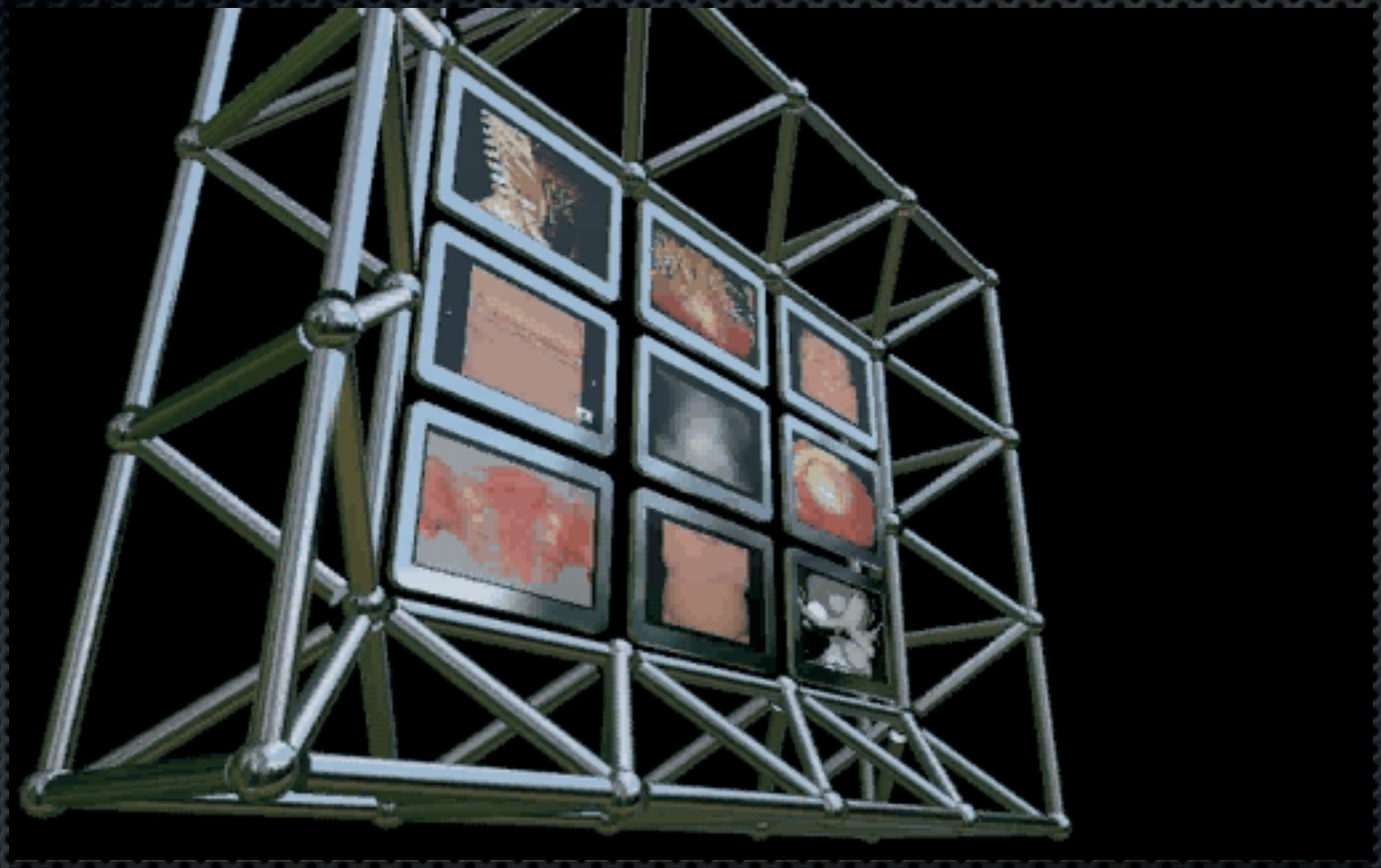
Cardiovascular and 3D Imaging



Richard L. Hallett, MD
Northwest Radiology Network

St. Vincent Hospital 18 May 2011 12:00

DISCLOSURES: NONE

PDF (Handout) of Lecture available at:

http://stanford.edu/~hallett

Lecture Outline

I. Overview of CT Image Acquisition

II. Recent technology advances promoting 3D imaging

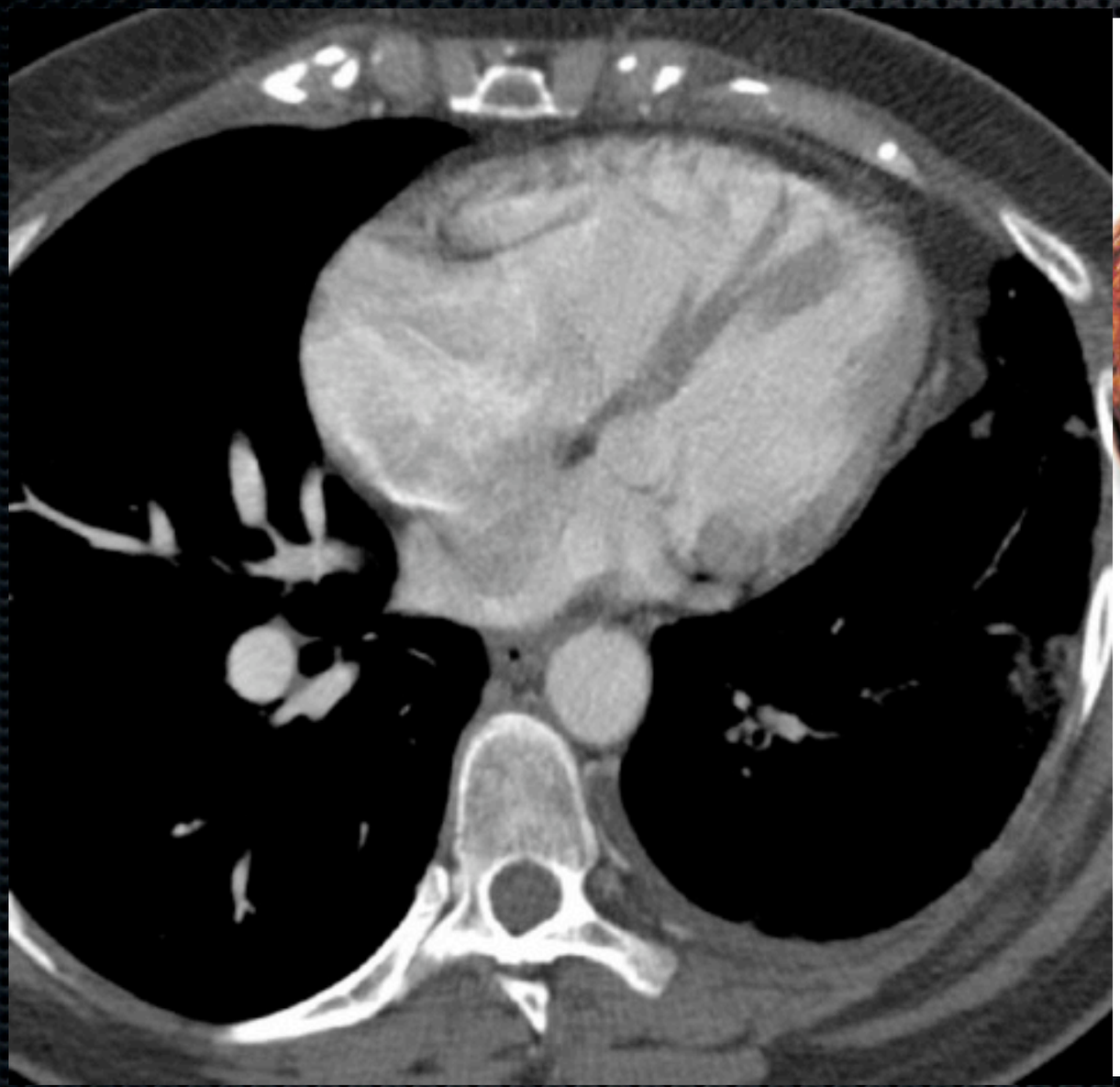
III. Specific Applications of 3D imaging

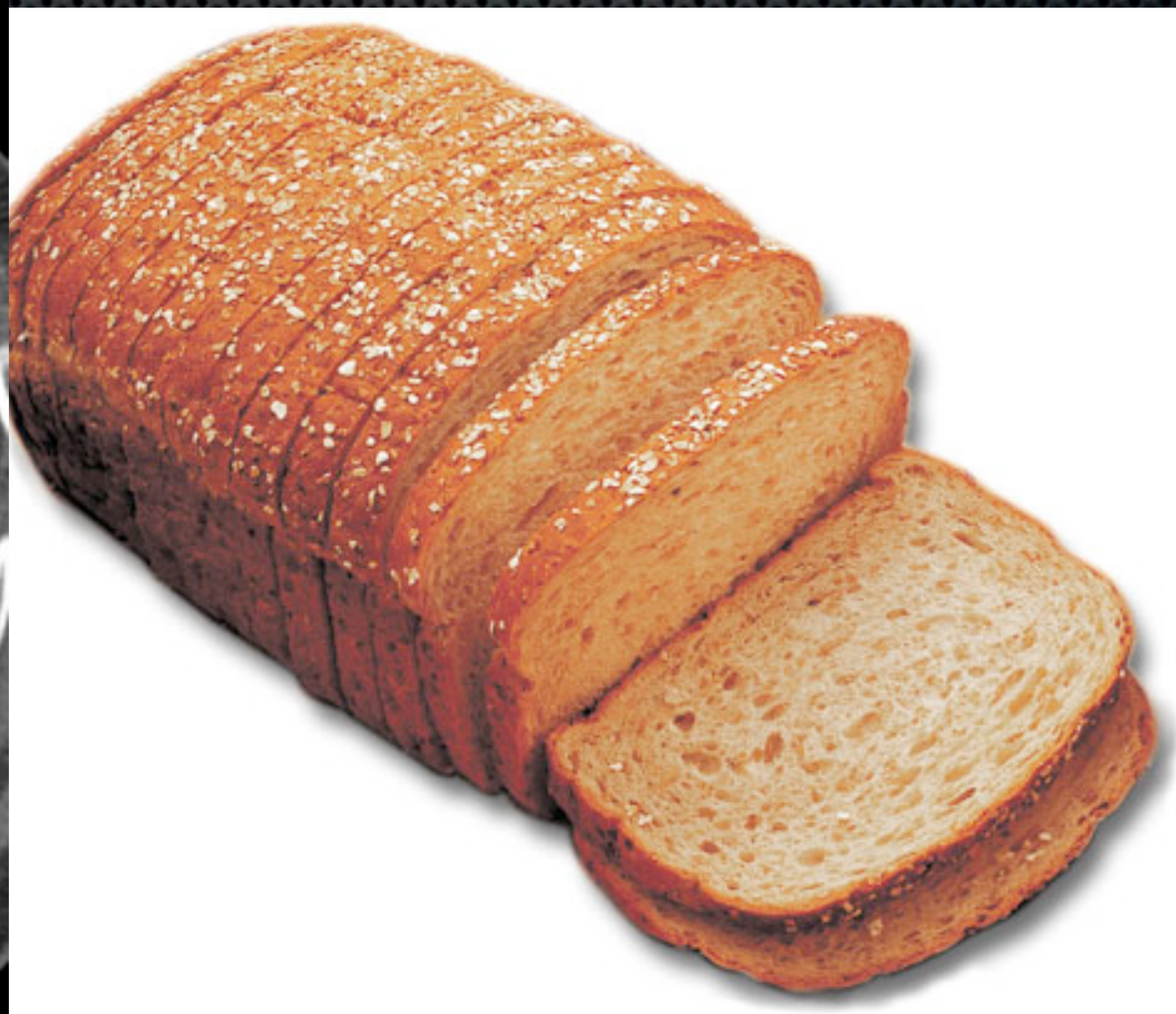
Overview of CT Image Acquisition

Overview: CT Image Aquisition

- X-Ray tube rotates- multiple detectors capture x-rays, computers reconstruct density and position
- Pixels displayed as range of :
  - *white (bone)*
  - *gray (soft tissue)*
  - *black (air)*

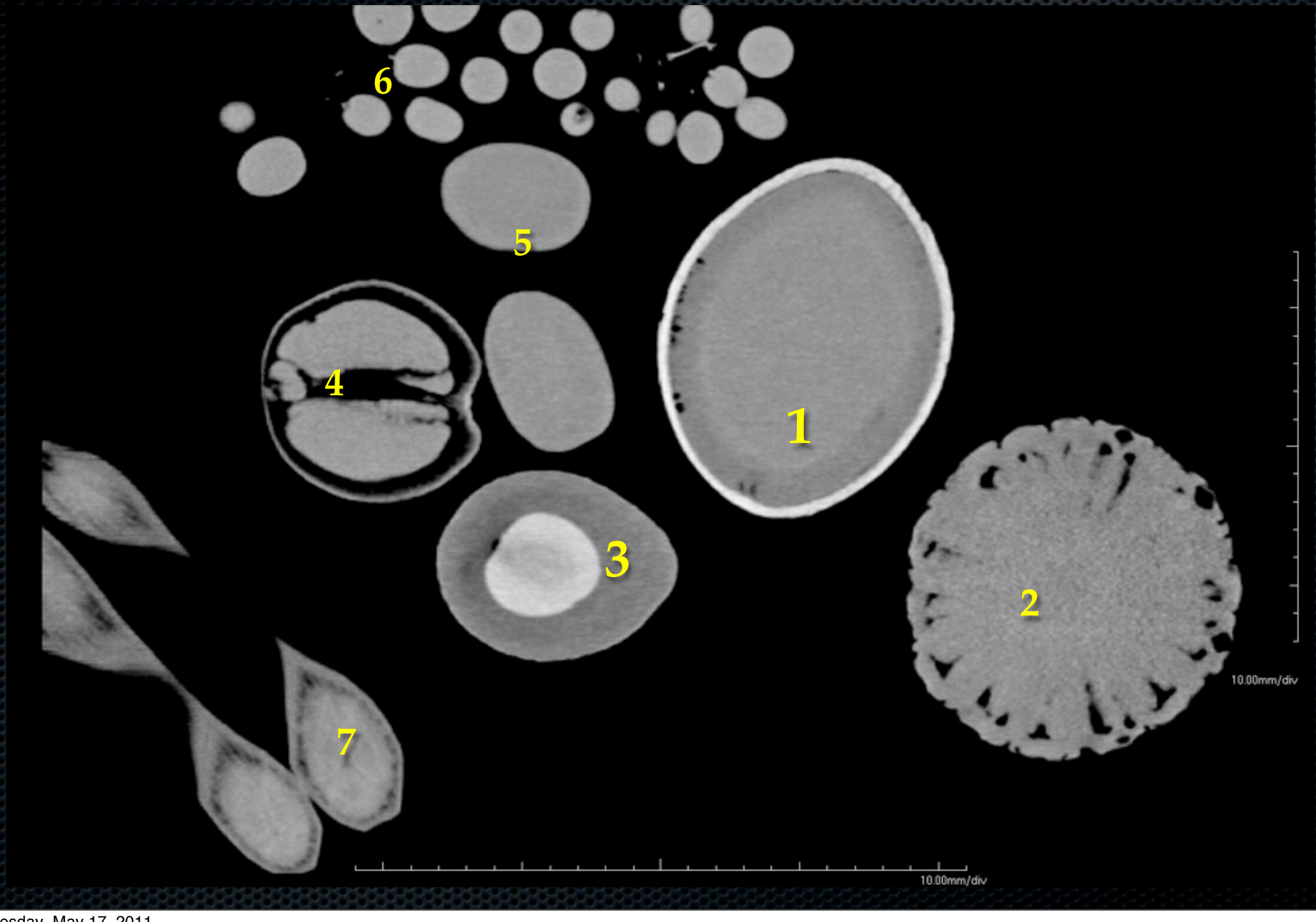
Can display “slices” various ways to see anatomy of interest....



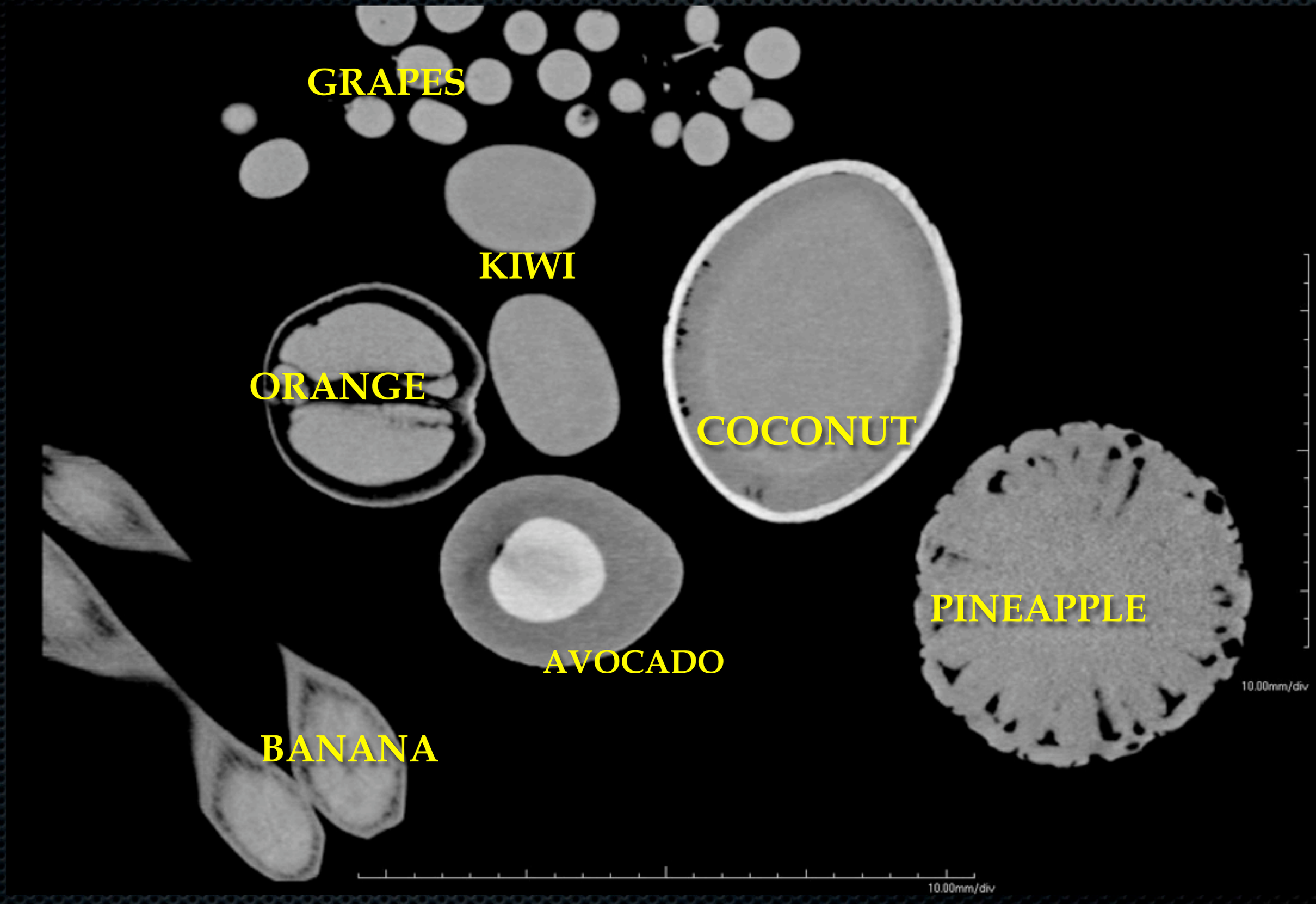


Here's a test....

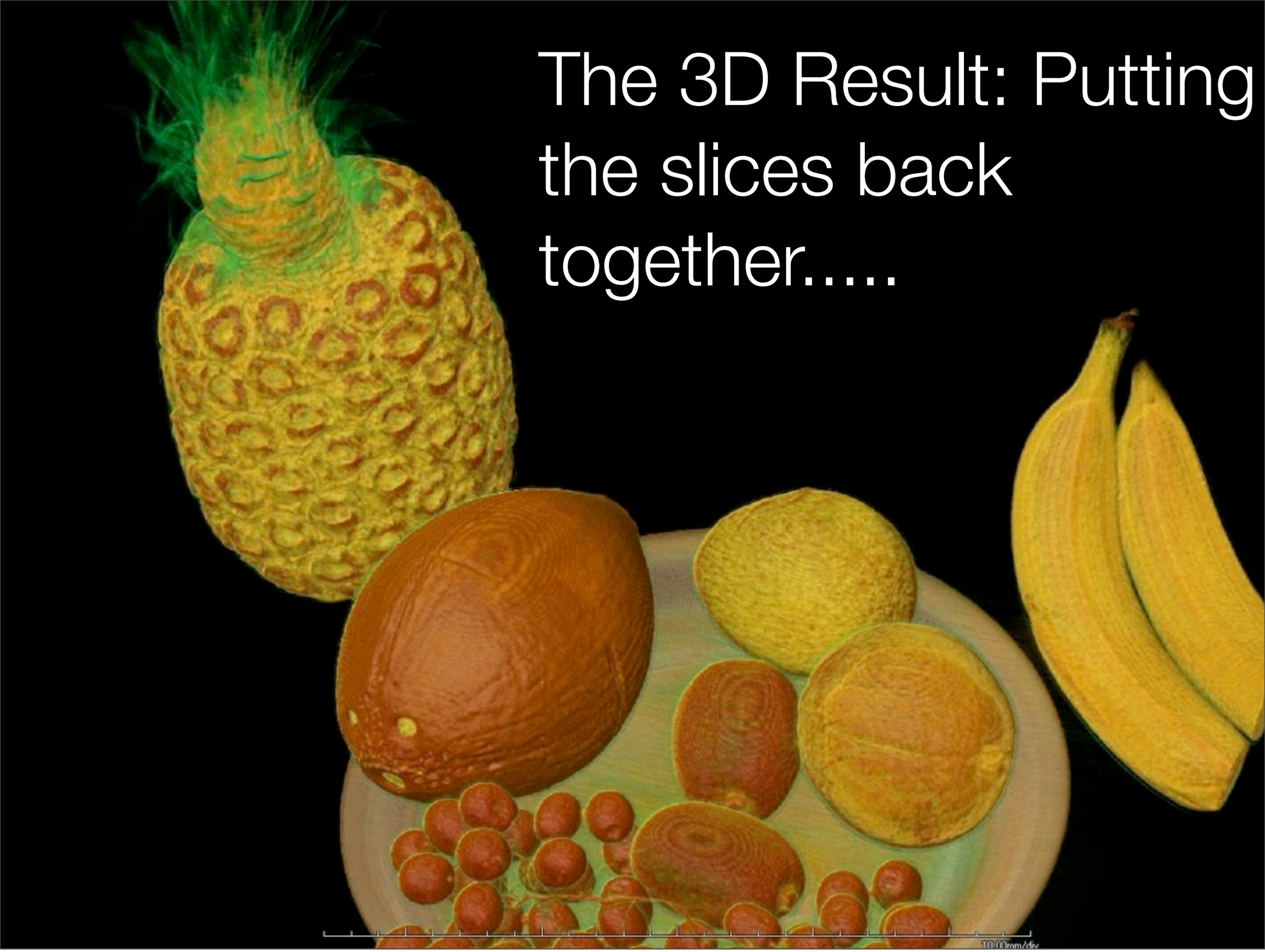
Example: Can you identify?



