Image Post-Processing, Workflow, & Interpretation

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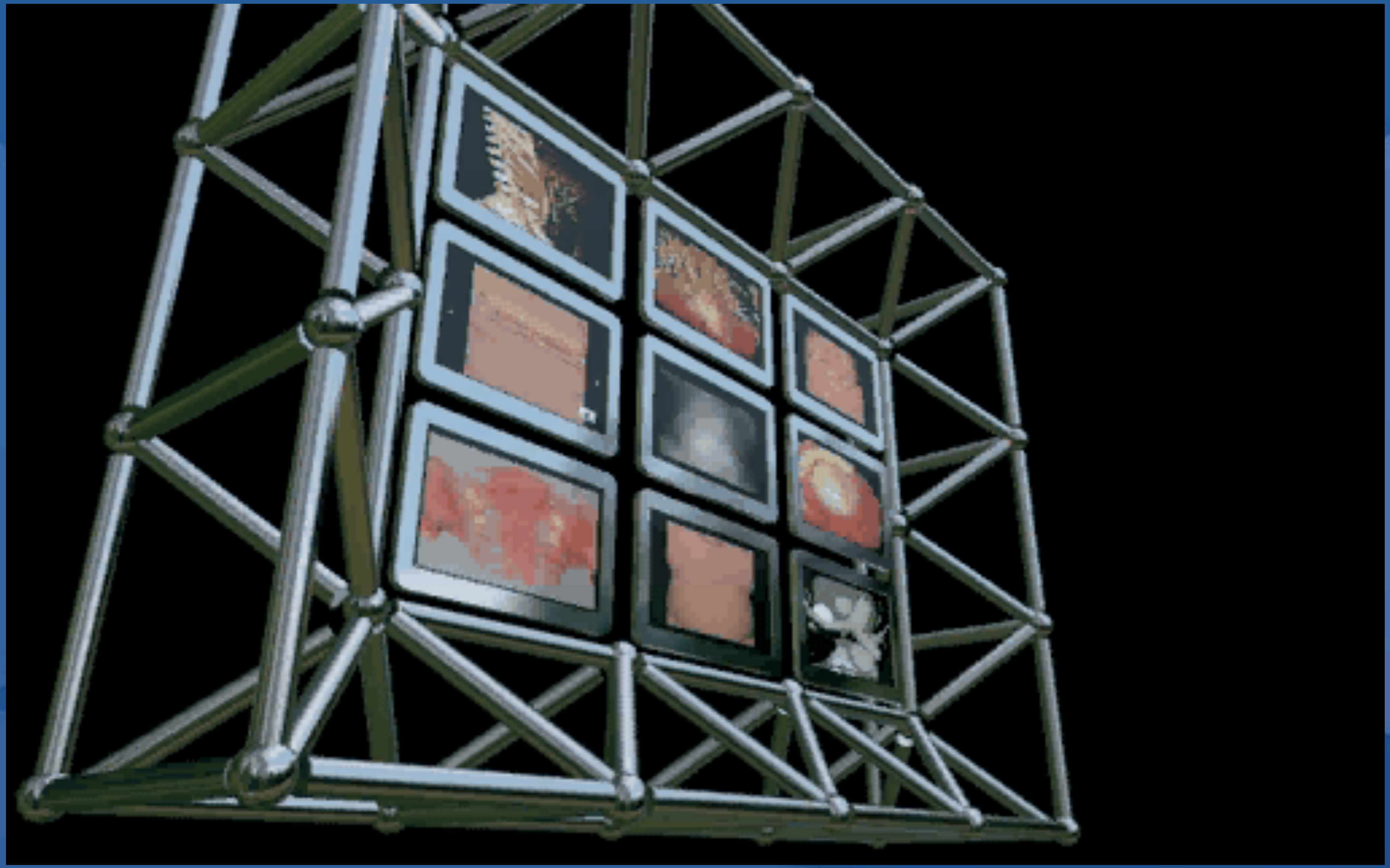

VV-31-10 30 November 2010 1045-1105

RSNA 2010
PERSONALIZED MEDICINE:
In Pursuit of Excellence

Disclosures: None

Online Handouts from Lecture:

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Outline

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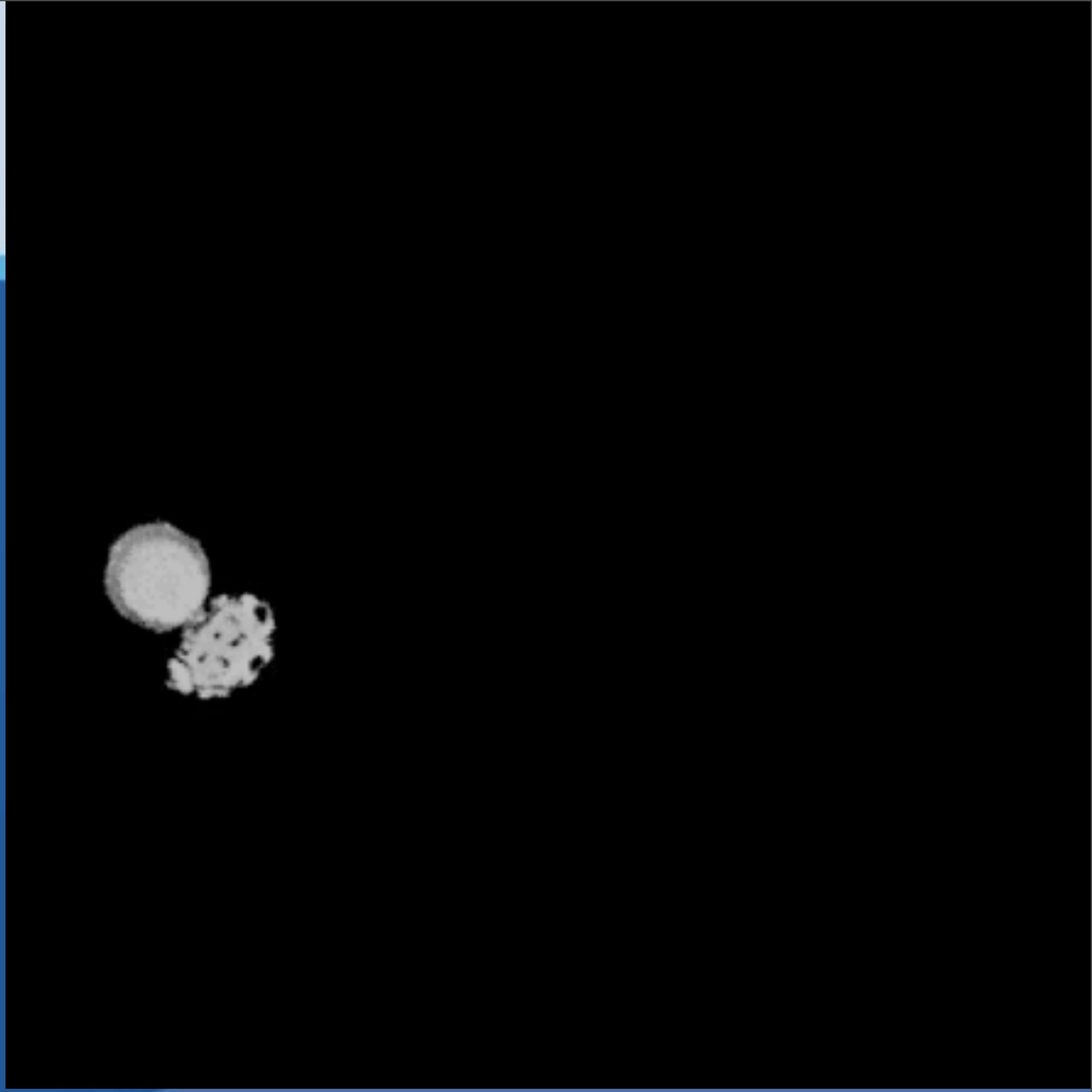
I. Image reconstruction and post-processing techniques

II. CTA Workflow and Interpretation Strategies



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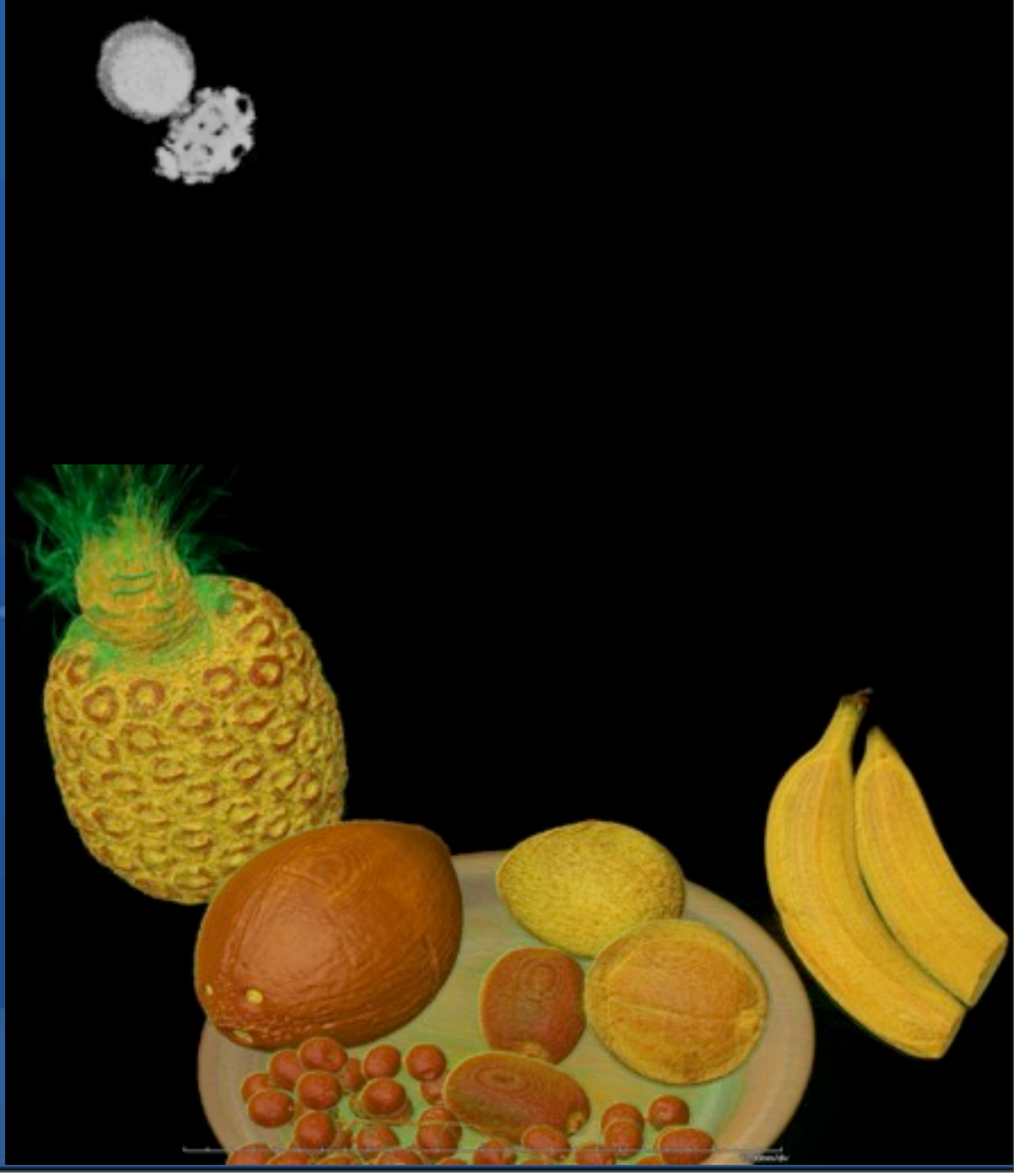
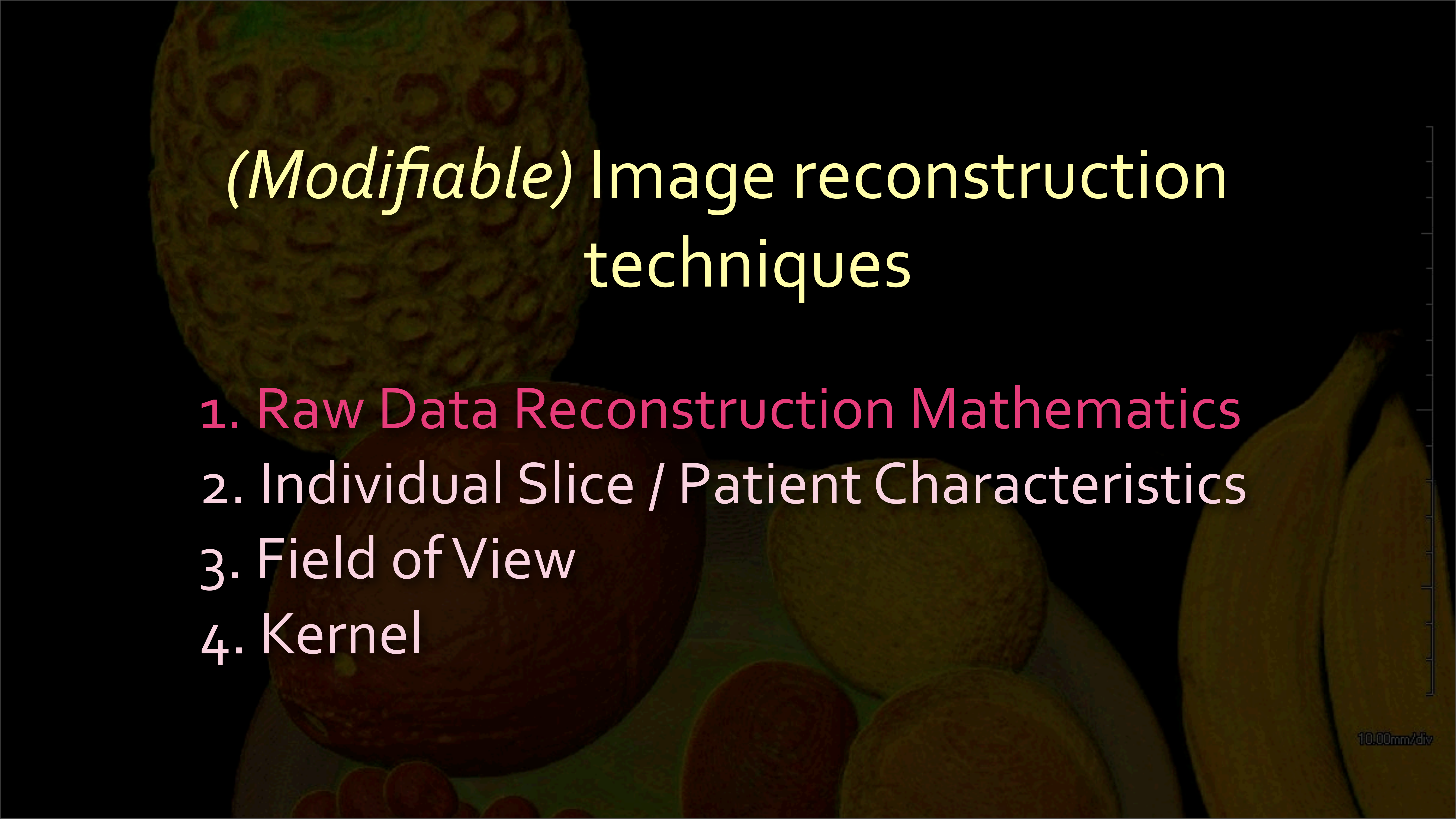


(Modifiable) Image reconstruction techniques

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



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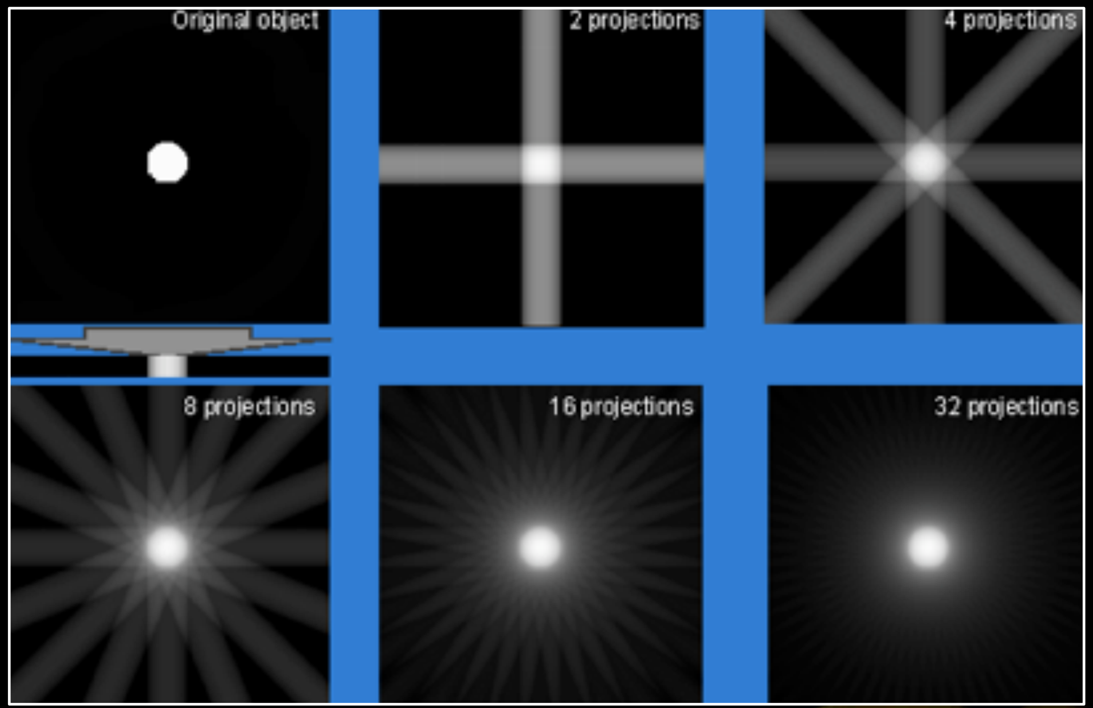
TRADITIONAL Raw Data Reconstruction



