CTA/MRA: Image Reconstruction, Post-Processing, Workflow

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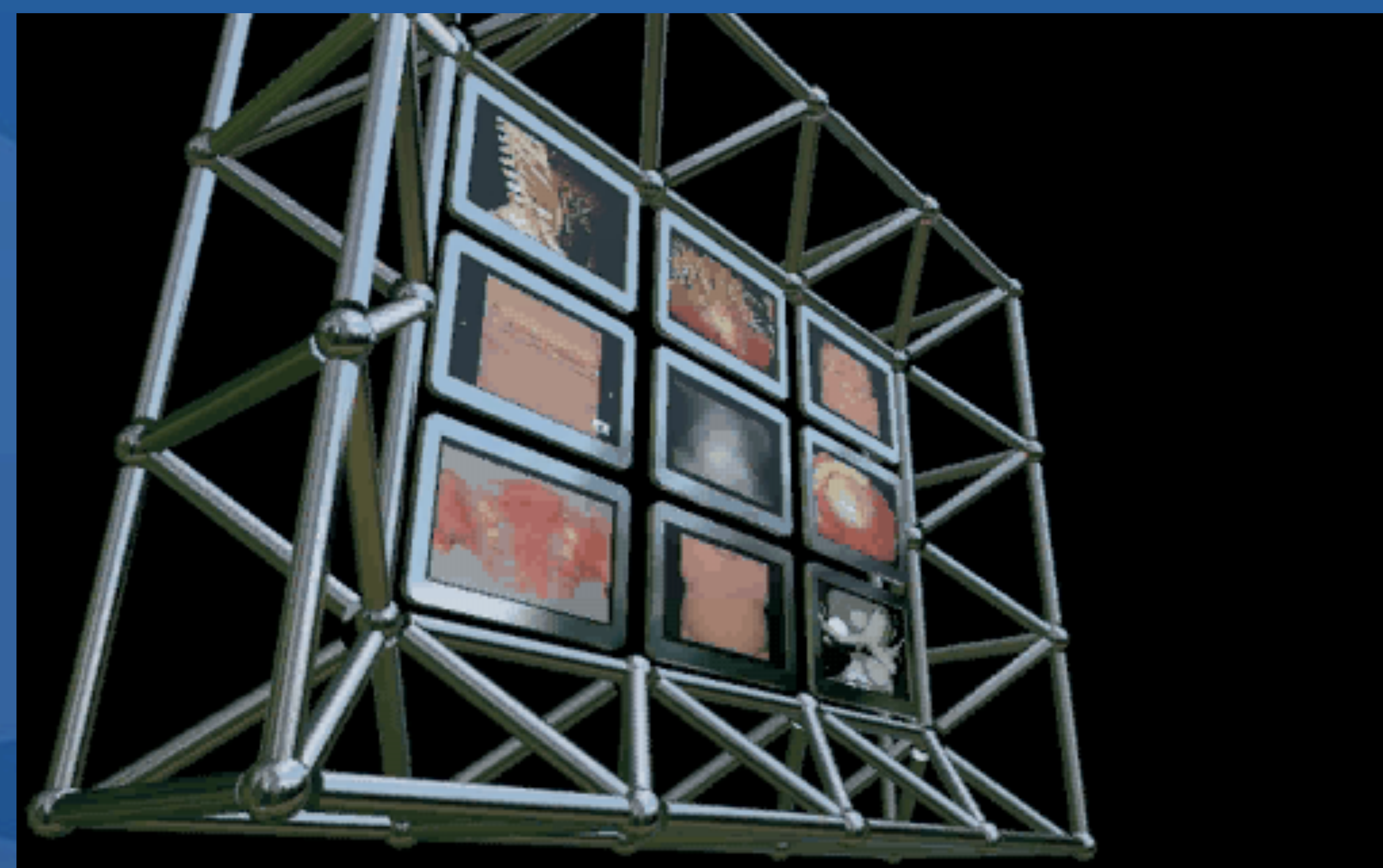

SIR 2010 27-28 March 2011
0800-1000

Disclosures: None

Online Handouts from Lecture:

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Outline

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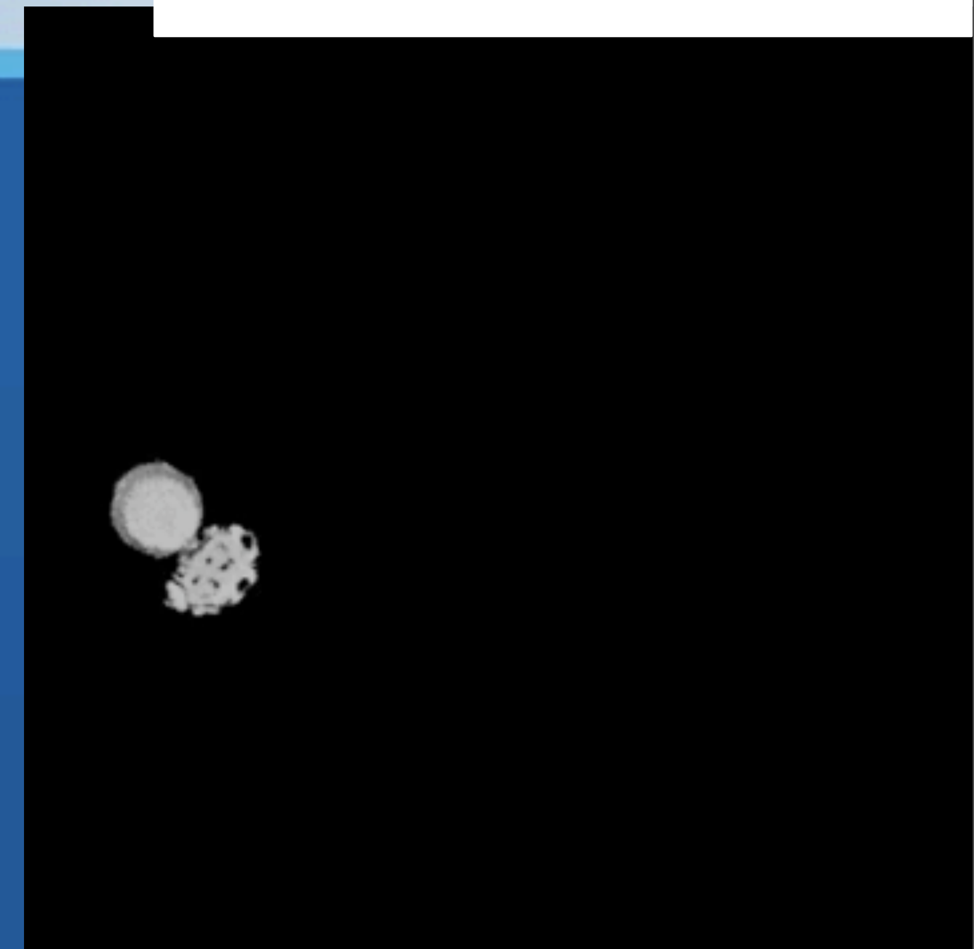
I. Image reconstruction

II. Post-processing techniques

III. Workflow / Interpretation



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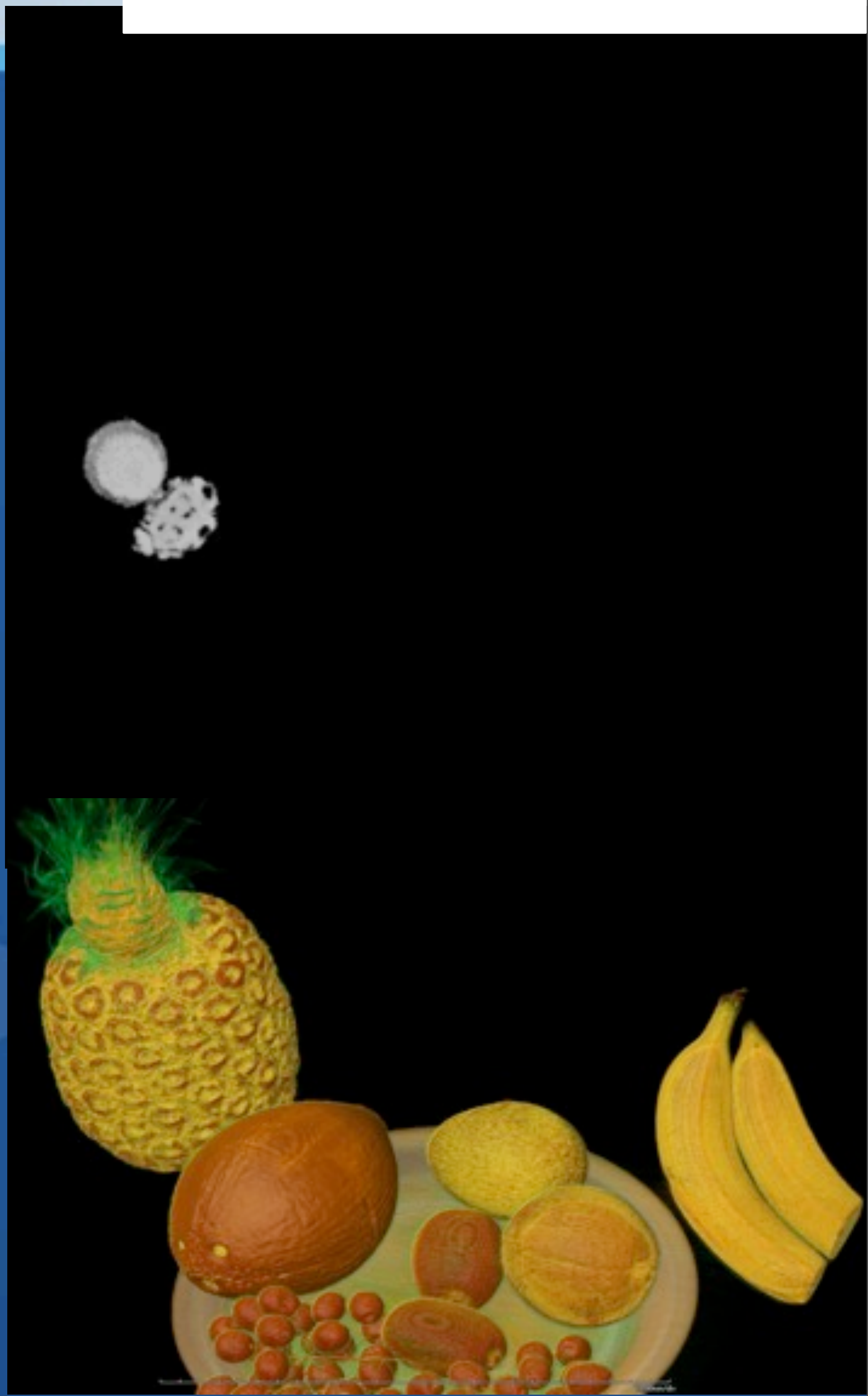

(Modifiable) Image reconstruction parameters

1. Raw Data Reconstruction Mathematics
2. Individual Slice / Patient Characteristics
3. Field of View
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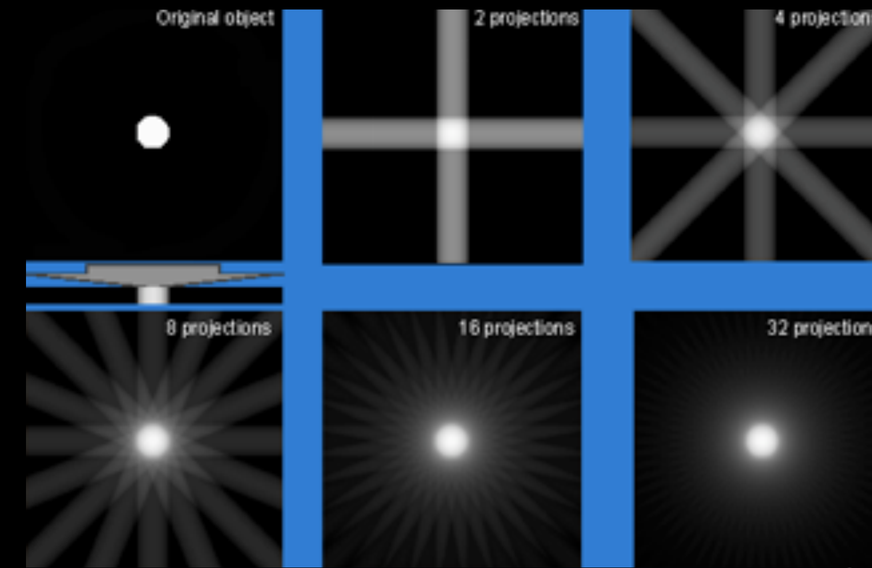
TRADITIONAL

Raw Data Reconstruction



- Traditionally reconstructed using Filtered Back Projection (FBP)
- Necessary ASSUMPTIONS:
  - Focal spot infinitely small
  - Detector is single point in center of detector cell
  - Reconstructed voxel - no shape or size
  - Measured signal has no error from photon statistics or image noise

" New" Data Reconstruction

- **<u>Iterative Reconstruction</u>** (IR)
  - Used in SPECT and PET years ago……
  - Models CT system optics (geometric information) as well as statistics (noise)
    - ➡ Compares model to real raw data, correct, repeat
    - ➡ Model can be *iterated* over and over until image is essentially constant
  - Reduced noise, but <u>computationally expensive</u>

