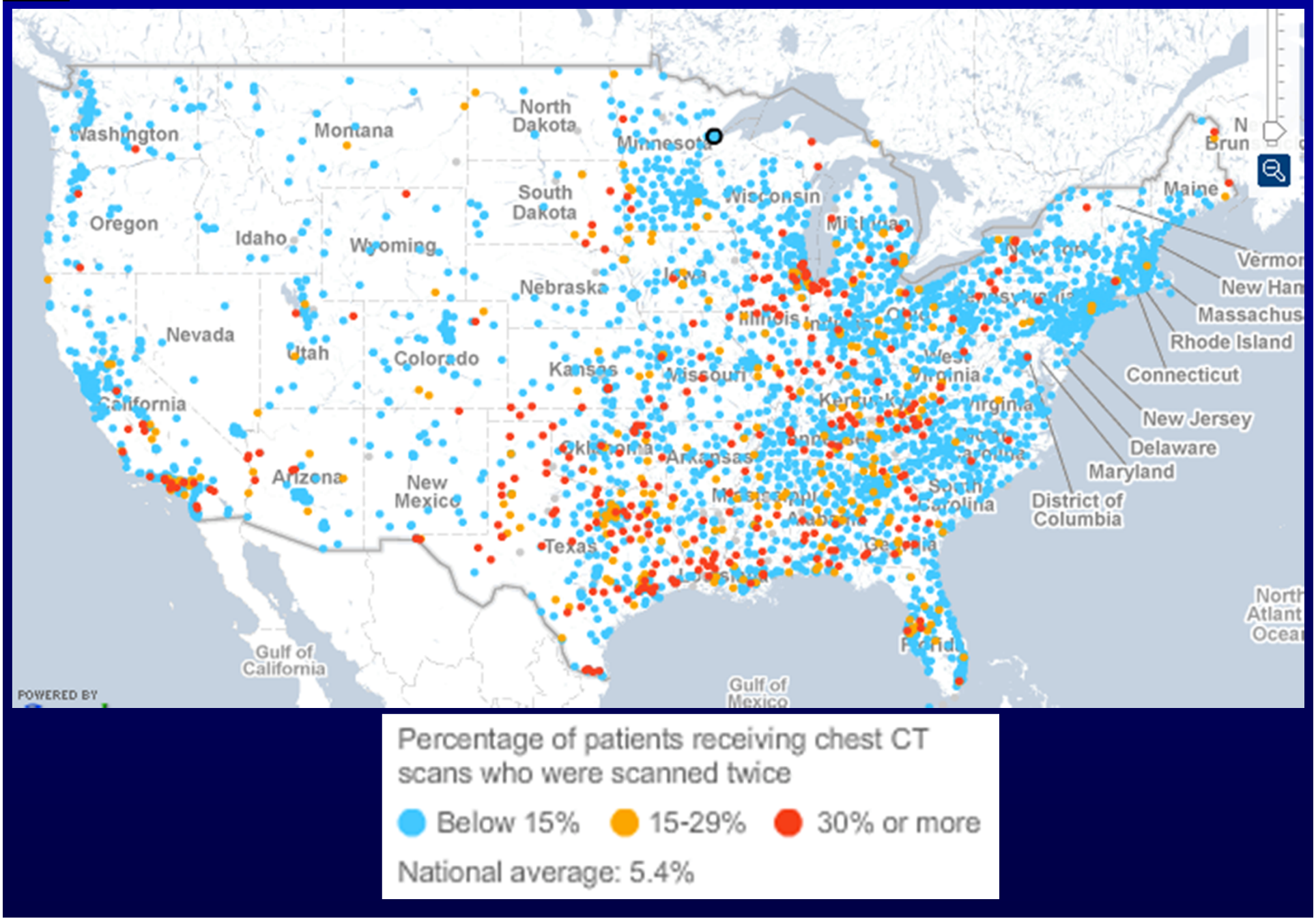
The Medicare agency distributed the data to hospitals last year to show how they performed relative to each other and to encourage more efficient, safer practices. The review of that data found more than 200 hospitals that administered double scans on more than 30 percent of their Medicare outpatients — a percentage that the federal agency and radiology experts considers far too high. The national average is 5.4 percent.

The figures show wide variation among states as well, from 1 percent in Massachusetts to 13 percent in Oklahoma. Overall, Medicare paid hospitals roughly $25 million for double scans in 2008.