- 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

10.00mm/div

" New" Data Reconstruction Mathematics

- <u>**Iterative Reconstruction**</u> (IR)
  - Used in SPECT and PET years ago……
  - Models CT system optics (geometric information) as well as statistics (noise)
    - ➡ Compare 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>

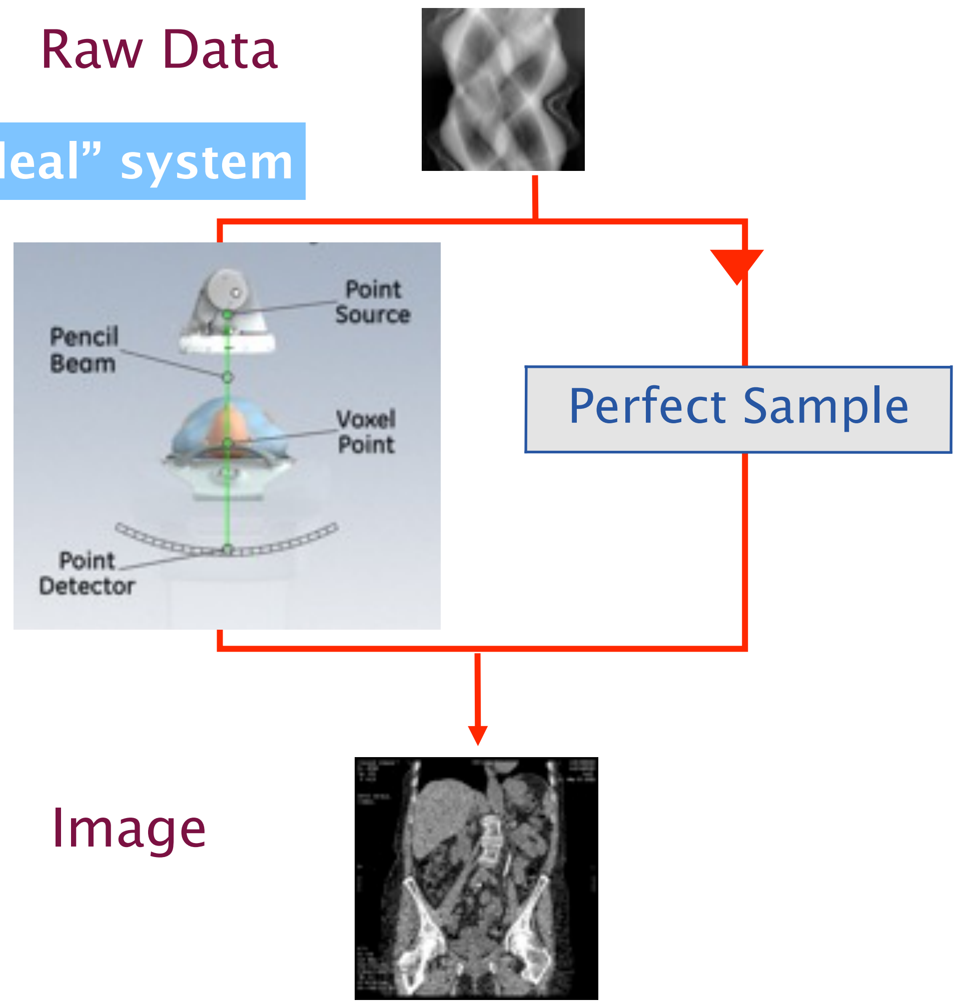
Hara AK, et al. Am J Roentgenol. 2009;193(9):764-771

Conventional FBP vs. Iterative Reconstruction

FBP Reconstruction

Raw Data

Assume "ideal" system

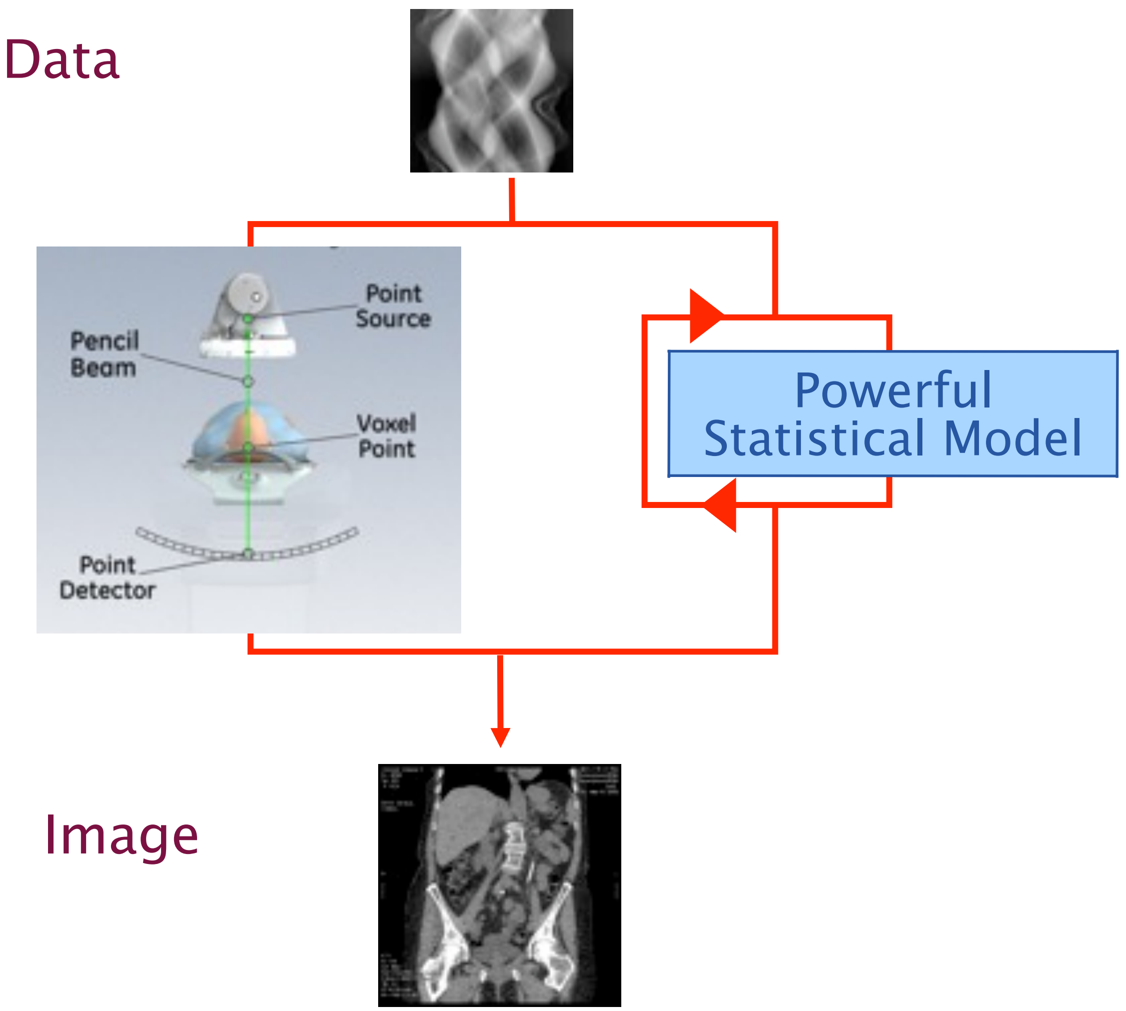


Image

Simple
Fast reconstruction
High Noise

ASiR Reconstruction

Raw Data

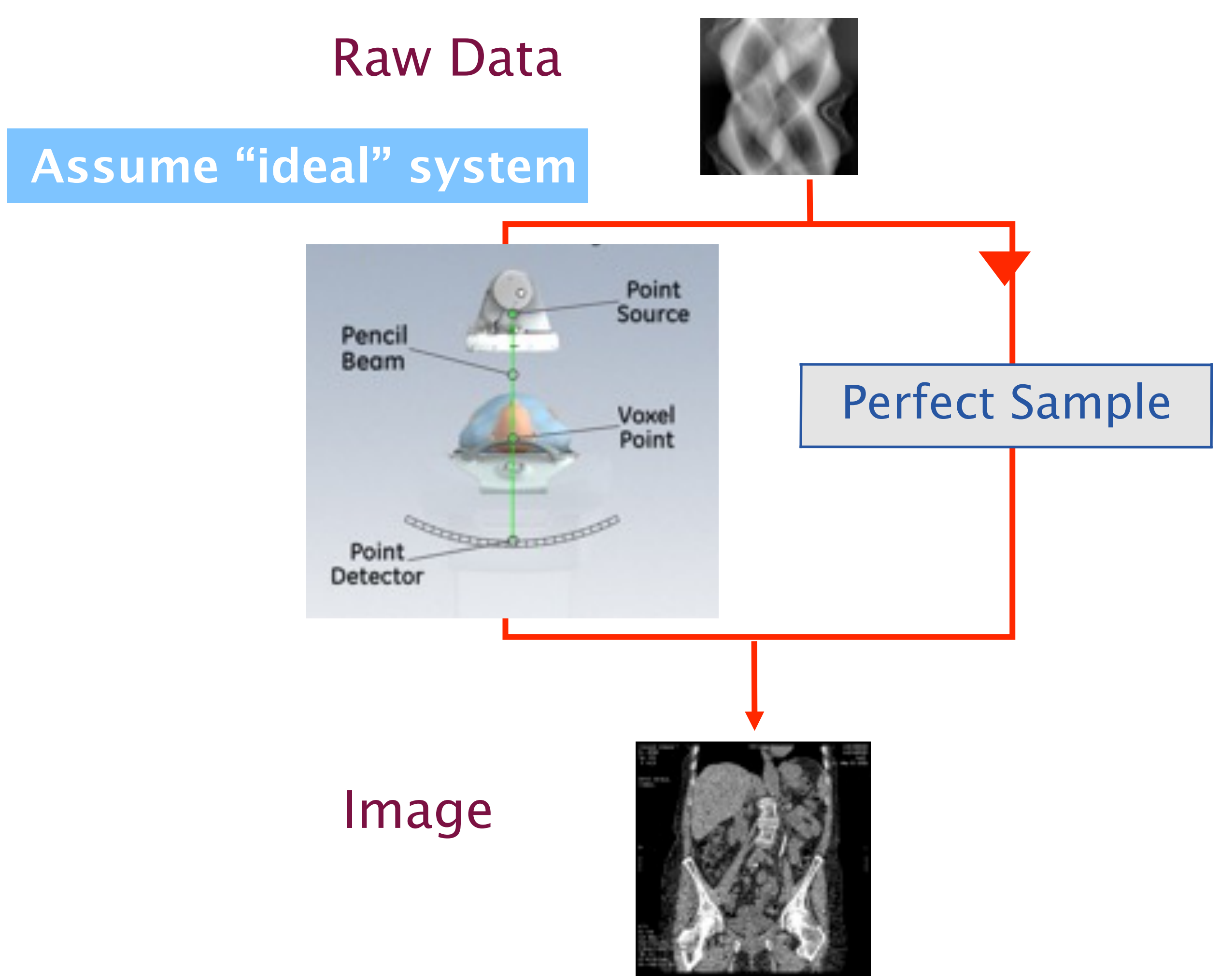


Image

Better Image Quality
Low Noise
Lower Dose

Conventional FBP vs. Iterative Reconstruction

FBP Reconstruction



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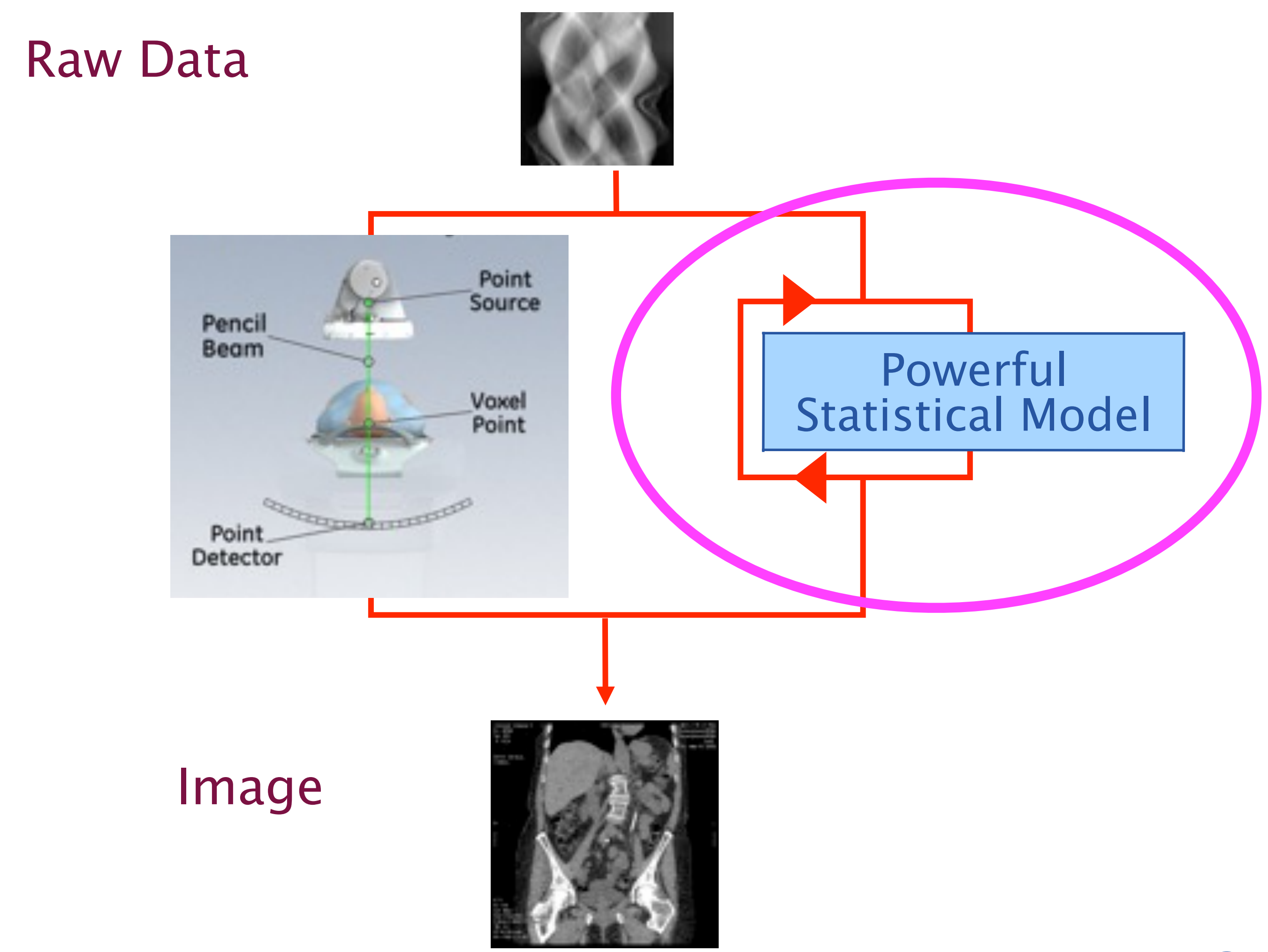