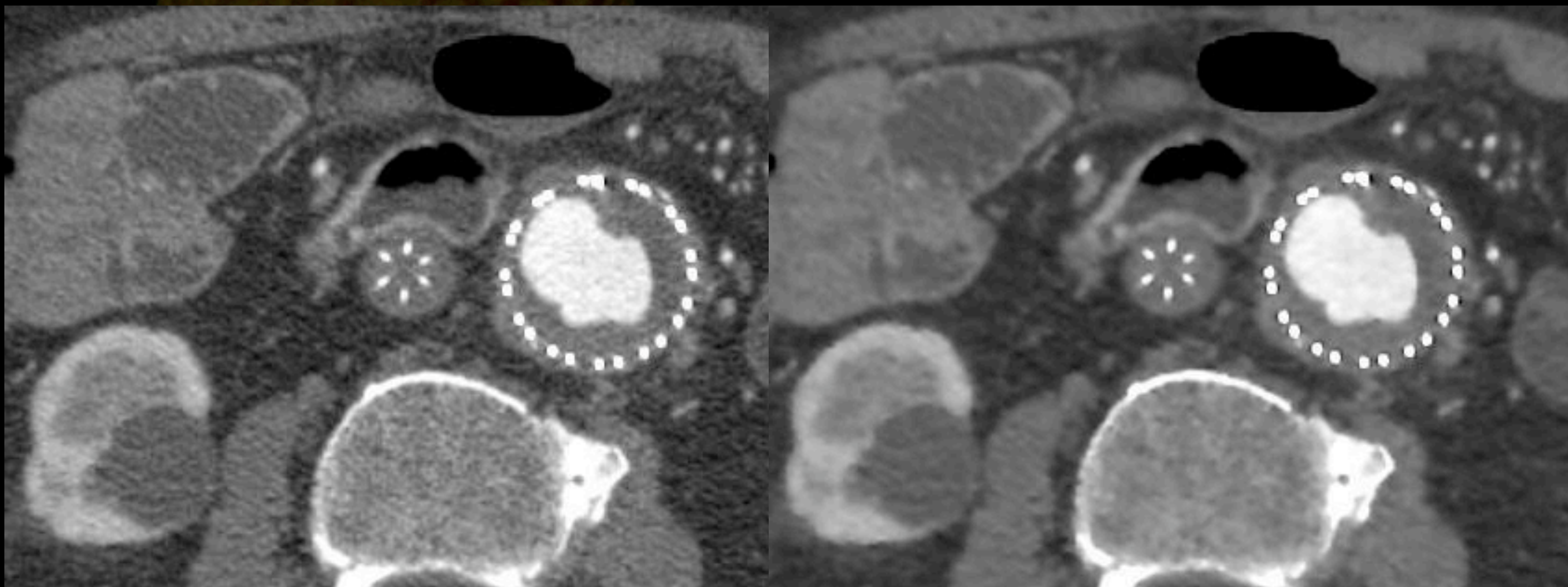
Hara AK, et al. Am J Roentgenol. 2009;193(9):764-771

Iterative Reconstruction

- Up to <u>50% dose reduction</u> is possible at same image noise
  OR:
  Improved image quality at same dose
- 40% improvement in low contrast detectability

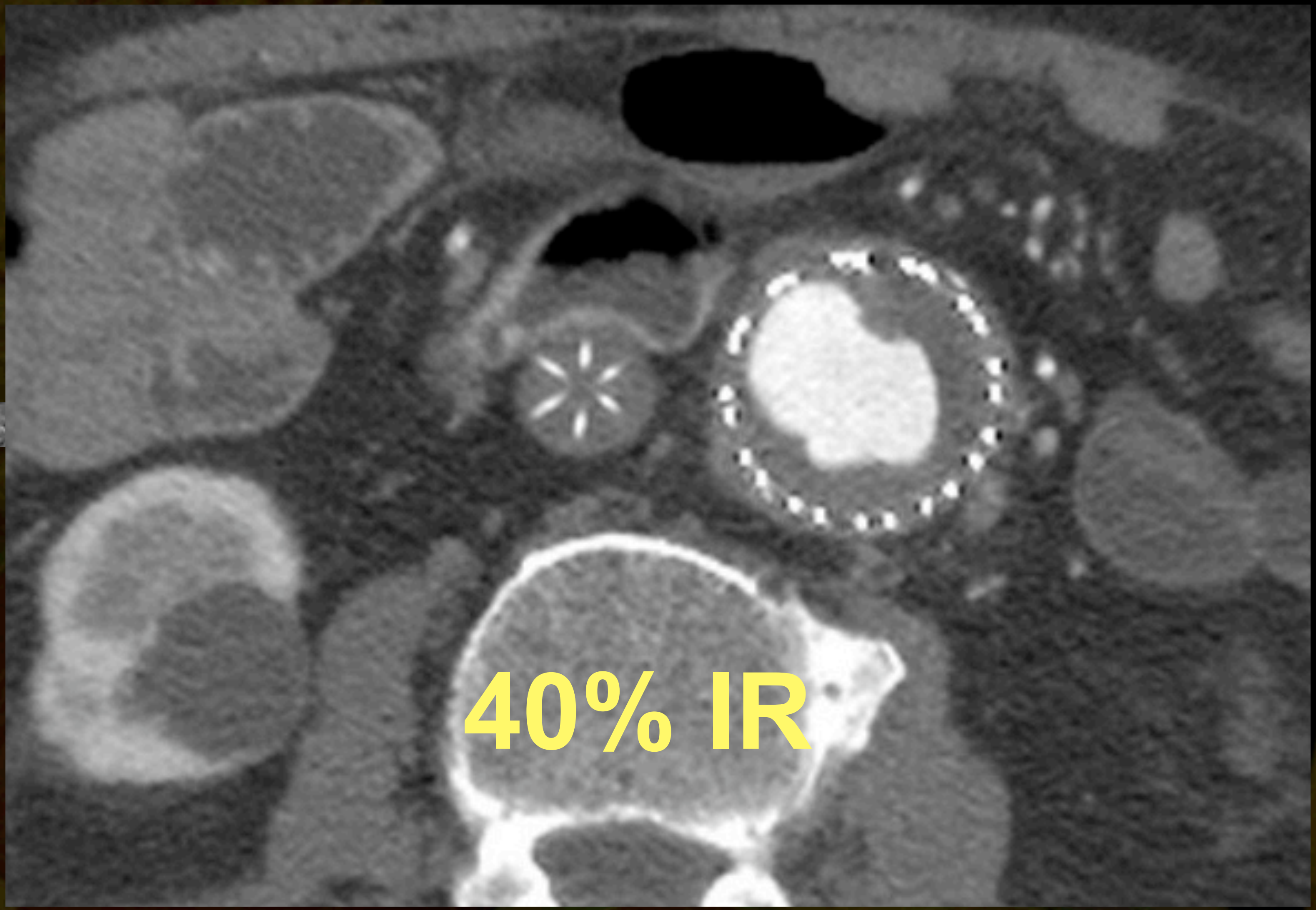
Images courtesy of Mayo Clinic Arizona

Iterative Reconstruction:



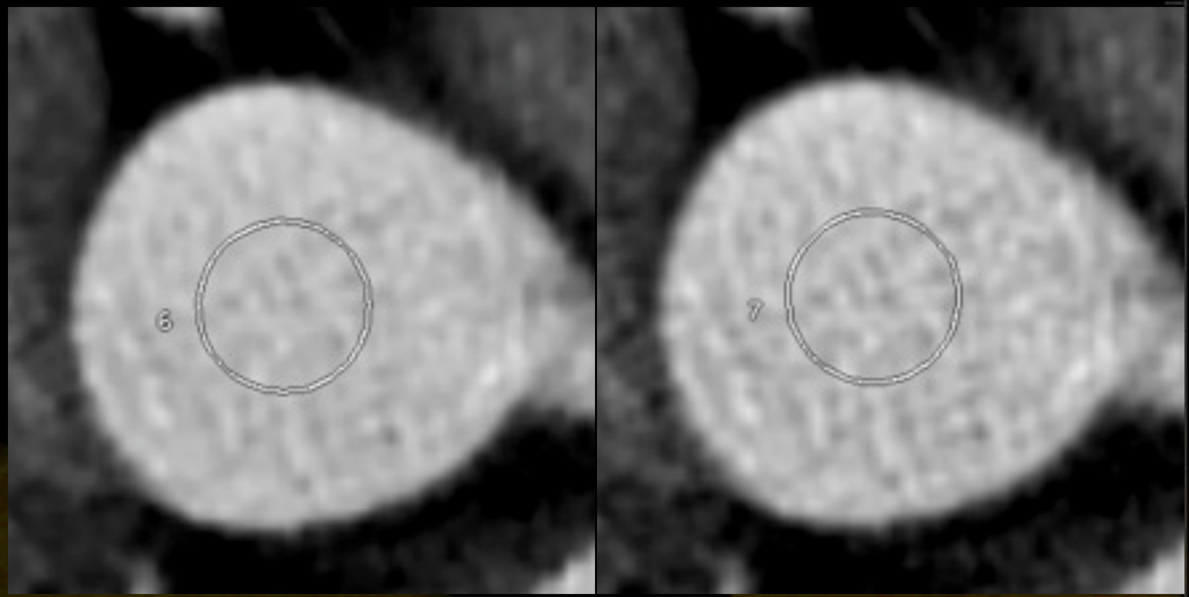
0% IR **100% IR**

Iterative Reconstruction:



Iterative Recon for CCTA: the **ERASIR STUDY**

- 574 consecutive pts at 3 sites referred for CCTA: FBP vs. 40% ASiR blend
- 27% dose reduction from IR utilization, without increased image noise or non-evaluable segments
- 45% total reduction including other scan parameters (100 kV, etc)



	FBP	40% ASIR
Density, HU	718.6	719.3
SD (noise)	52.3	38.5

Leipsic J, et al. AJR 2010; 195:655-660

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Characteristics of the CT "slice"…

- "Effective" slice thickness
  - defined by the selection of collimator thickness during scan acquisition
- Thicker (but not thinner) recons
- Multi-planar reconstructions (MPR) obtained by *interpolation*
- MPR enhanced if your initial dataset is overlapped by ~ 30%
  - e.g. 1mm ST at 0.7 mm RI
  - Less "aliasing" (stairstep)

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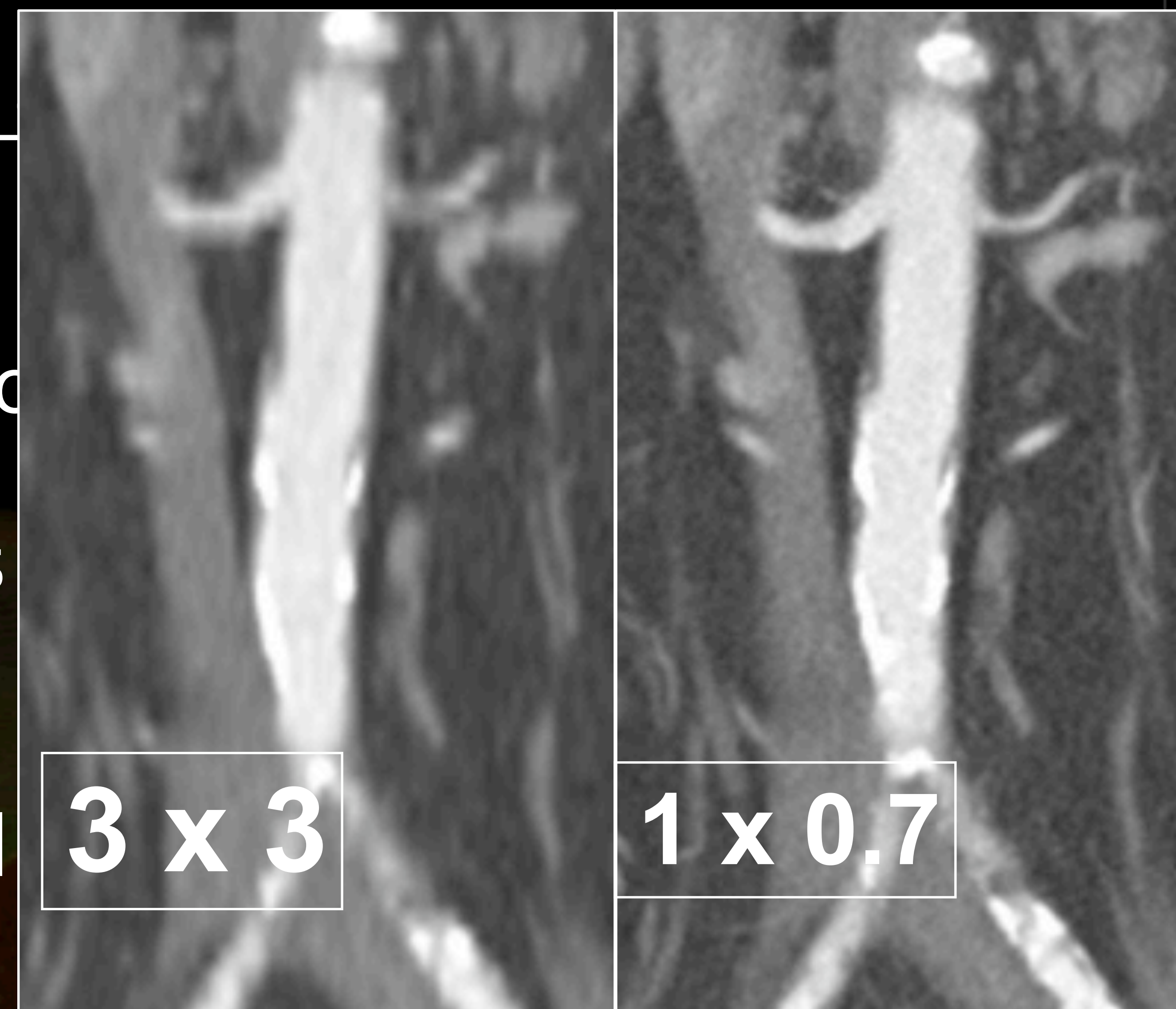