The Answers.....


GRAPES
KIWI
ORANGE
COCONUT
AVOCADO
PINEAPPLE
BANANA
10.00mm/div
10.00mm/div

The 3D Result: Putting the slices back together.....



How to Optimize 3D reconstruction

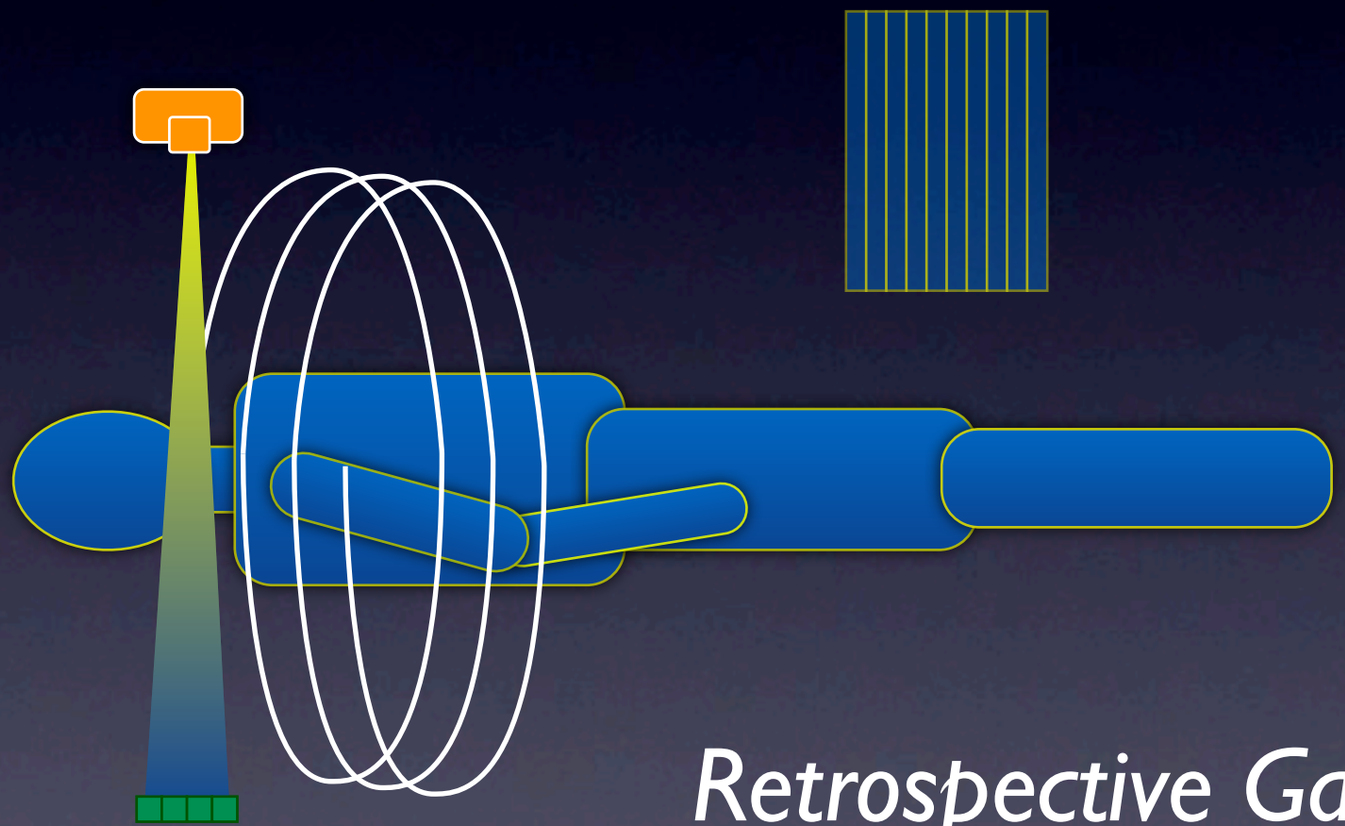
- Thin (< 1mm), overlapping (~ 30%) images
- Small field-of-view
- 3D workstation familiarity

Recent Advances for 3D Imaging

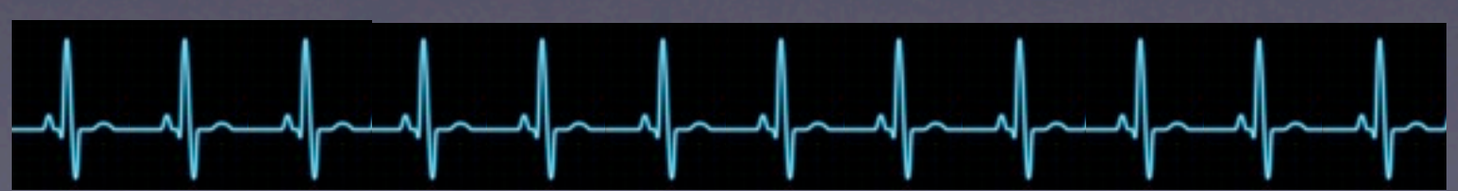
- CT Scanners
  - Faster rotation times, thinner slices
  - ECG-syncronization (gating)
- Computing and data interaction advances

ECG Synchronized CT

CT data acquired with EKG data

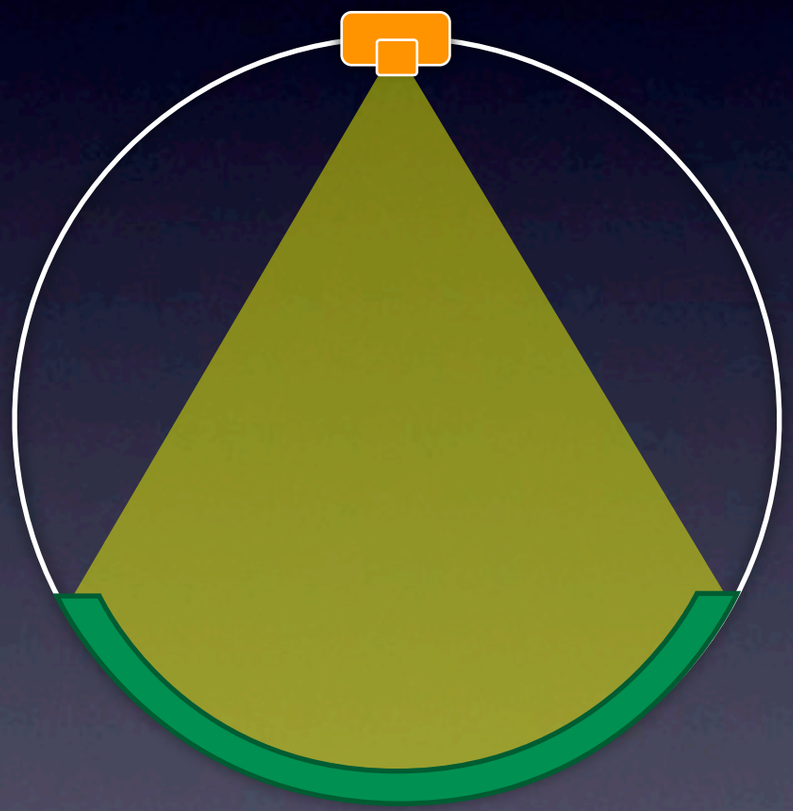


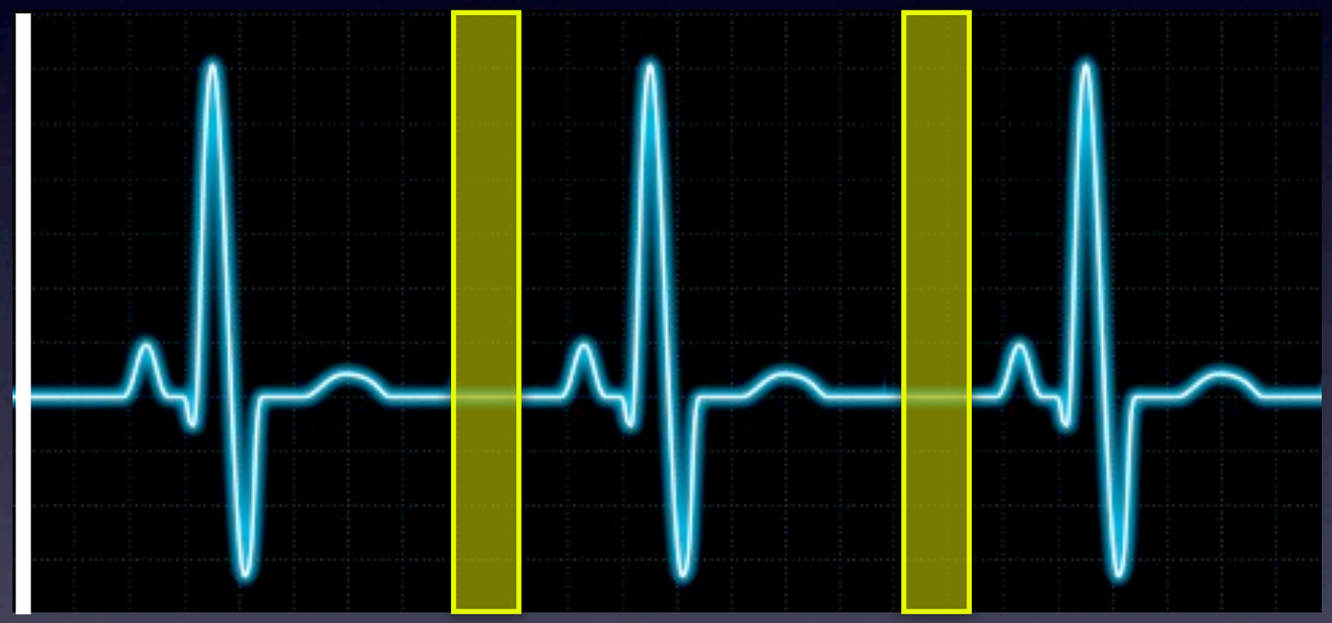
Retrospective Gated CT



ECG Synchronized CT

Prospective Gating a.k.a. "step and shoot"





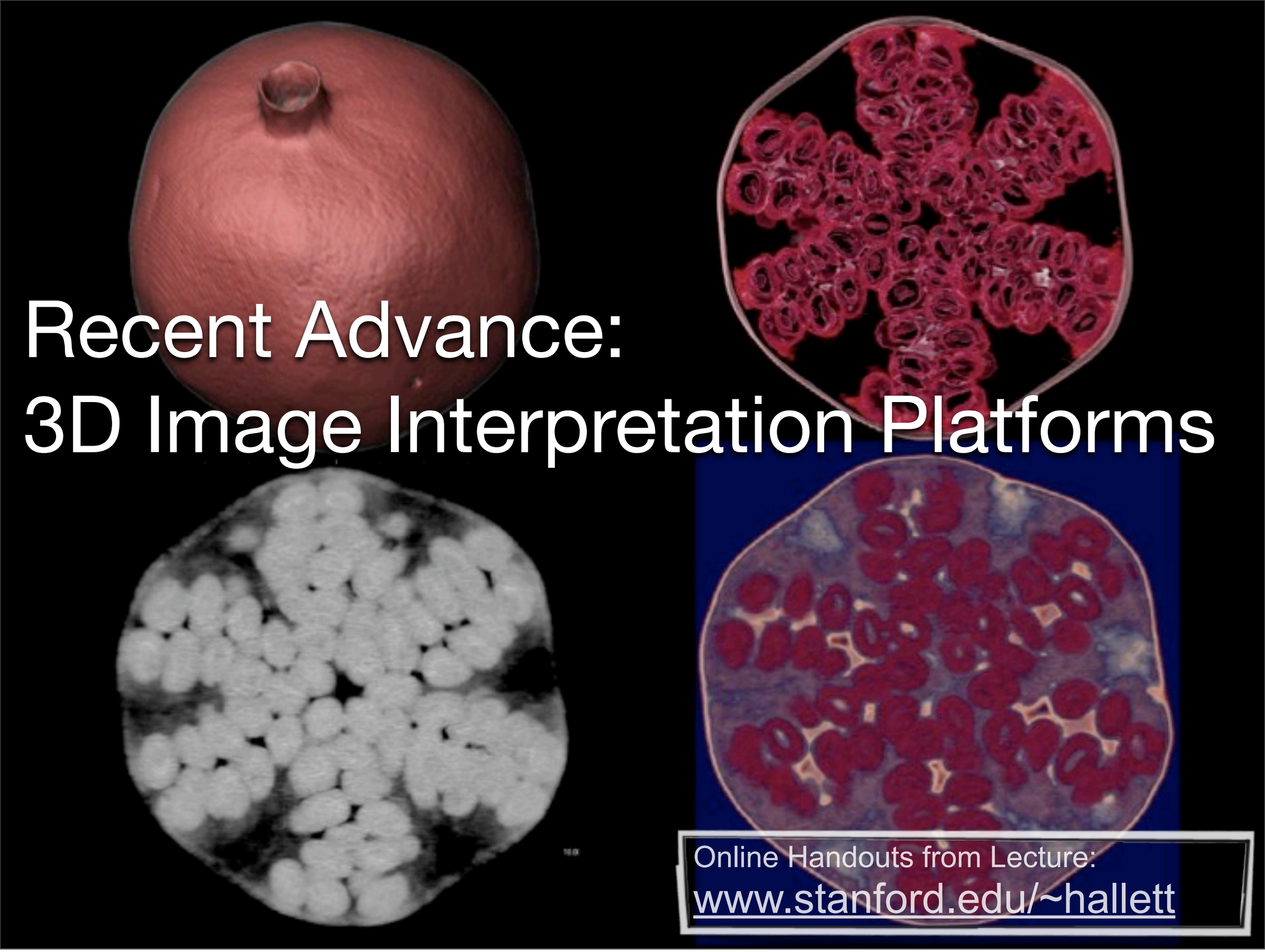
Provides up to 80% dose reduction over conventional retrospective gating

***Technique dependent on stable** heart rates*

Result of Retrospective ECG Gating… 4D MOTION (cine)

Courtesy of Ivan Petrovich, MD
Northern Virginia Radiology

Recent Advance:
3D Image Interpretation Platforms



Online Handouts from Lecture:
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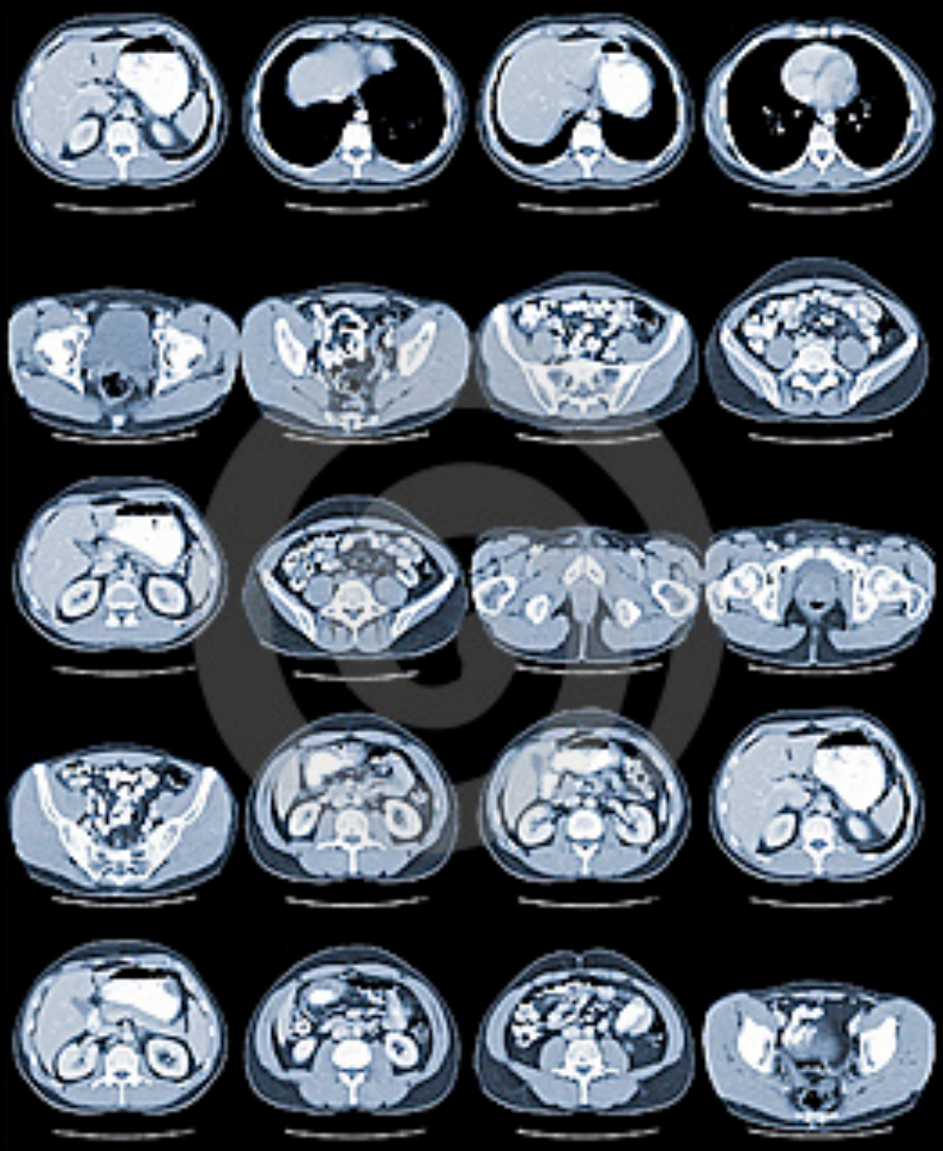
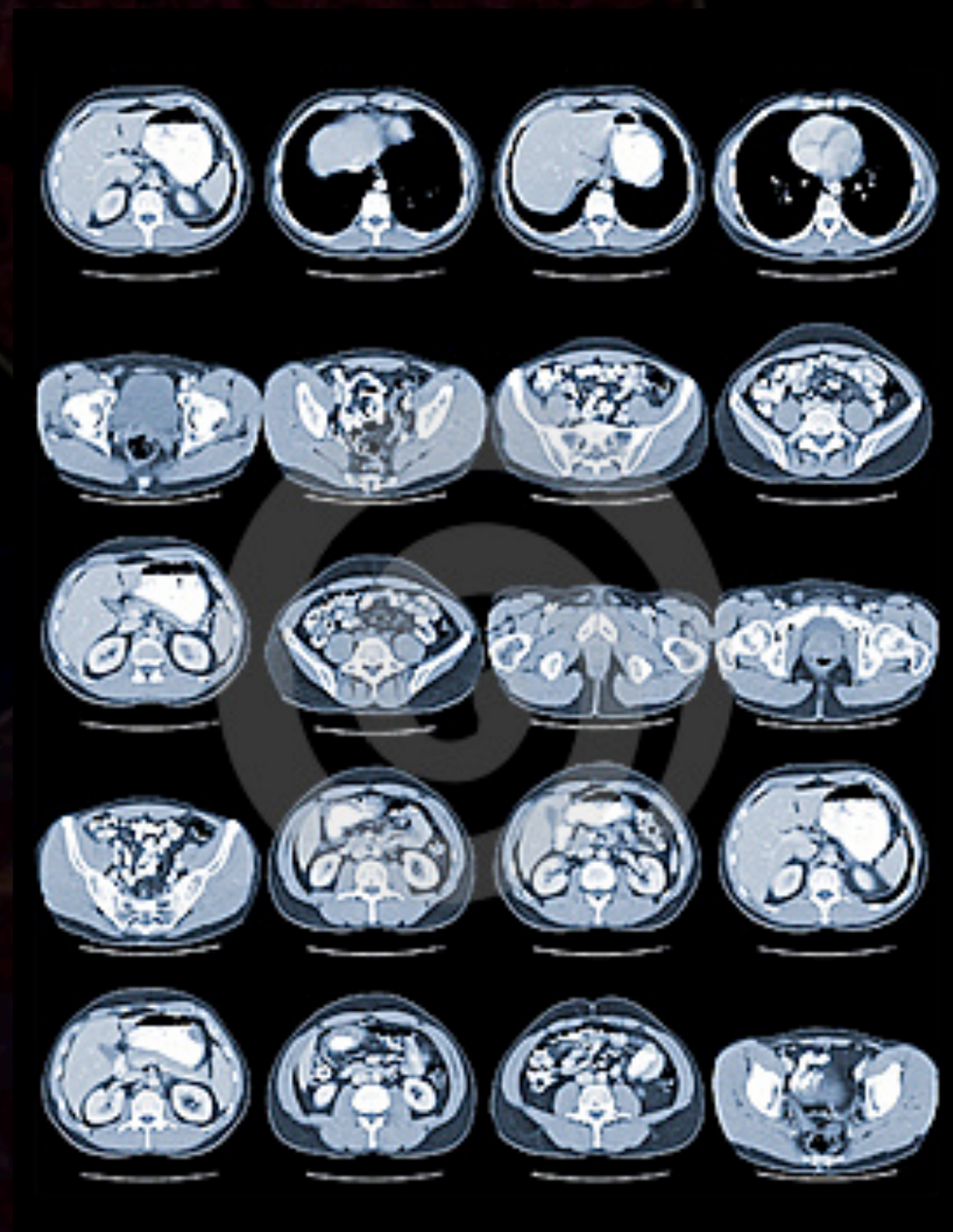
Image Interpretation platform

- Originally: CT viewed on film, printed 9 -20 images per page



Printed Image Review

- Could not window/ level images (e.g. had to print more images with “bone windows”, “lung windows”, etc)



Printed Image Review

- Thin slice CT acquisition yields **large** number of images (≥2000)
- All source data should be reviewed
- If exam is 1200 images, review each for 3 sec →

60 minutes to review, ~100 pages of film!!