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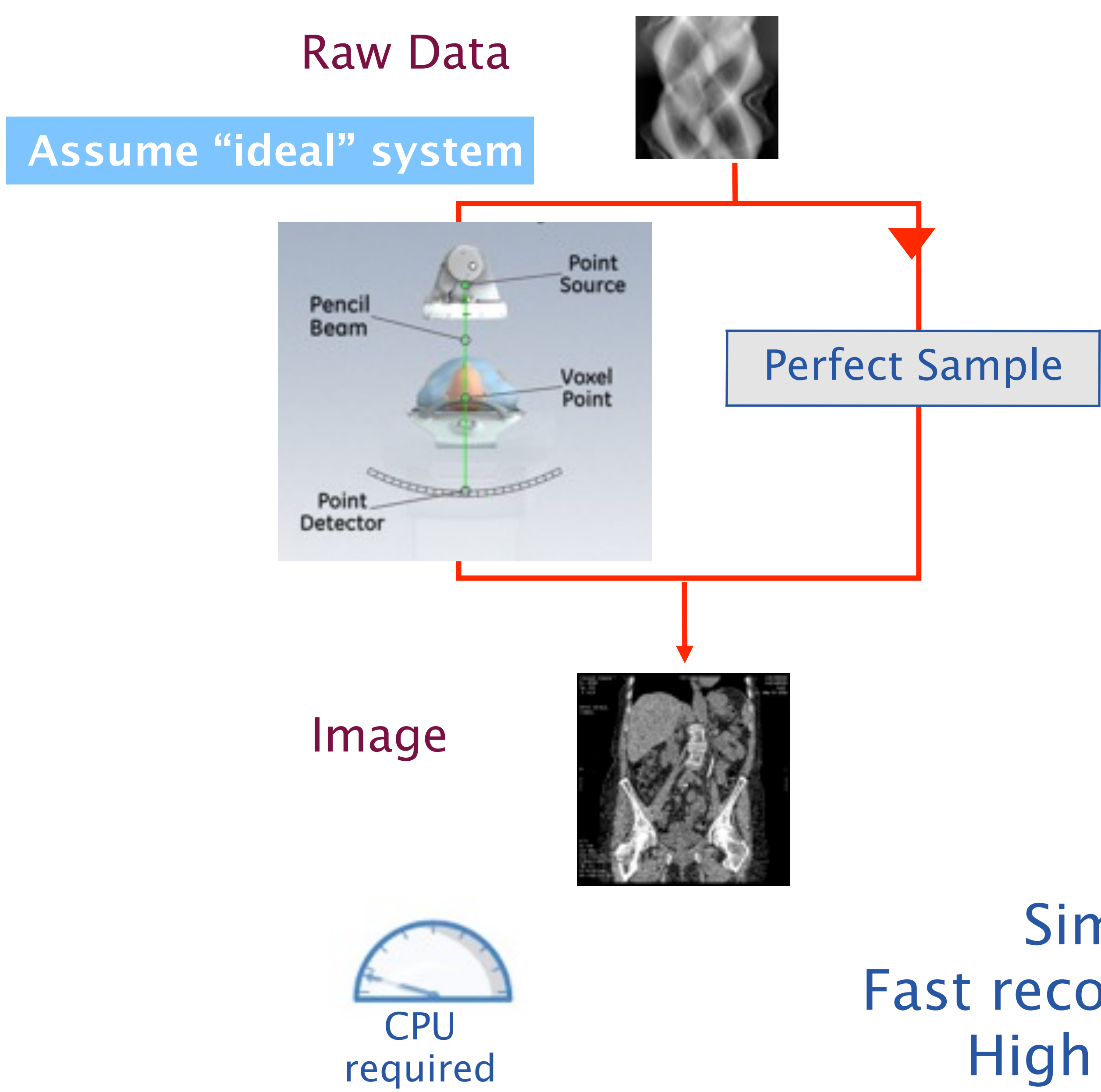

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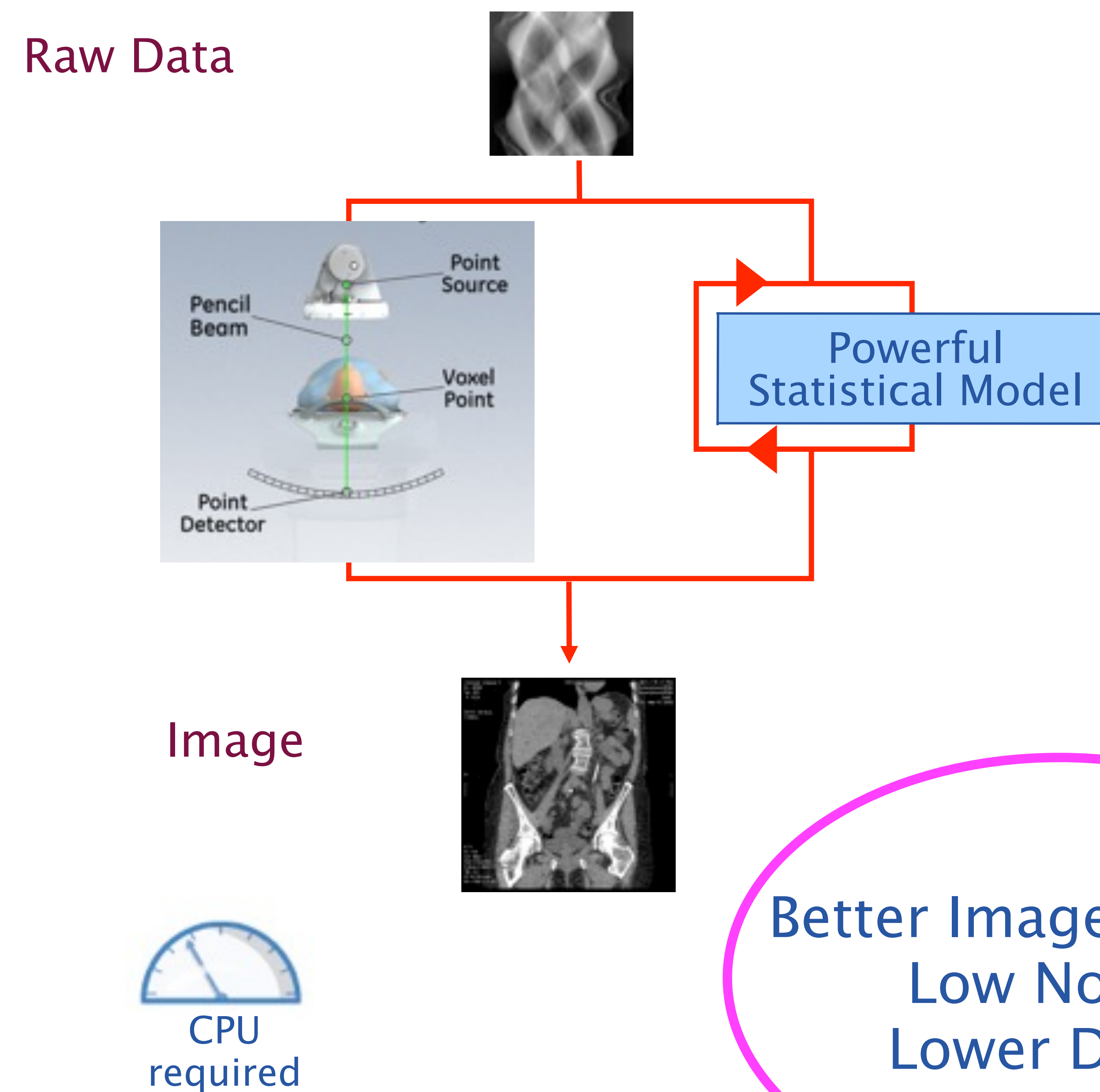

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Iterative Reconstruction Benefits

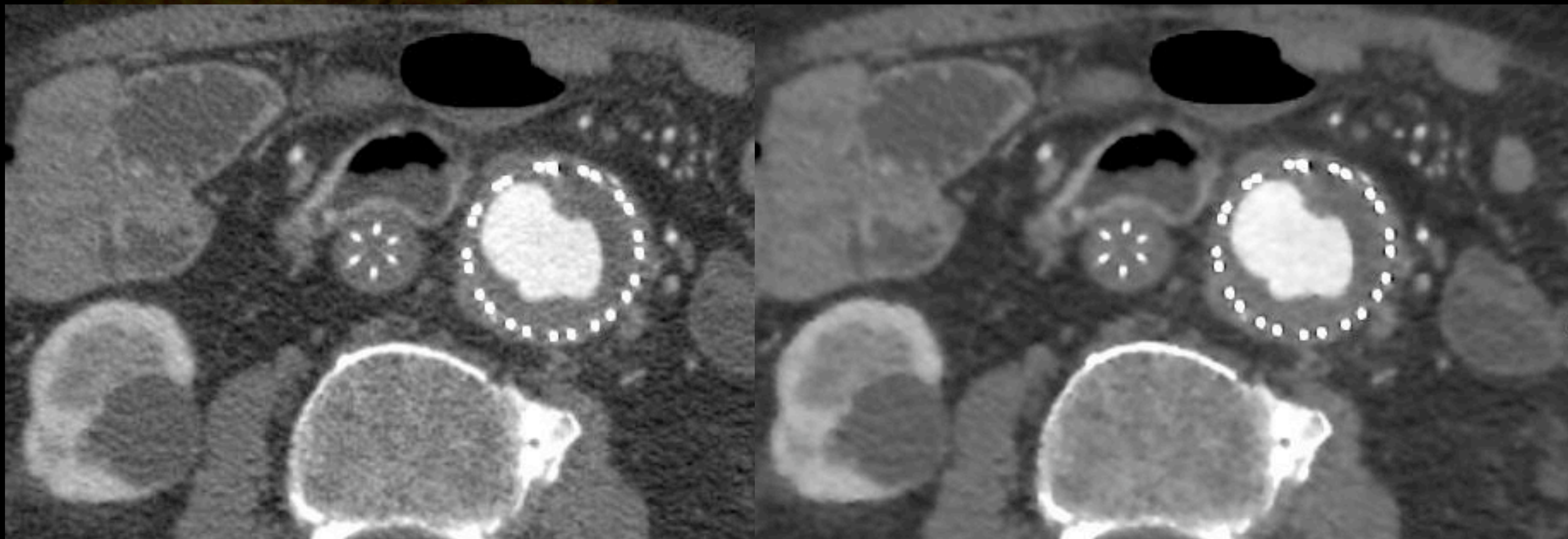
- Up to 50% dose reduction is possible at same image noise
- OR: Improved image quality at same dose
- 40% improvement in low contrast detectability