Tweaking / Help for Tough Datasets

- **LARGE** Patients:
  - Scan with thicker collimation (1.25 - 2.5 mm)
  - Use 140 kV
  - Slow down gantry rotation
- Smaller Patients:
  - Use 100 kV

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Effect of changing FOV

- Standard CT image:
  - 512x512, FOV = 30 cm
  - Pixel size ~ 0.35 mm^2
- Small FOV:
  - 512x512, FOV = 15 cm
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- BUT: “Isotropic” voxels easier to obtain at thicker slice / larger FOV

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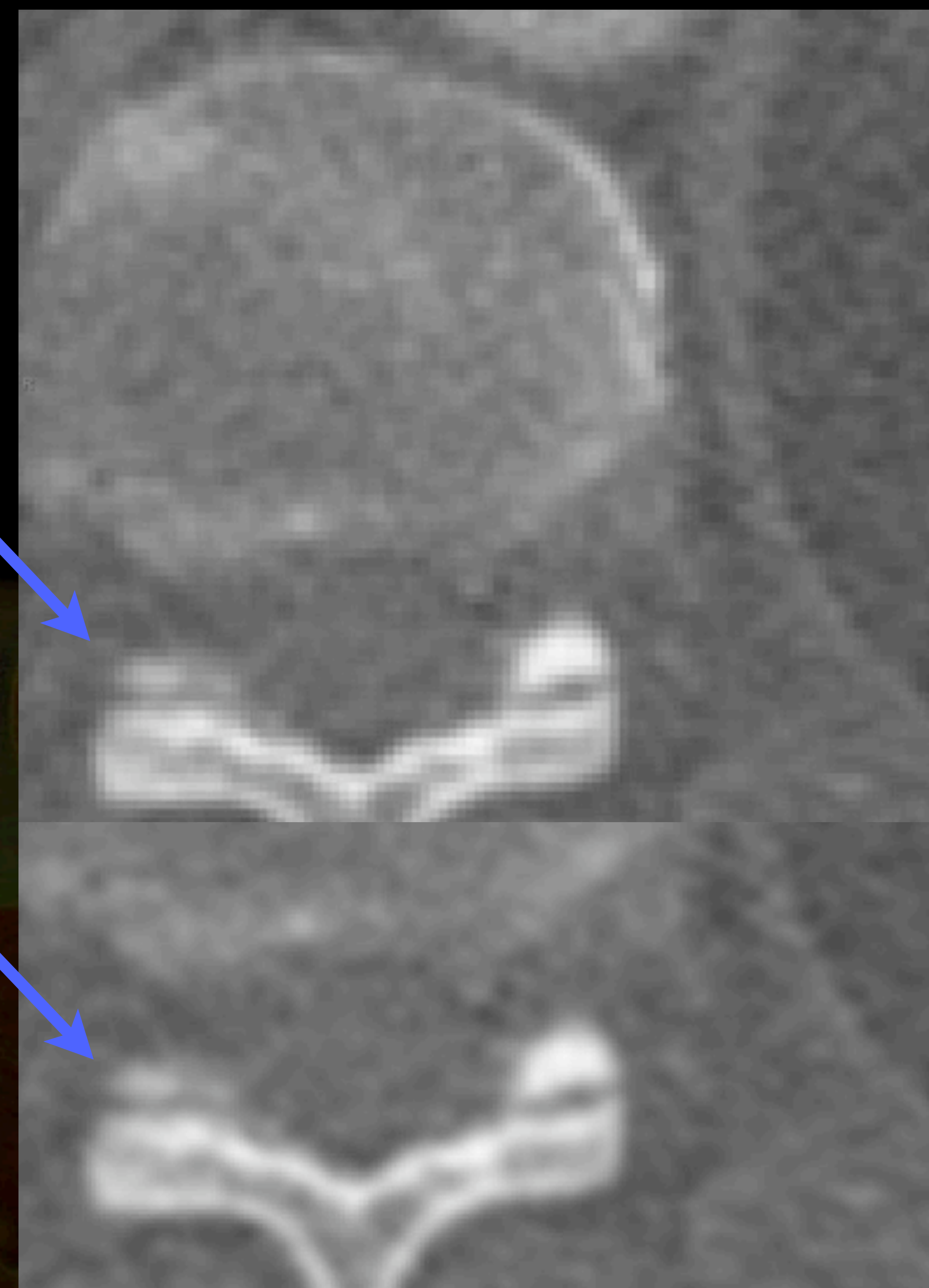

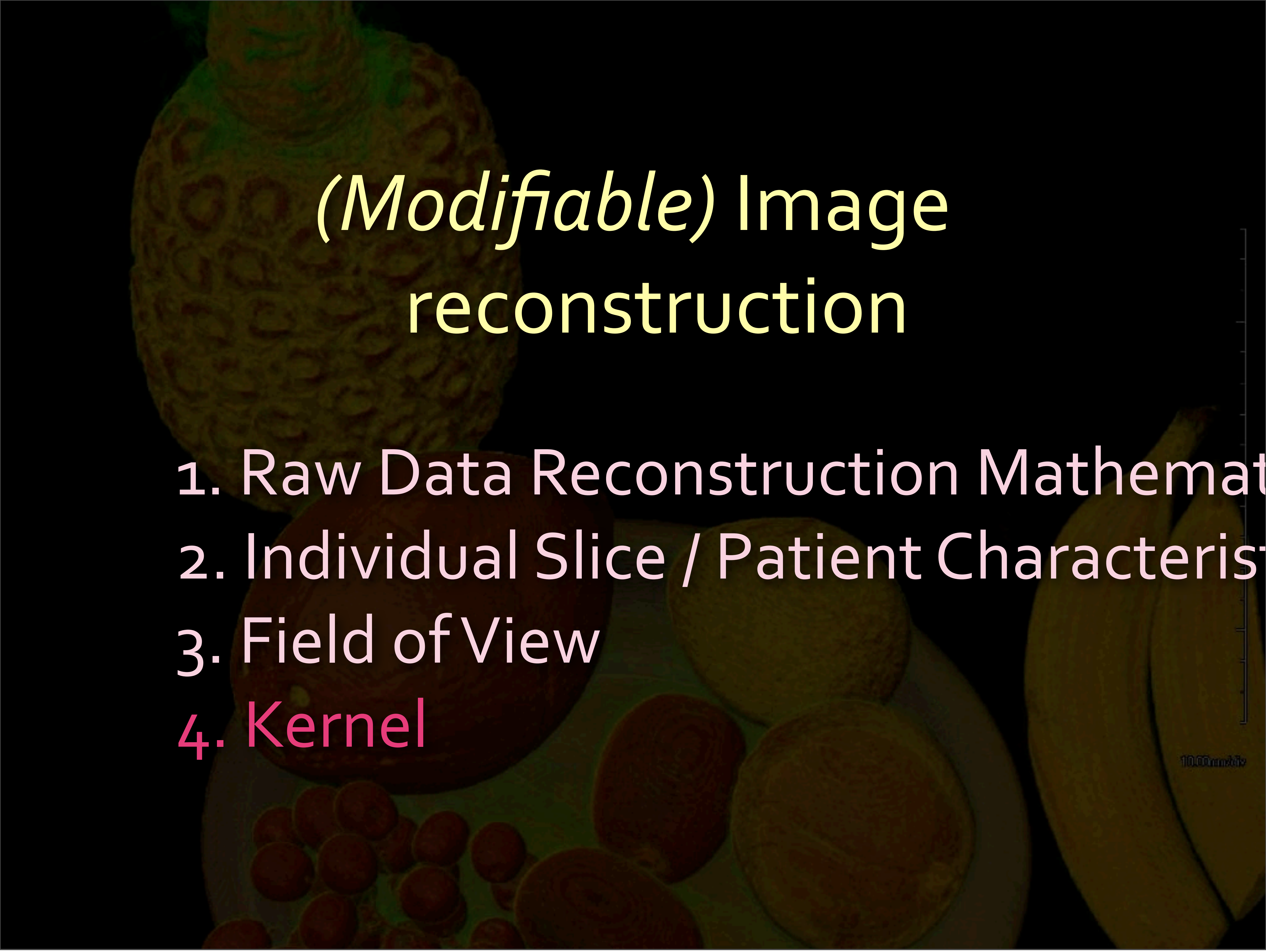
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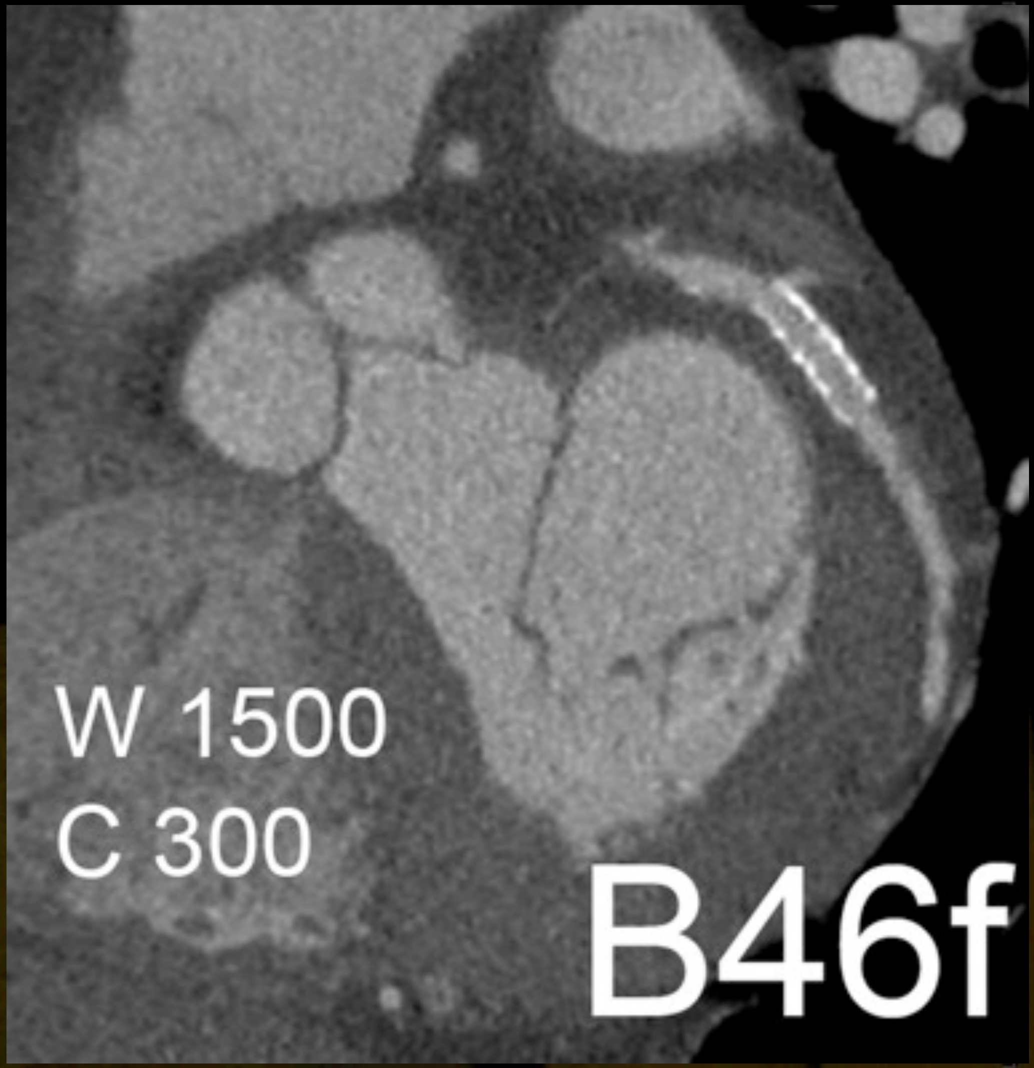
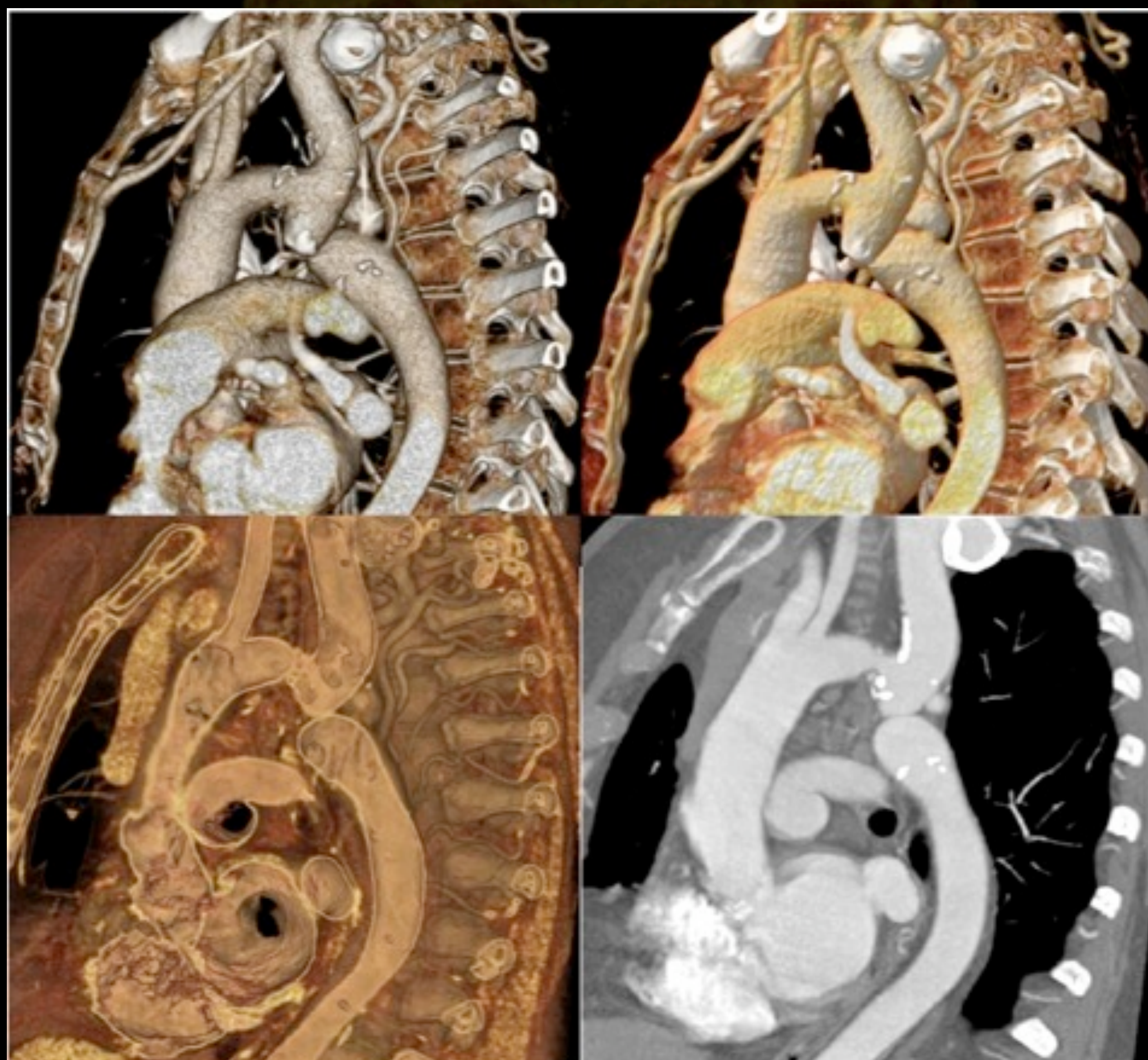
Effect of Recon Kernel