Image Interpretation platform

- **Next: PACS**
  - Picture Archiving and Communication System
  - stack review of images
  - Spatial relationships realized more quickly and with higher fidelity than “tiled” film images

Stack Review

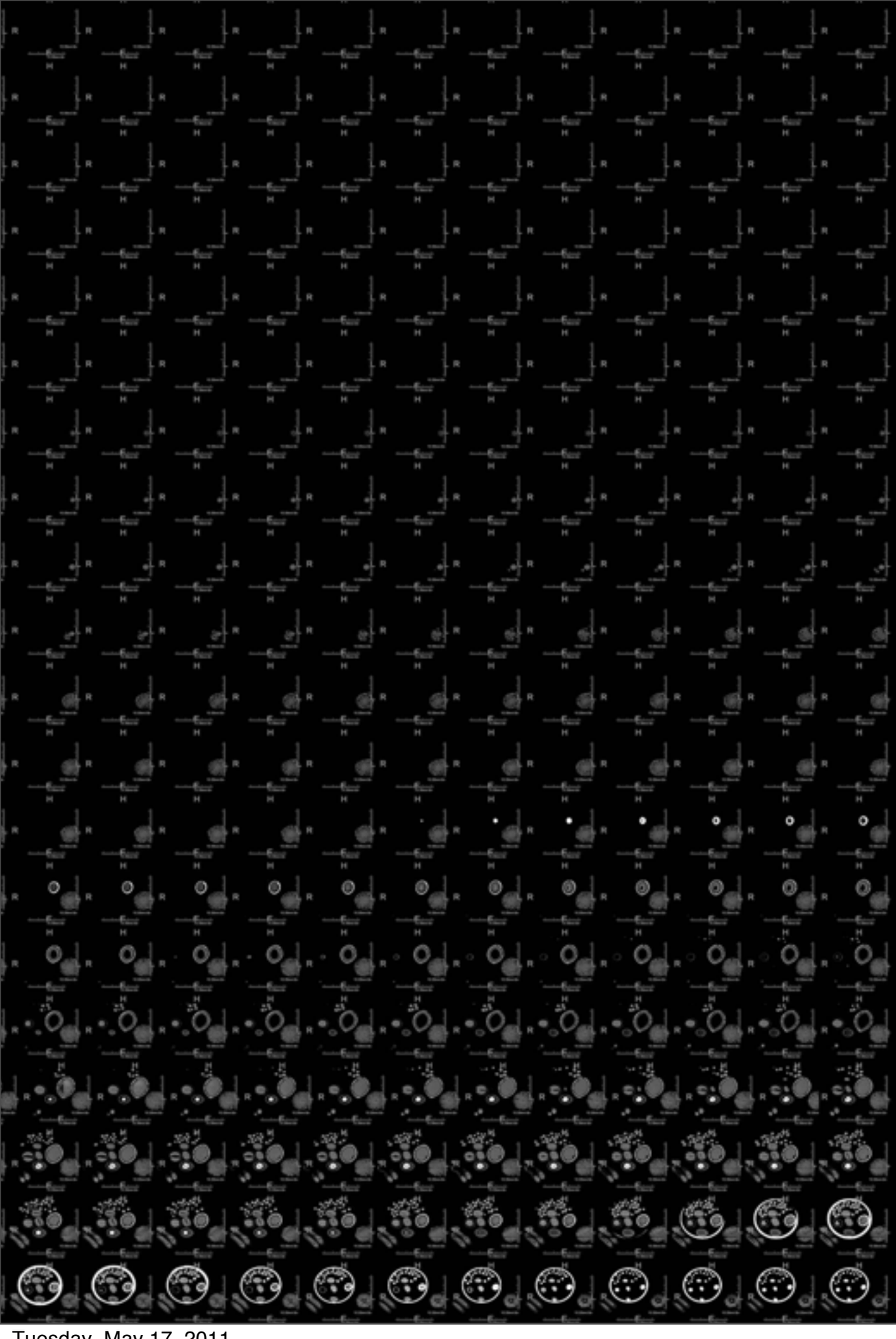
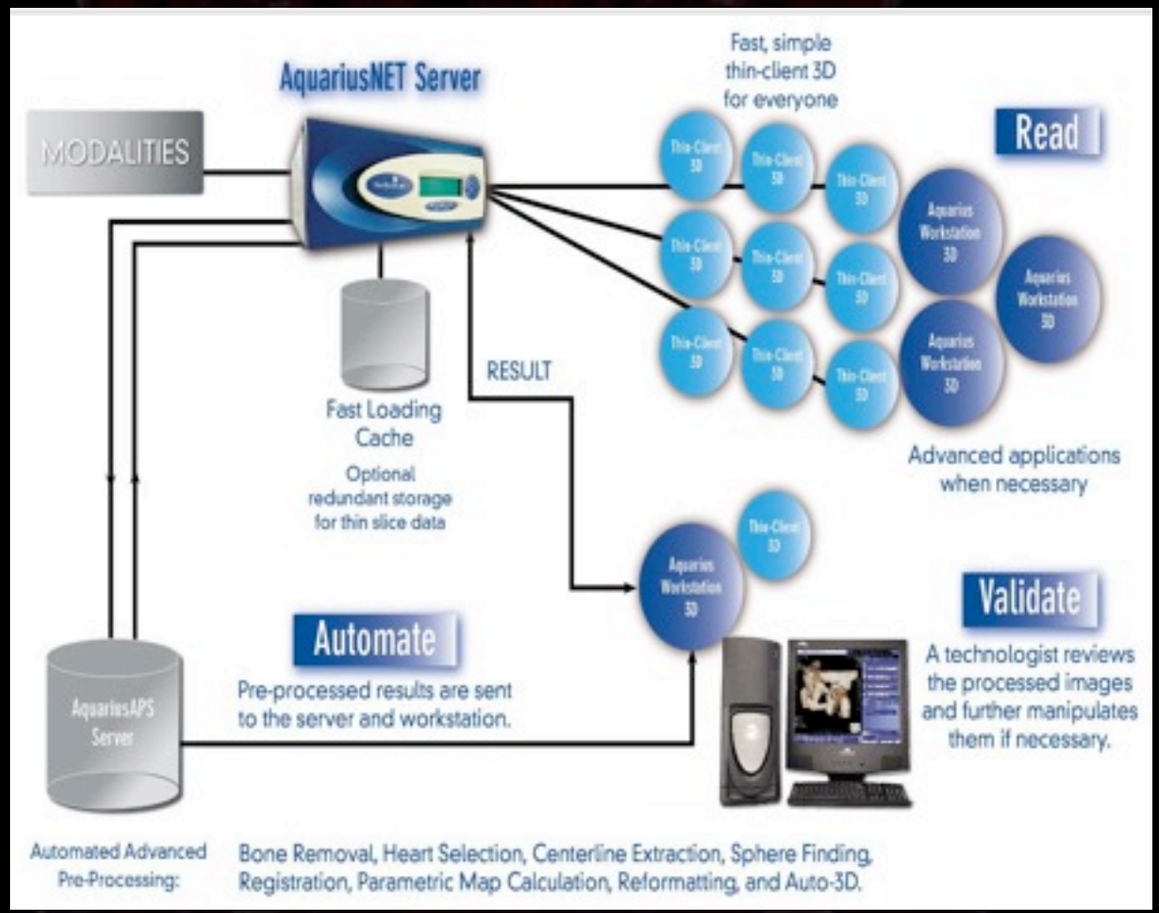


Image Interpretation platform

- Today: 3D Interactive Review
  - Workstation
  - Thin-client - Server
  - Hybrid systems



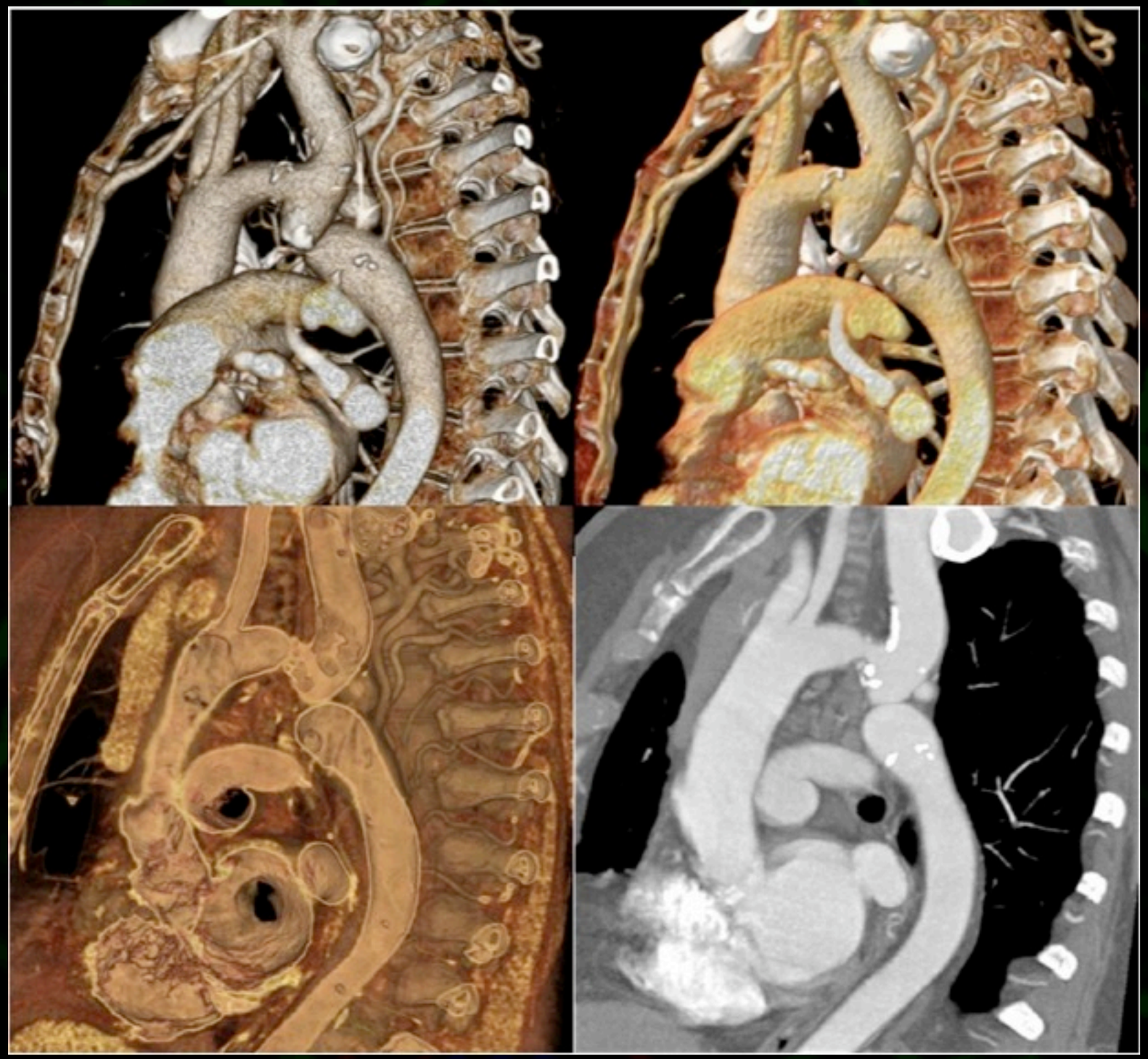
Tomorrow's Image Interpretation

- **"The Cloud"**

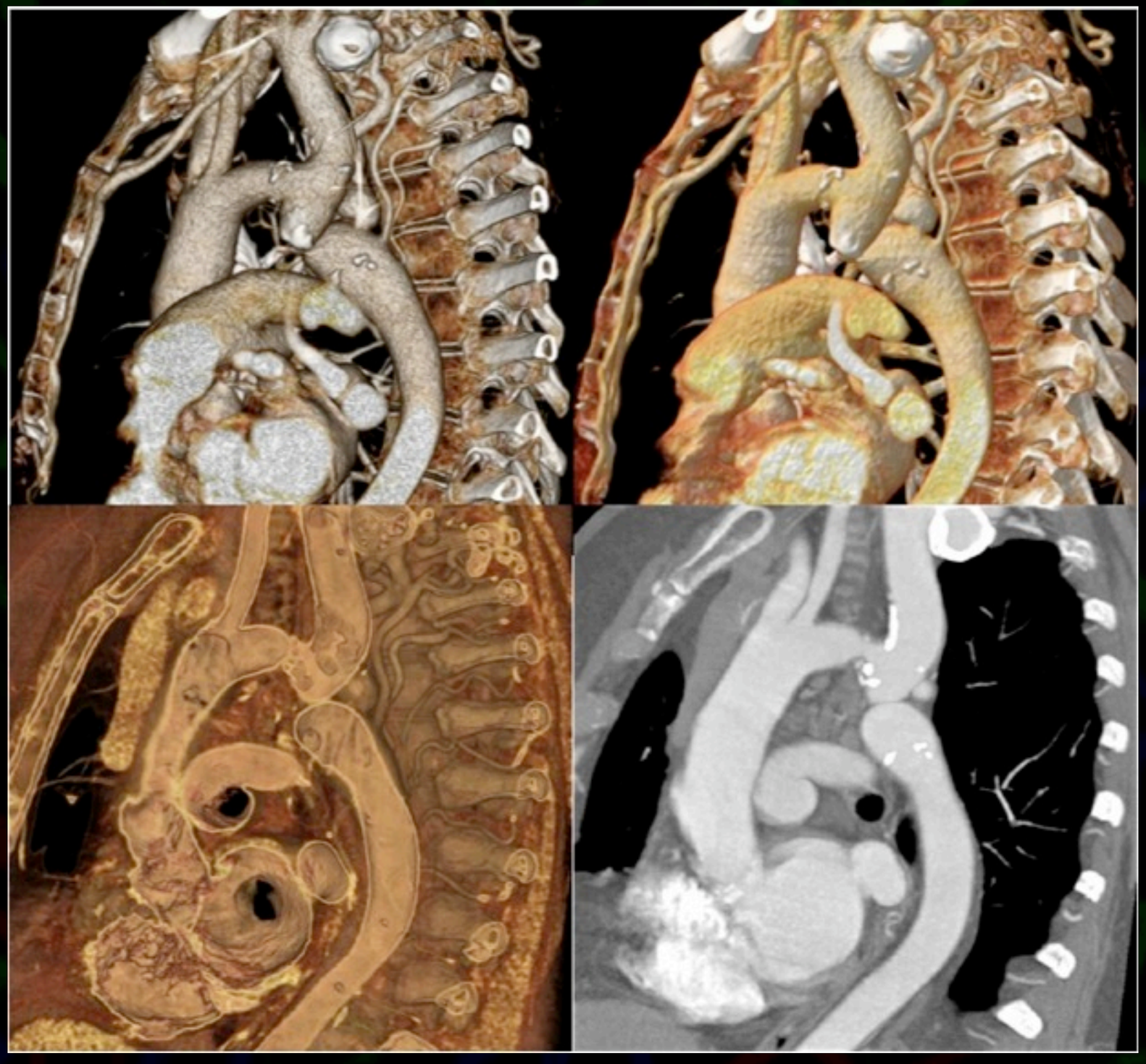
"The Cloud"

- Just need a browser
  - Laptop
  - iPad
  - Smart phone
- Enhance (someday replace?) current on-site servers
- Will require attention to privacy / data safety

3D Image Post-Processing



Recent Advance: Computer Processing Power

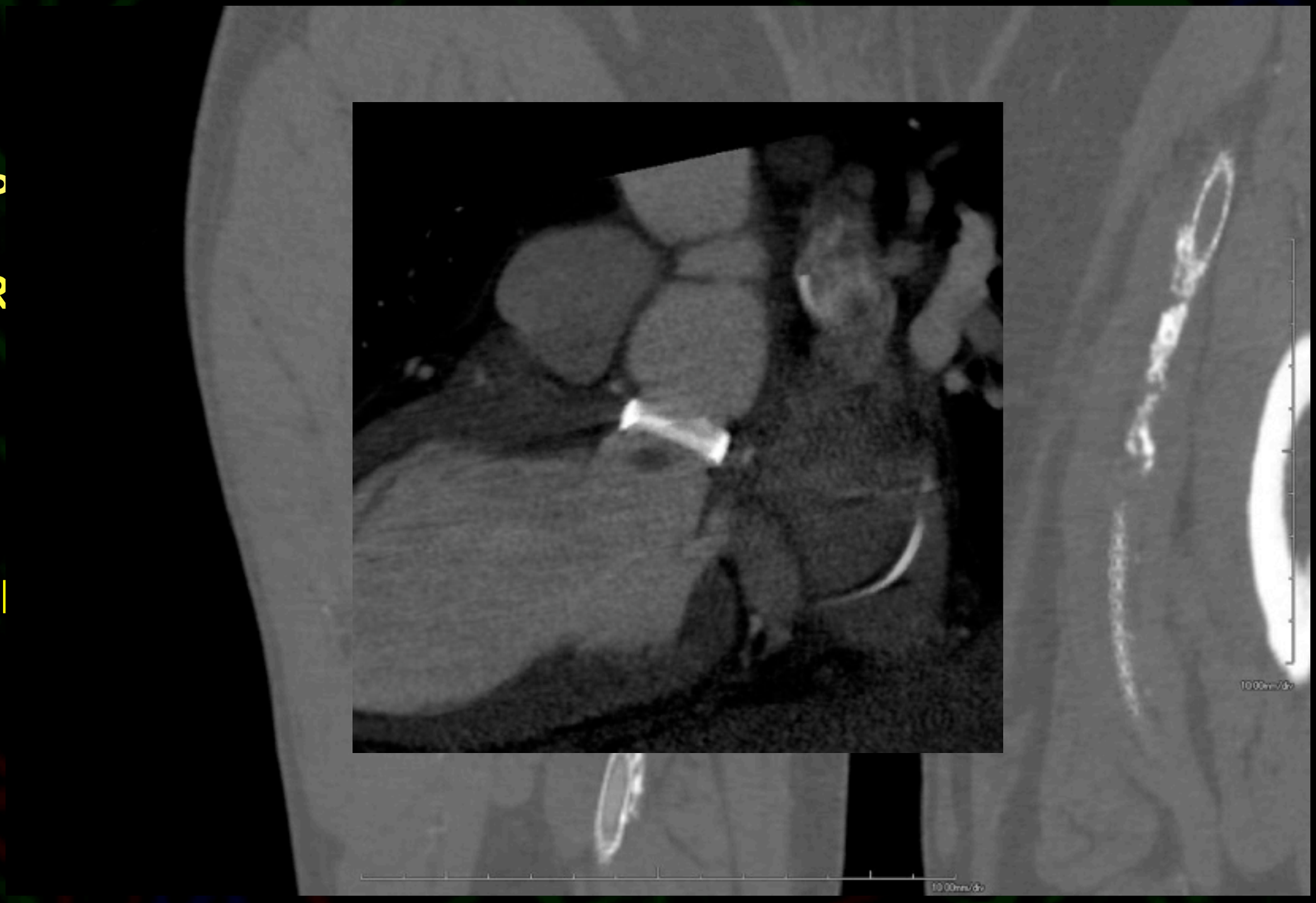


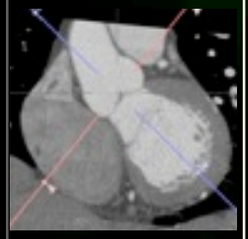
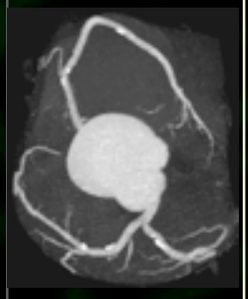
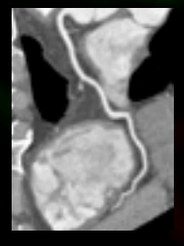
Recent Advance: Computer Processing Power

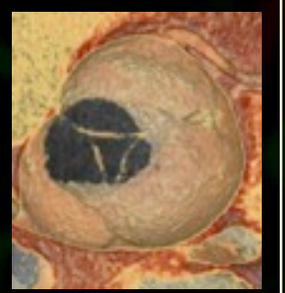
- Newer 3D Platforms require greater CPU and GPU power to render data rapidly and effectively.
- A typical CTA dataset may have 1000 - 2000 images, “4-D” datasets up to 4000+
- Computing power has had to catch up to image acquisition

Reconstruction "Alphabet Soup"

- MPR
- MIP
- MINIP
- AIP (R
- CPR
- VR
- BPI-V
- 4-D



	Major Uses	Advantages	Disadvantages
MPR 	Stenosis, vessel wall analysis Lung nodule measurement Orthogonal Measurements	Accurate for stenosis, nodule, orthogonal measurements Calcification, stent evaluation **"Thick MPR": salvage noisy datasets**	**Limited spatial relationships** **Limited display if curving vessel**
MIP **(MINIP)** 	Angiographic overview, contextual with adjacent structures Lung nodule detection (coronal STS) Valves, Airways (MINIP)	Depicts course of small and/ or poorly enhancing vessels Object - background contrast	**Vessel, bone, visceral overlap** **Limited stent, calcium evaluation** **Stenosis Overestimation** **NOISE IS ADDITIVE!!**
CPR 	Flow lumen, vessel wall analysis Curved Objects	Best for mural stenosis, occlusions, calcifications, stents Slice through display (perpendicular to CPR)	**Distortion of extra-vascular structures** **Dependent on accurate centerline (Needs Oversight)**

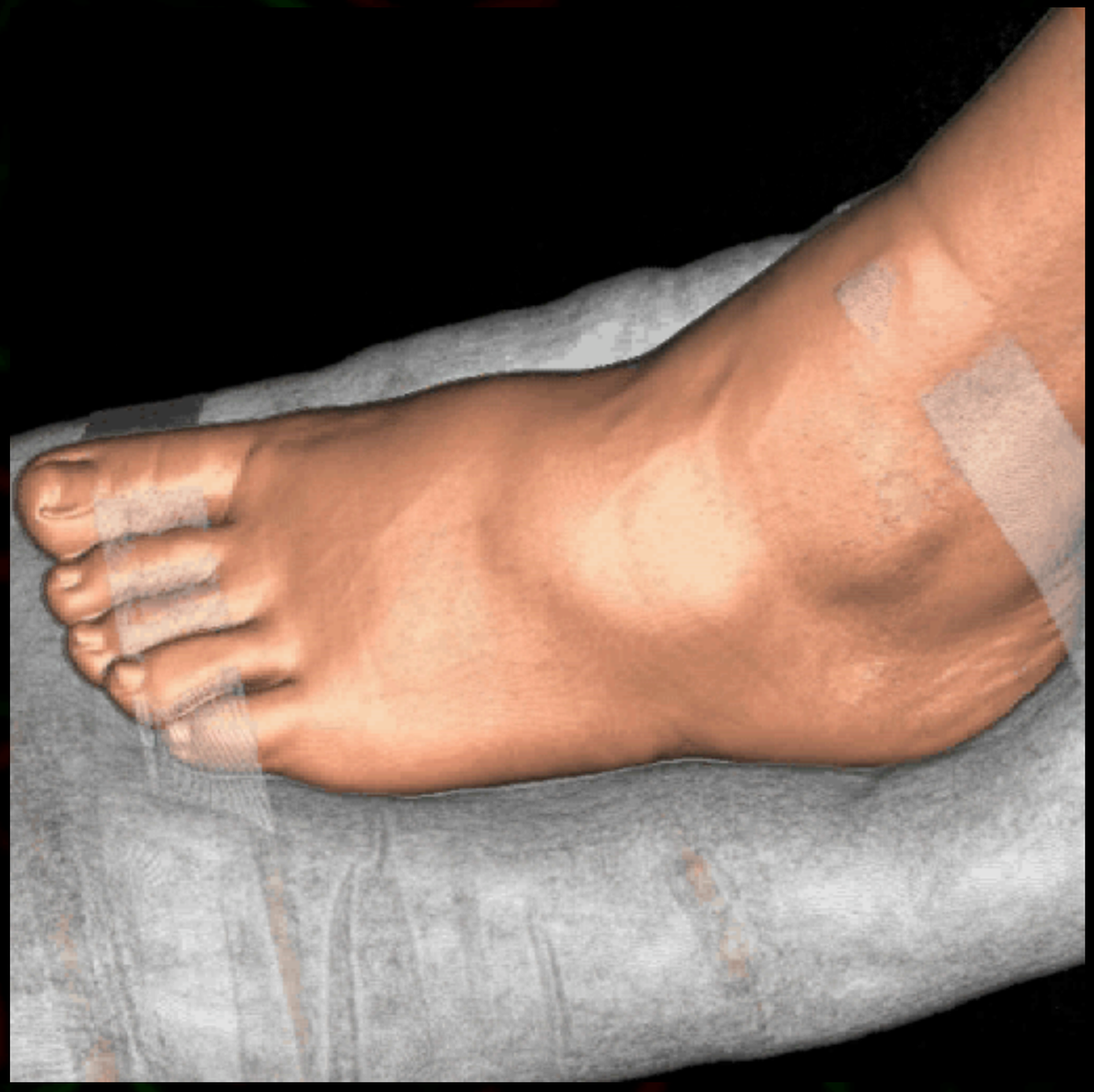
	Major Uses	Advantages	Disadvantages
VR 	Angiographic overview, contextual with adjacent structures Pre-procedural planning	• Best for complex relationship display •Valves •Vessel Origins •EVAR, DSX, etc **WOW** factor	**Opacity transfer function and operator dependent** **No accurate measurements**
BPI- VR 	Valves, vessel orifices, DSX flaps		