2007, Std.
Technique
CTDI=19

2008
ASiR
CTDI=9

Images courtesy of Mayo Clinic Arizona

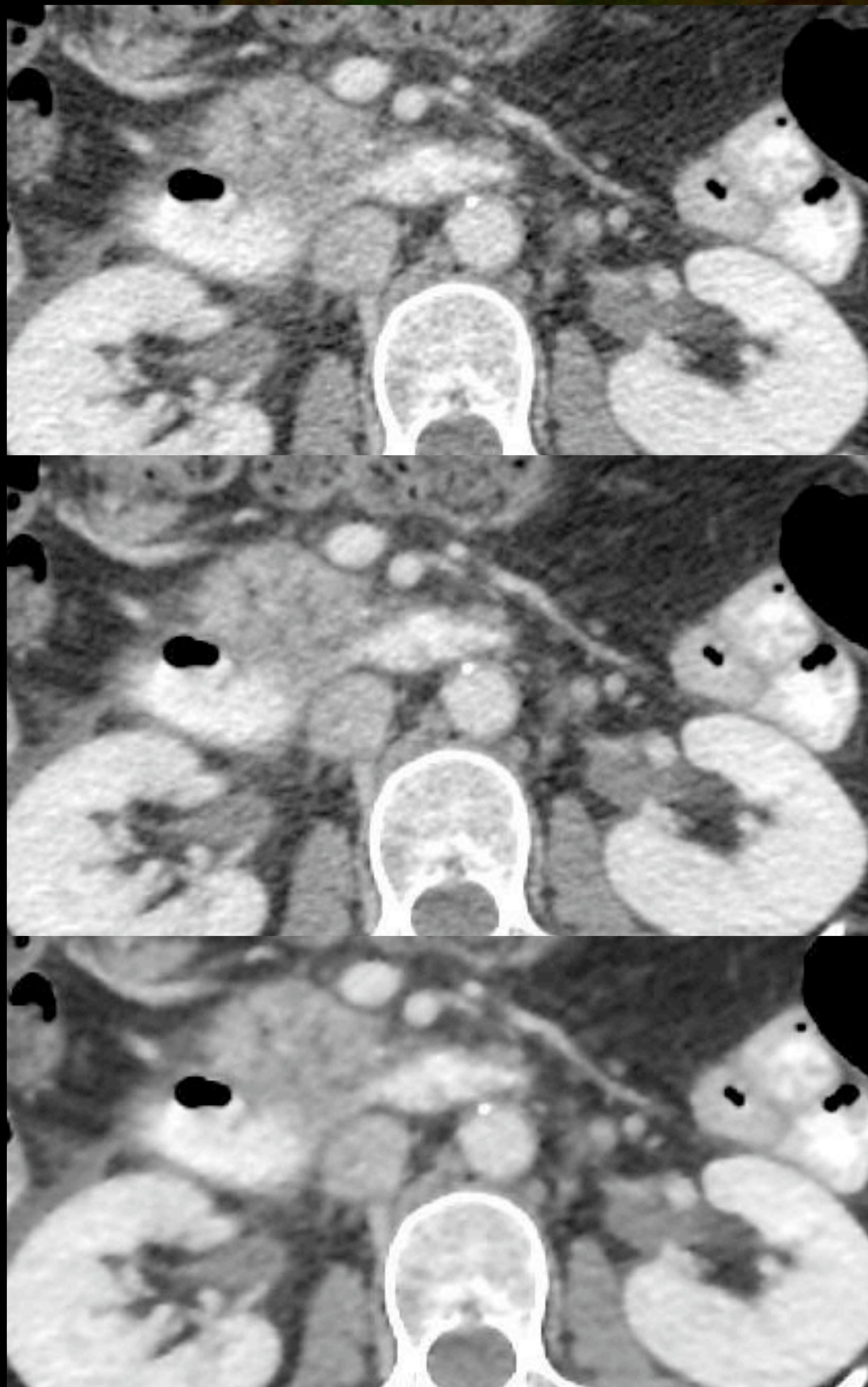
Iterative Reconstruction: Appearance



0% IR **100% IR**

10.00mm/div

Iterative Reconstruction Appearance



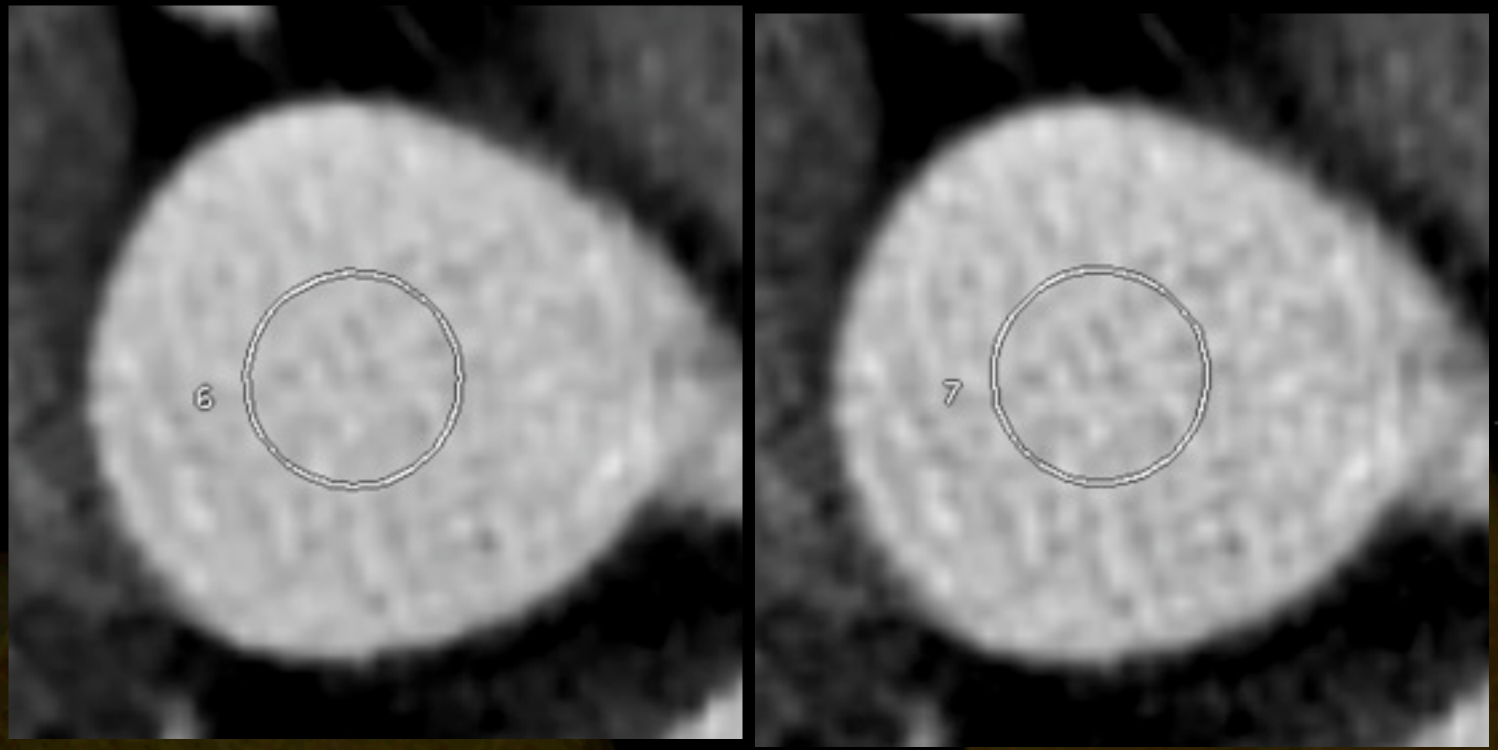
0% IR

40% IR

100% IR

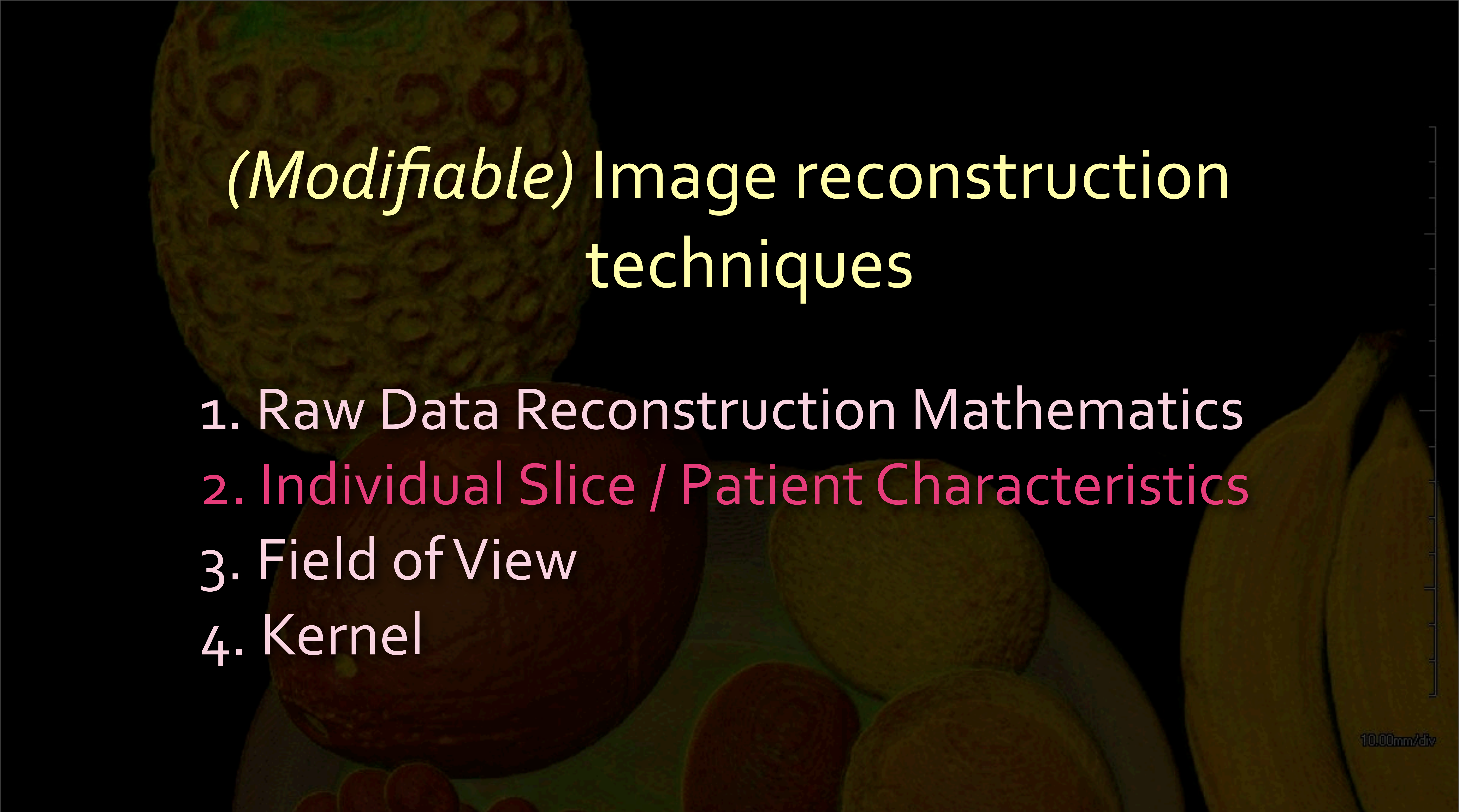
Iterative Recon for CCTA: the ERASIR STUDY

- 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 (signal)	**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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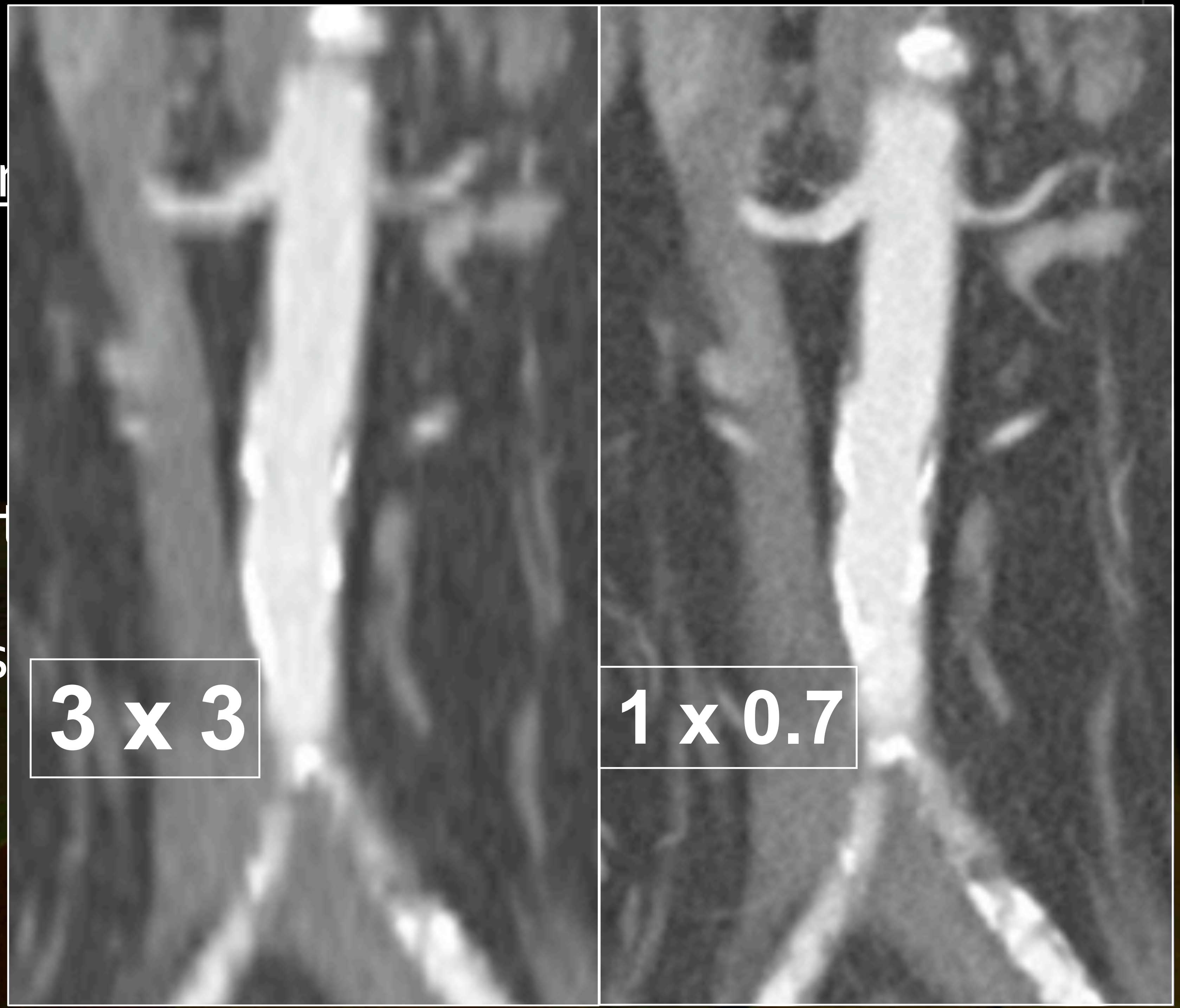

Tweaking / Help for Tough Datasets

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

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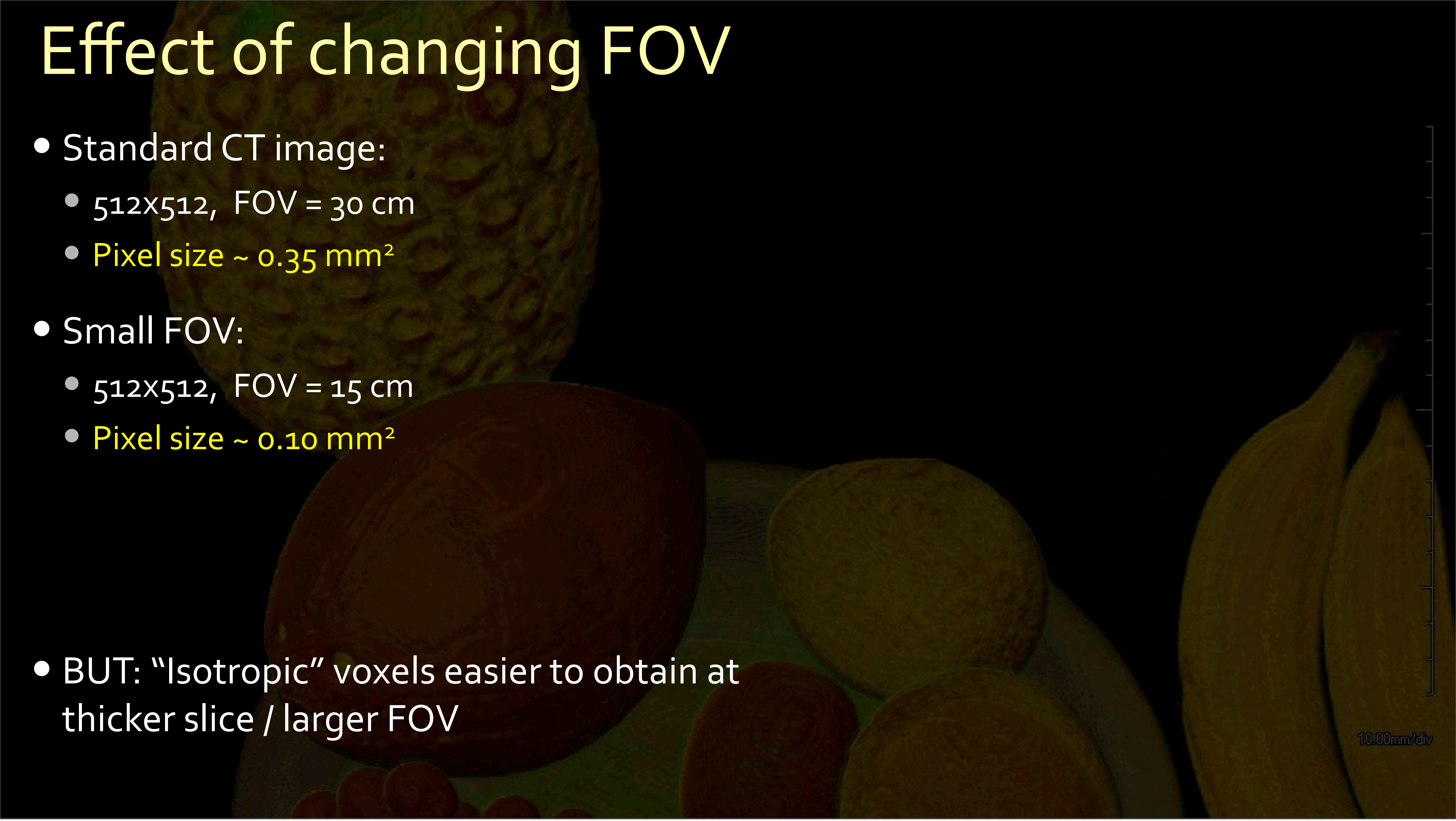
10.00mm/div

Effect of changing FOV

- Standard CT image:
  - 512x512, FOV = 30 cm
  - Pixel size ~ 0.35 mm^2
- Small FOV:
  - 512x512, FOV = 15 cm
  - Pixel size ~ 0.10 mm^2
- BUT: “Isotropic” voxels easier to obtain at thicker slice / larger FOV



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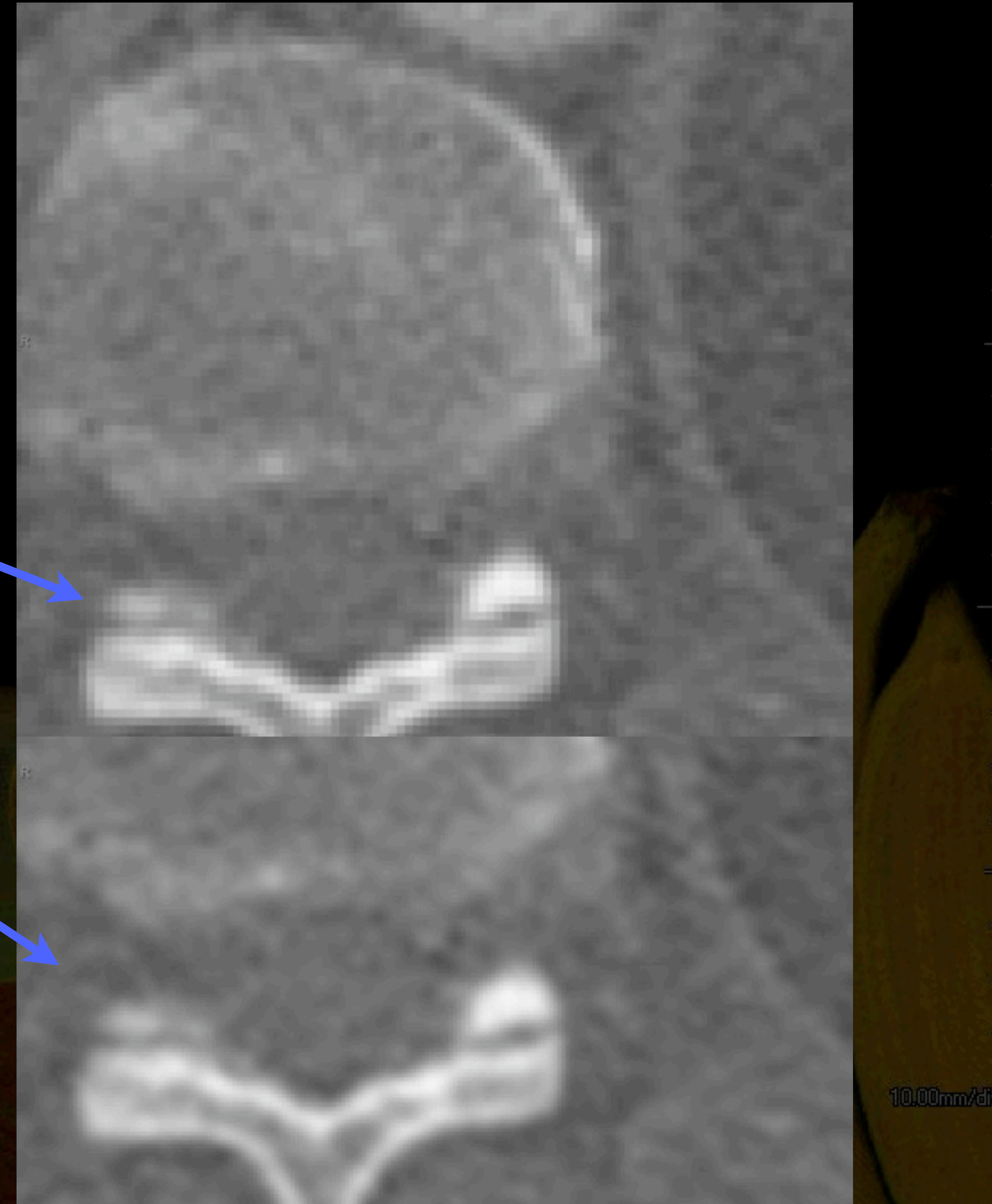