Double scanning is more likely to occur at smaller, community hospitals such as Memorial Medical Center of West Michigan in Ludington. It gave two scans to 89 percent of its Medicare chest patients..



June 18, 2011


Washington
Montana
North Dakota
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Oregon
Idaho
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South Dakota
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Iowa
Nevada
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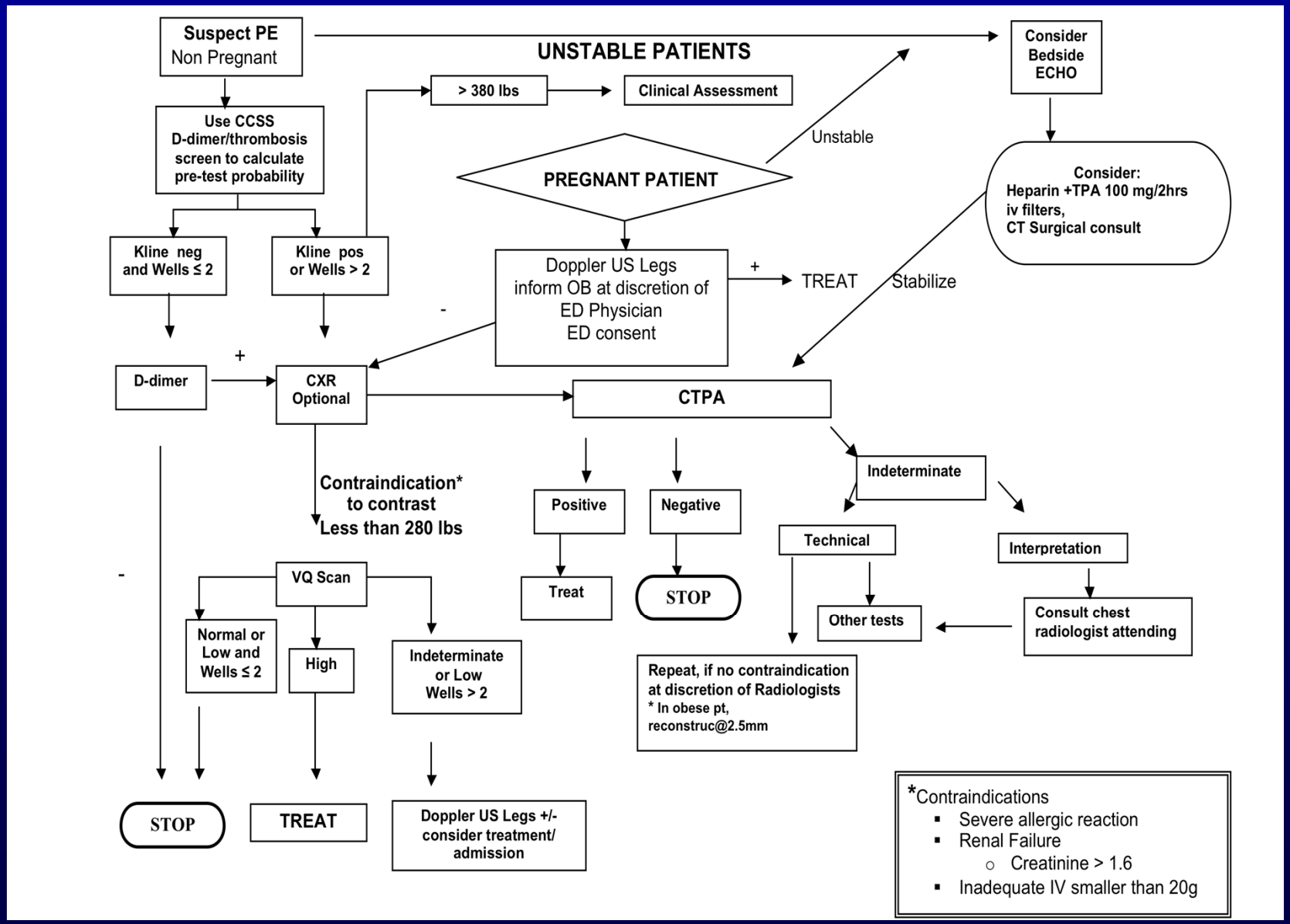
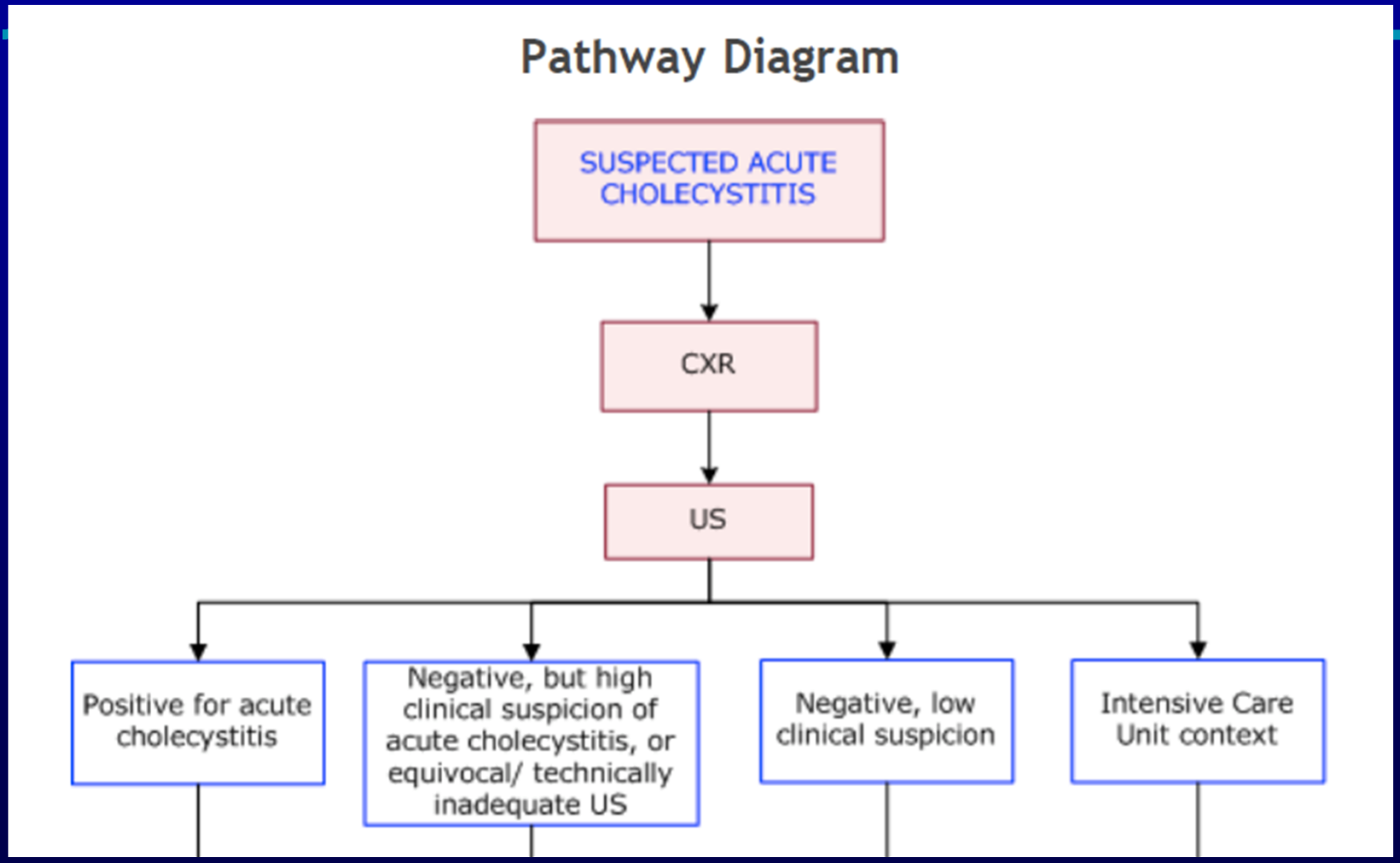
Missouri
California
Arizona
New Mexico
Texas
Maine
Vermont
New Hampshire
Massachusetts
Rhode Island
Connecticut
New Jersey
Delaware
Maryland
District of Columbia
Gulf of California
Gulf of Mexico
POWERED BY
Percentage of patients receiving chest CT scans who were scanned twice
Below 15%
15-29%
30% or more
National average: 5.4%