- Softer kernel: Less noise, less sharp
  - Better 3D / Multiplanar recons
- Sharper kernel: Higher detail, more noise
  - STENTS!! (coronary, peripheral)



Pugliese, F. et al. Radiographics 2006;26:887-904

Image Post-Processing



Review of Image Types
New Directions

Reconstruction "Alphabet Soup"

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

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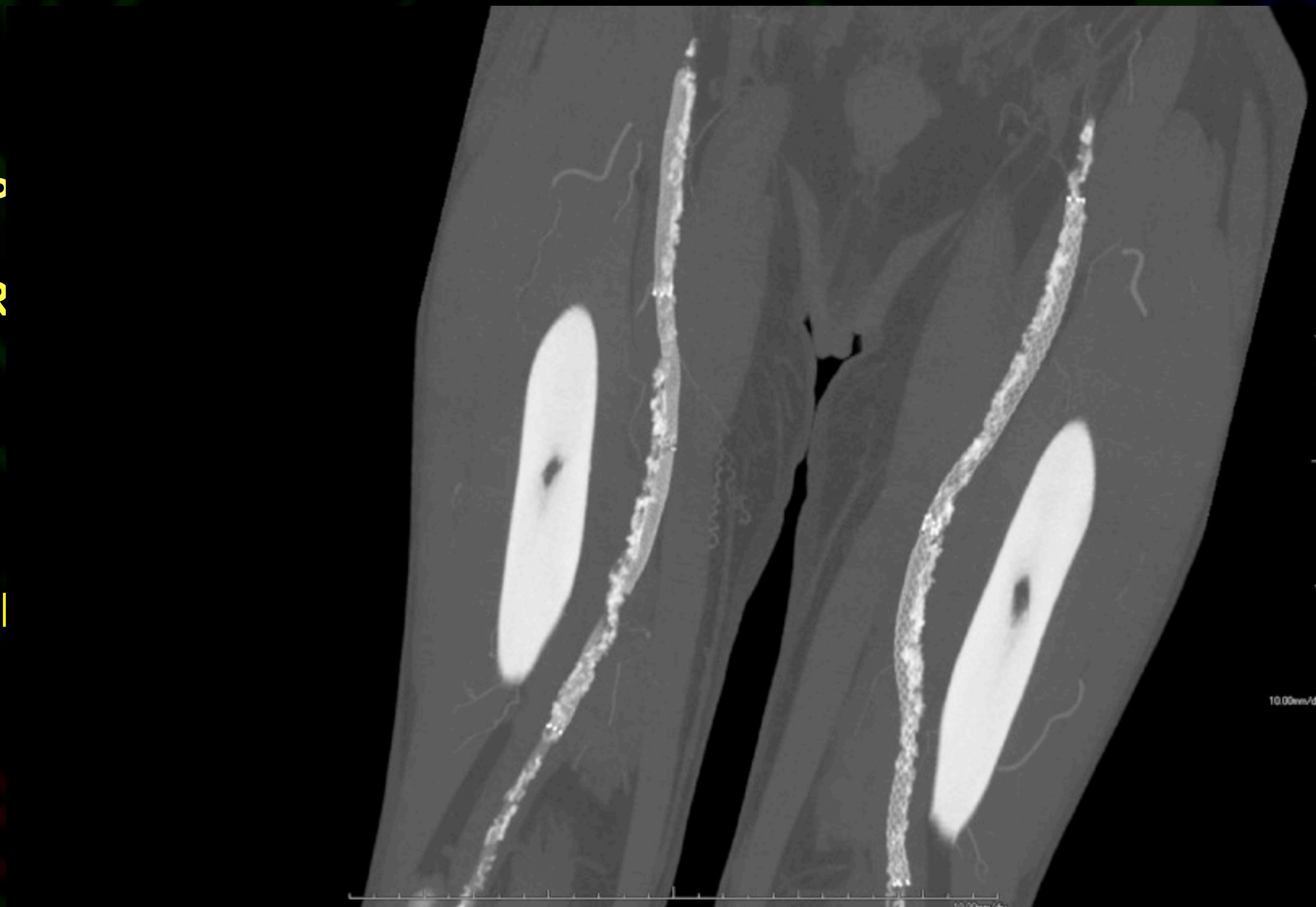

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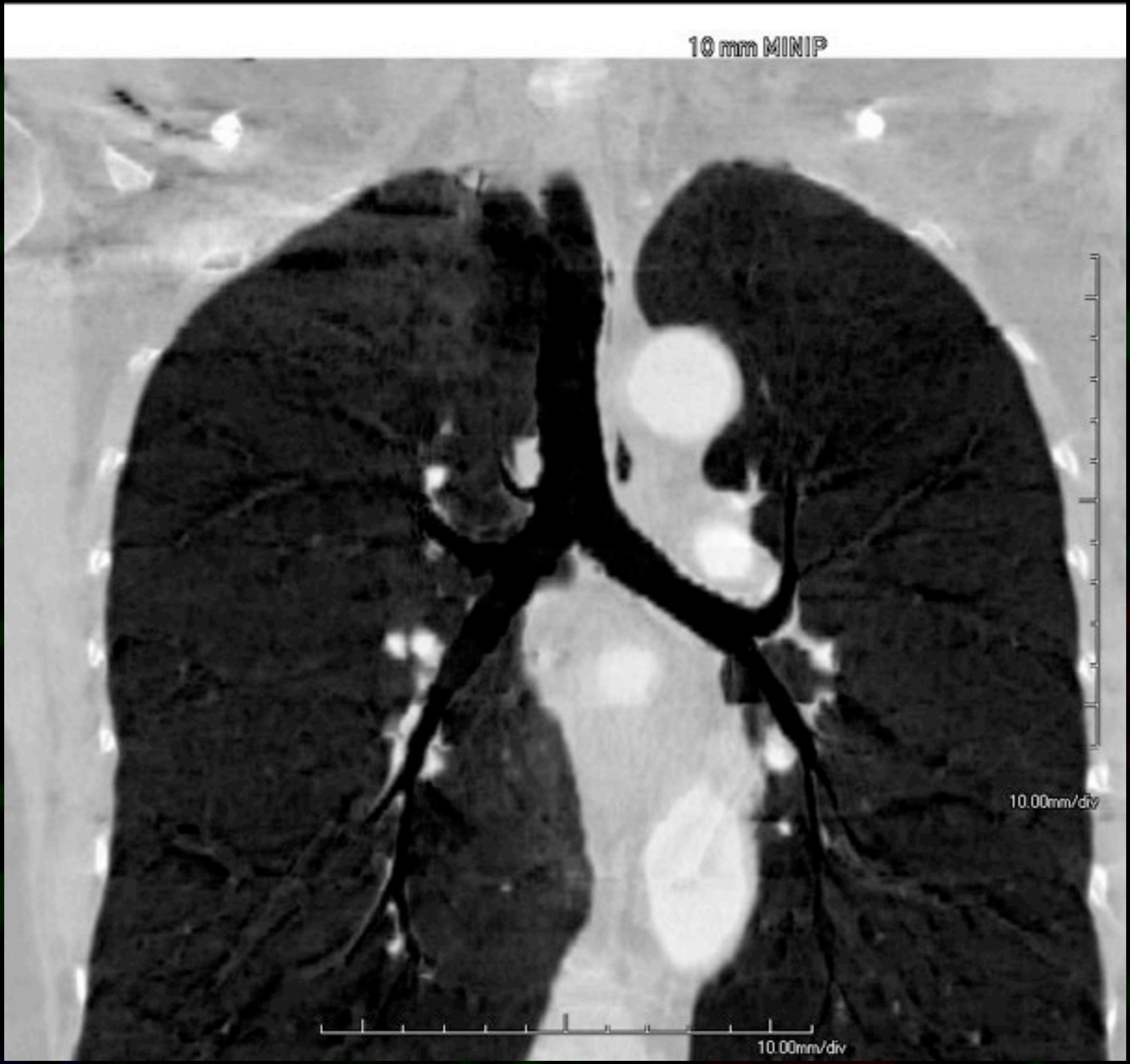

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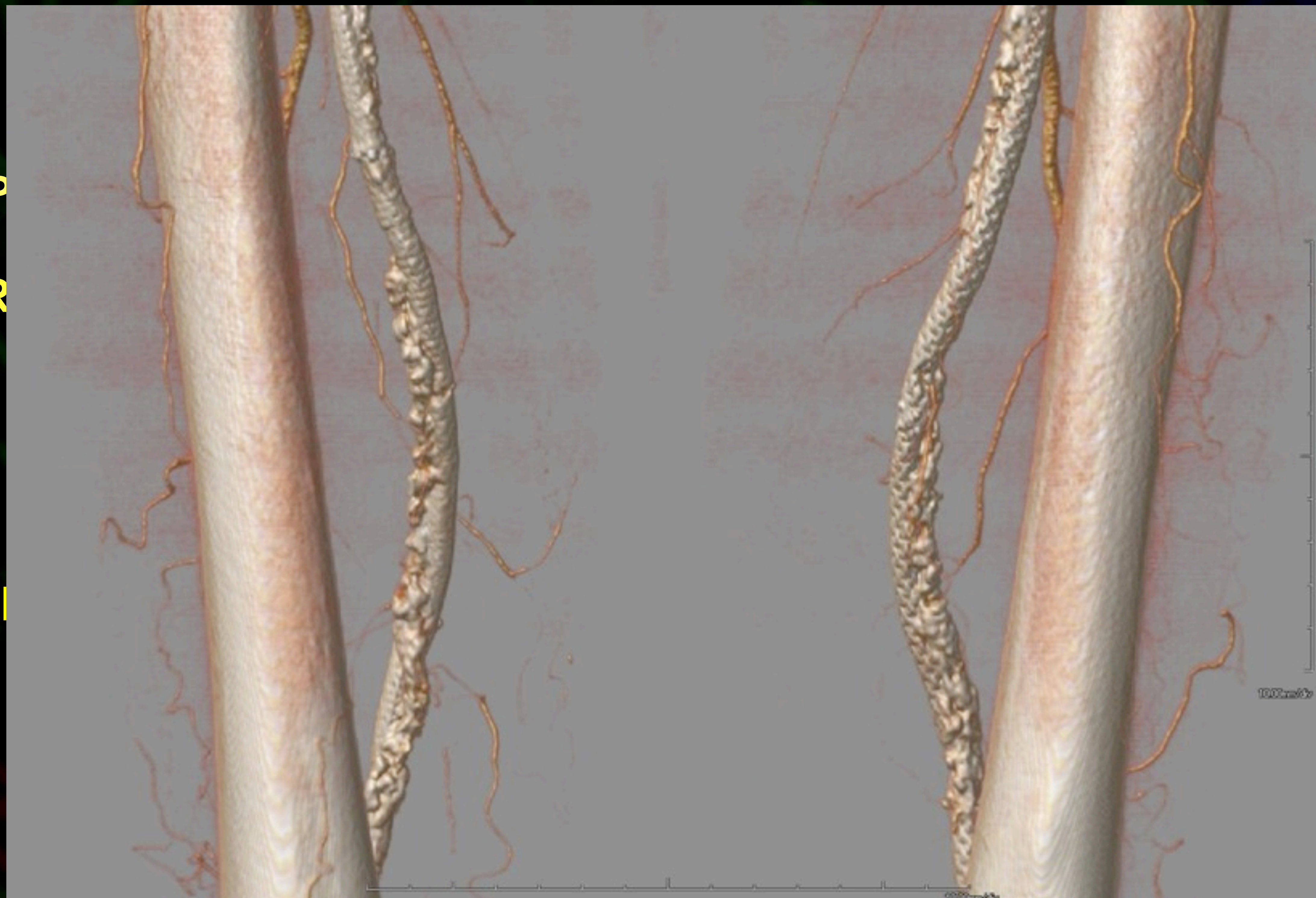