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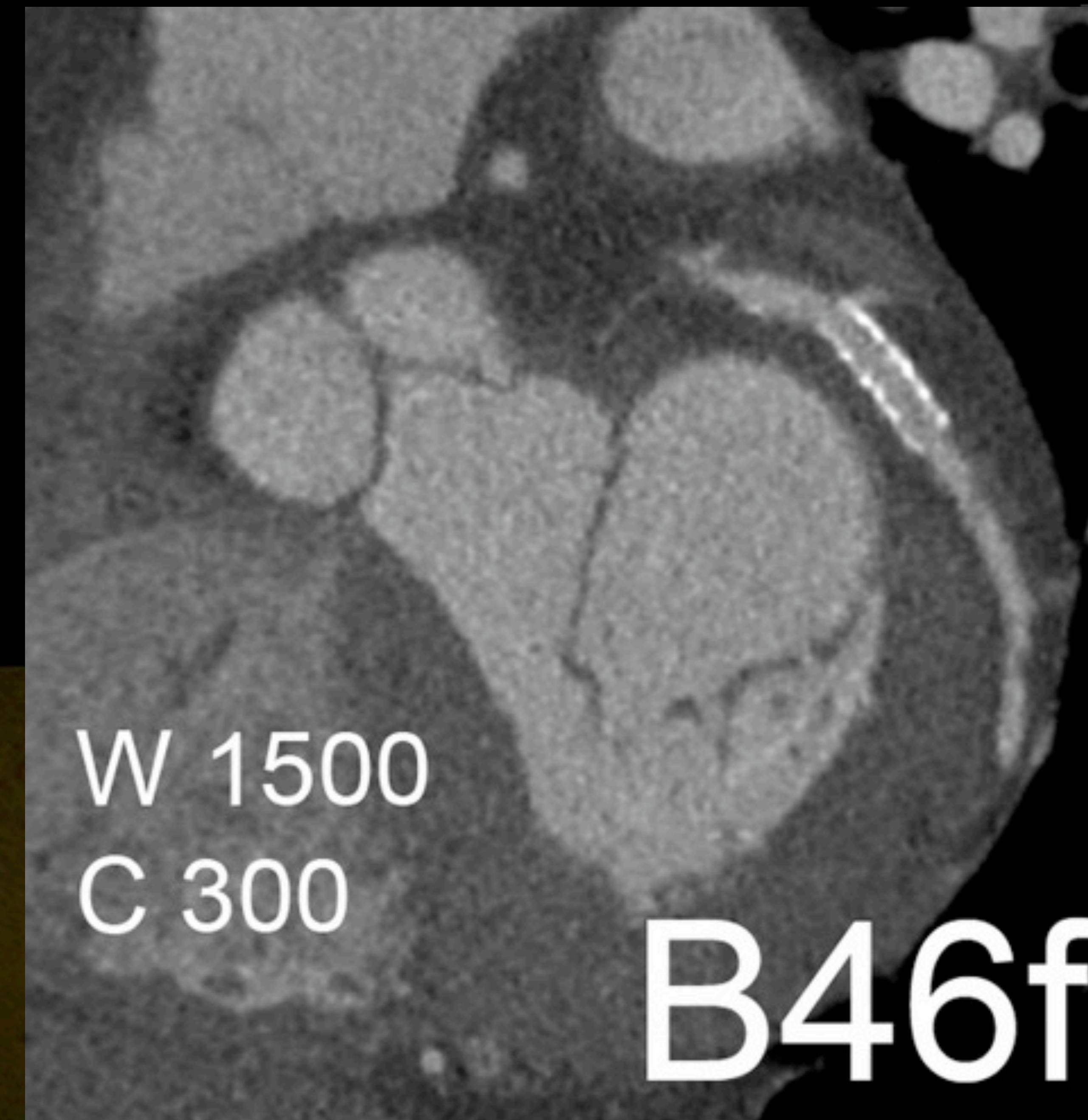
Effect of Recon Kernel

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



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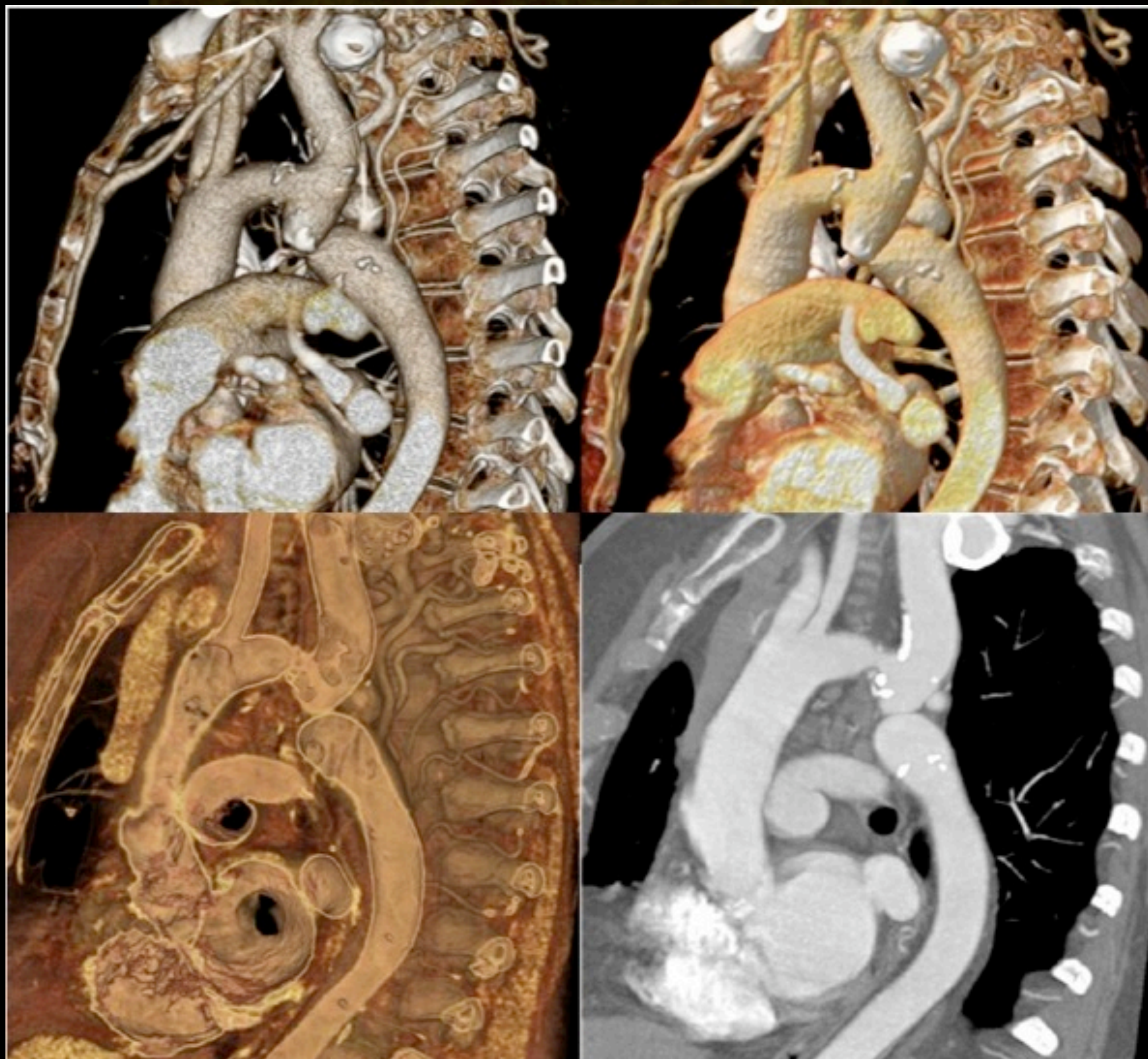
Pugliese, F. et al. Radiographics 2006;26:887-904

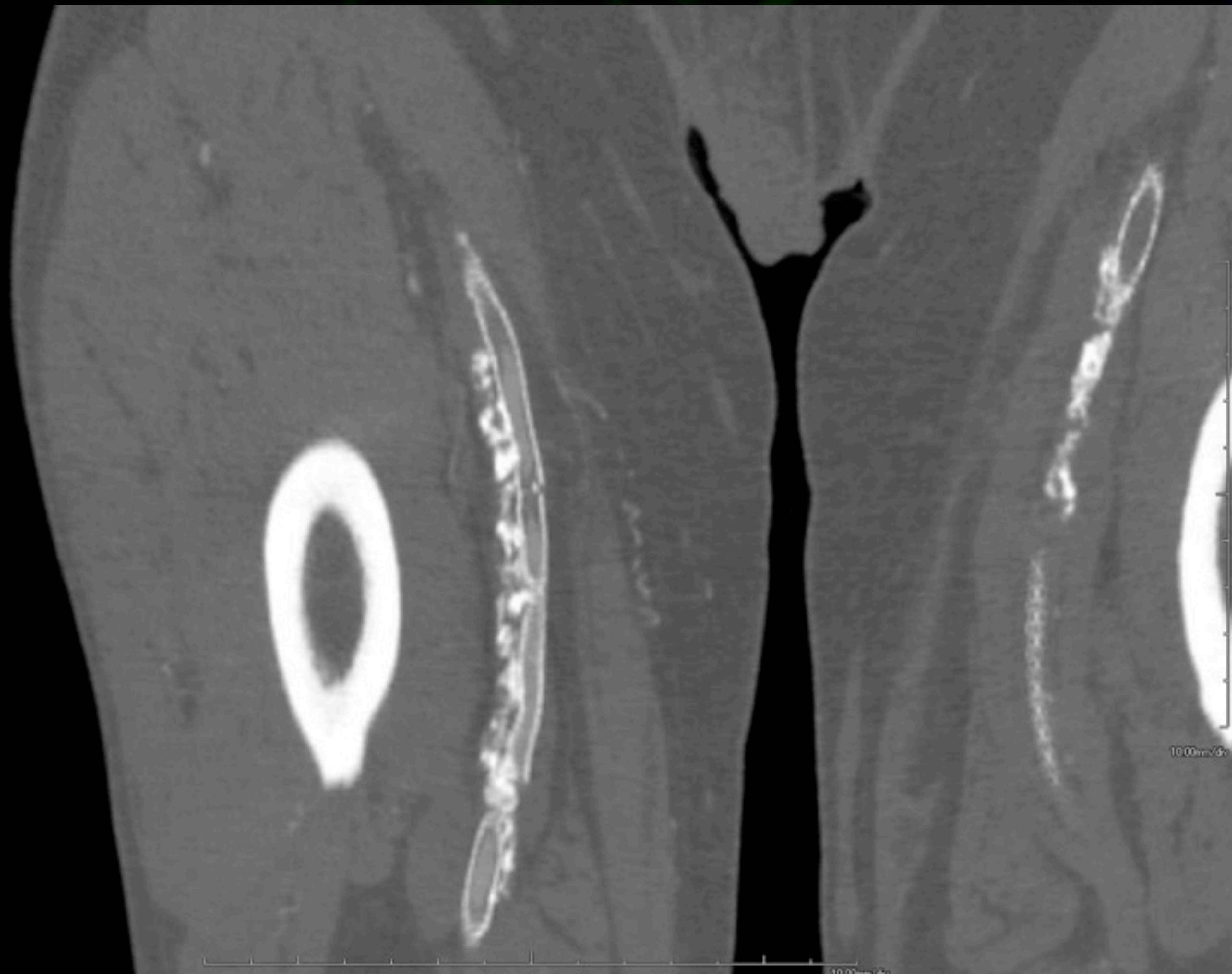
Image Post-Processing



Review of Image Types
New Directions

Reconstruction "Alphabet Soup"

- MPR
- MIP
- MINIP
- AIP (Raysum)
- CPR
- MP-CPR
- VR
- BPI-VR
- V-IVUS
- 4-D



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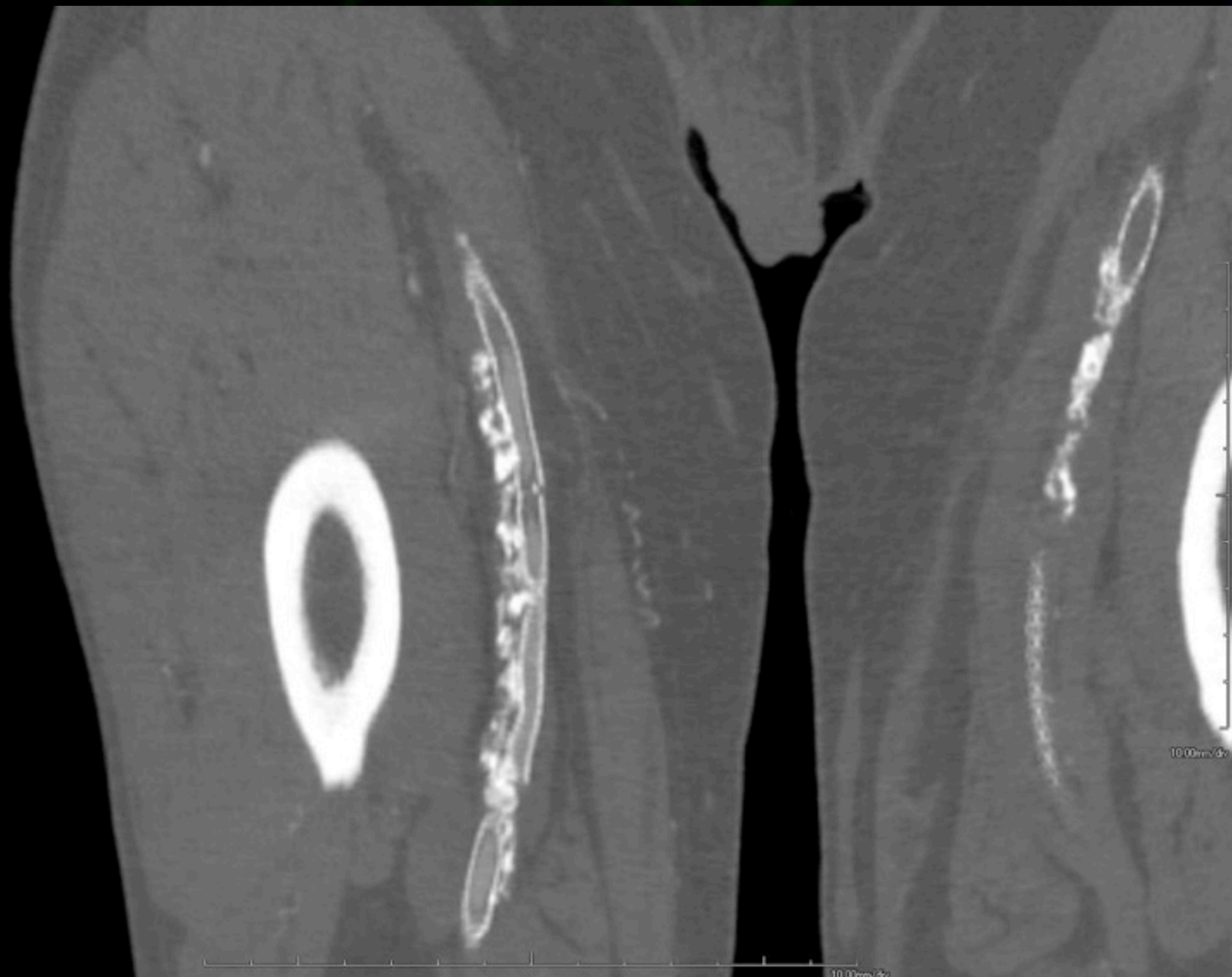

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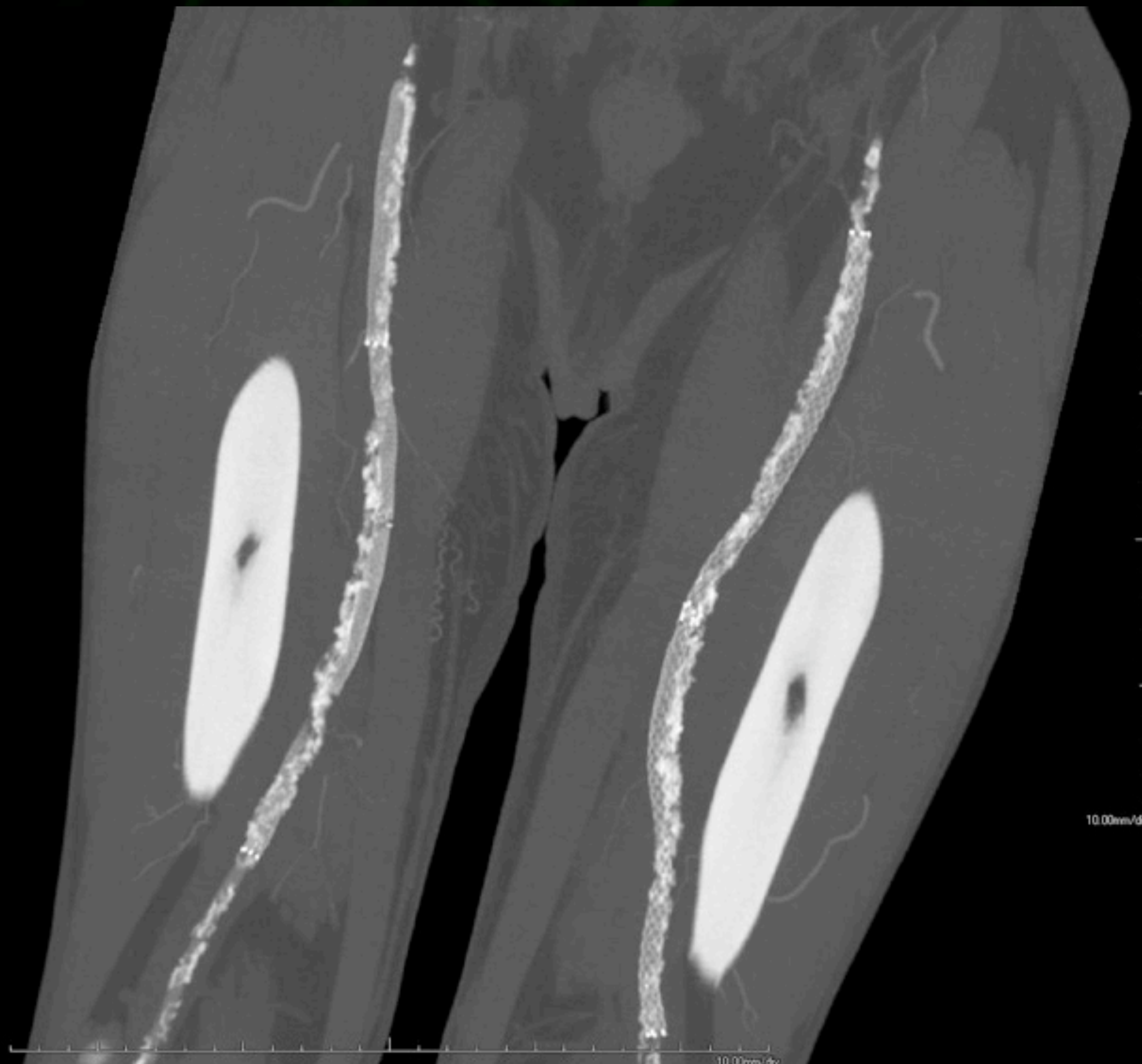