Diagnostic Algorithm for Suspected PE

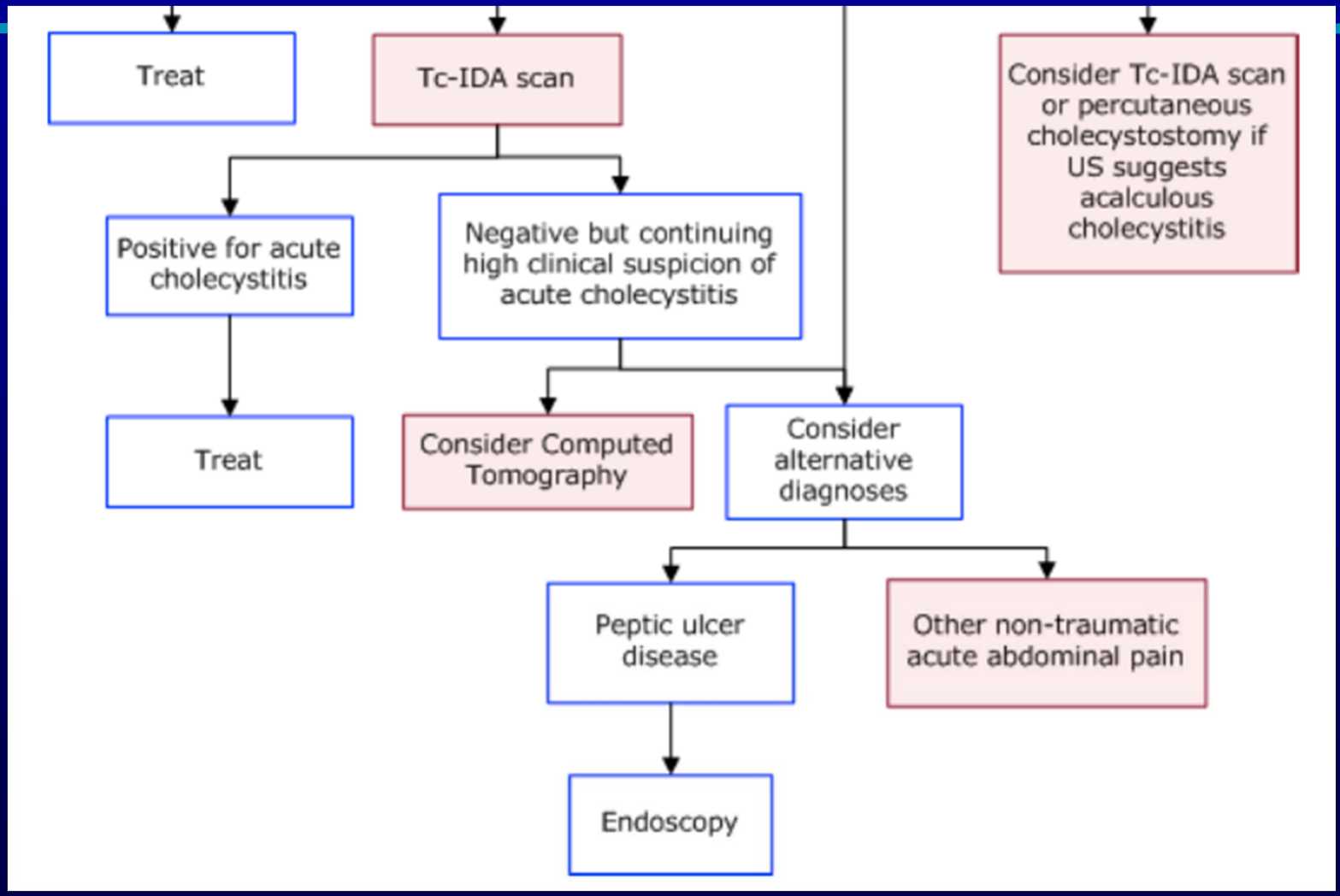


Australian Diagnostic Pathways



http://www.imagingpathways.health.wa.gov.au

Australian Diagnostic Pathways



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Australian Diagnostic Pathways