Volume Rendering (VR)

- Originally developed for motion picture animation
- Usually a COLOR technique
- Assigns color spectrum and opacity value (0-100 %) to voxels along artificial line of sight

- Can change lighting and perspective
- "Opacity Ramp": curve that describes relative opacities and colors
- Changing the ramp ->

  changes displayed tissues →
- Computer processing requirements much greater



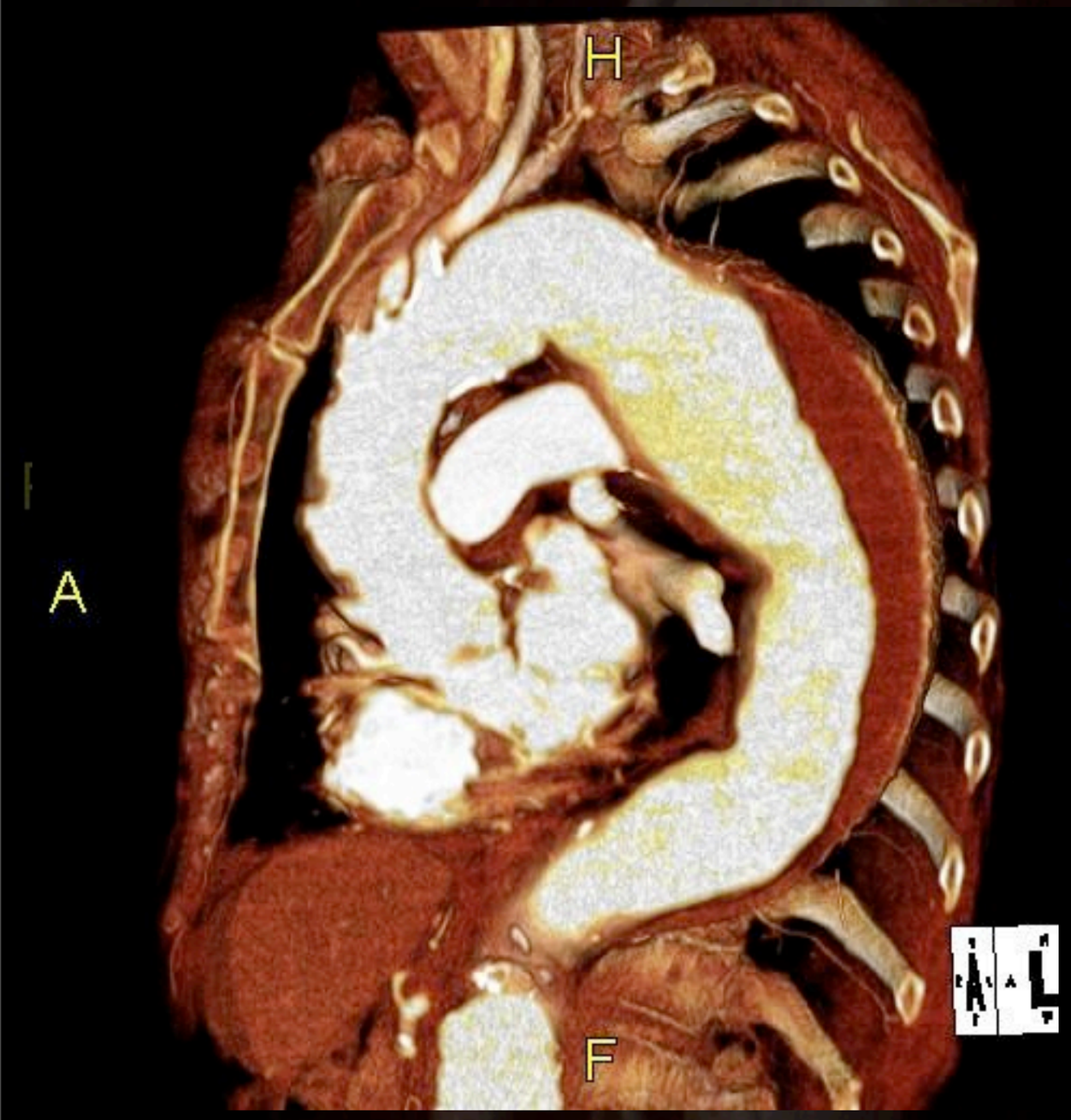
3D imaging for CV Disease: Clinical utility

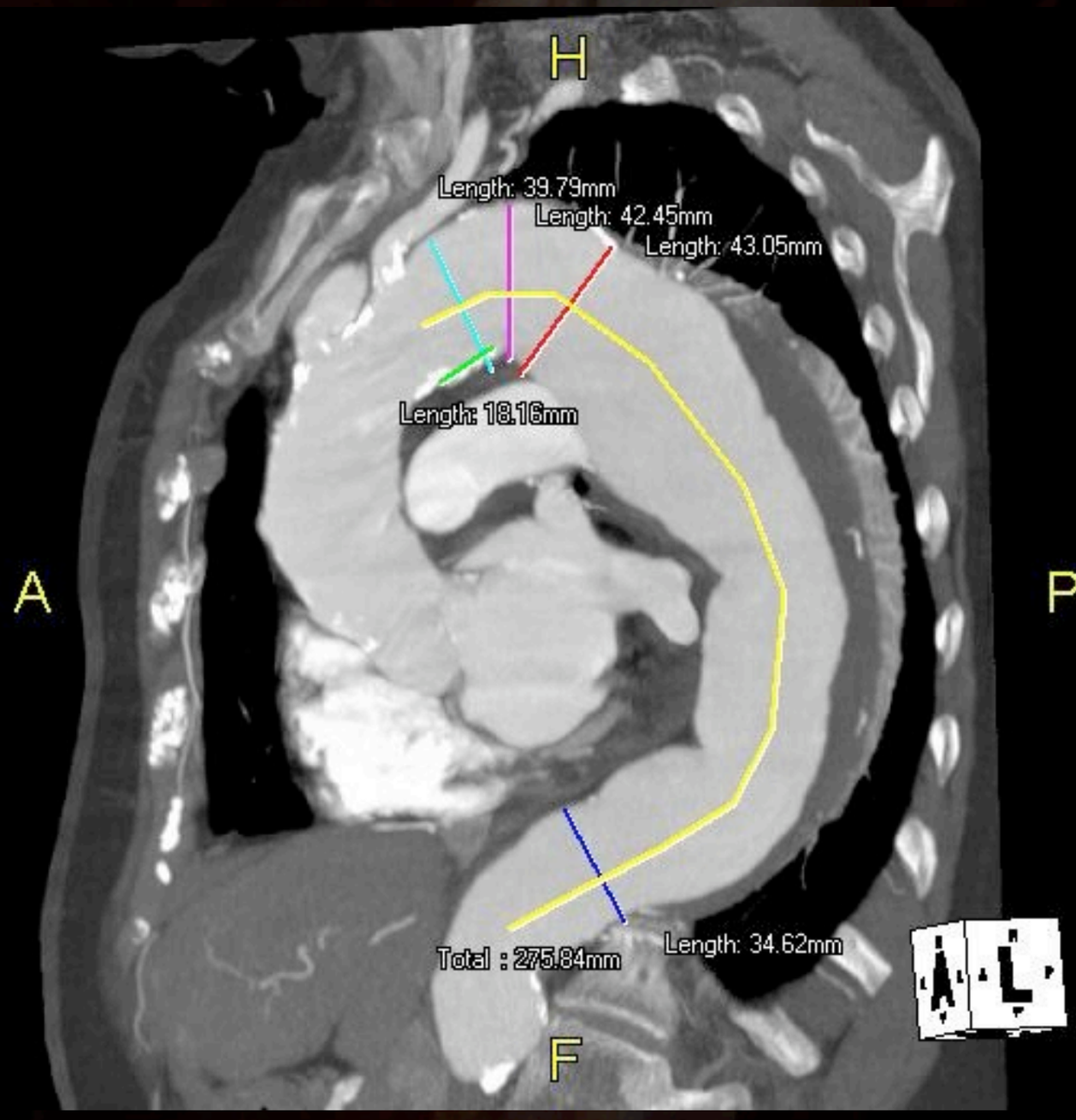
- ✦Thoracic
- ✦Abdominal
- ✦Peripheral
- ✦Cardiac / Coronary

THORACIC

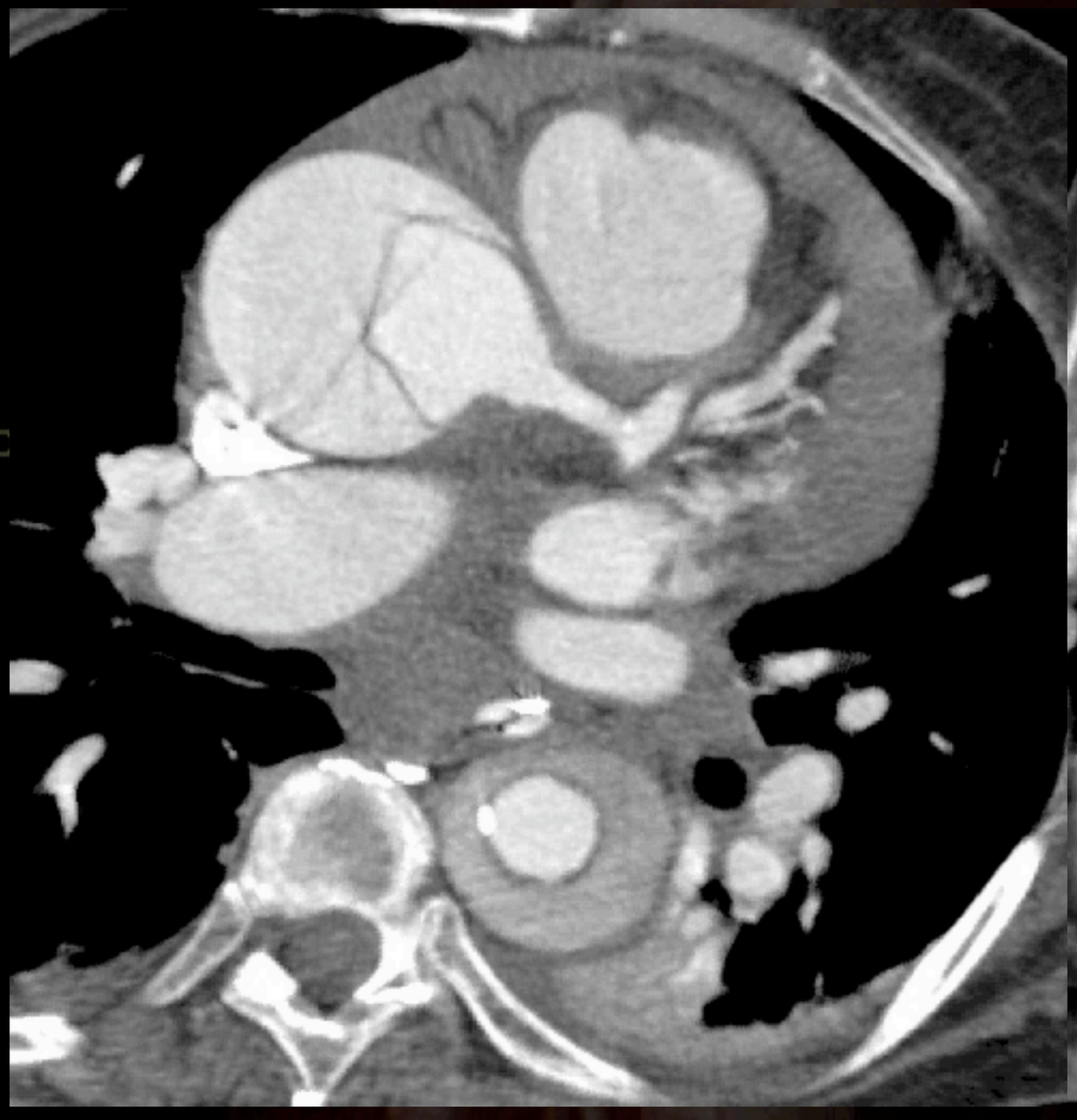
- ✦Thoracic Aortic Aneurysms
- ✦Aortic Dissection
- ✦Aortic valve and root
  - ✦pre-op, post-op, pre-TAVI