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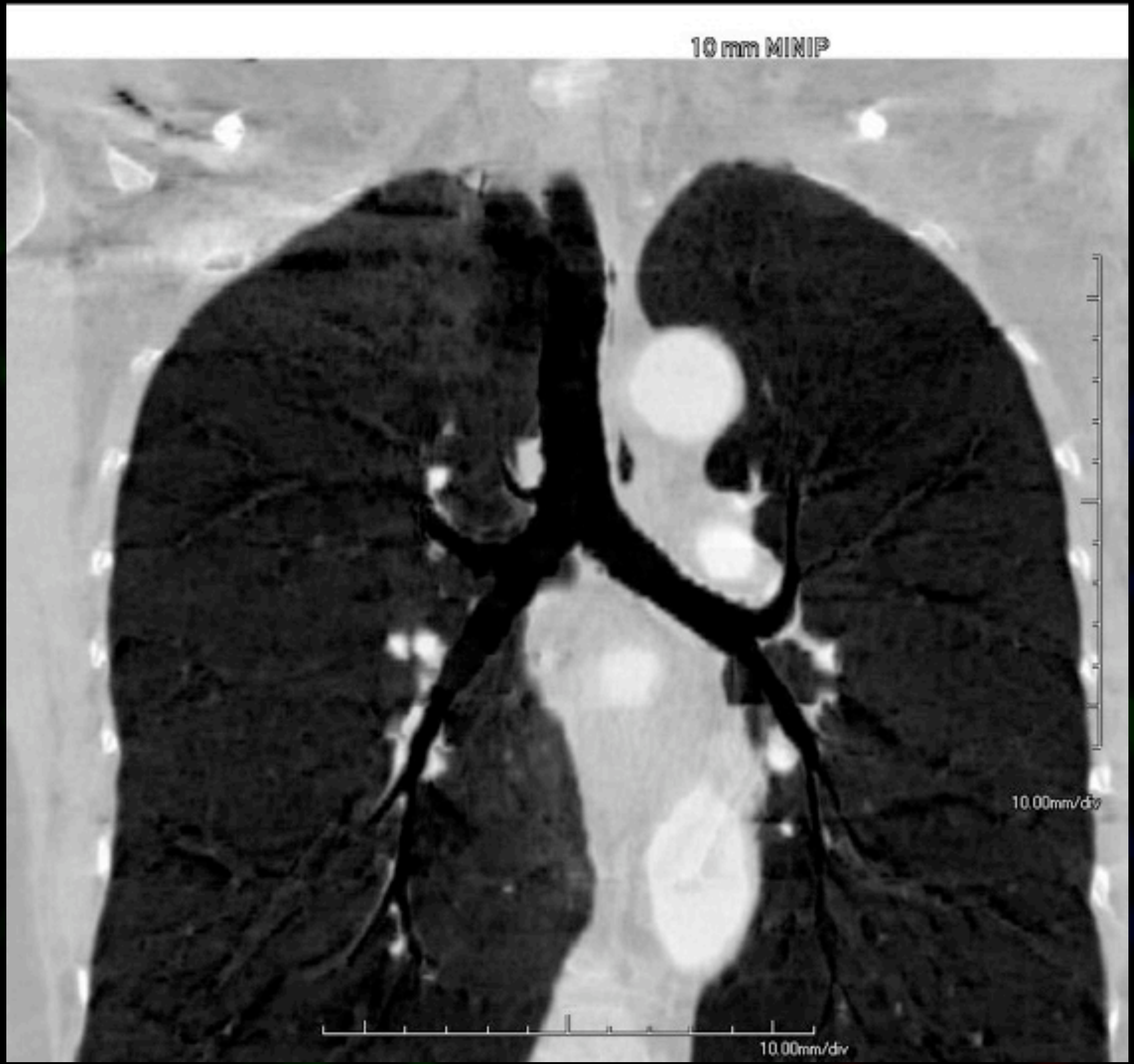

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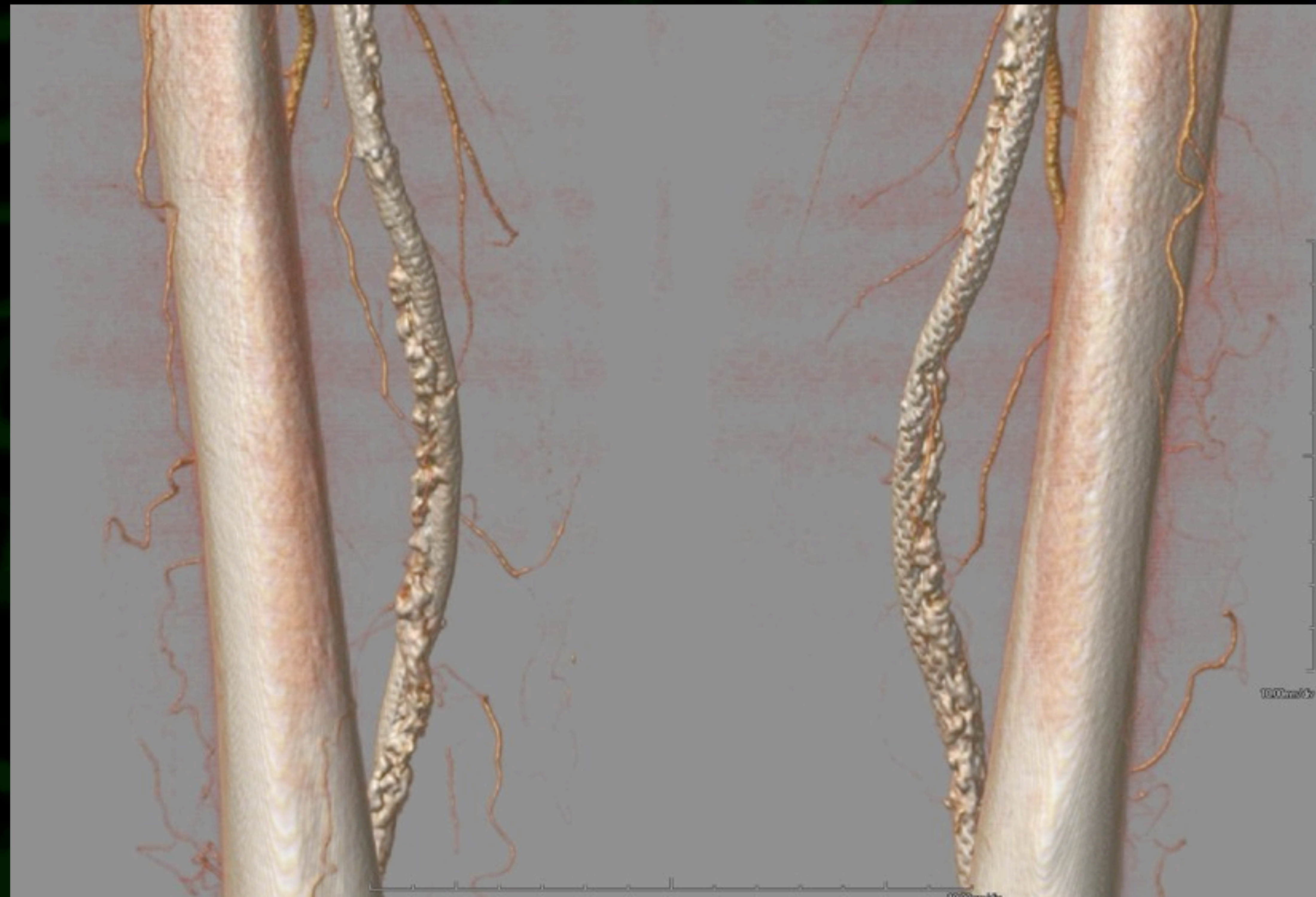

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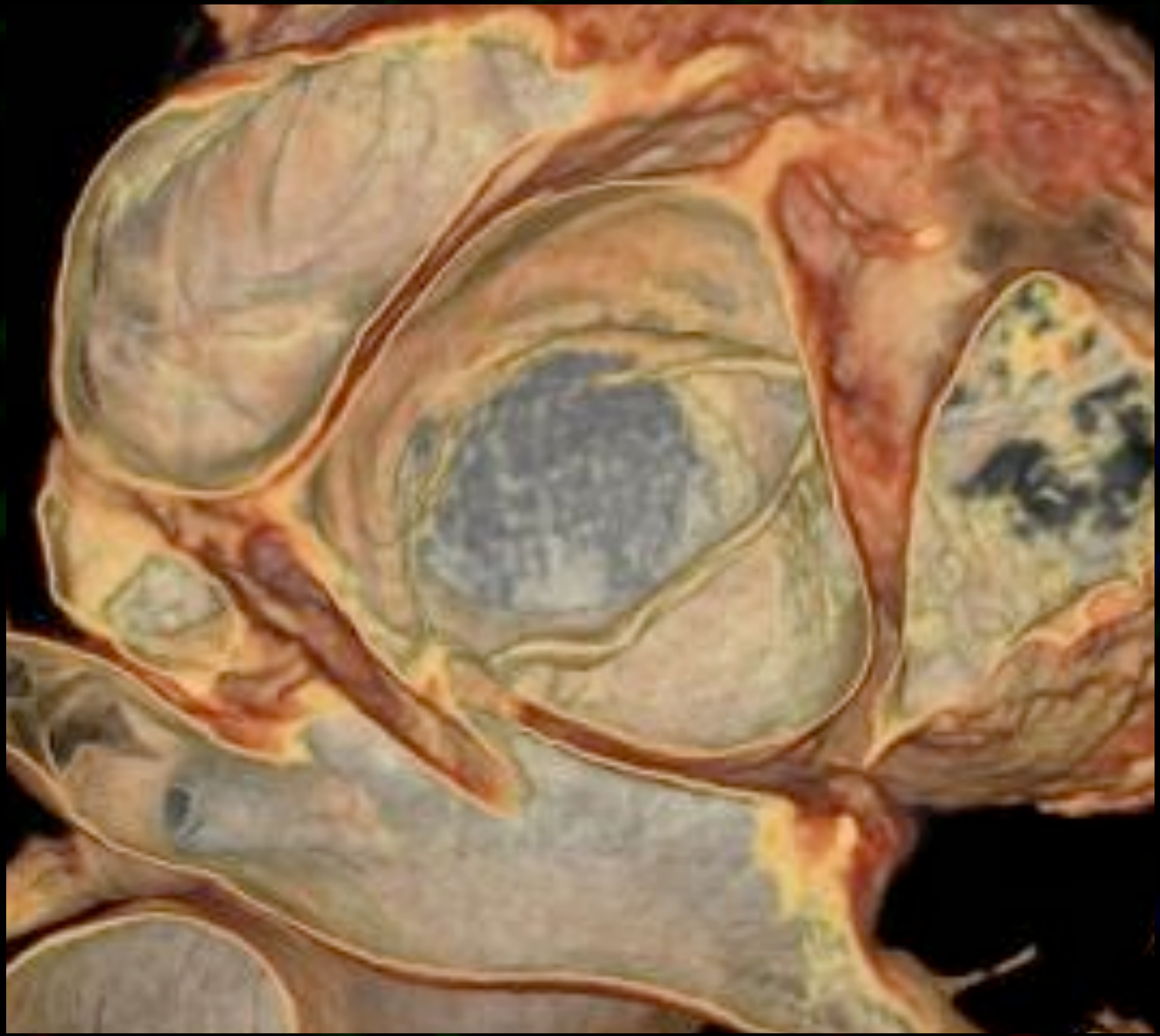

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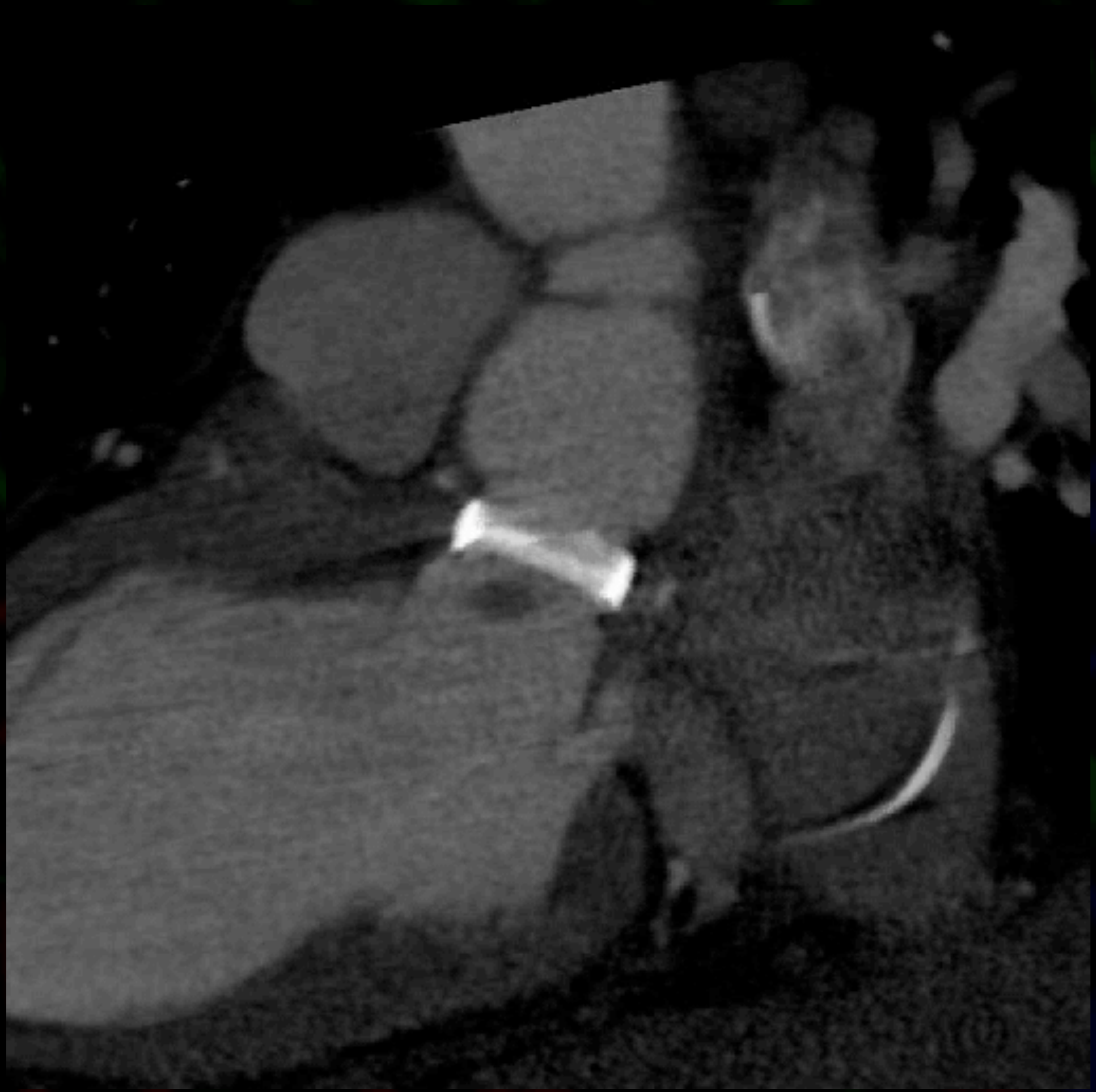
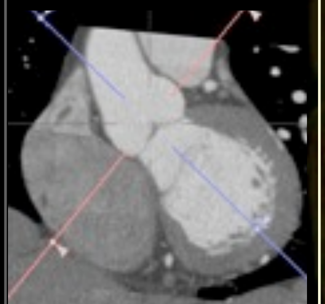
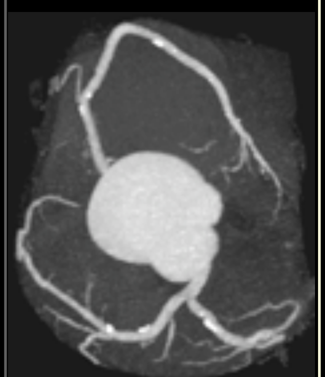
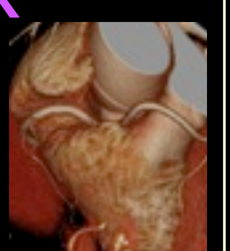
- 4-D