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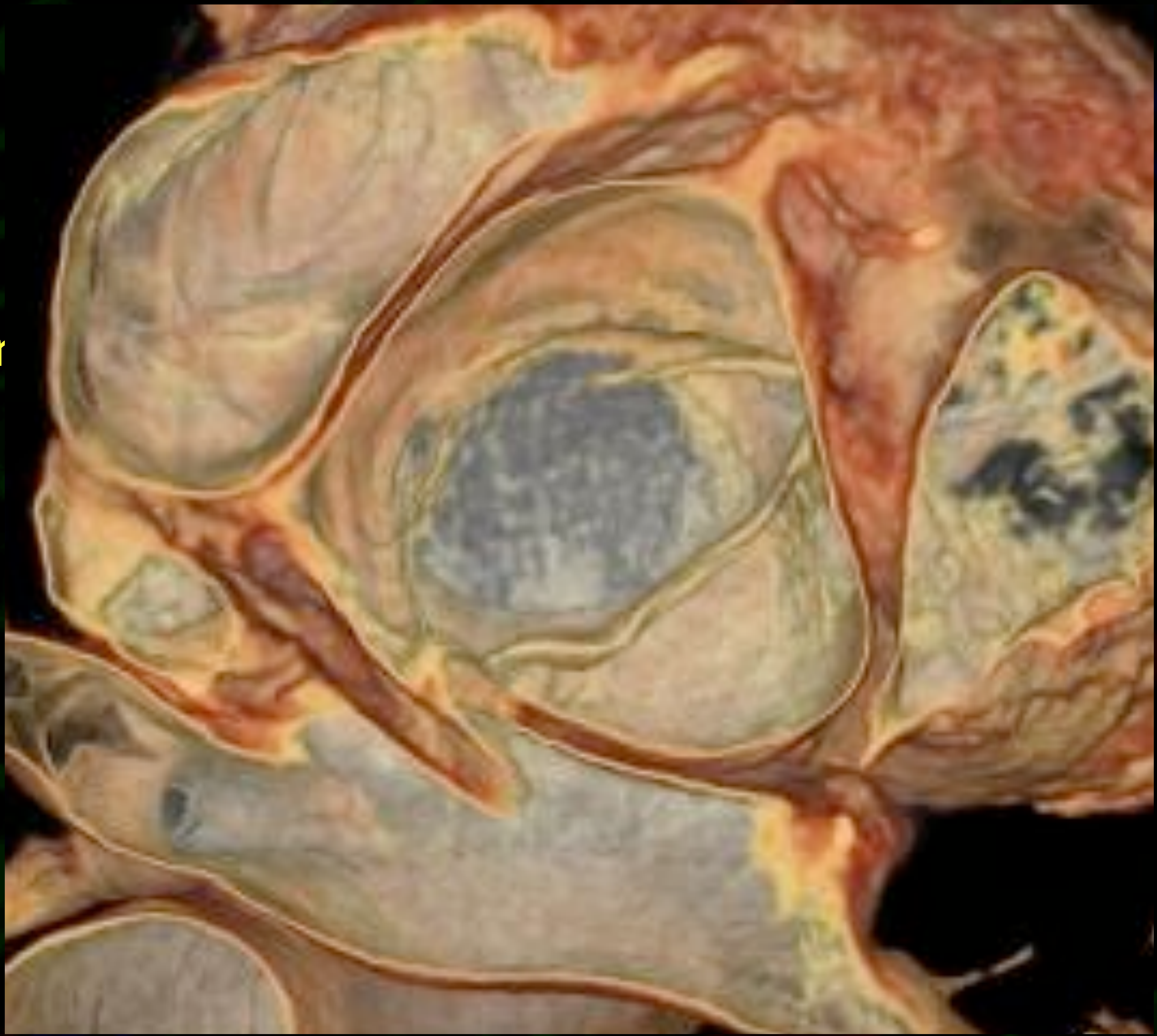

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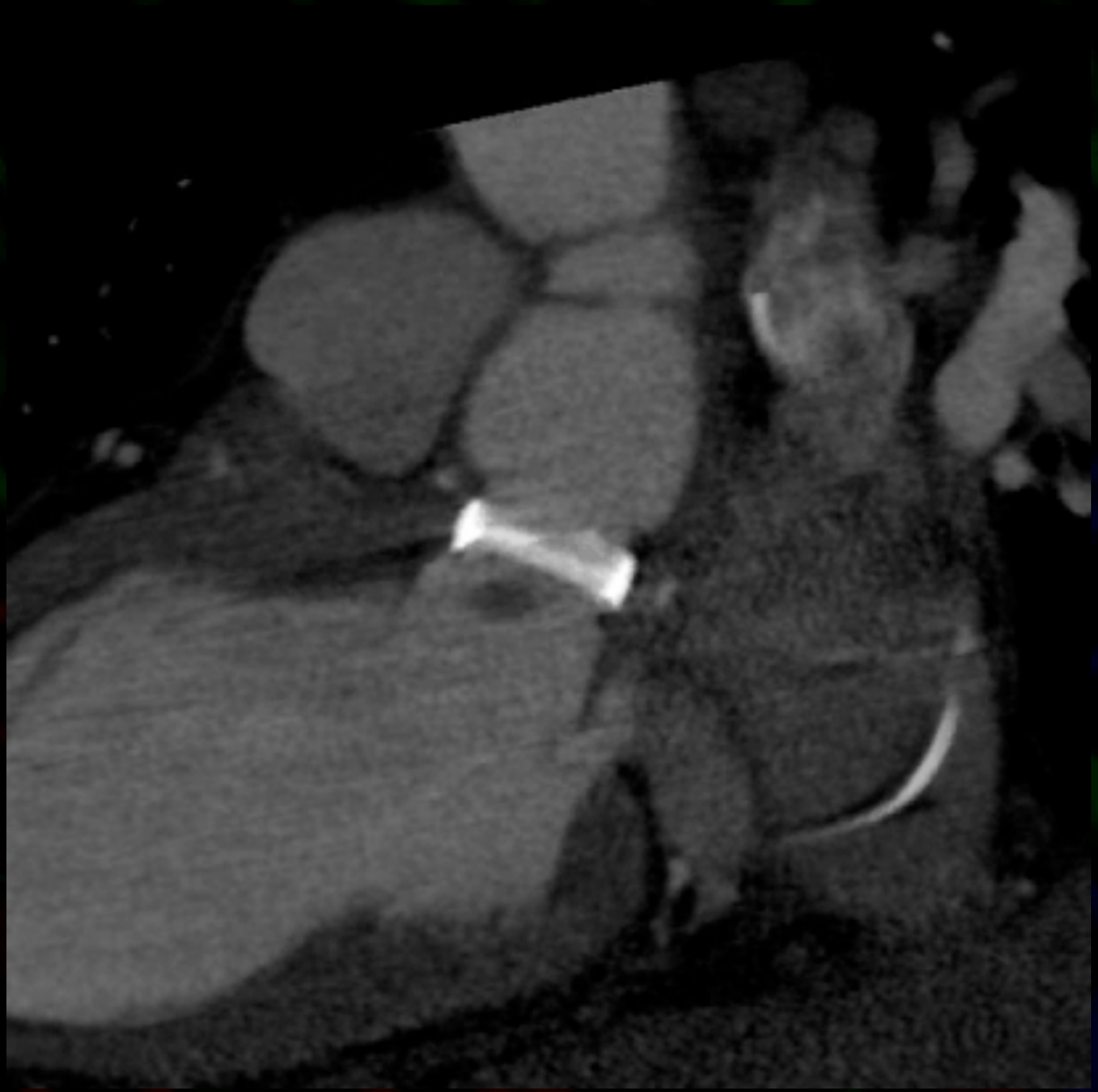
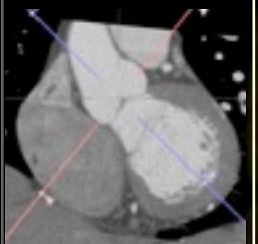
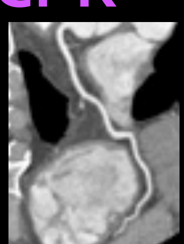
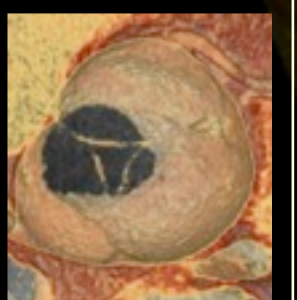
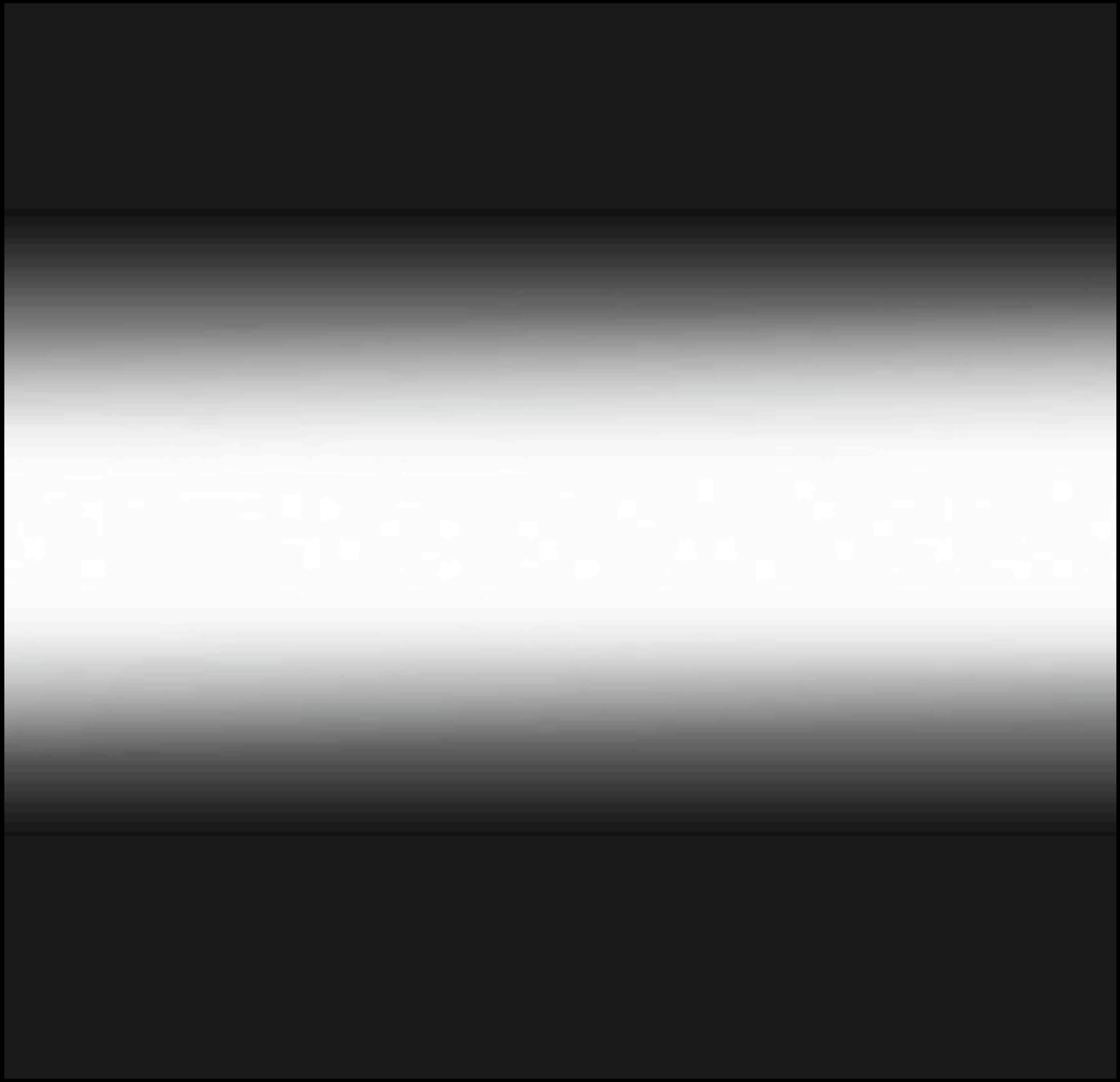