Thoracic Aneurysm

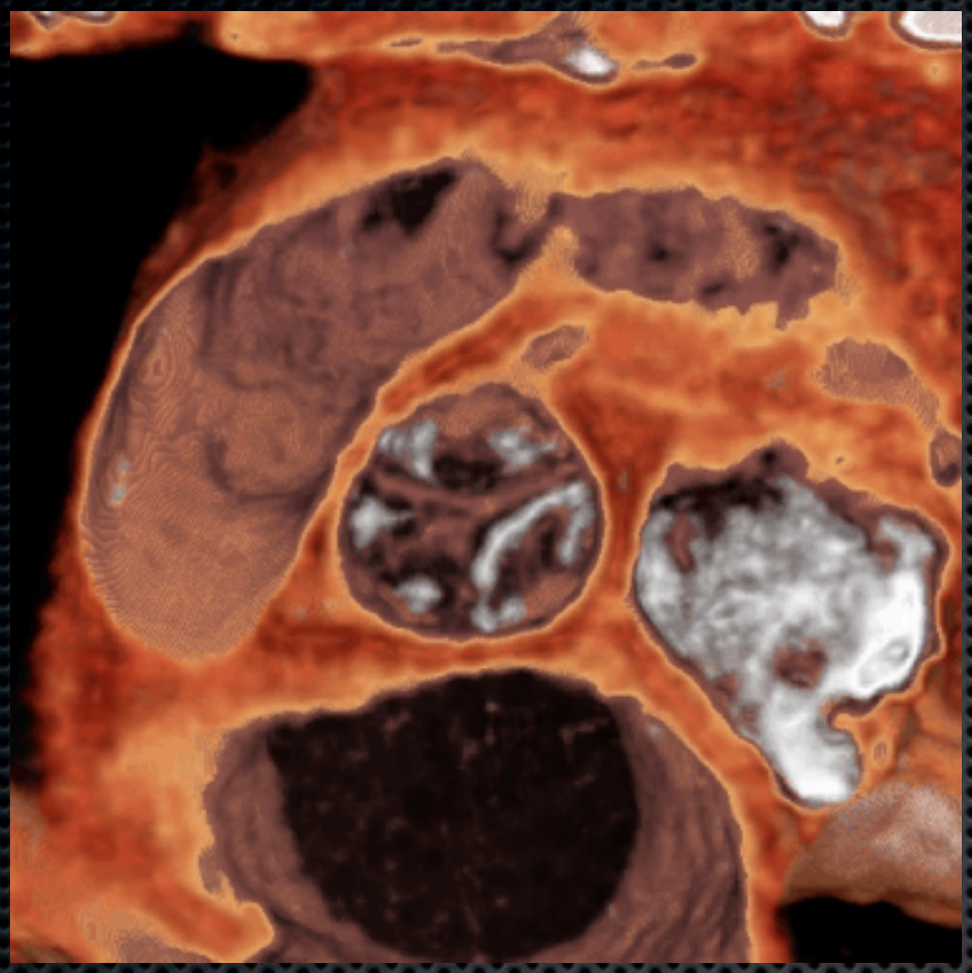




Aortic Dissection - Utility of 4D Imaging

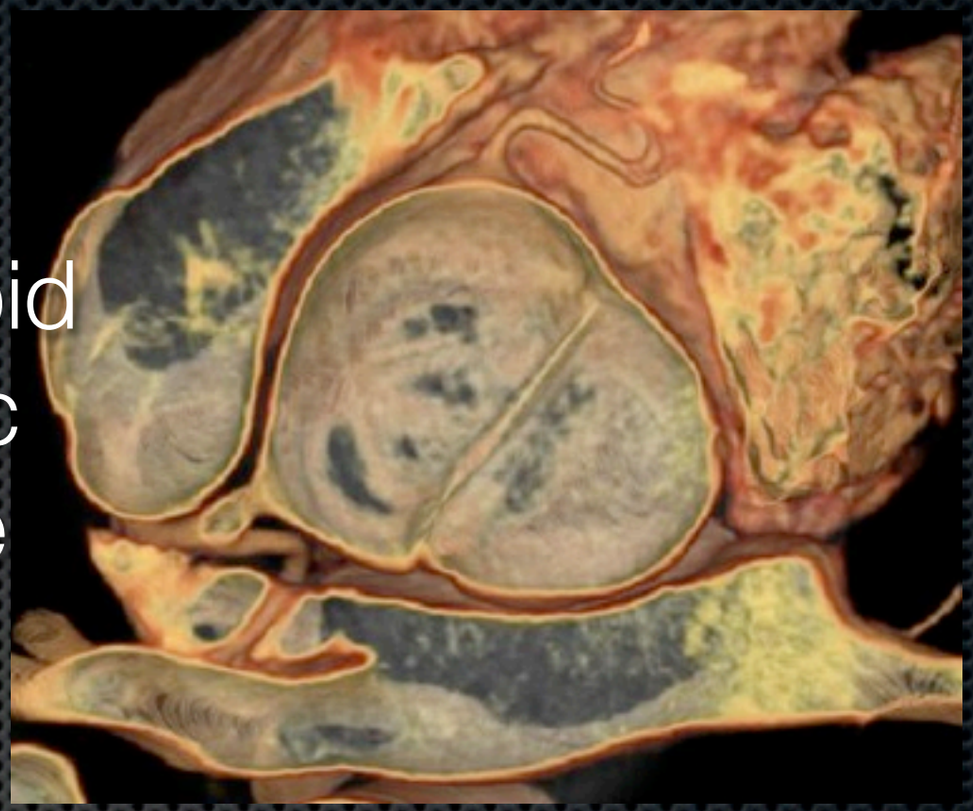


Aortic Valve / Root

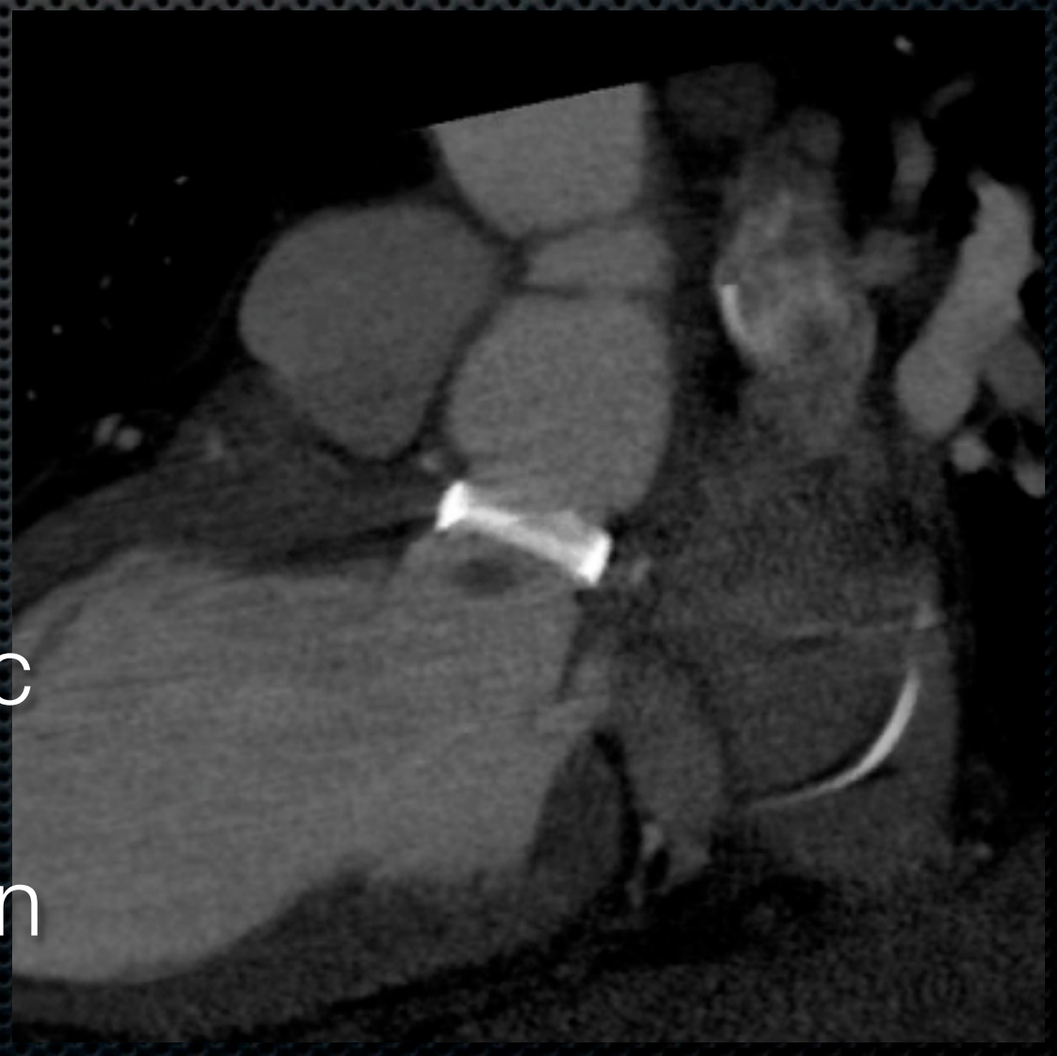


Calcific Aortic Stenosis

Bicuspid
Aortic
Valve

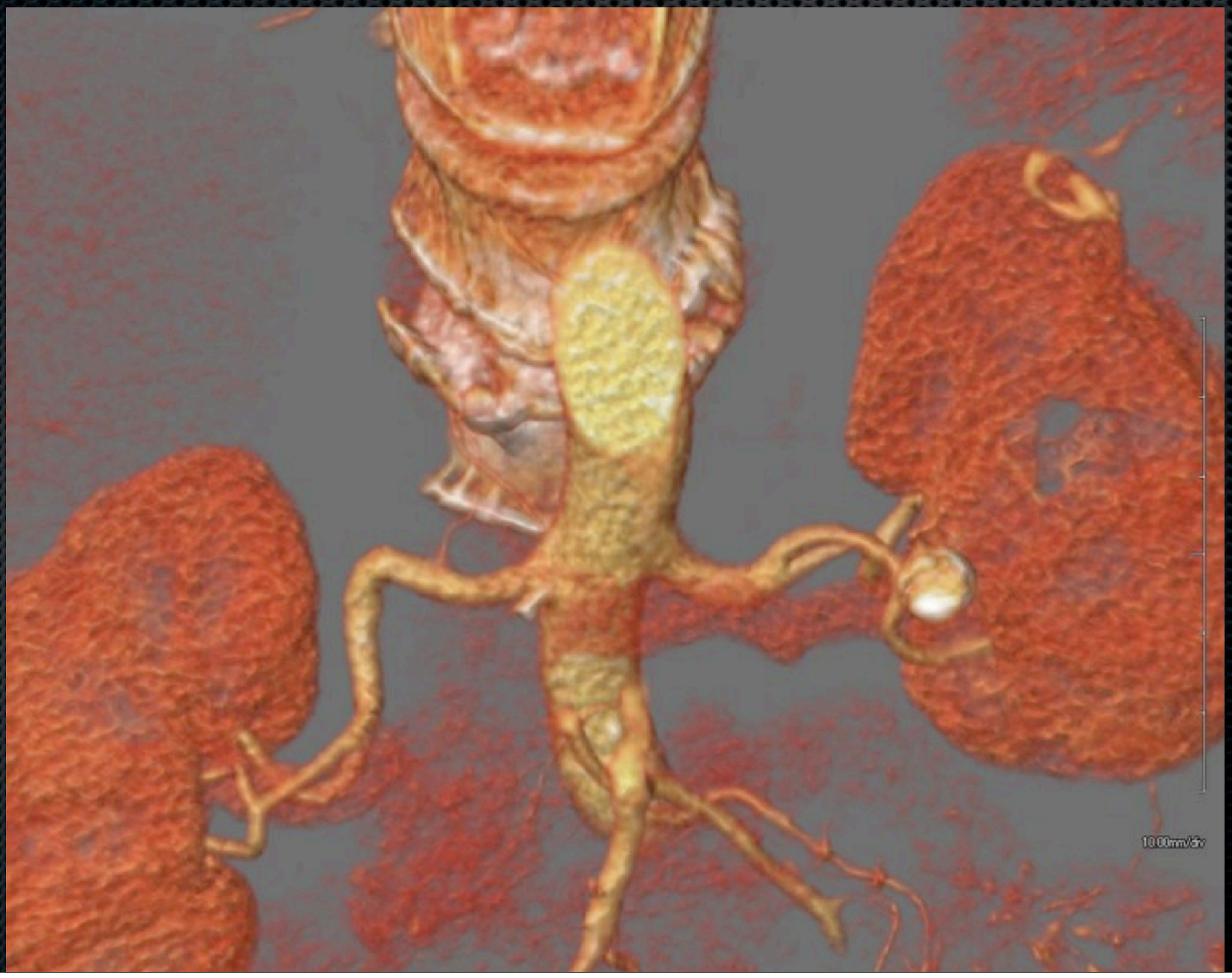


Prosthetic
Valve
Vegetation



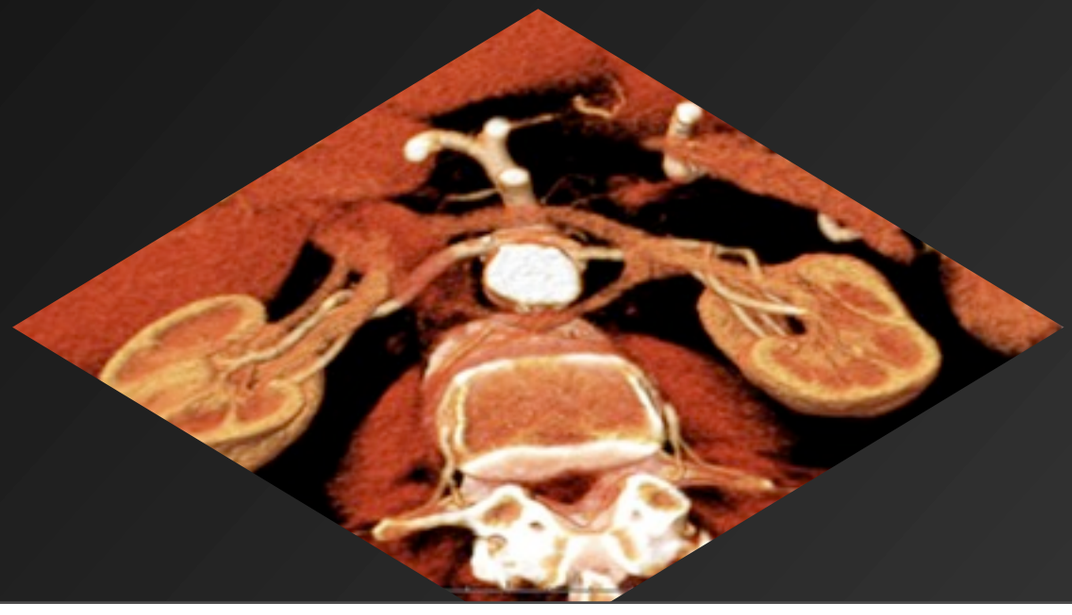
Abdominal

Renal CTA



Renal CTA

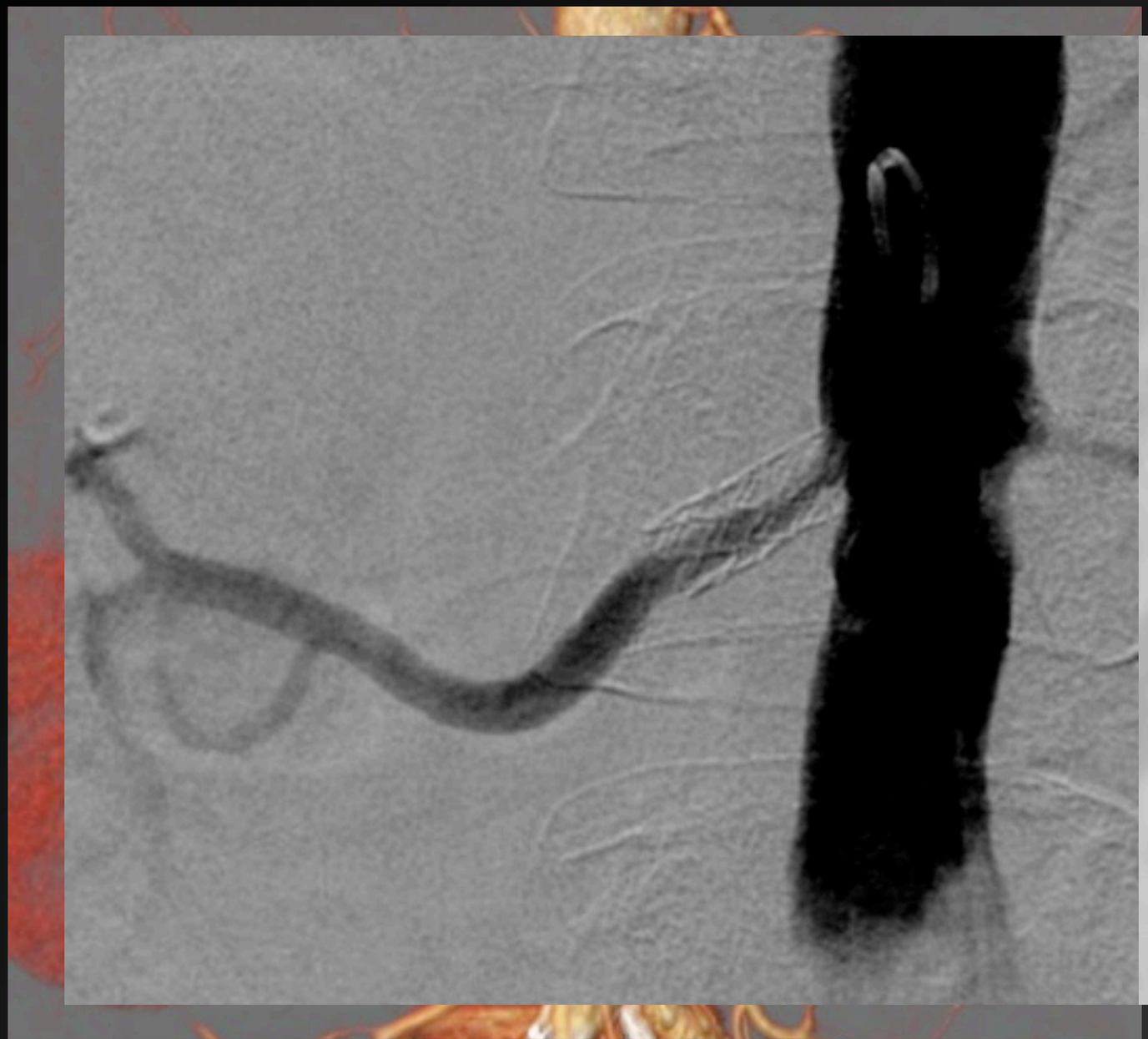
- INDICATIONS
  - Renal Artery Stenosis
  - Post-Stenting worsening HTN
  - Renal aneurysms
  - Renal AVM / AVF
  - Evaluation of UPJ Obstruction
  - Transplant Donor evaluation
  - Renal vein evaluation



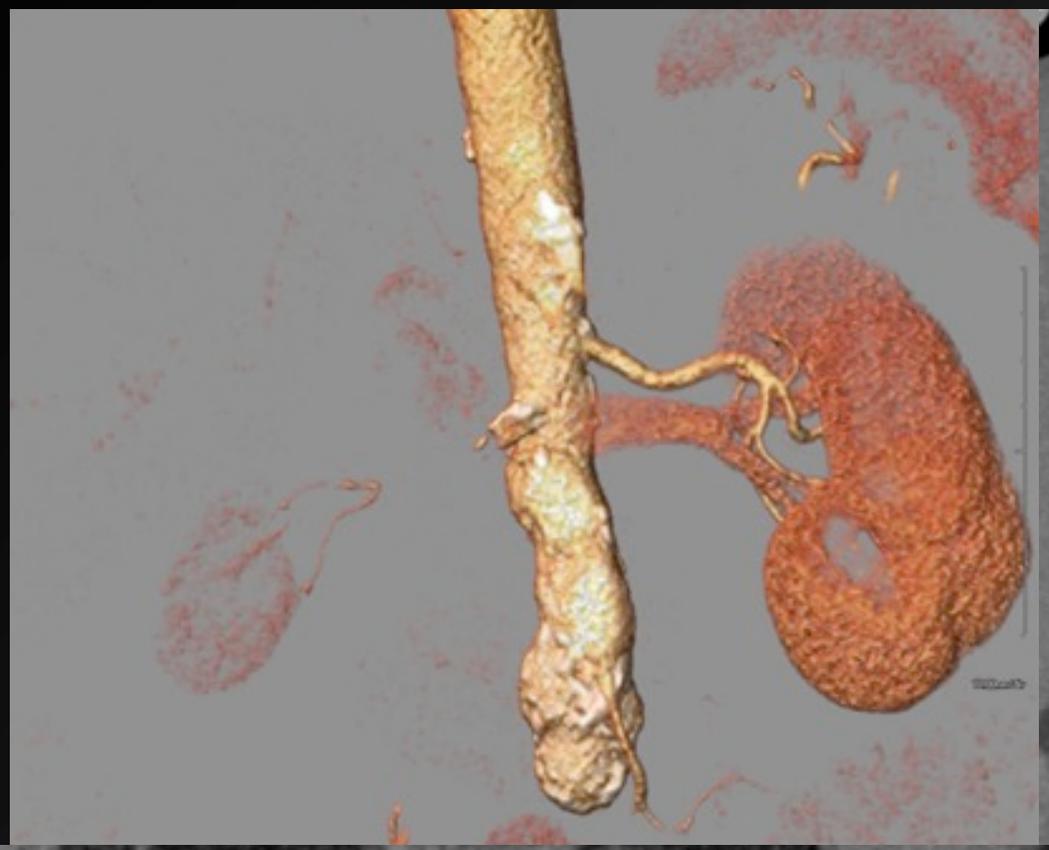
Atherosclerotic RAS

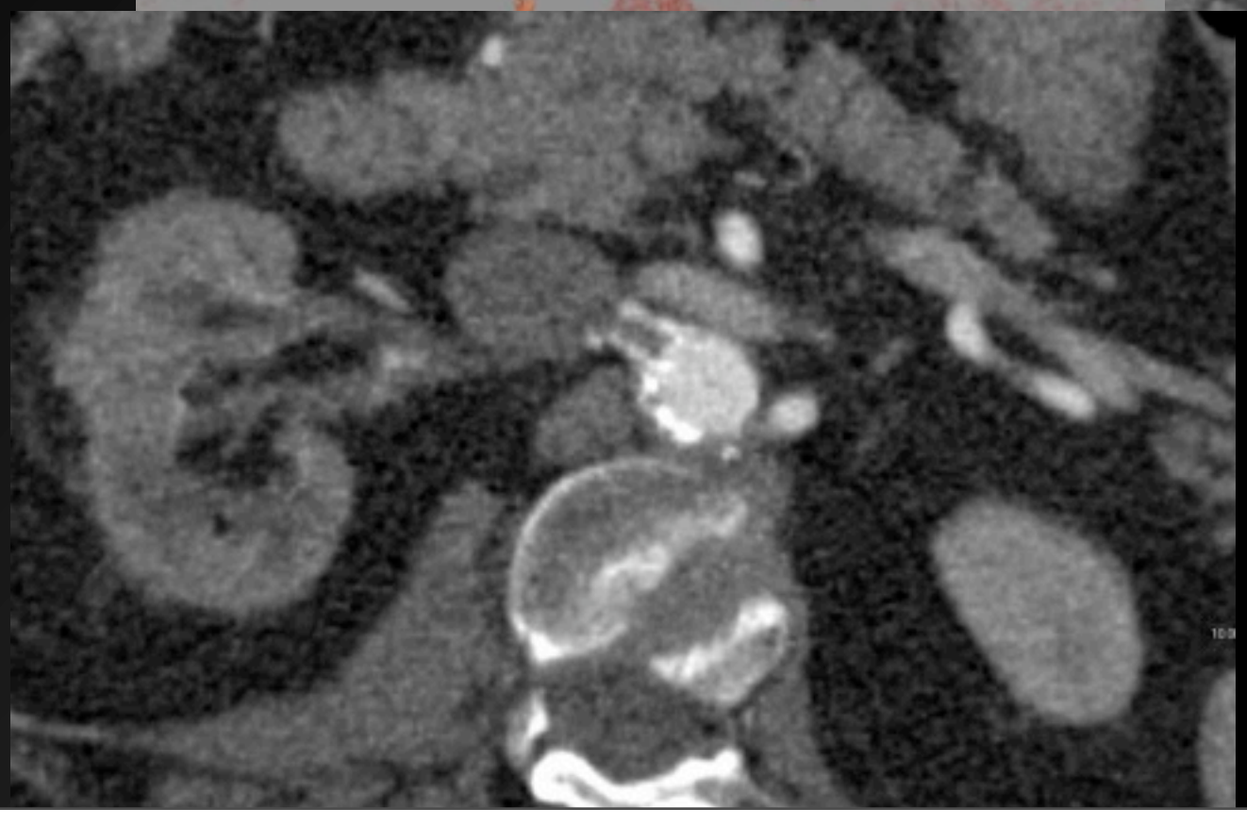
Renal FMD (Fibromuscular Dysplasia)