	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)
VR 	Angiographic overview, contextual with adjacent structures Pre-procedural planning	• Best for complex relationship display wow factor	Opacity transfer function and operator dependent No accurate measurements

Recent Reconstruction Advances

- Automatic Segmentation
- Multipath - CPR (MP-CPR):
  - Simultaneous CPRs of all LE vessels at once
- Partial Vector Shape Projection (PVSP)
  - Knowlege-based extrapolation of centerlines for SFA occlusions
  - Independent of local density and gradient information

Roos JE, et al. Radiology 2007; 244 (1) 281-90.
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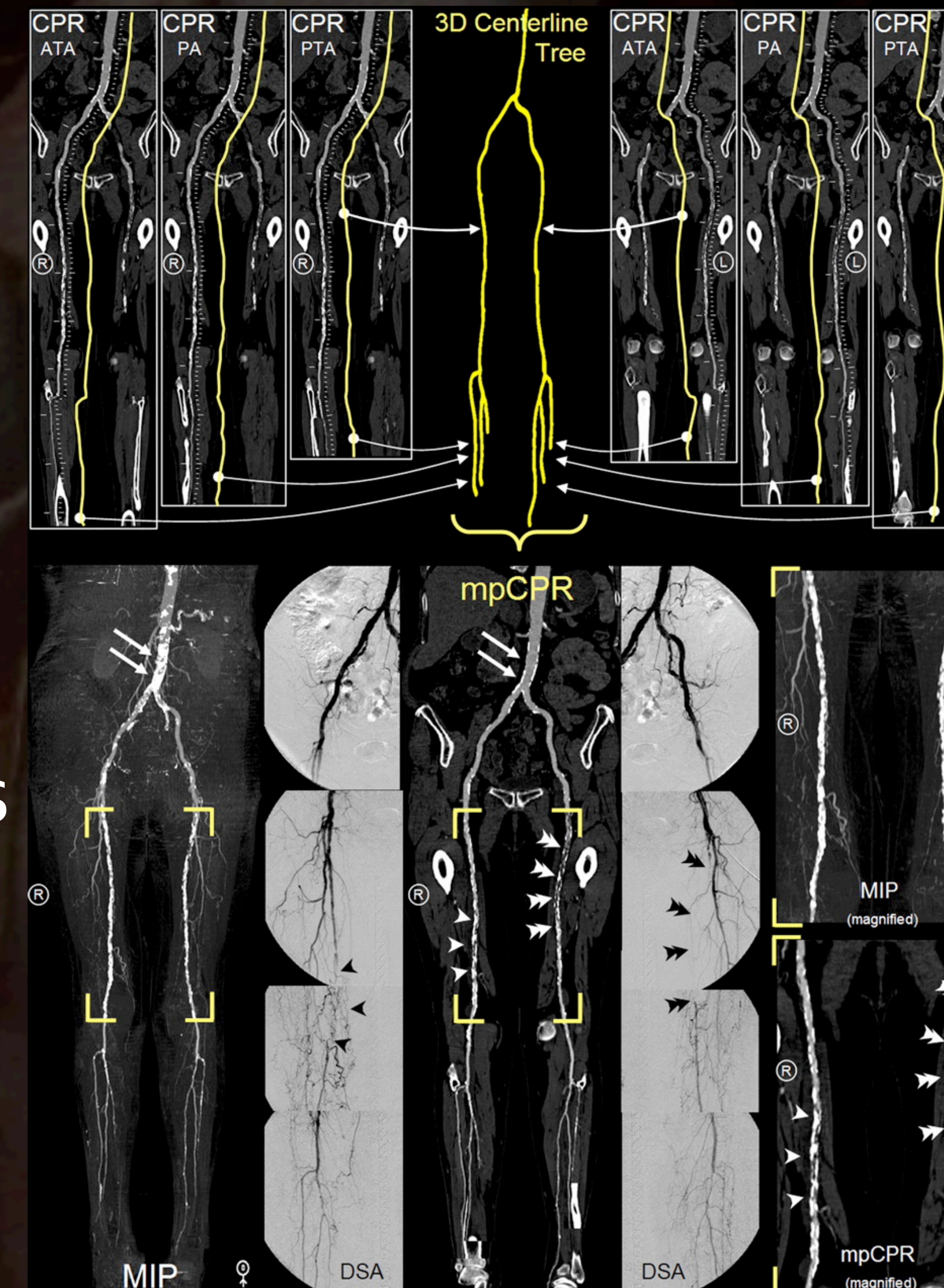

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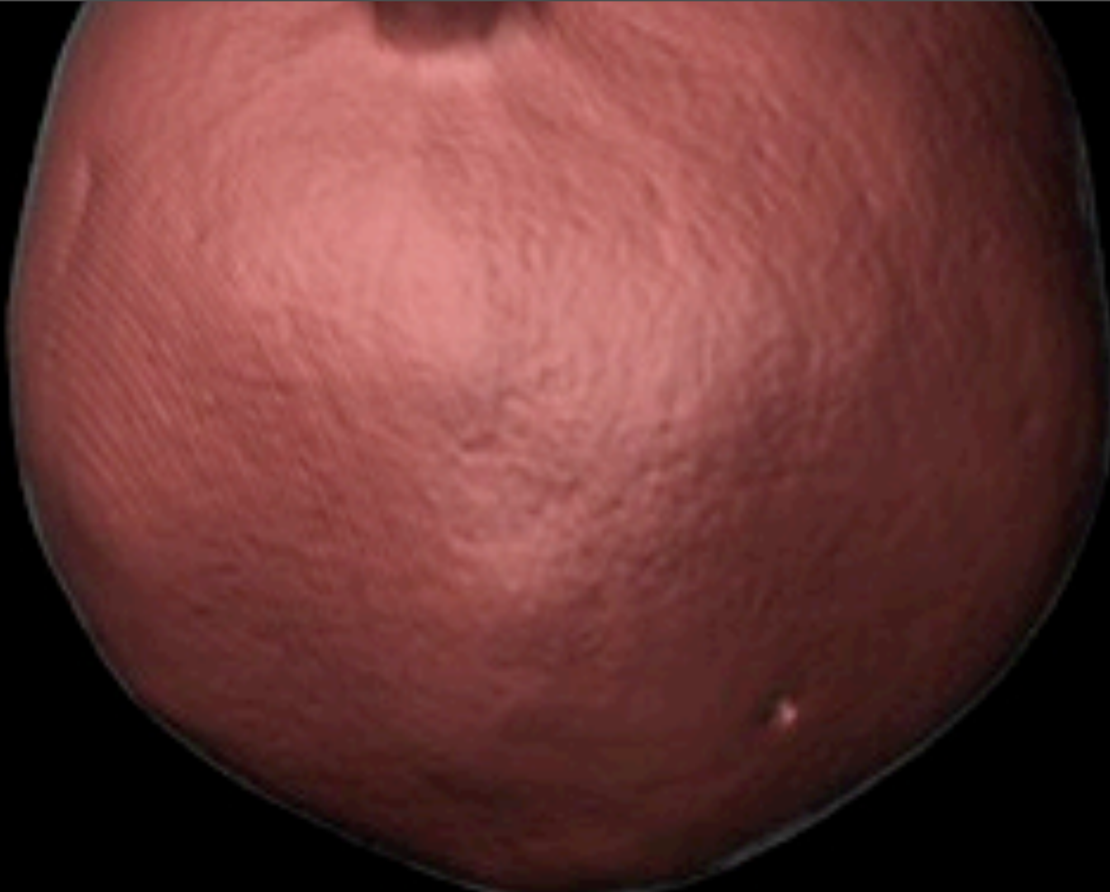
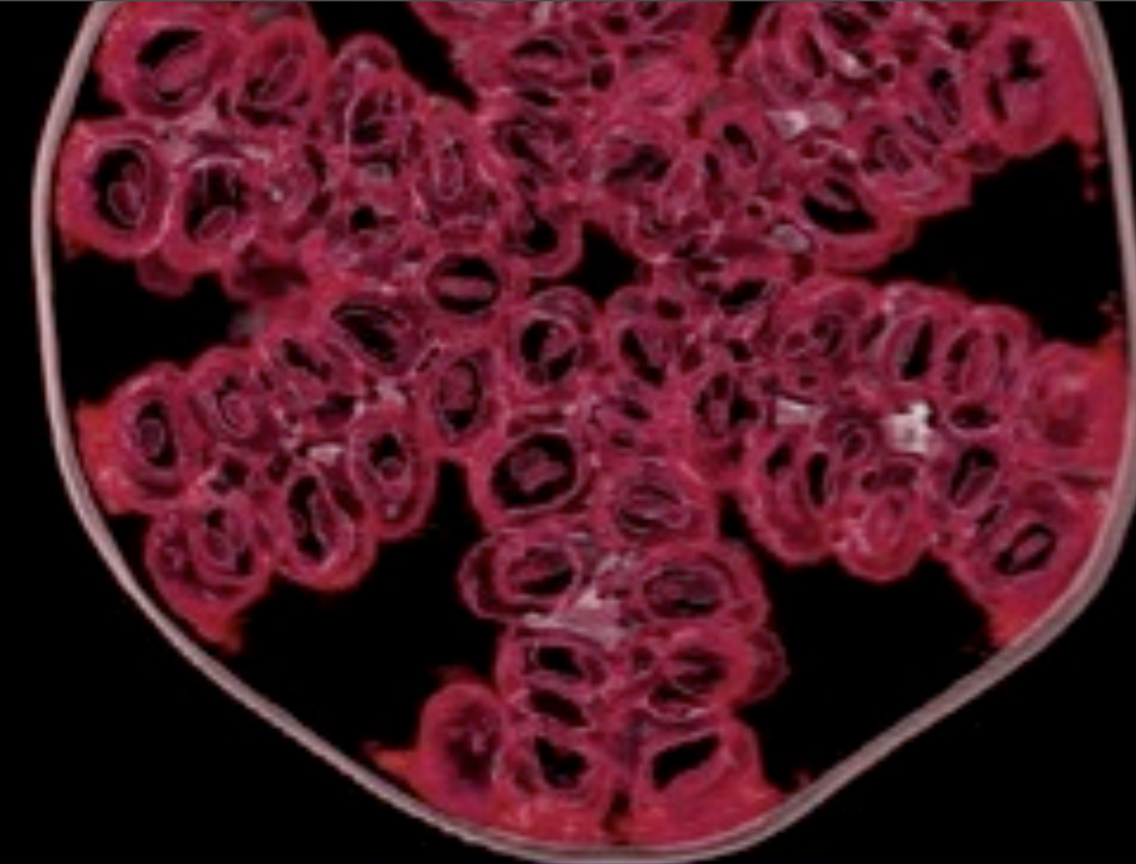
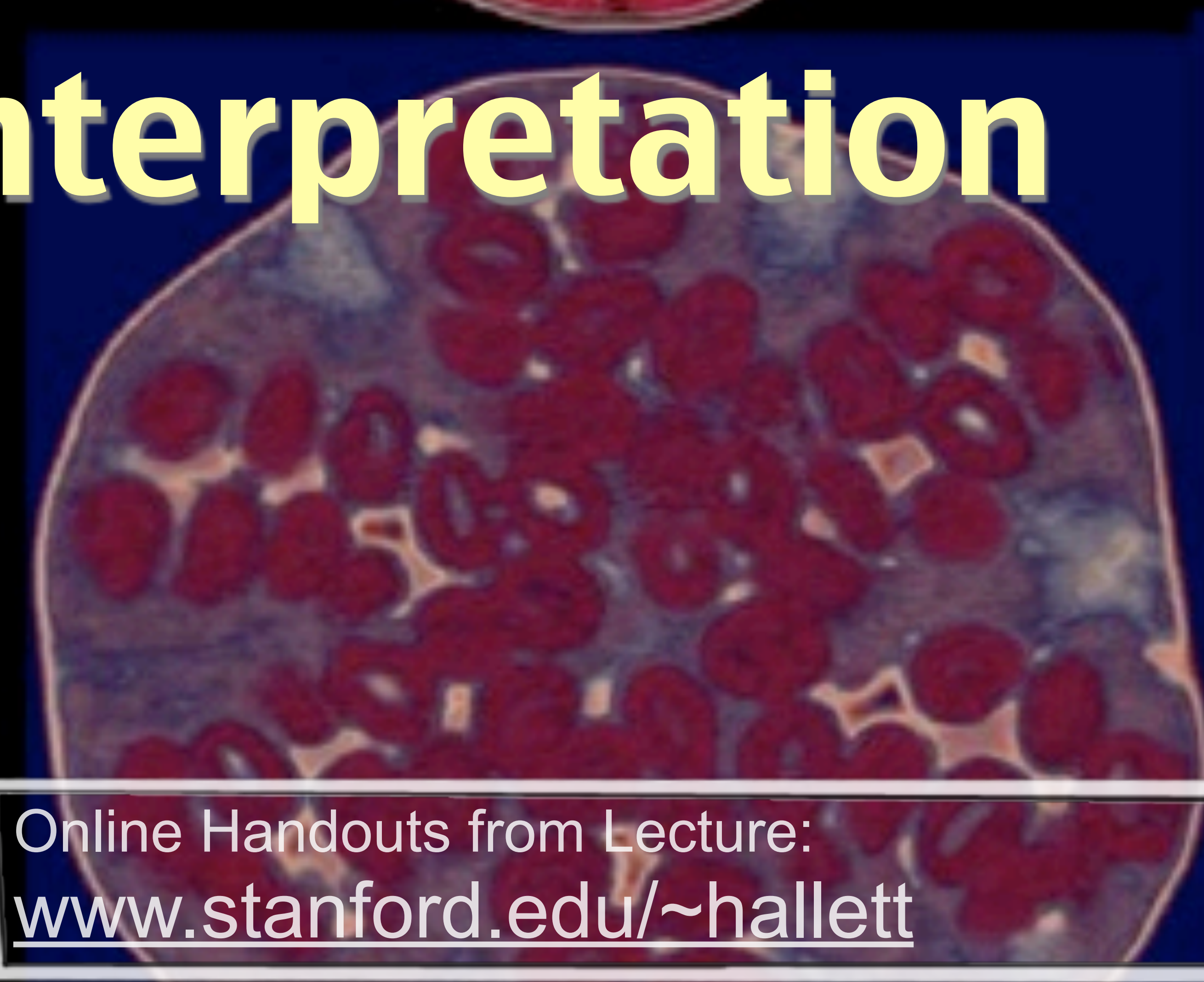




CTA
Workflow and Interpretation



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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

(think Ultrasound!)

- Physician-directed for primary interpretation
- Technologist-directed for measurement, documentation, reporting ~ 3D Laboratory

Physician -Directed 3D

- 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 Strategies:

- Good: Stack Review (PACS, workstations, etc)
- Better: Volumetric Review
  - "Volumetric datasets are best reviewed volumetrically"
- Interactive MPR review more accurate than review of pre-rendered CPR, MIP, etc

Ferencik M, et al. 2007; 243 (3): 696-702

What is An Effective Platform for Volumetric Interpretation?

- ✦Fast and available
- ✦Ergonomic
- ✦Easy DICOM Import / Export
- ✦email, JPG capabilities
- ✦Allows Comparison to Prior / Loads multiple datasets

Platform Options

- *Dedicated workstation*
  - + Most features, high performance
  - – Local availability only, relatively expensive
- *Software running on standard PC*
  - + Distributed (depends on pricing), relatively inexpensive
  - – Less features, lower performance
- *Server-Client*
  - + Distributed, lowest cost per “workstation”
  - – Less features, performance is network dependent

Platform Options

PRACTICE DEPENDENT !!