Endorsed by the Royal Australian and New Zealand College of Radiologists

The Royal Australian and New Zealand College of Radiologists

Endorsed by the Royal Australian College of General Practitioners

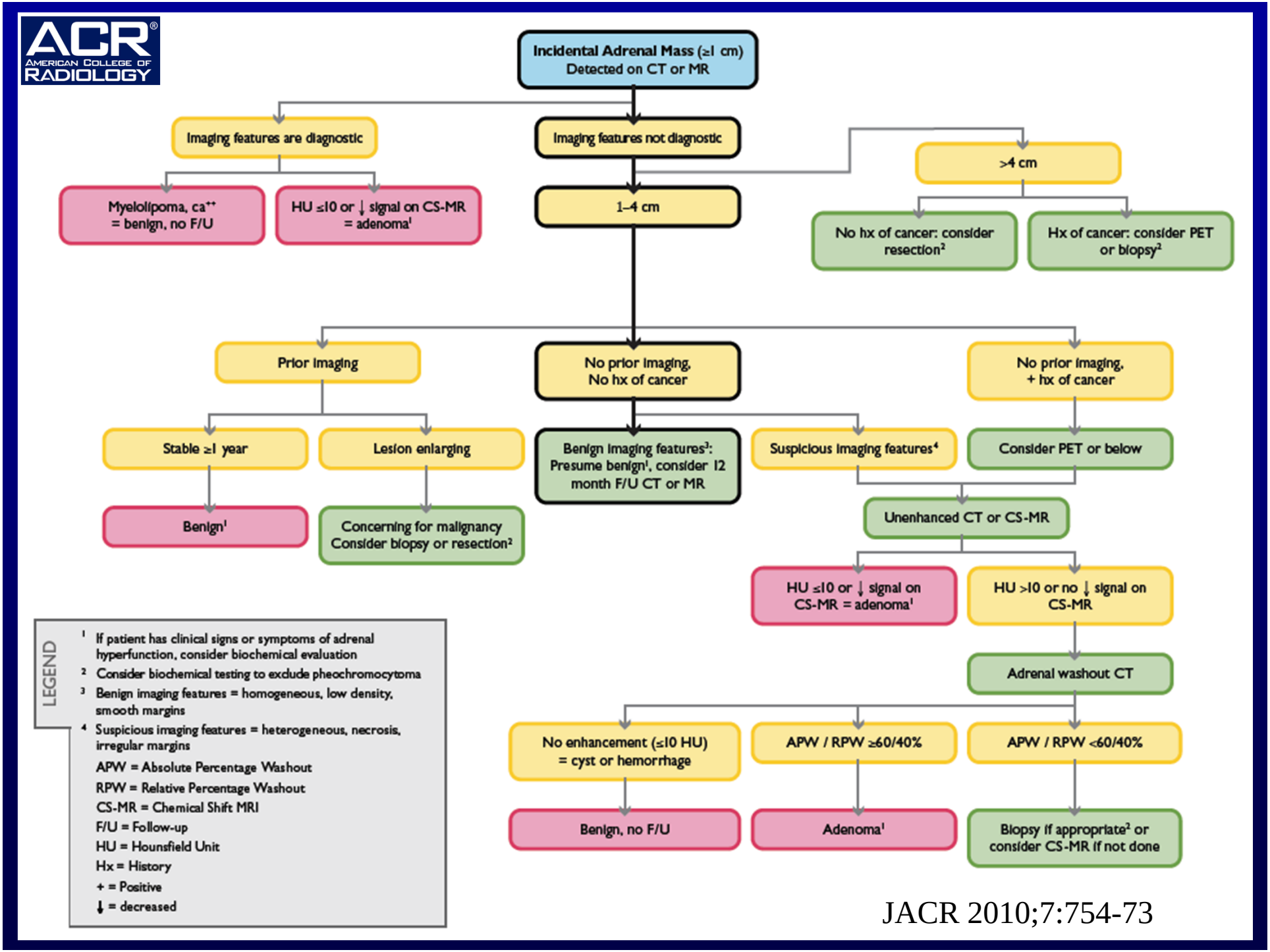
THE ROYAL AUSTRALIAN COLLEGE OF GENERAL PRACTITIONERS

http://www.imagingpathways.health.wa.gov.au

Managing Incidental Findings on Abdominal CT: White Paper of the ACR Incidental Findings Committee

J Am Coll Radiol 2010;7:754-773.

- Algorithms for Liver, Pancreas, Kidney, Adrenal
- Next Steps:
  - Seek buy-in from other professional societies
  - New effort for Adnexa, Vasculature, GB/ Biliary Tree, Spleen, Lymph Nodes



JACR 2010;7:754-73

That's all…