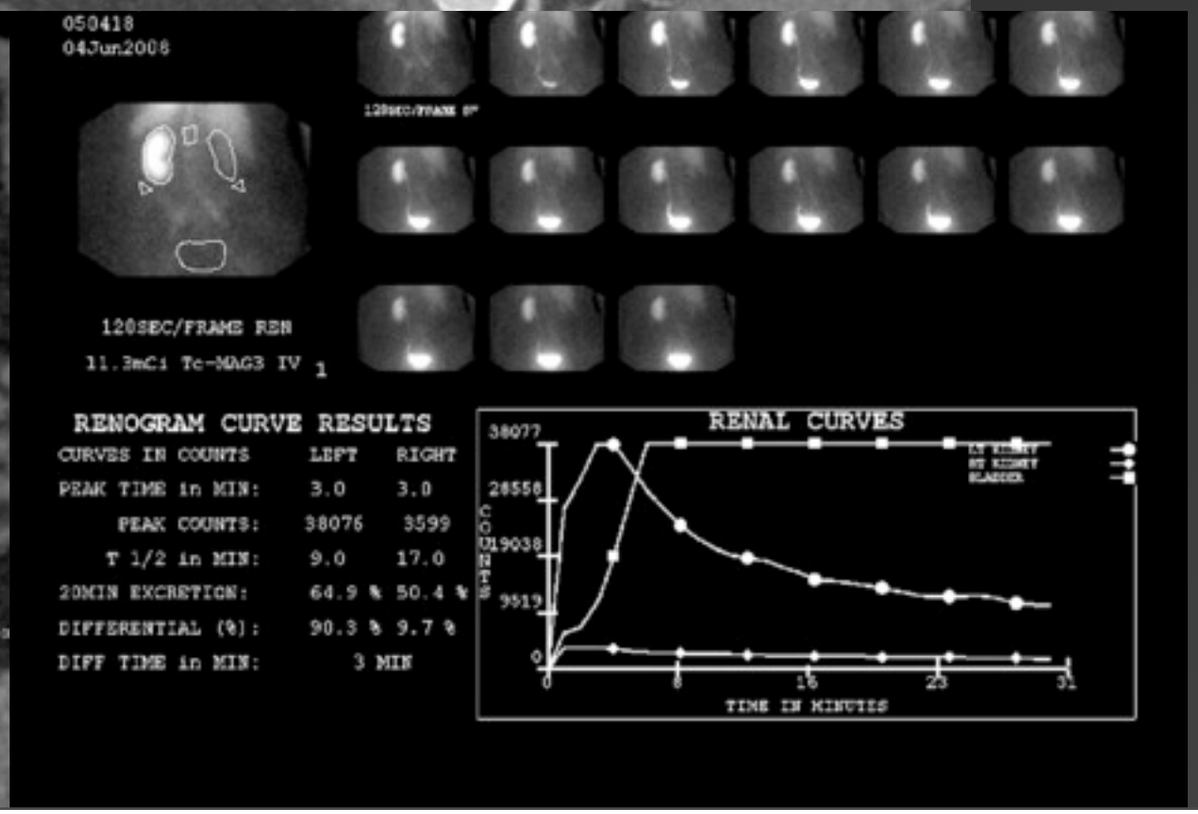
Stented RAS



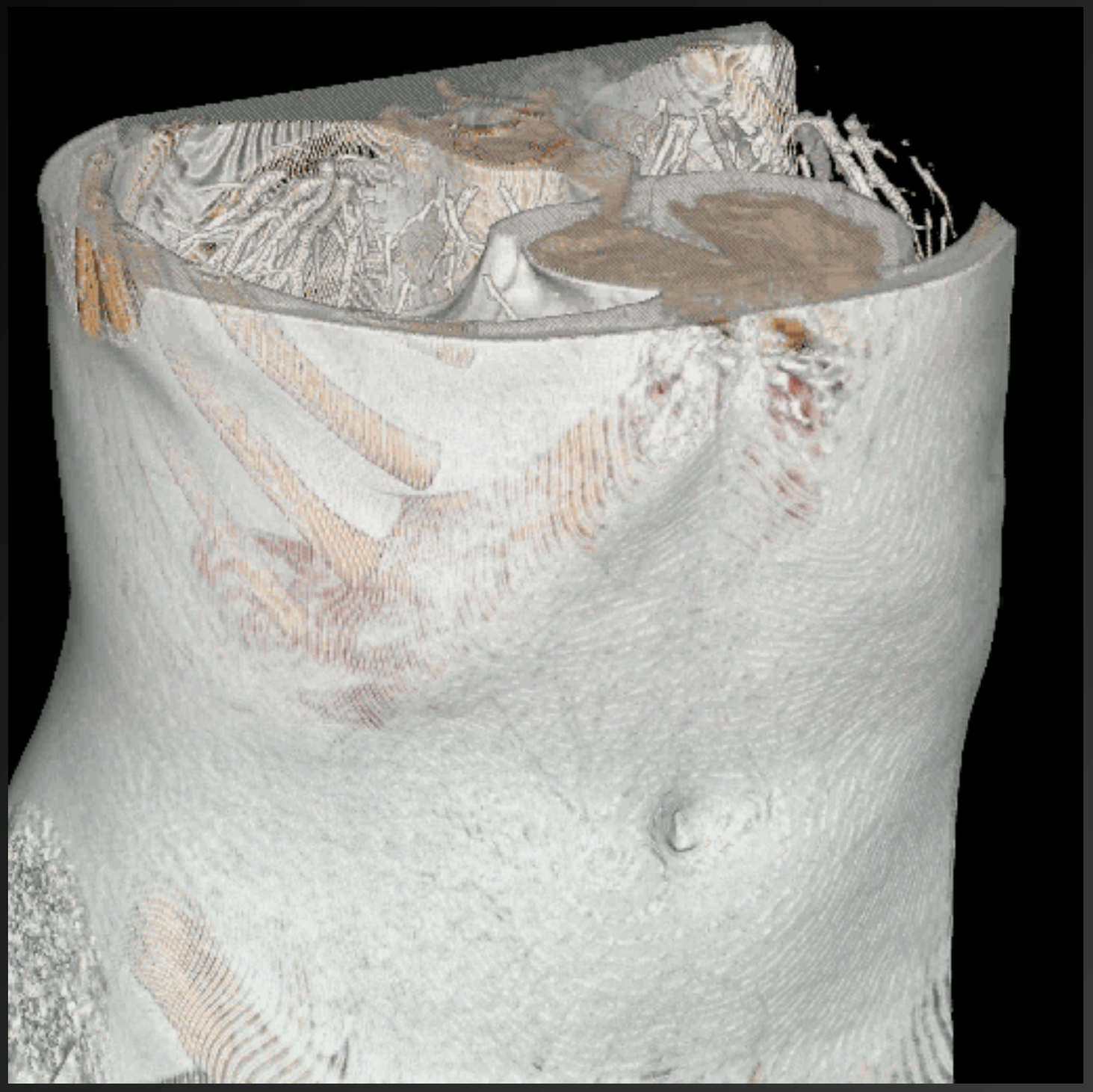
Renal Stent Occlusion







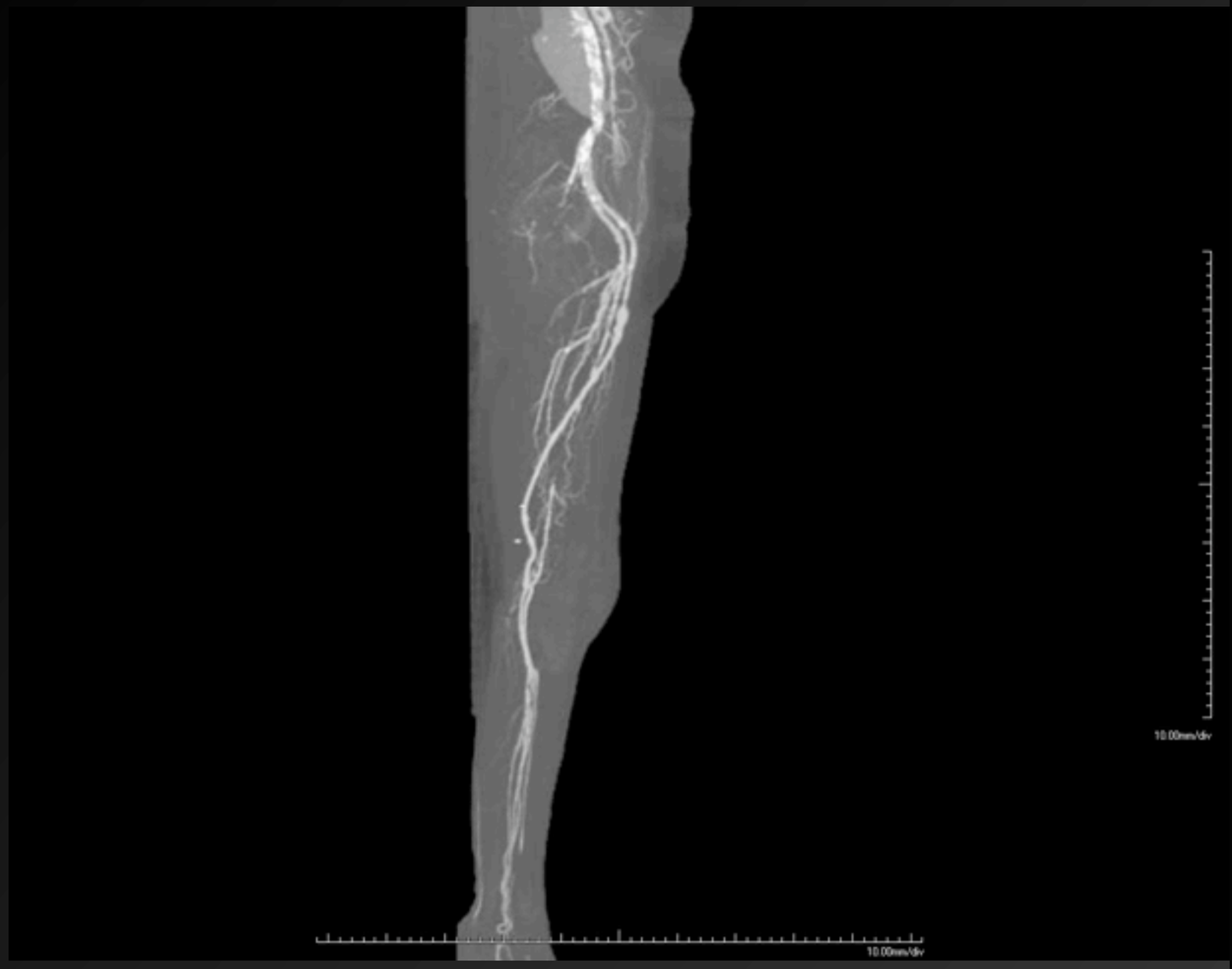
20 year old male with Kaulman syndrome, hypertension

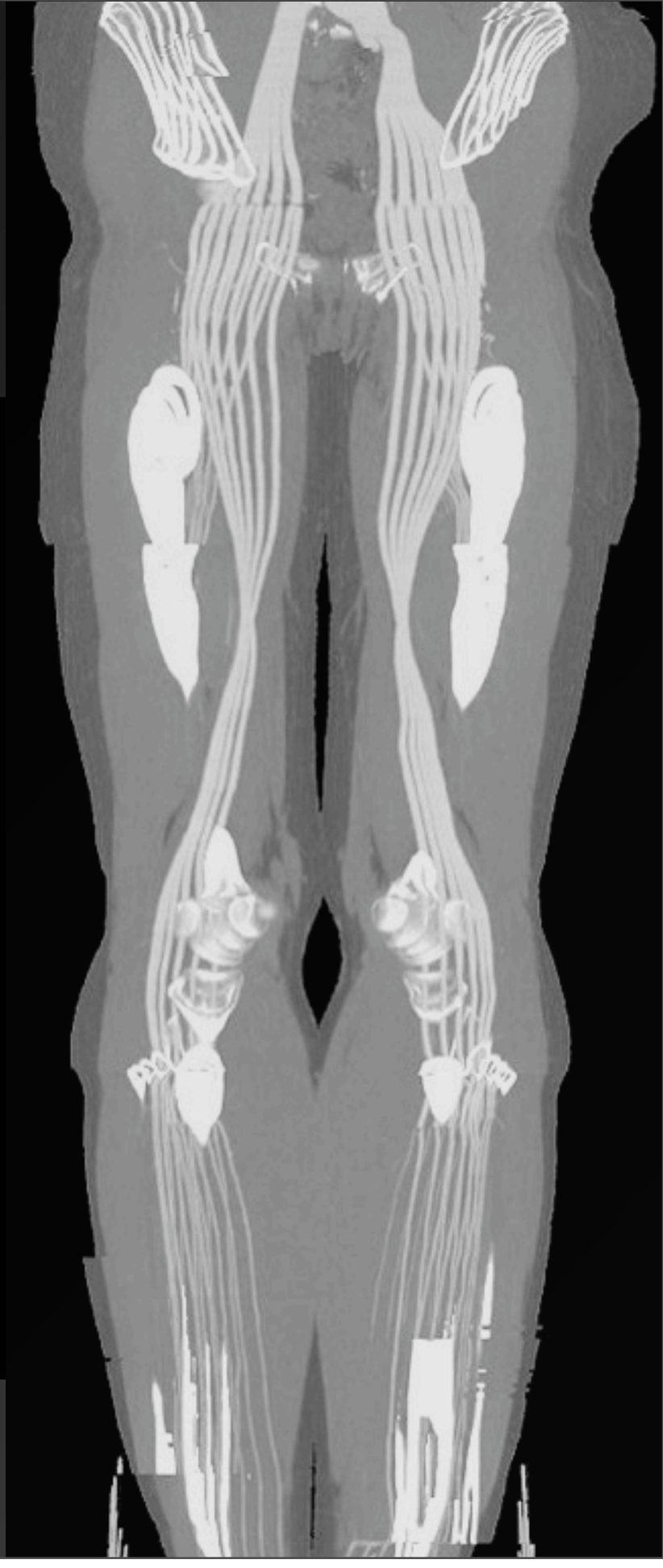


25mm slab VR

DSA

Extremity CTA





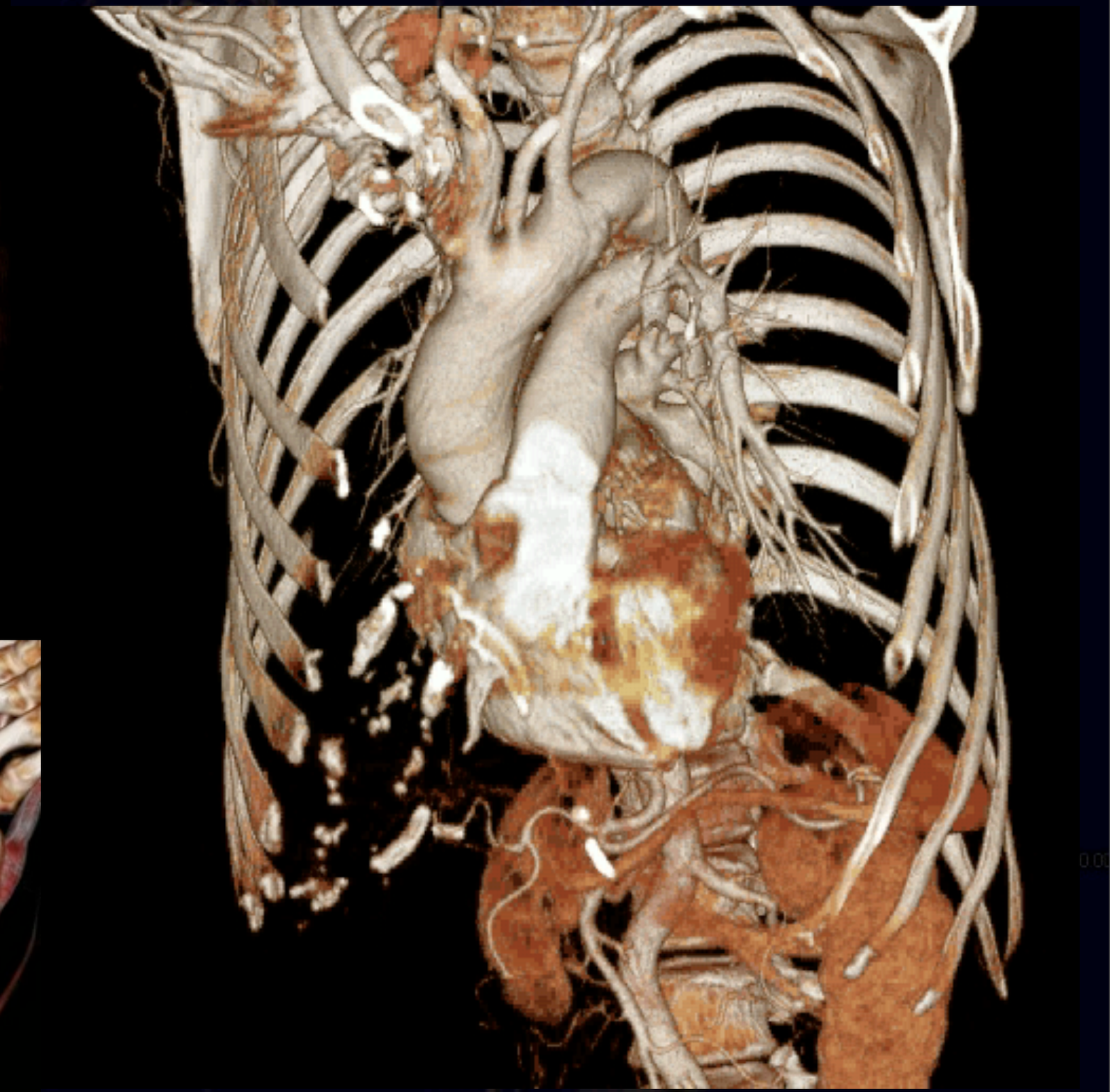
LE Vascular Disease

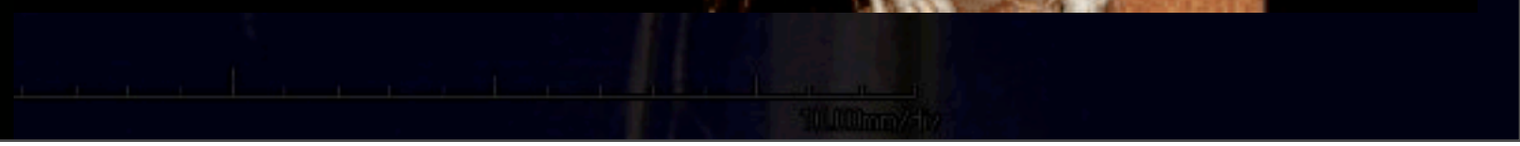
- 27 million pts in US / Europe with PAD
  - 16% of all people >55yo
  - Lower > Upper extremity
- Goals of CTA:
  - Evaluate presence and extent of disease
  - Therapy planning
  - Lesion number, diameter, length
  - Distal targets

Indications for CTA Runoff

- Atherosclerotic Disease
  - Intermittent claudication
  - Rest pain
- Thromboembolic Disease
- Vasculitis
- Trauma
- Entrapment syndromes
- Surgical planning (free-flap)