	Major Uses	Advantages	Disadvantages
MPR 	Stenosis, vessel wall analysis Lung nodule measurement Orthogonal Measurements	Accurate for stenosis, nodule, orthogonal measurements Calcification, stent evaluation **"Thick MPR": salvage noisy datasets**	**Limited spatial relationships** **Limited display if 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		

Caveat for MIP: Effect of Background Noise on apparent stenosis



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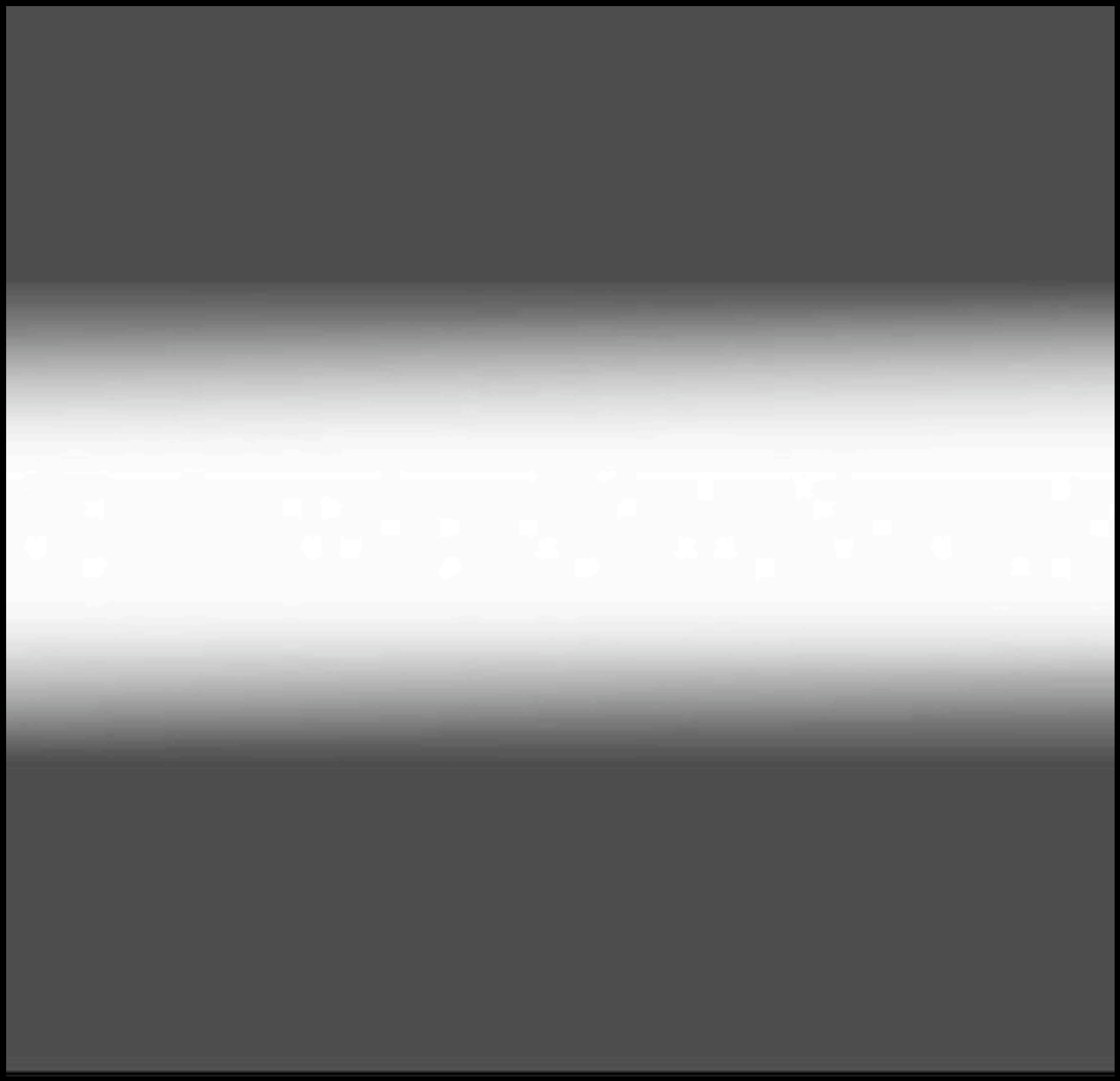

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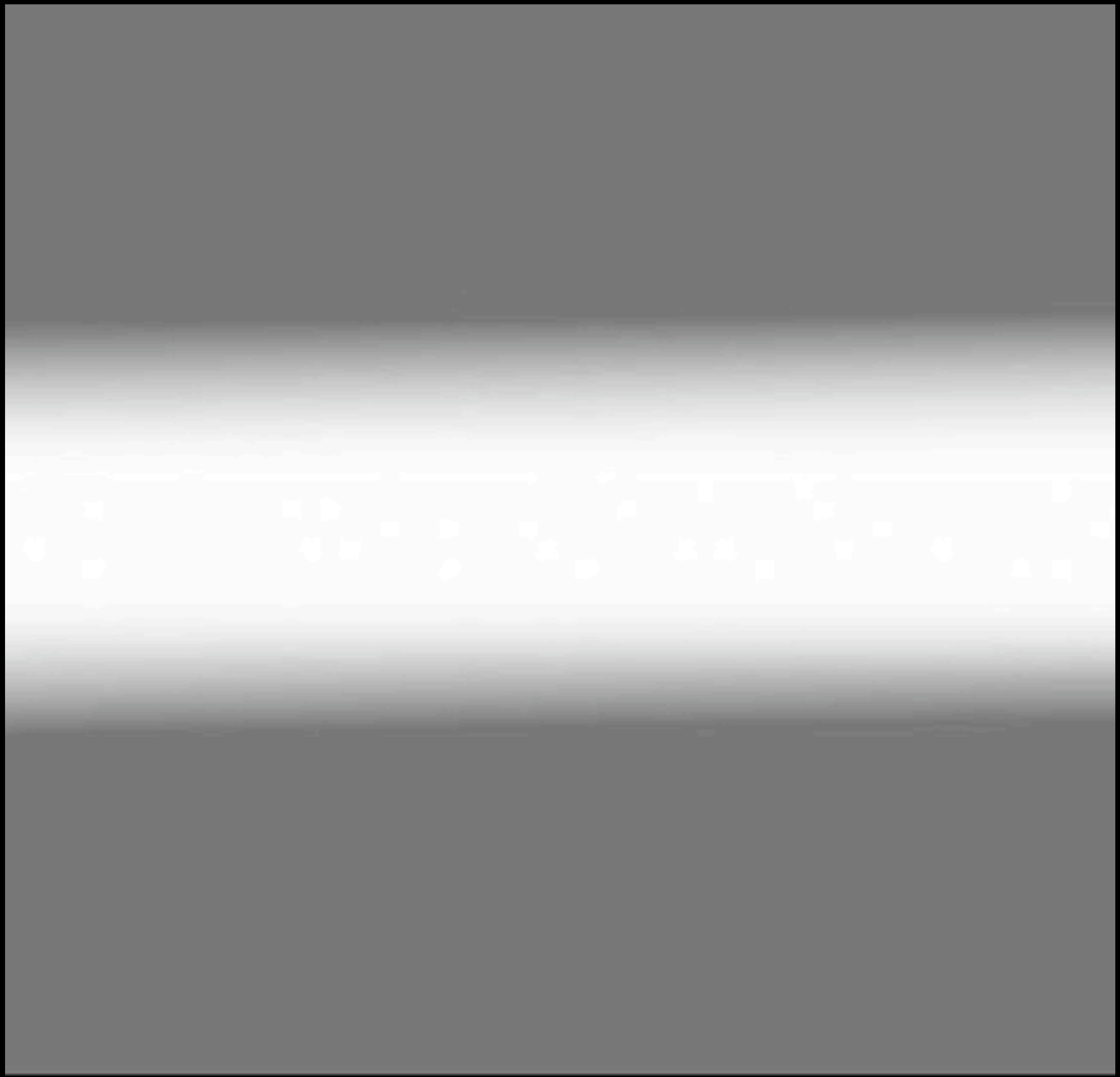
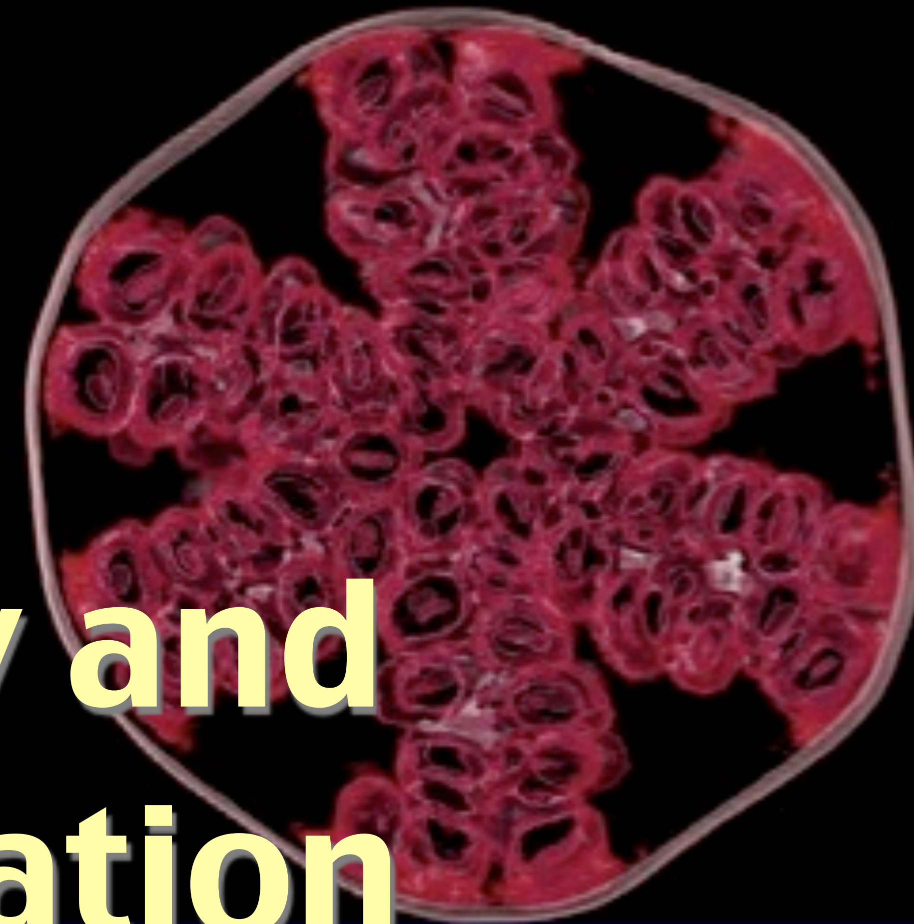
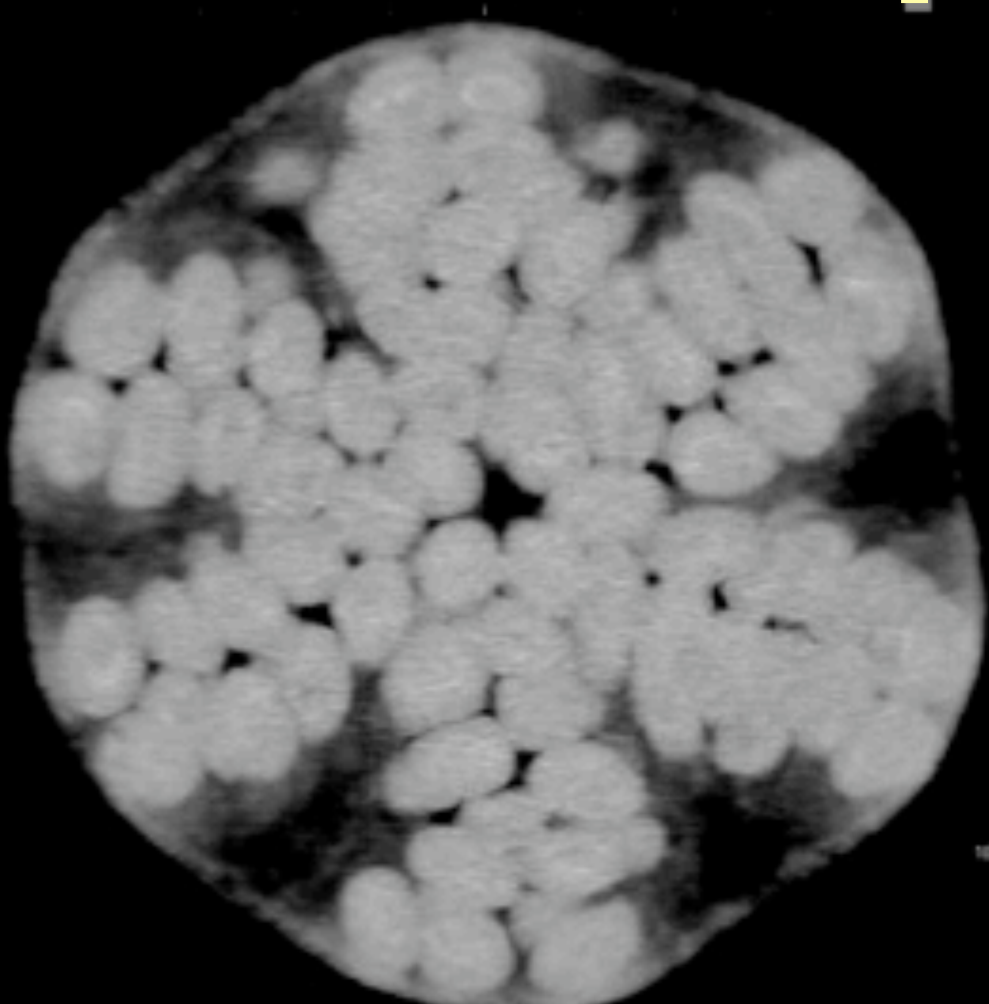
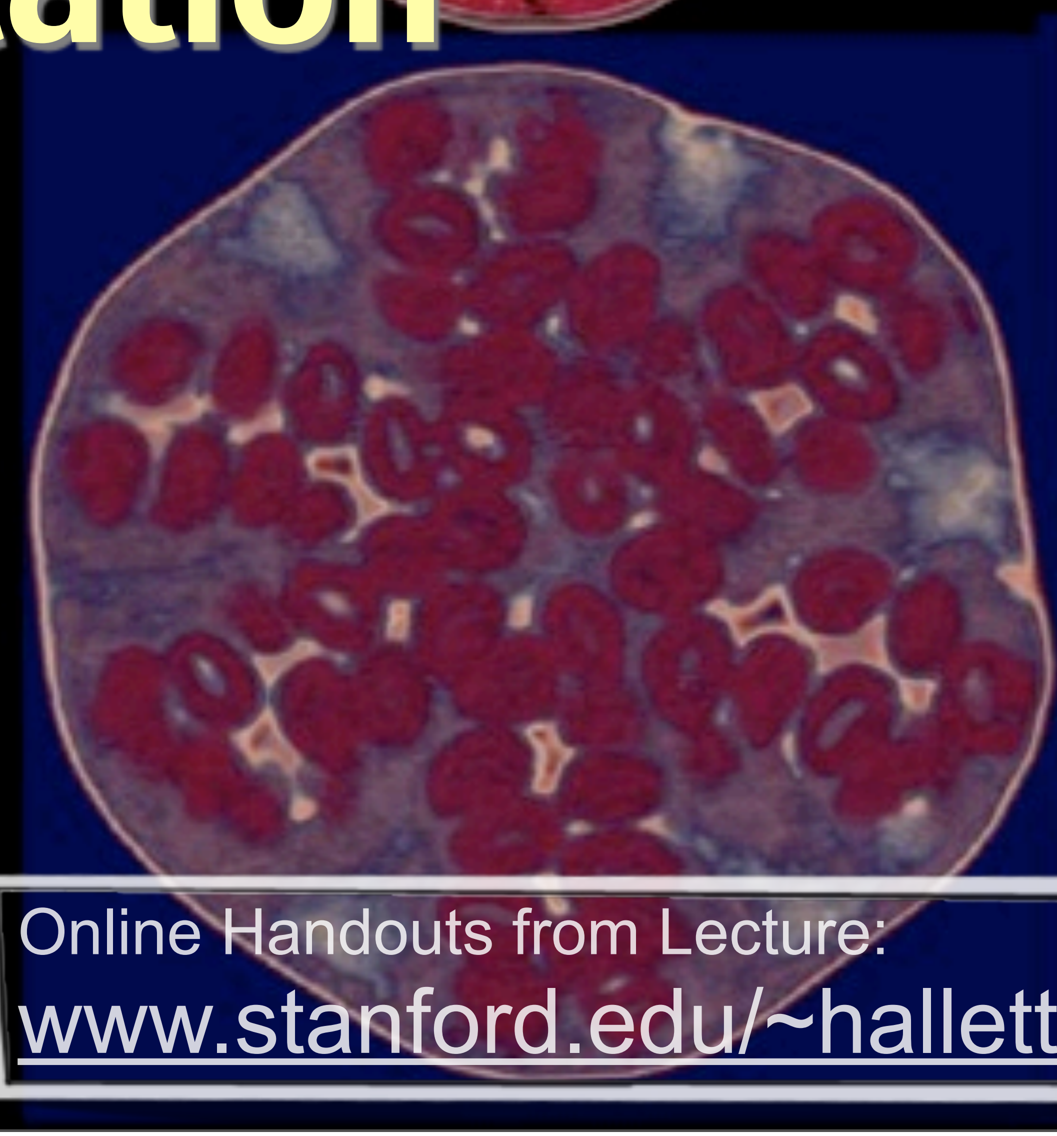