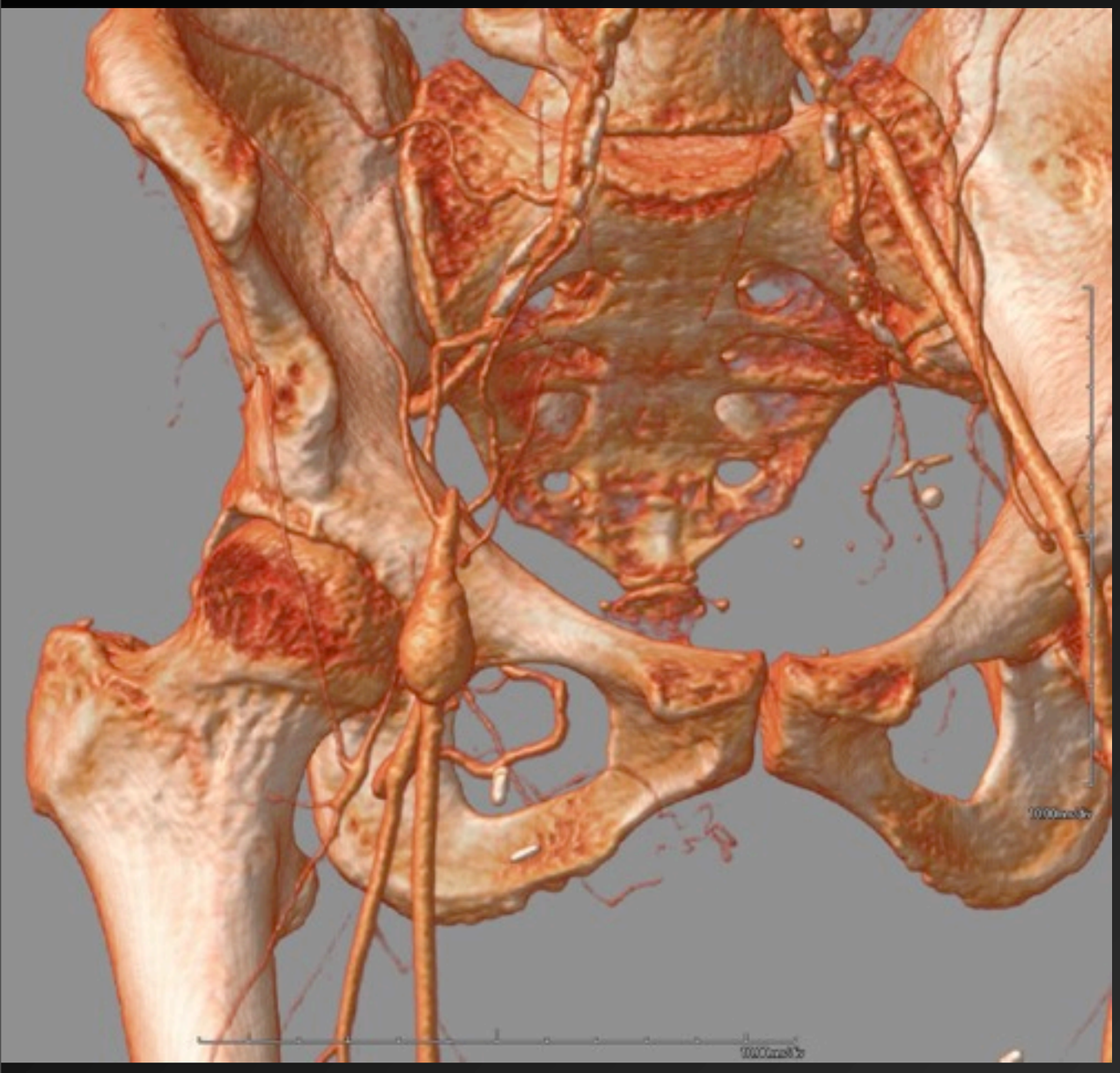
“Rule out embolic disease”
68 YO Female

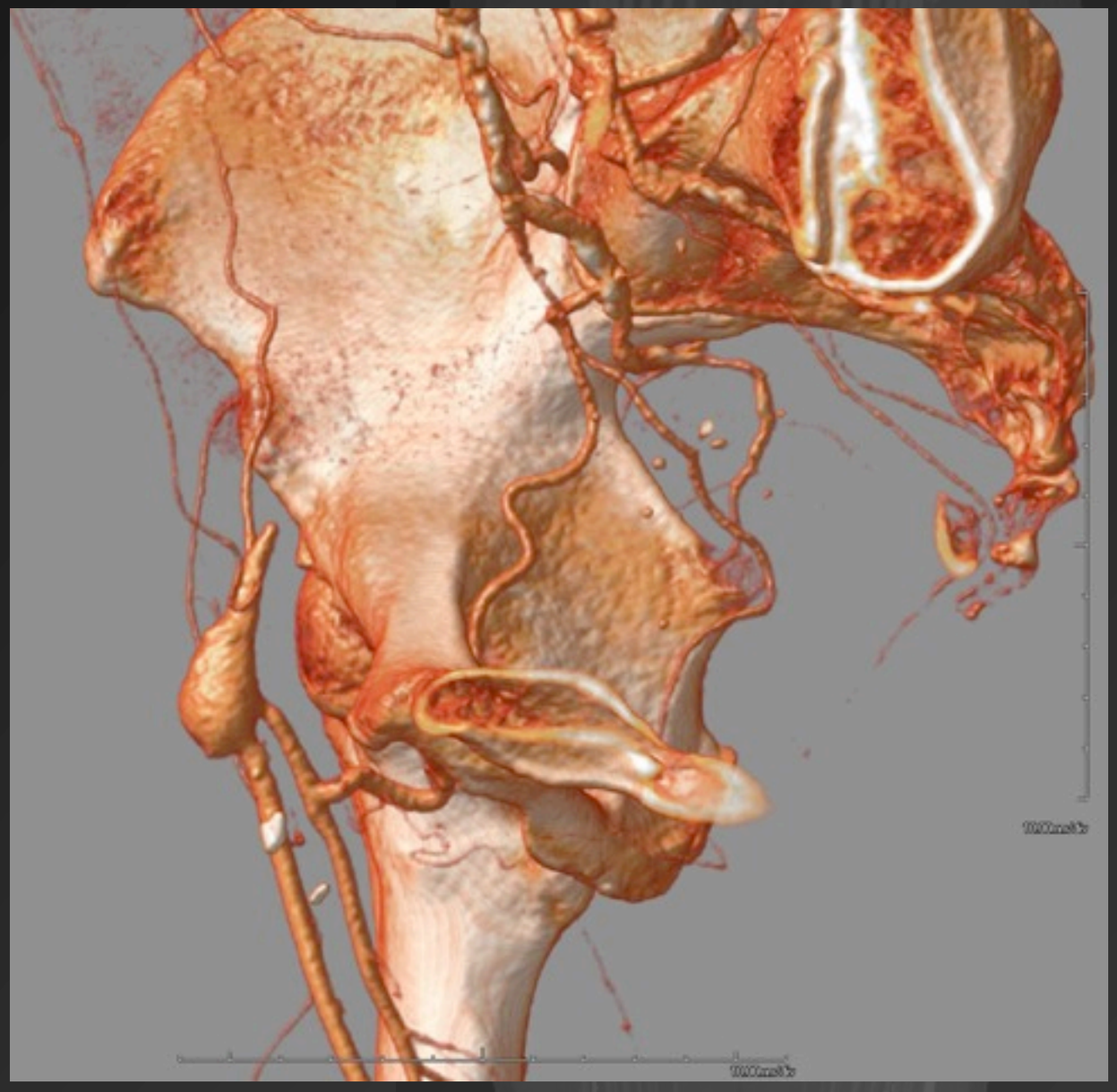




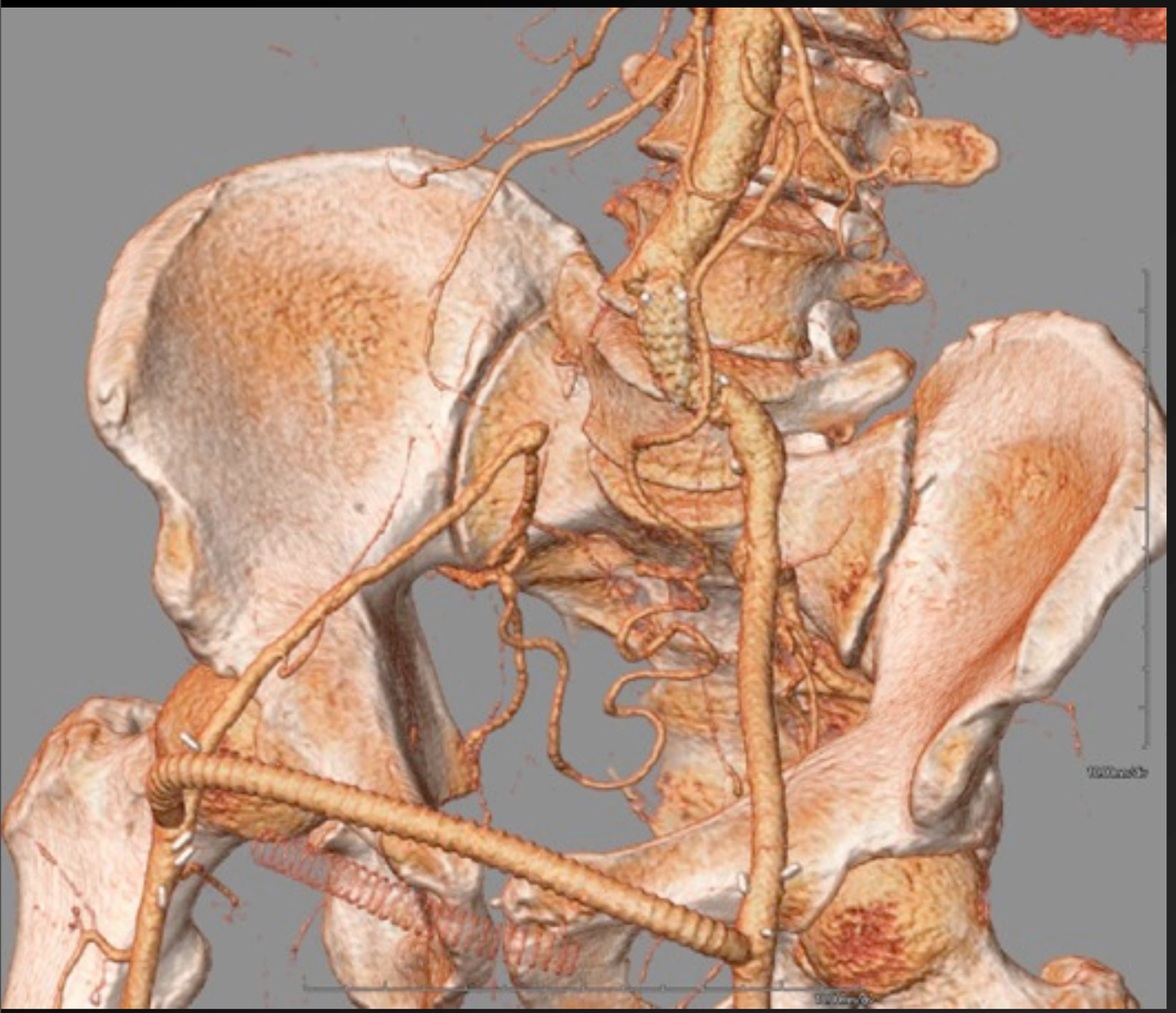
Tuesday, May 17, 2011

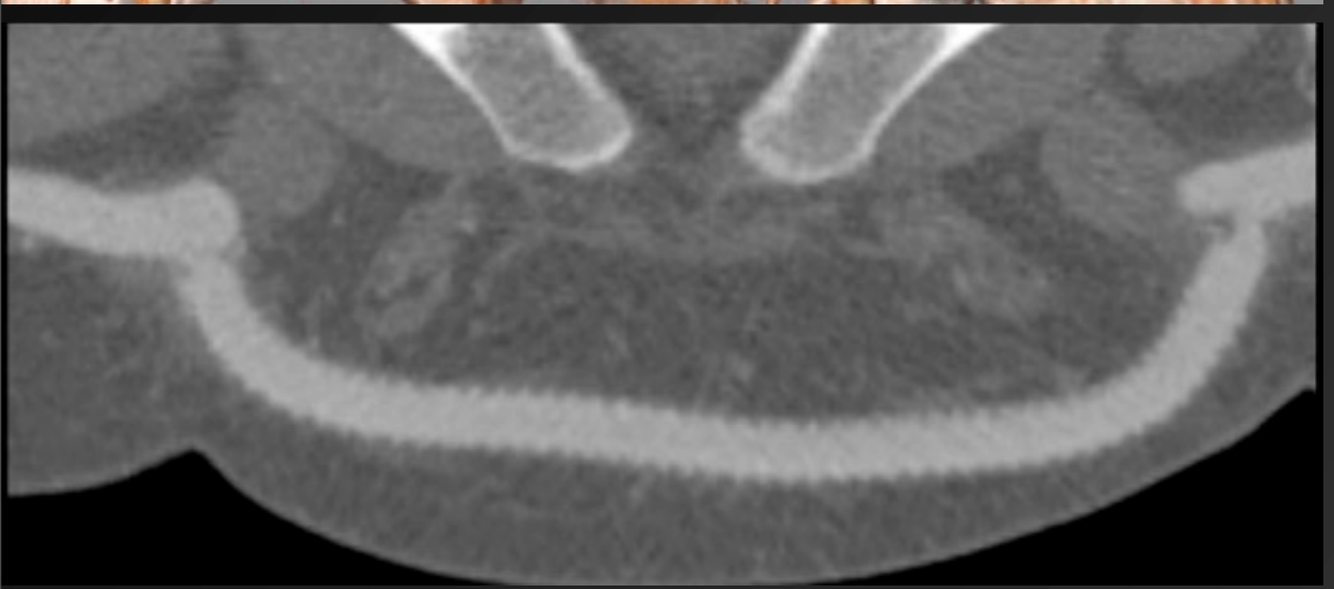
R leg Claudication



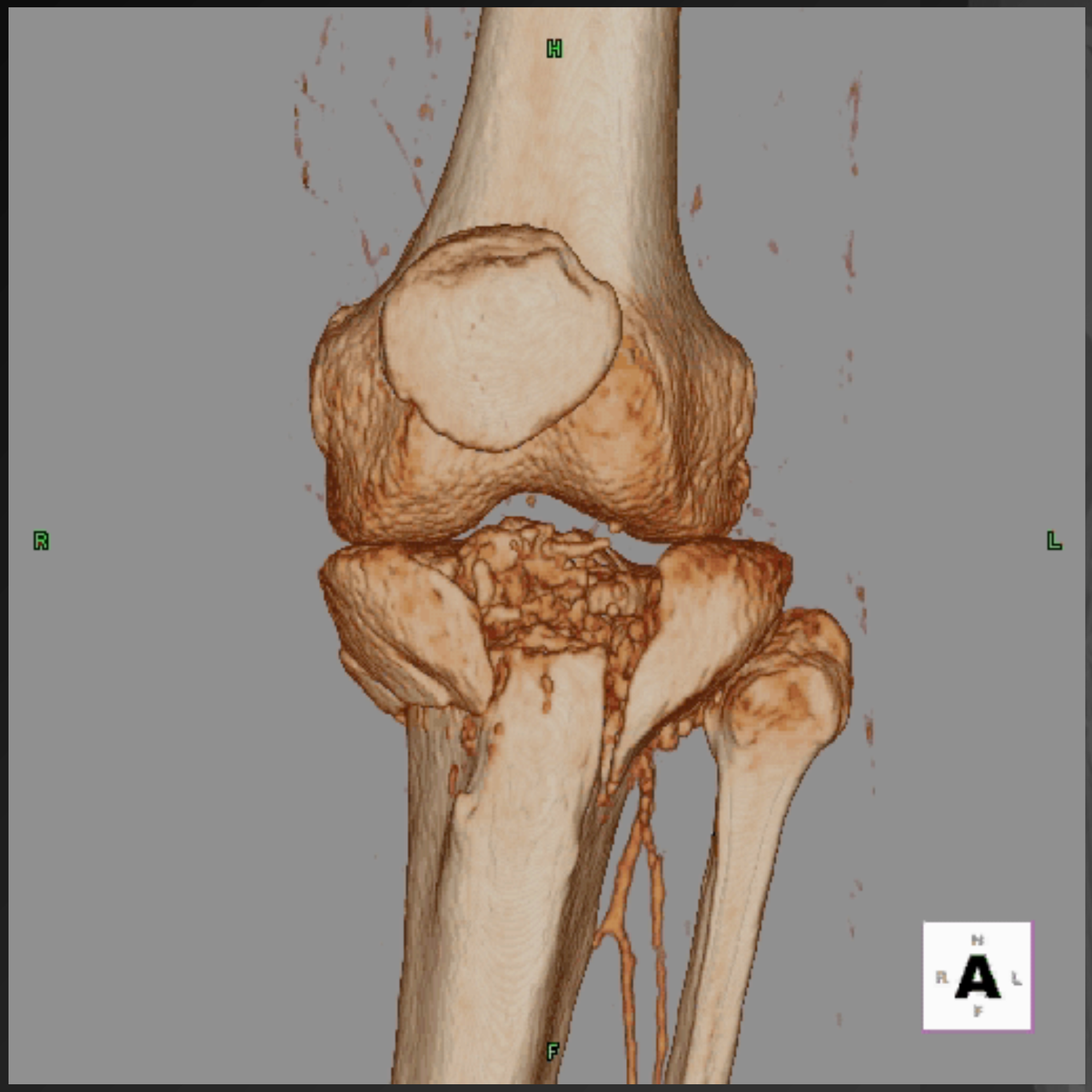


F/U Bypass





“Trauma”



Coronary / Cardiac Imaging

Coronary Artery Disease

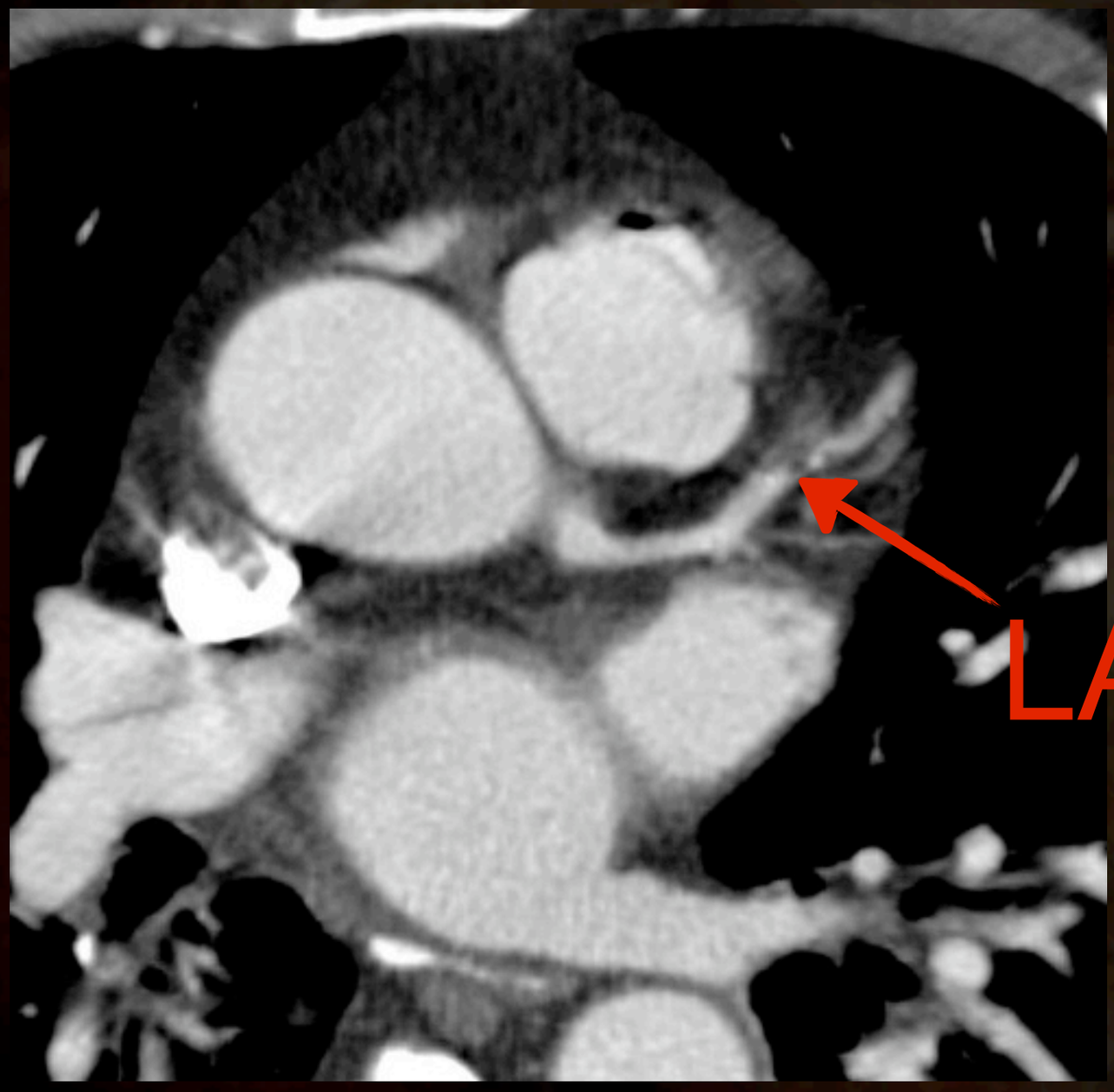
- Coronary Artery Disease
- Coronary Anomalies
- Cardiac Lesions

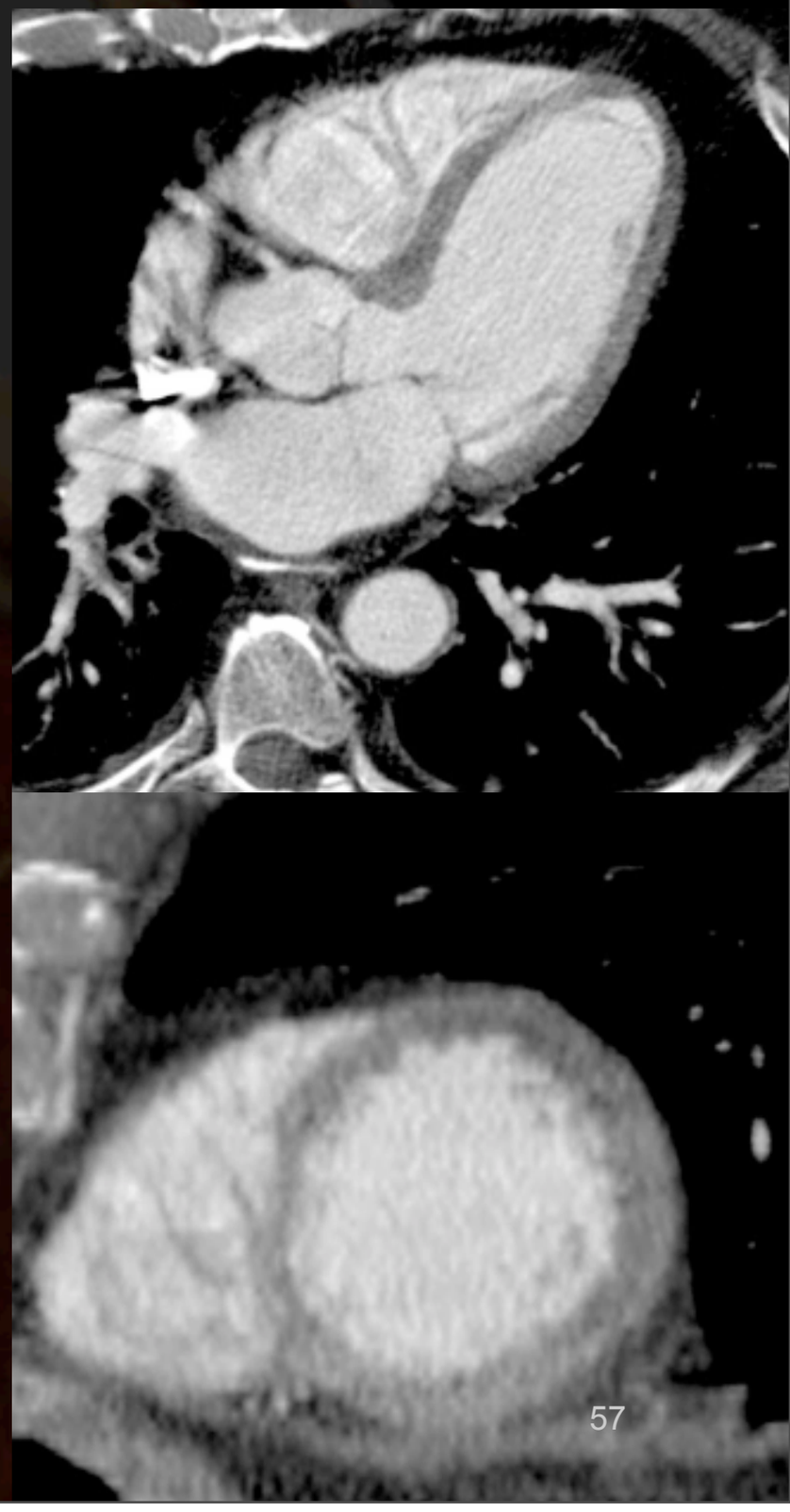
APPROPRIATE INDICATIONS: CORONARY AND CARDIAC CT

CLINICAL SCENARIO	FOR THESE INDICATIONS:	ORDER
NON-ACUTE SX (WITHOUT KNOWN HEART DZ)	•Low or Intermediate Pretest Probability *+/- ECG uninterpretable +/- can exercise*	**CCTA**
ACUTE or URGENT SX (WITHOUT KNOWN HEART DZ)	•Low or Intermediate Pre-test Probability *Negative, Non-diagnostic or Equivocal Biomarkers and/or ECG*	**CCTA**
New Onset CHF (WITHOUT KNOWN HEART DZ)	•LOW or INTERMEDIATE Pretest Probability	**CCTA**
SYMPTOMATIC PT	•Evaluate suspected coronary Anomalies	**CCTA**
PRE-OP NON-CORONARY CARDIAC SURGERY (WITHOUT KNOWN HEART DZ)	Intermediate Pretest Probability	**CCTA**
PRIOR STRESS TESTS	•CONTINUING OR WORSENING SYMPTOMS •DISCORDANT STRESS ECG / IMAGING •EQUIVOCAL STRESS IMAGING	**CCTA**
•CARDIAC MASS / THROMBUS **•VALVULAR DISEASES** **•PERICARDIAL EVALUATION**	•If limited info from Echo, TEE, or MRI (problem solving) •For Morphology and/or Function Calculation	**Cardiac CT** (no B-blocker or NTG)
CORONARY ARTERY BYPASS GRAFT MAPPING	Prior to Re-Do CABG (to assess positions and patency of bypass grafts- esp. LIMA)	**CTA CHEST- BYPASS GRAFT**
CORONARY CALCIUM SCORE	•Low-Intermediate Pretest Probability •Intermediate Pretest Probability •Diabetics >40 yr old	**Coronary Calcium Scoring CT**
CONTRAINDICATIONS to CORONARY CTA: (MOST ARE RELATIVE)	•Weight >300 lbs •Calcium Score >500 •Iodine (Contrast) allergy (and not pre-medicated) •Contraindication to B-blocker, NTG •Severe Asthma or COPD •AFIB	

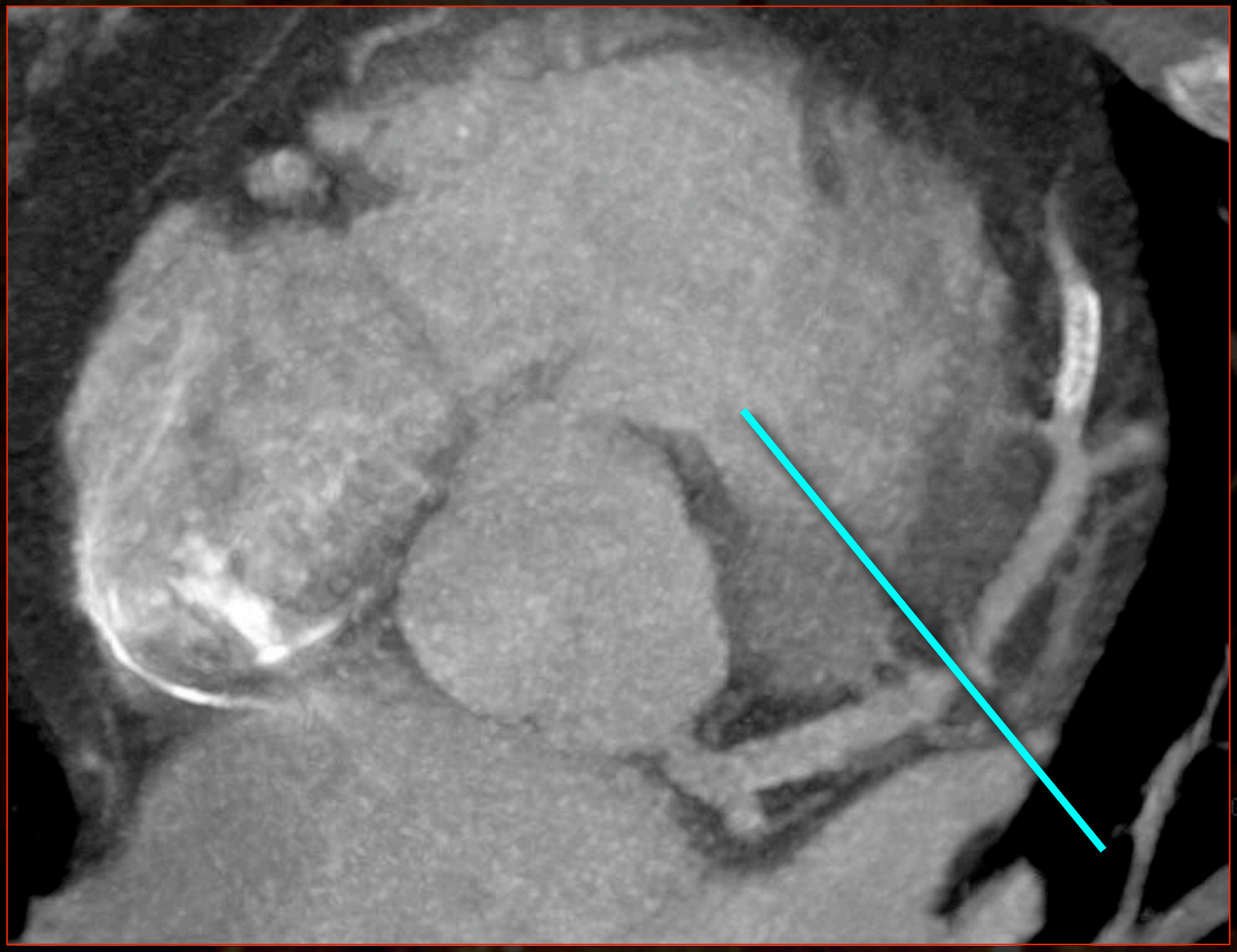
Adapted from:
Taylor AJ, et al. Circulation 2010 (21) pp. e525-55