CTA Workflow and Interpretation







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Goals of CTA workflow

- Process studies efficiently
- Capture all appropriate charge codes
- Provide access to thin-slice datasets for radiologist interpretation and review
- Provide timely reports to referring clinicians / services

Coordinated Efforts Yield Best Results

- Physician-directed - for primary interpretation
- Technologist-directed - for protocol-driven reconstructions and measurements

Physician -Directed CTA

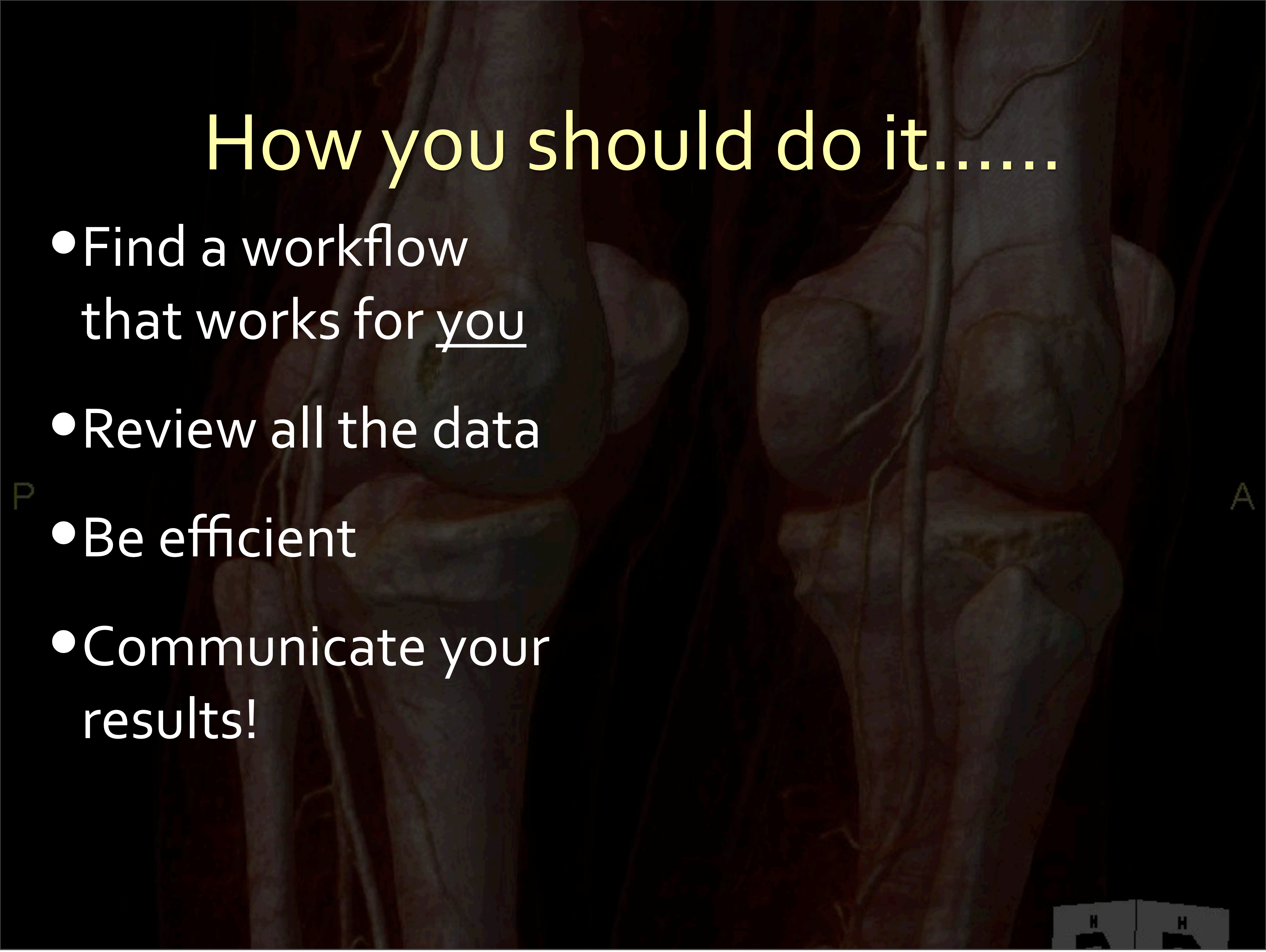
- Volumetric Interpretation via:
  - Workstation
  - Thin Client - Server
  - PACS
- Like Ultrasound, “Clarify” images obtained by 3D Lab / Techs
- Output:
  - Sent to PACS, emailed to referring MD
    - can also real-time “consult”

Technologist (3D Lab) Tasks

- Template-Driven processing of cases:
  - Segmentation
  - Detailed measurements, volumes
  - Consistent output format
- Triage urgent exams
- Temporal tracking of measurements (AAA)
- Transfer of data to MDs, clinical reports, and PACS

Interpretation: How I do it........

- RTs: process CPR, MIP, volumes
- Read from thin client whenever possible
- VR Overview then review axials
- Targeted interactive STS MIP and MPR evaluation of abnormalities
- My pertinent images - sent to PACS as a series
- VR images, stenosis evaluation emailed to referring MD
- Web-based "consult" feature: Use for intra-op consultation



How you should do it……

- Find a workflow that works for you
- Review all the data
- Be efficient
- Communicate your results!