CCTA - Chest pain

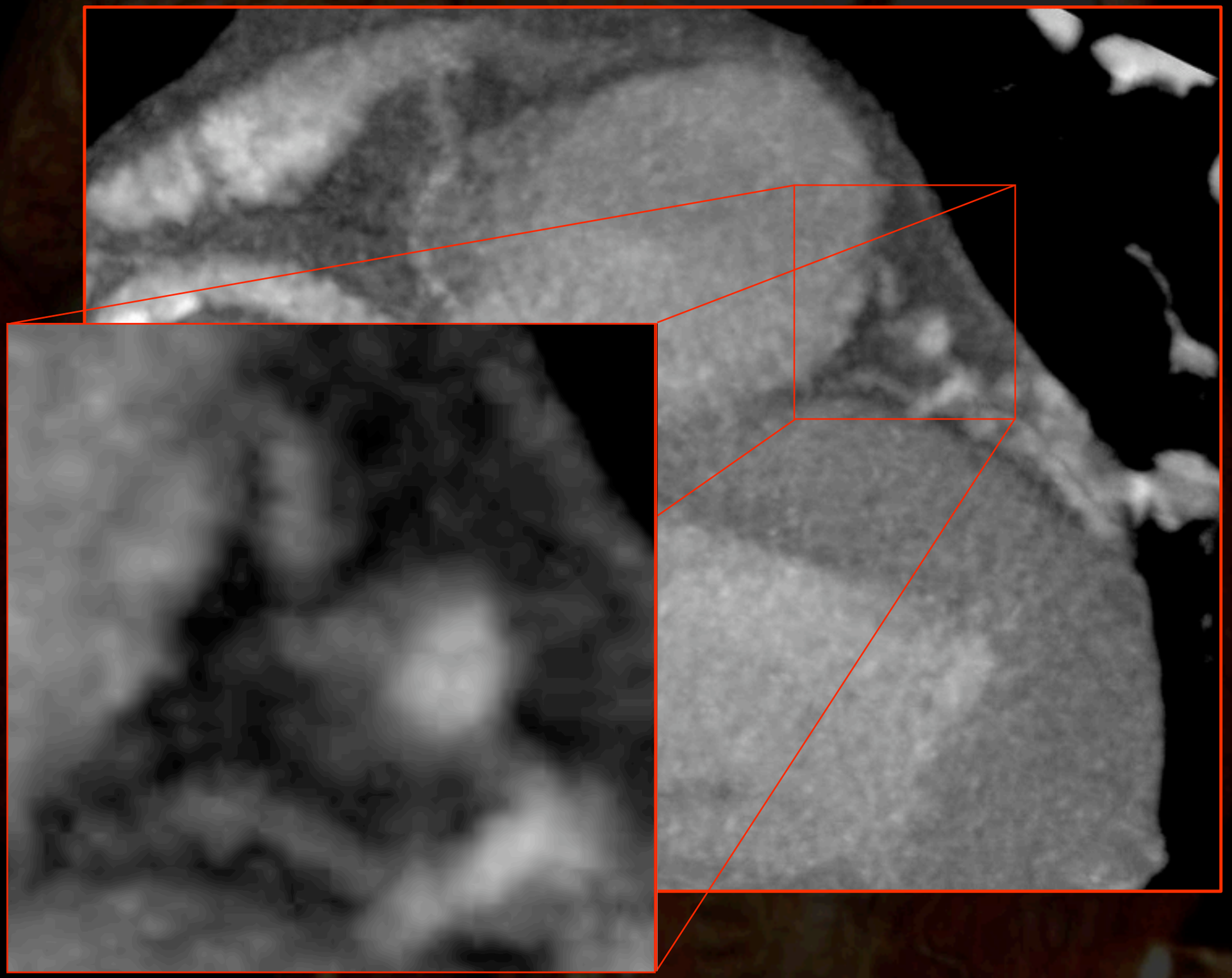




CCTA: 38 yo post LAD stent

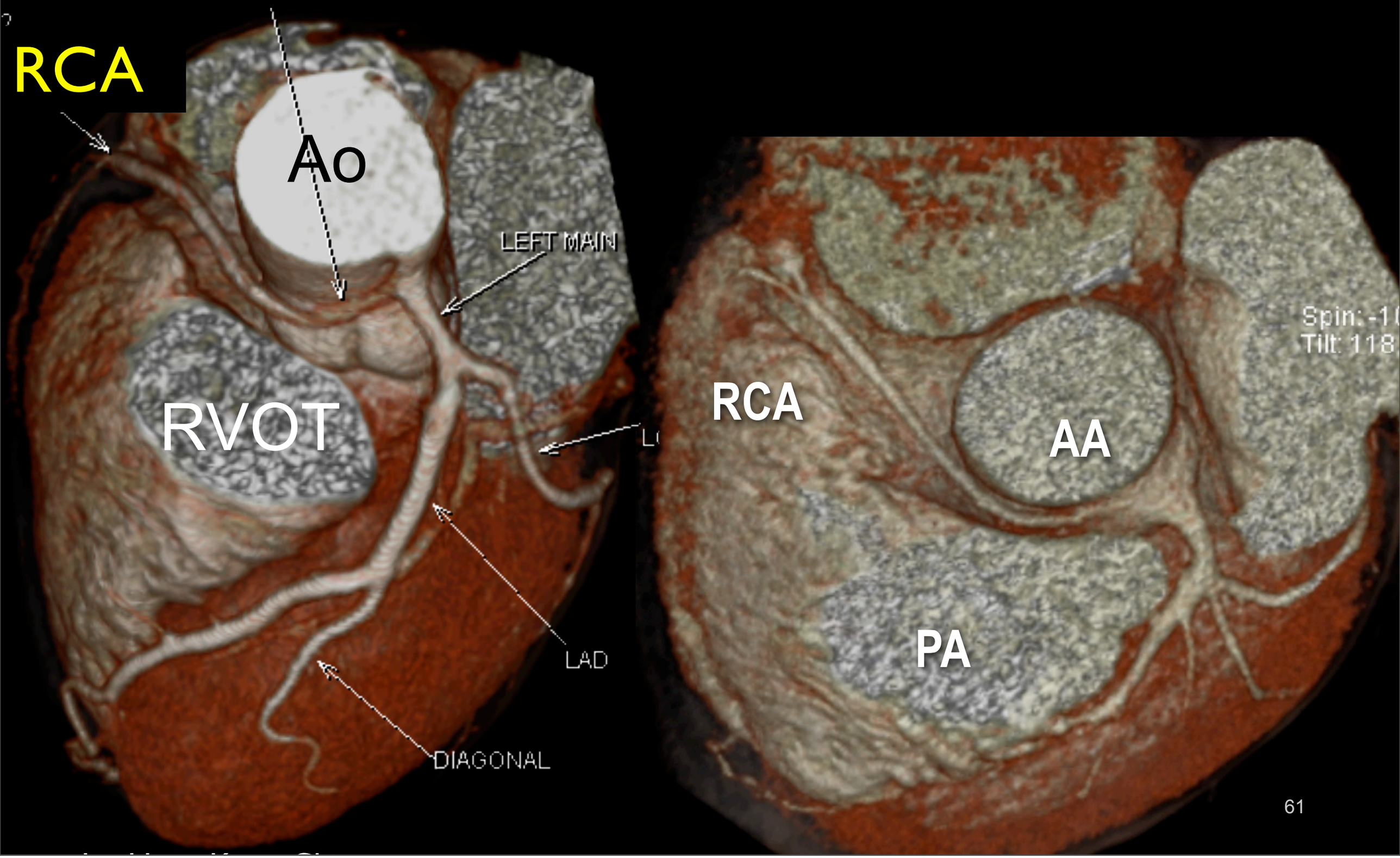


Soft Plaque in LAD (~ 40% stenosis)

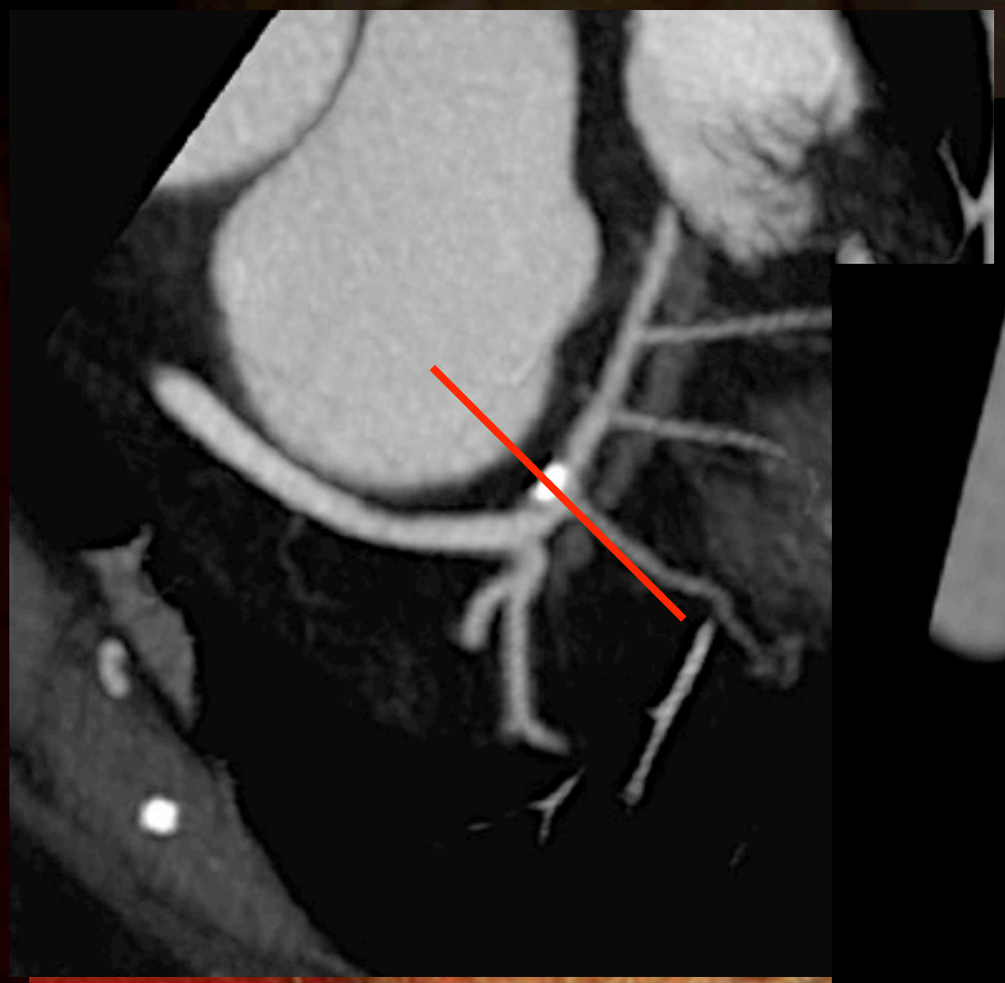


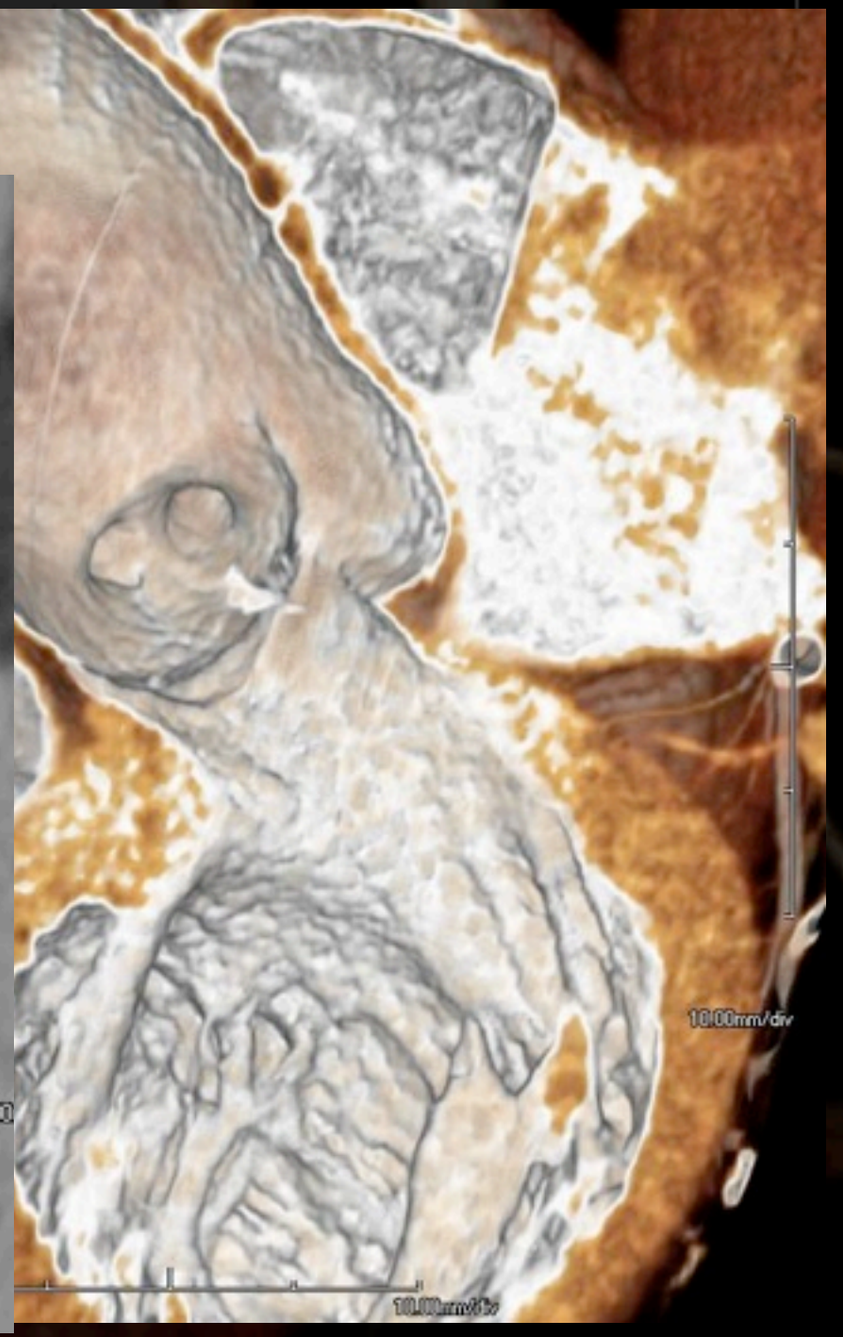
BPG Aneurysm

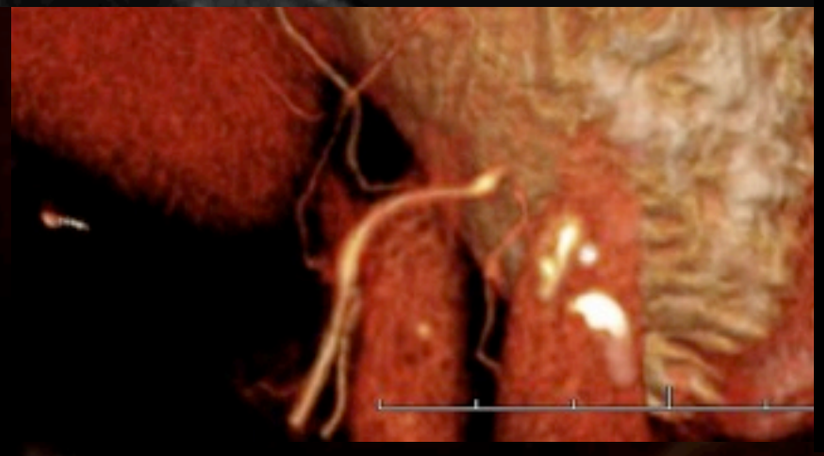
Anomalous RCA



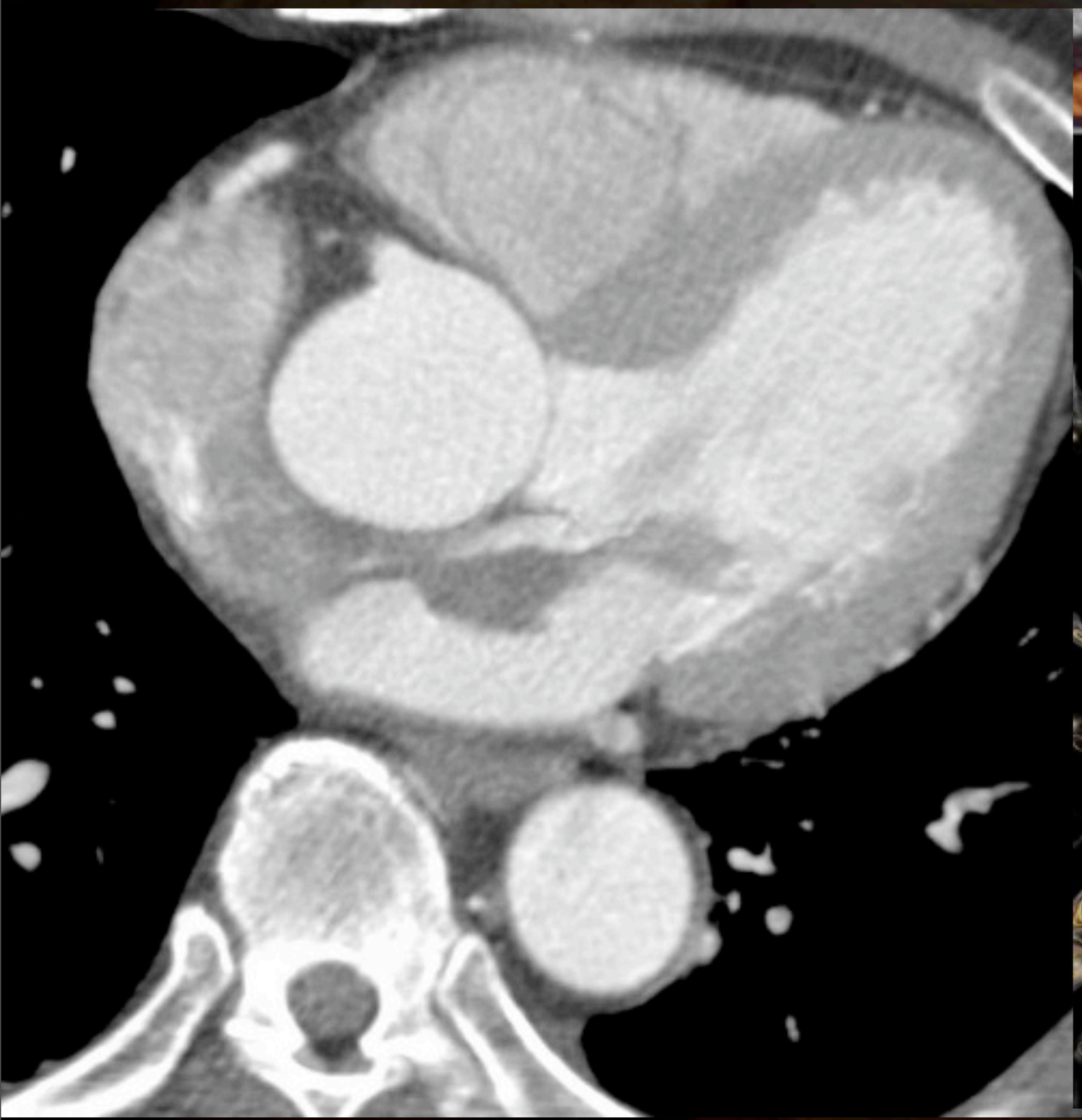
A “Benign” Coronary Anomaly (?)







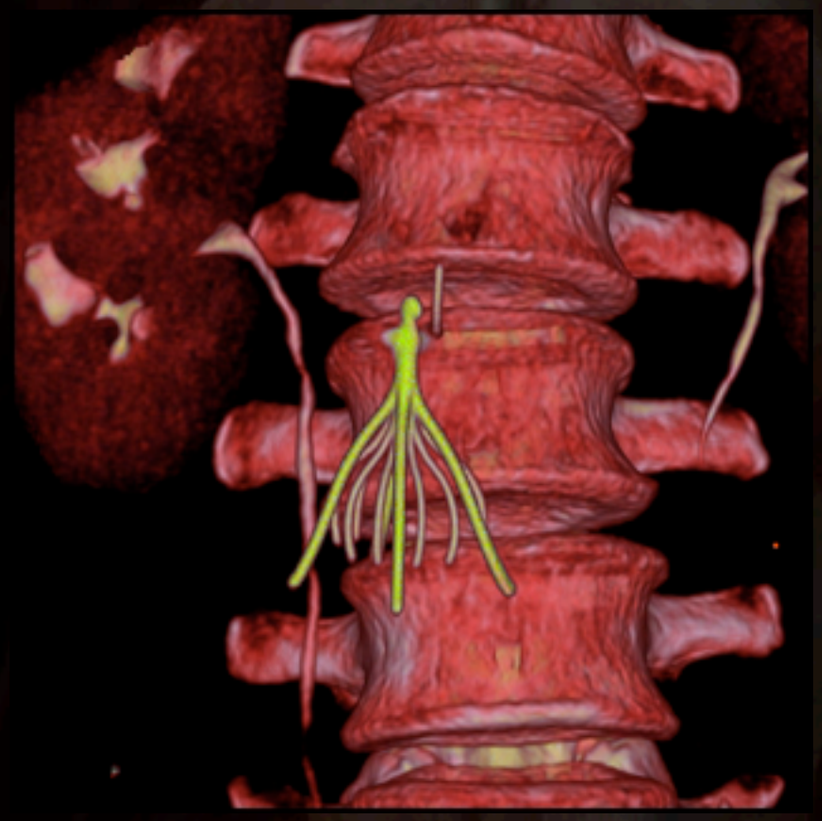
Example: Cardiac Tumor



LA Myxoma

CONCLUSION

- Advances in CT technology and computer processing speed have allowed tremendous advance in 3D CV imaging
- Ability to synchronize to ECG allows "4D" imaging
- Applications now in all vascular beds



THANK YOU!!

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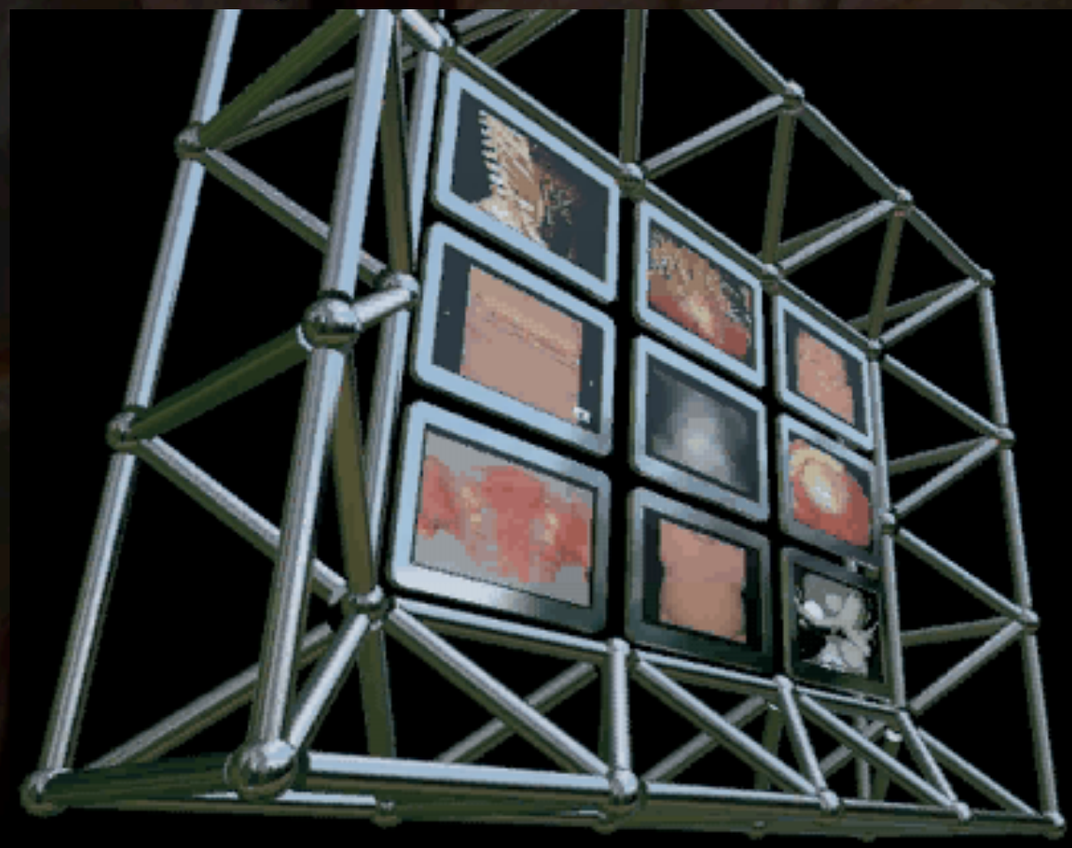
Ivan Petrovich, MD
Geoff Rubin, MD - Duke University
Dominik Fleischmann, MD - Stanford University



Online Handouts from Lecture:
www.stanford.edu/~hallett