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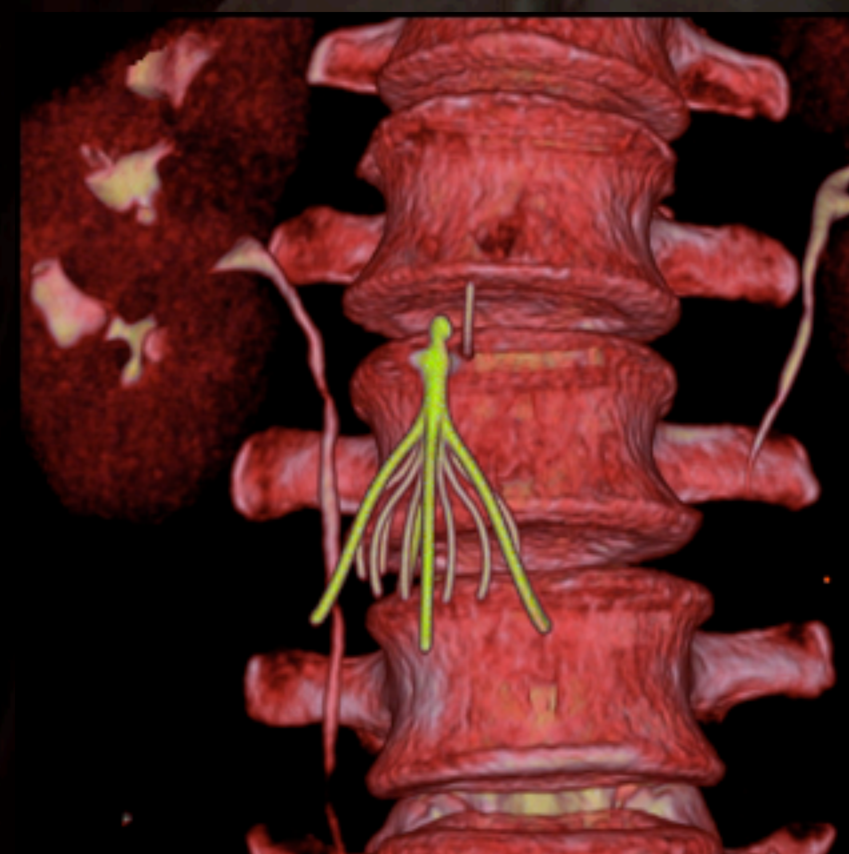
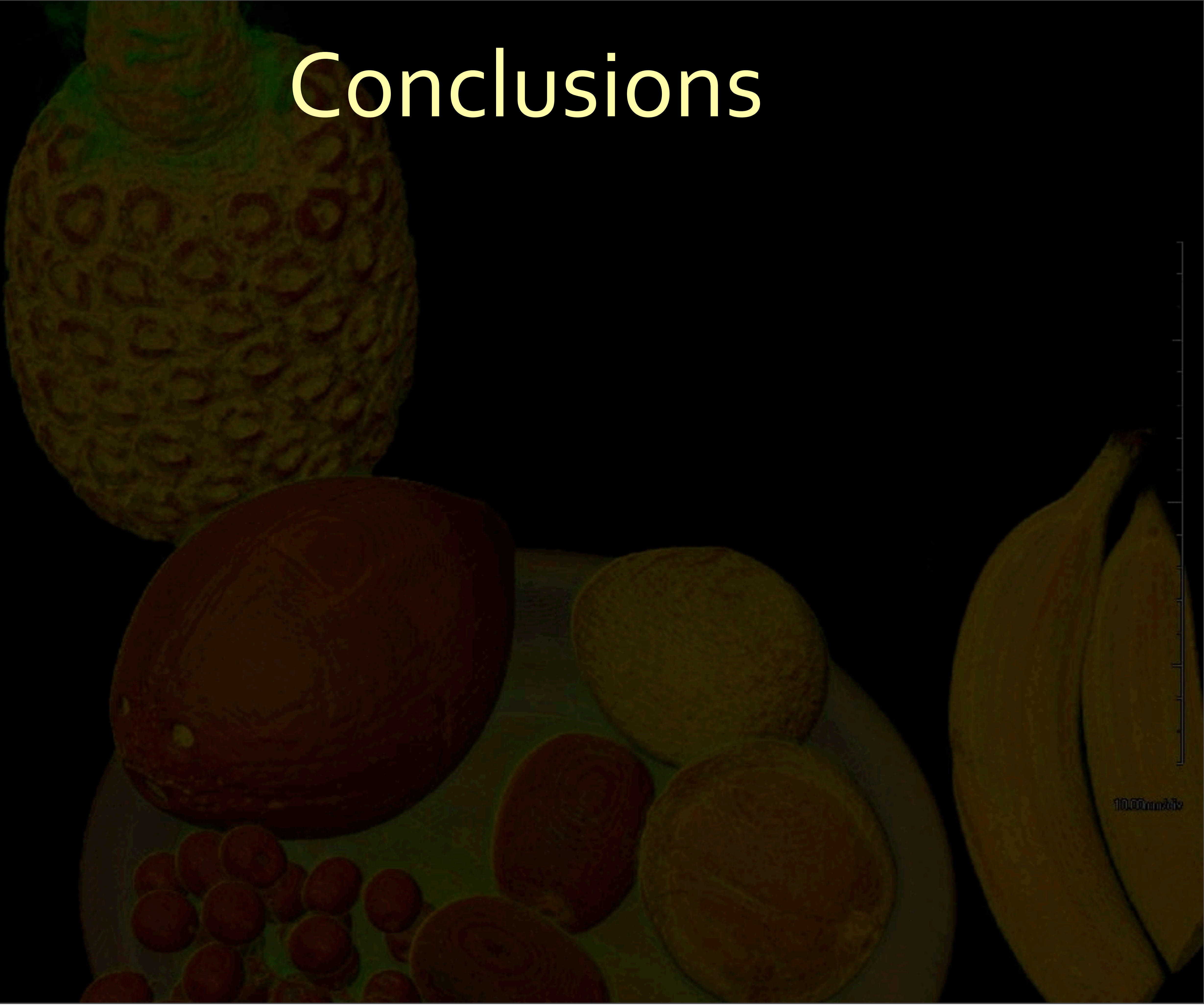


Conclusions



Conclusions

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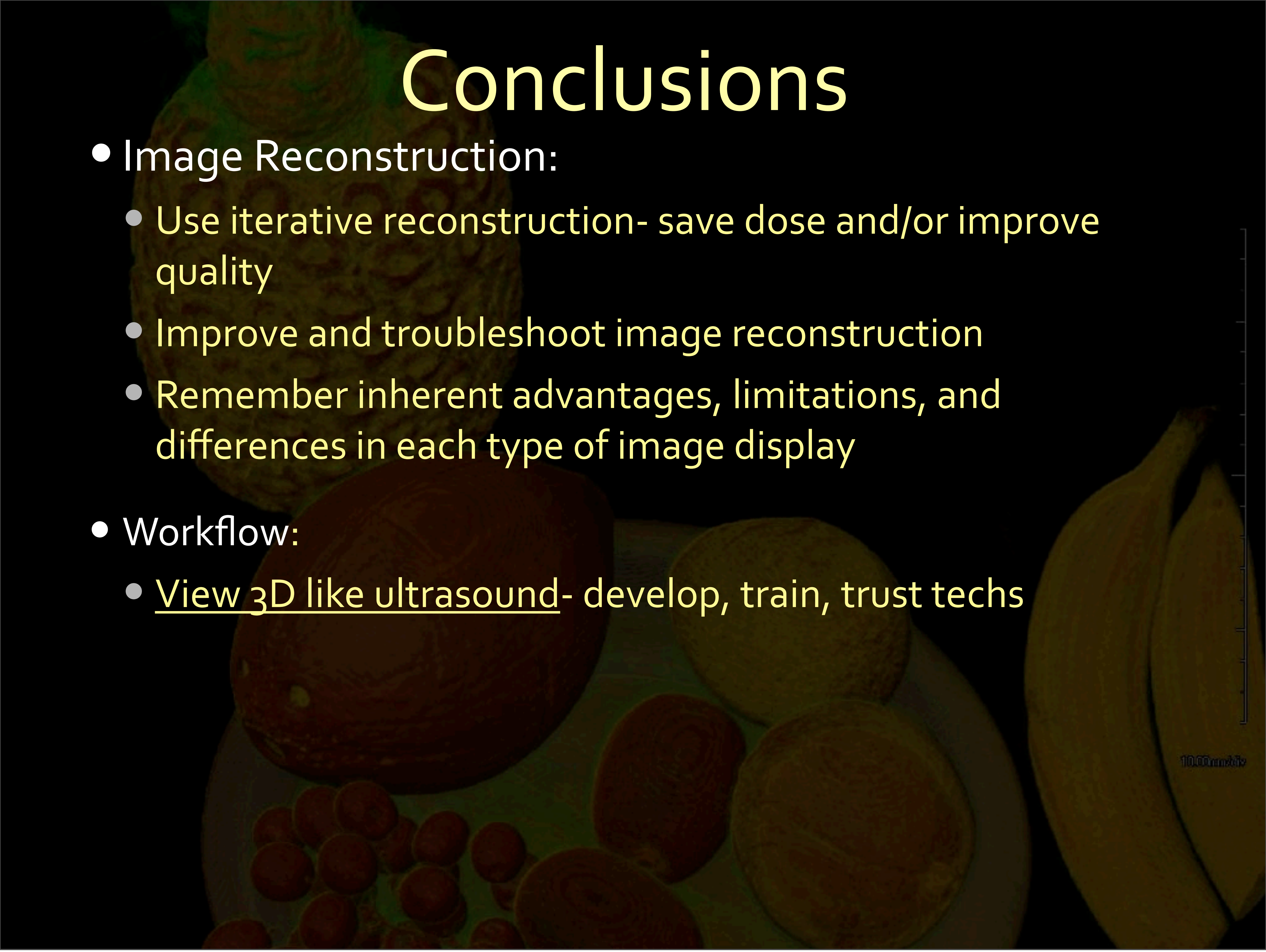
  - Use iterative reconstruction- save dose and/or improve quality
  - Improve and troubleshoot image reconstruction
  - Remember inherent advantages, limitations, and differences in each type of image display



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- Workflow:
  - View 3D like ultrasound- develop, train, trust techs
- Interpretation:
  - Develop a consistent reading algorithm, always have the source (thin) data available
  - Share your results!

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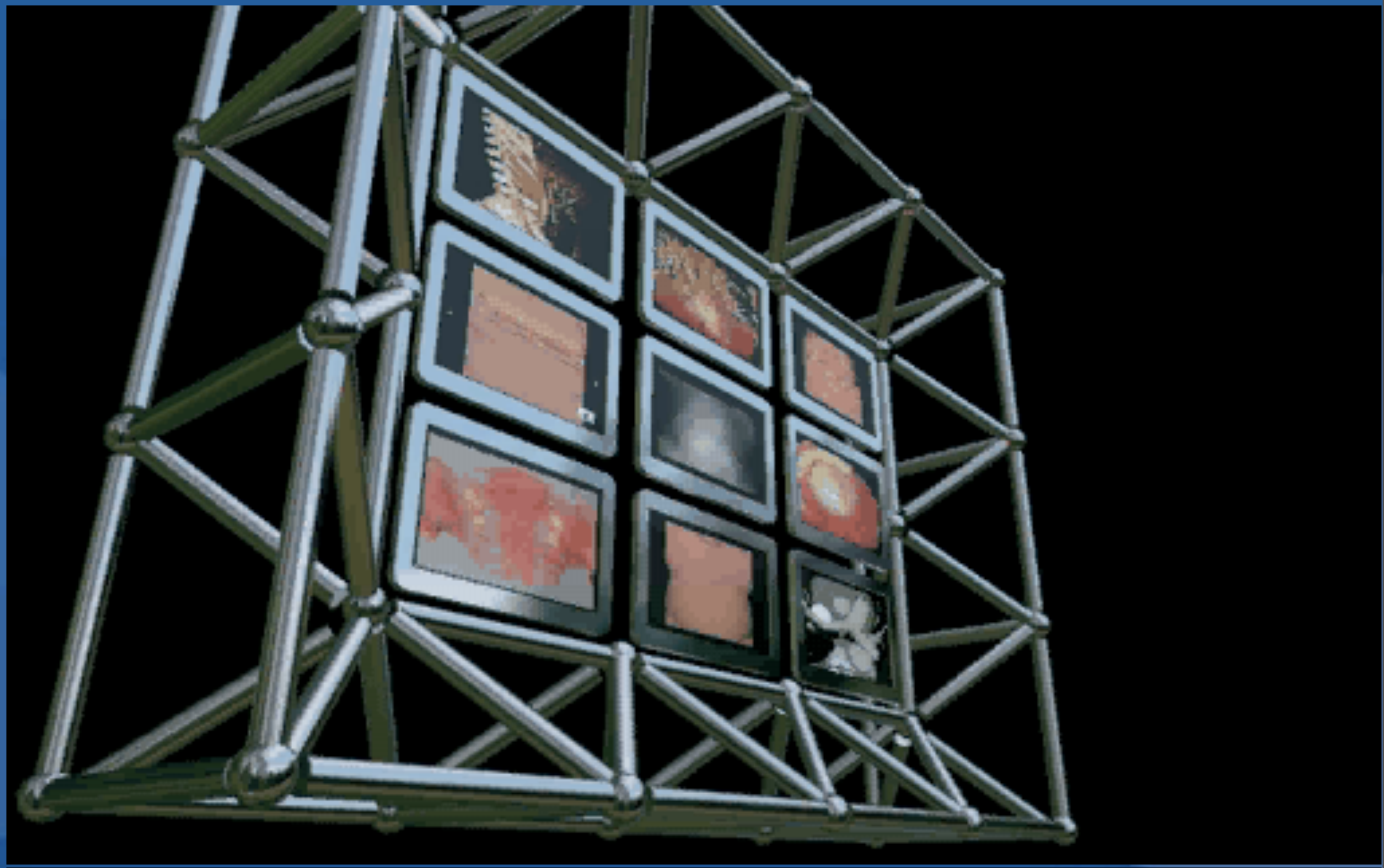
Special Thanks:

TeraRecon
Vital Images



Further Reading:

- Image Reconstruction:
  - Rubin GD, Sedat P, Wei JL: *Ch. 6. Postprocessing and Data Analysis.* In: Rubin GD and Rofsky N. CT and MR Angiography: Comprehensive Vascular Assessment Lippincott, Williams and Wilkins, 2008
  - Barrett JF, *RadioGraphics* 2004;24:1679-1691
  - Ch. 4: Image Reconstruction and Review. In: Lipson SA: MDCT and 3D Workstations. Springer, 2006.
  - Luccichenti G, et al. Eur Radiol 2005; 15: 2146 - 2156
  - Parrish FJ, AJR 2007; 189:528-534
  - Dalrymple NC, RadioGraphics 2005;25:1409-1428
  - Hara AK, et al. Am J Roentgenol. 2009;193(9):764-771
  - Roos JE, et al. Acad Radiol 2009; 16 (6) 646-653.

Further Reading

- CTA Workflow:
  - http://www.imagingcenterinstitute.com/RadInformatics/Volume1_No1/Radinformatics_CTA_0208.asp
  - http://209.85.173.104/search?q=cache:4gicroz9cPMJ:images.ctisus.com/cta_web/12_06/%20AR_12_06_CTA_Jacobs.pdf+%22applied+radiology%22+jacobs+CTA&hl=en&ct=clnk%20&cd=4&gl=us&client=safari
  - http://www.imagingeconomics.com/issues/articles/2004-07_10.asp

Further Reading

- CTA Interpretation Strategies:

  - Ferencik, M. Radiology 2007;243:696-702
  - Saba, et al. J Comput Assist Tomogr. 2007 Sep-Oct;31(5):712-6.
  - Maintz, D. et al. Am. J. Roentgenol. 2002;179:1319-1322
  - Pugliese, F. et al. Radiographics 2006;26:887-904

- OSIRIX (Free Image Viewer for MAC):
  - http://www.osirix-viewer.com/
  - WIKI: http://osirixmac.com/index.php/Main_Page