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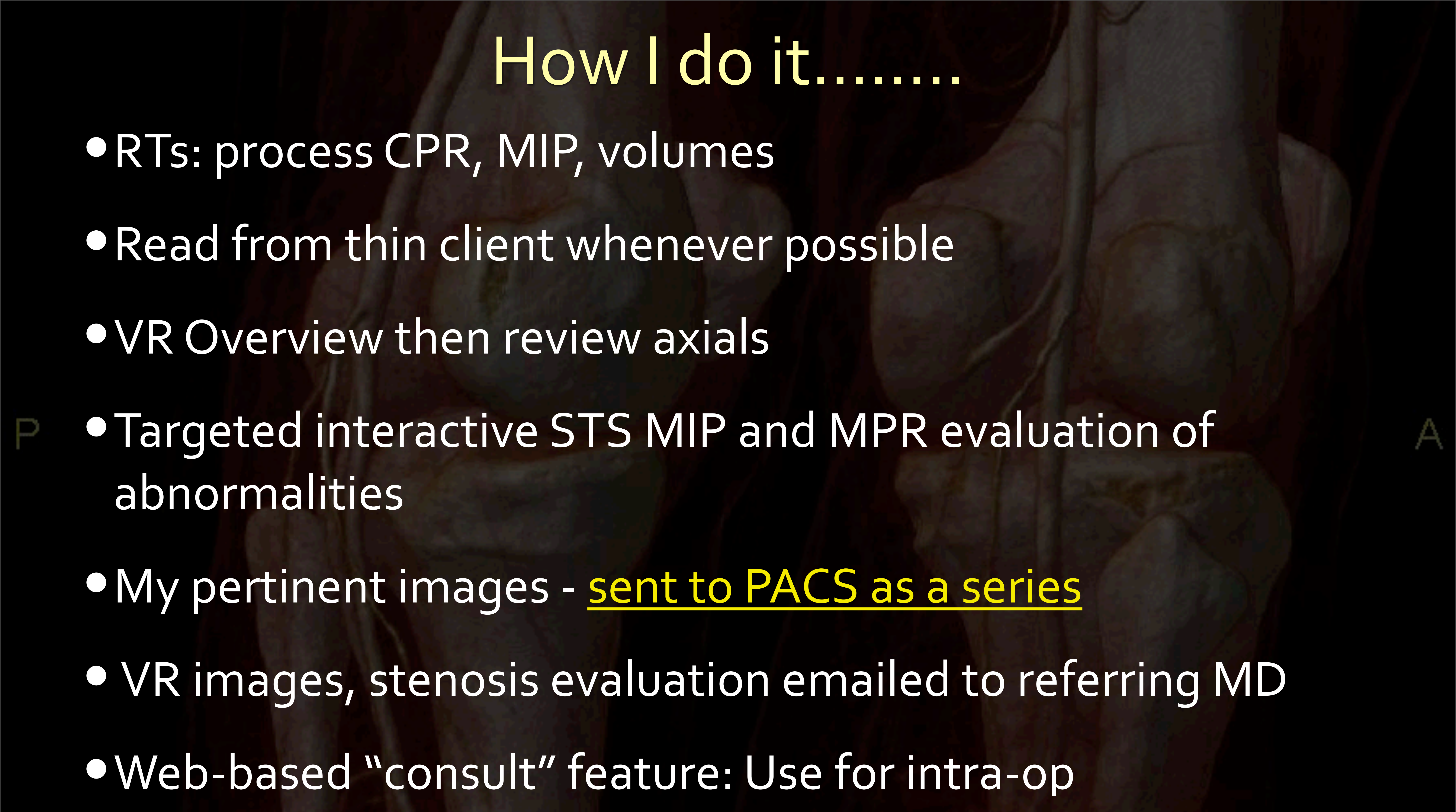
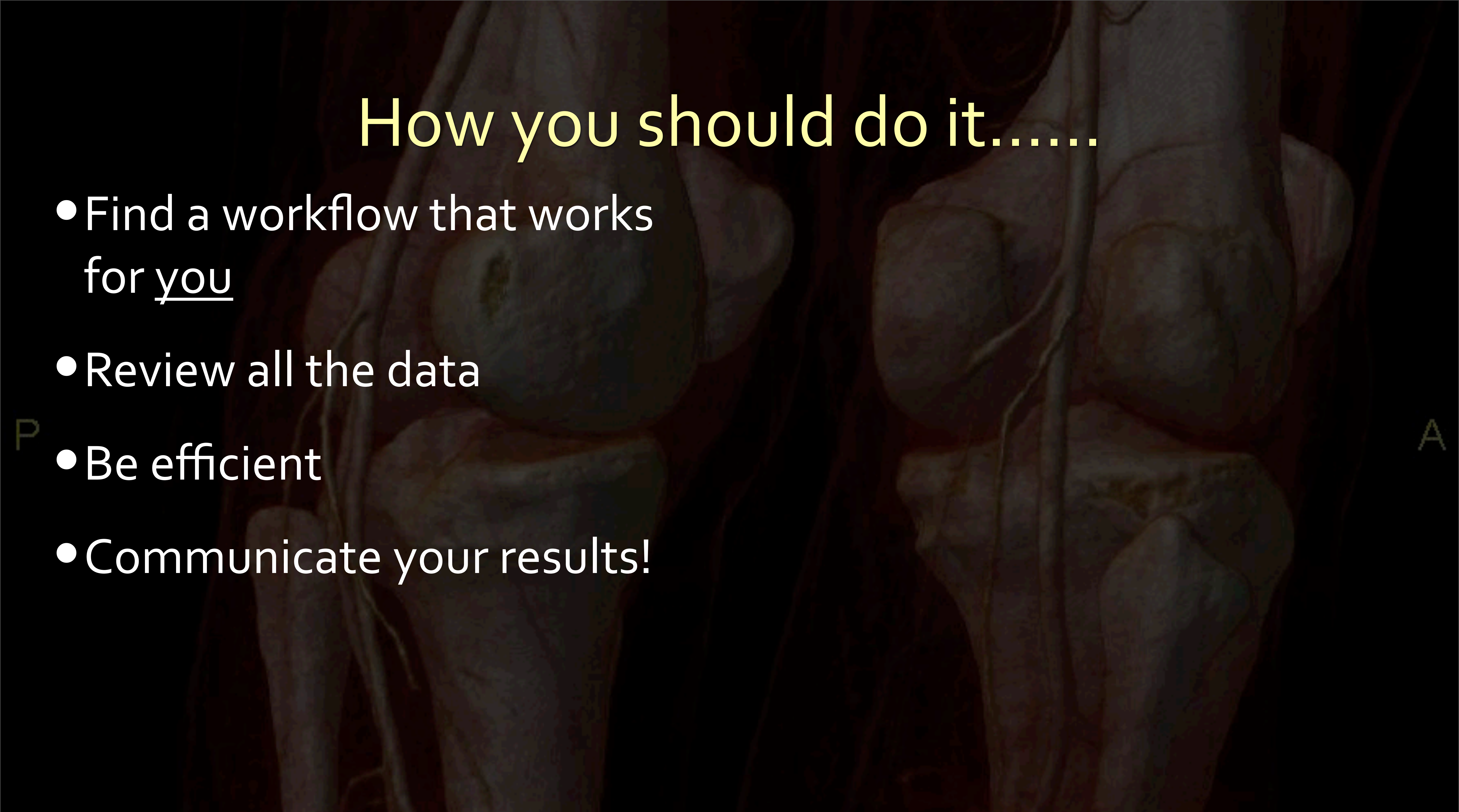
How I do it……..



- 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

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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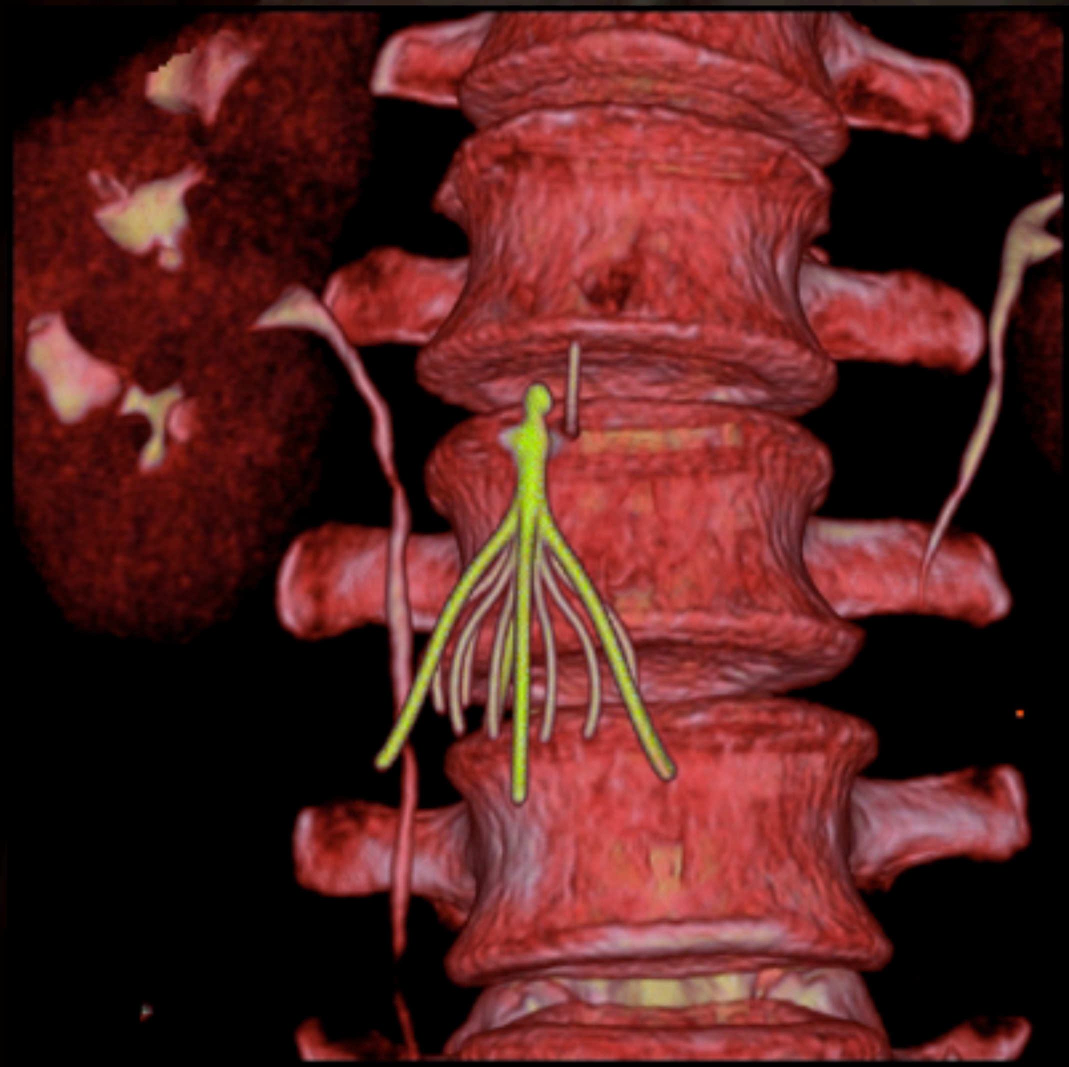
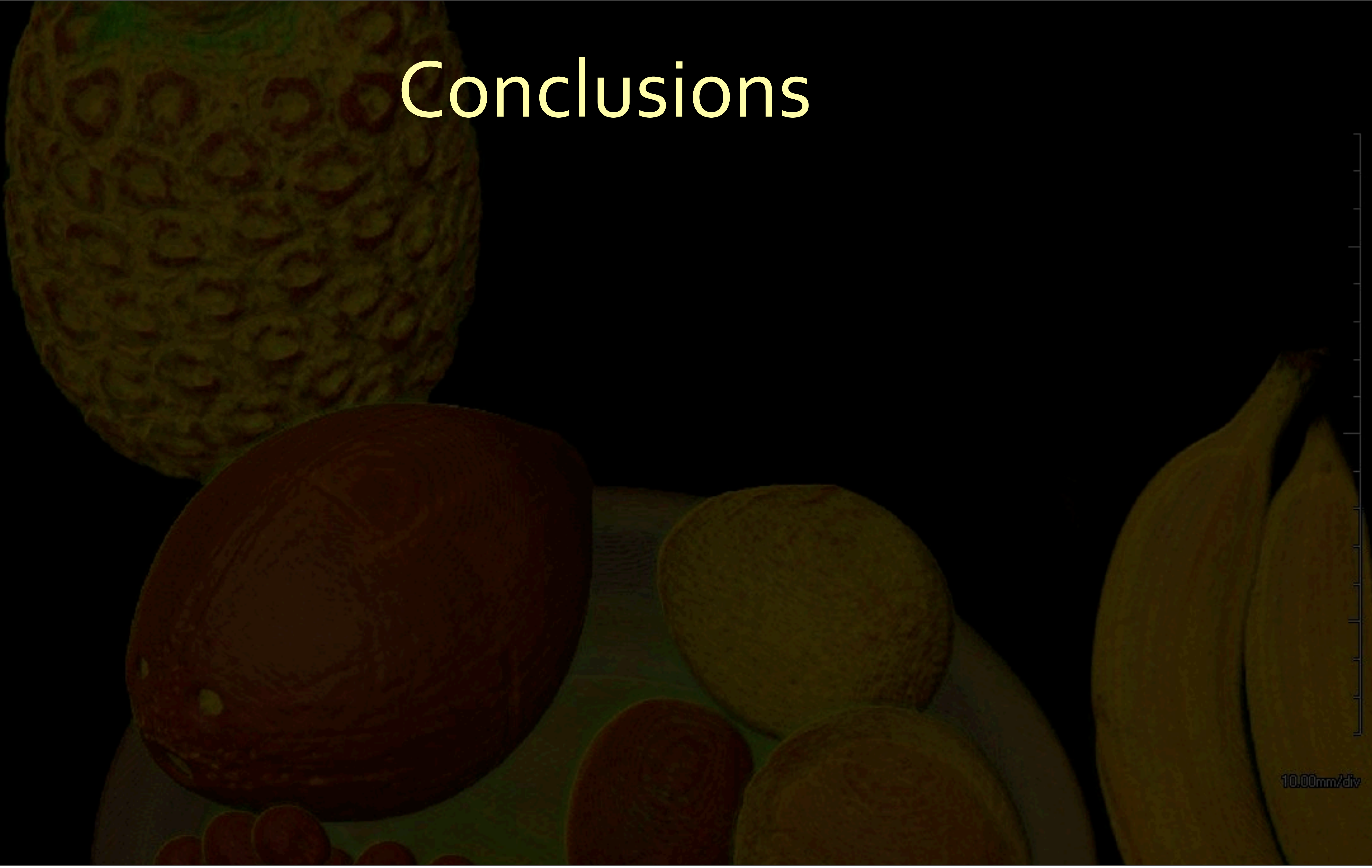


Conclusions



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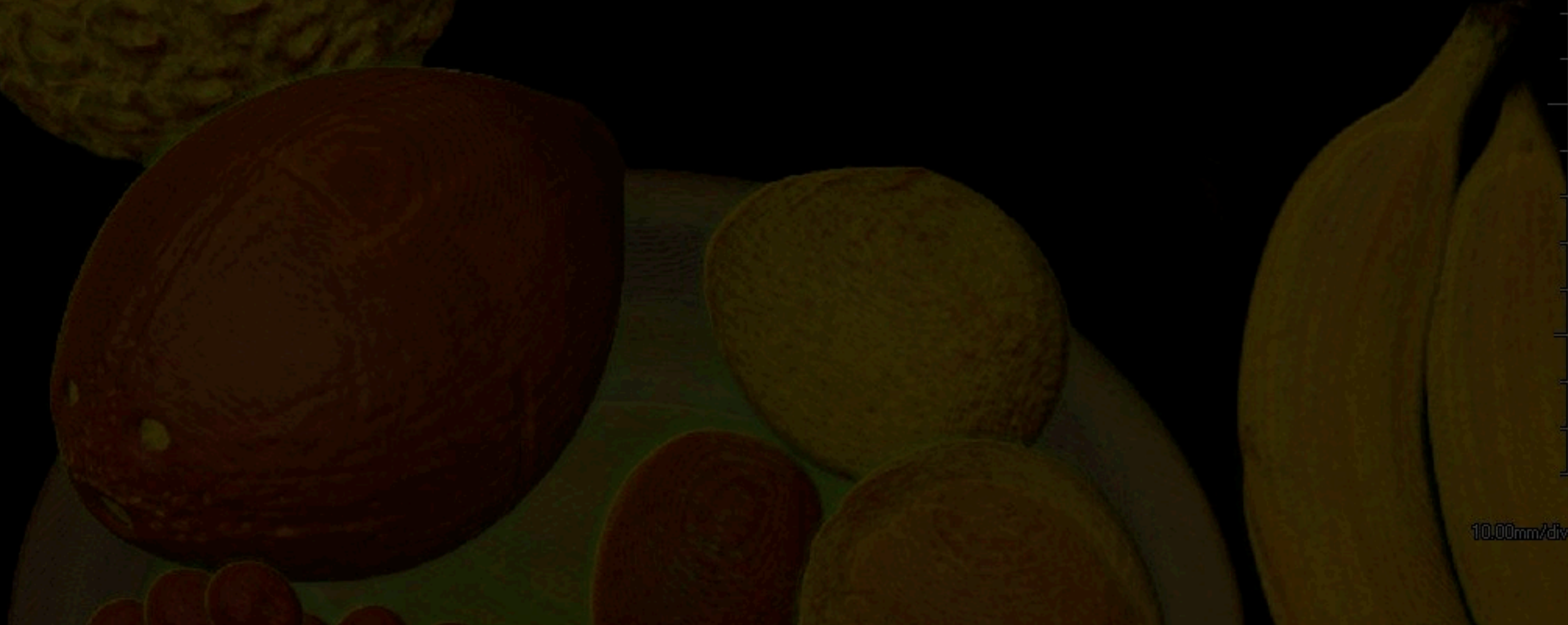

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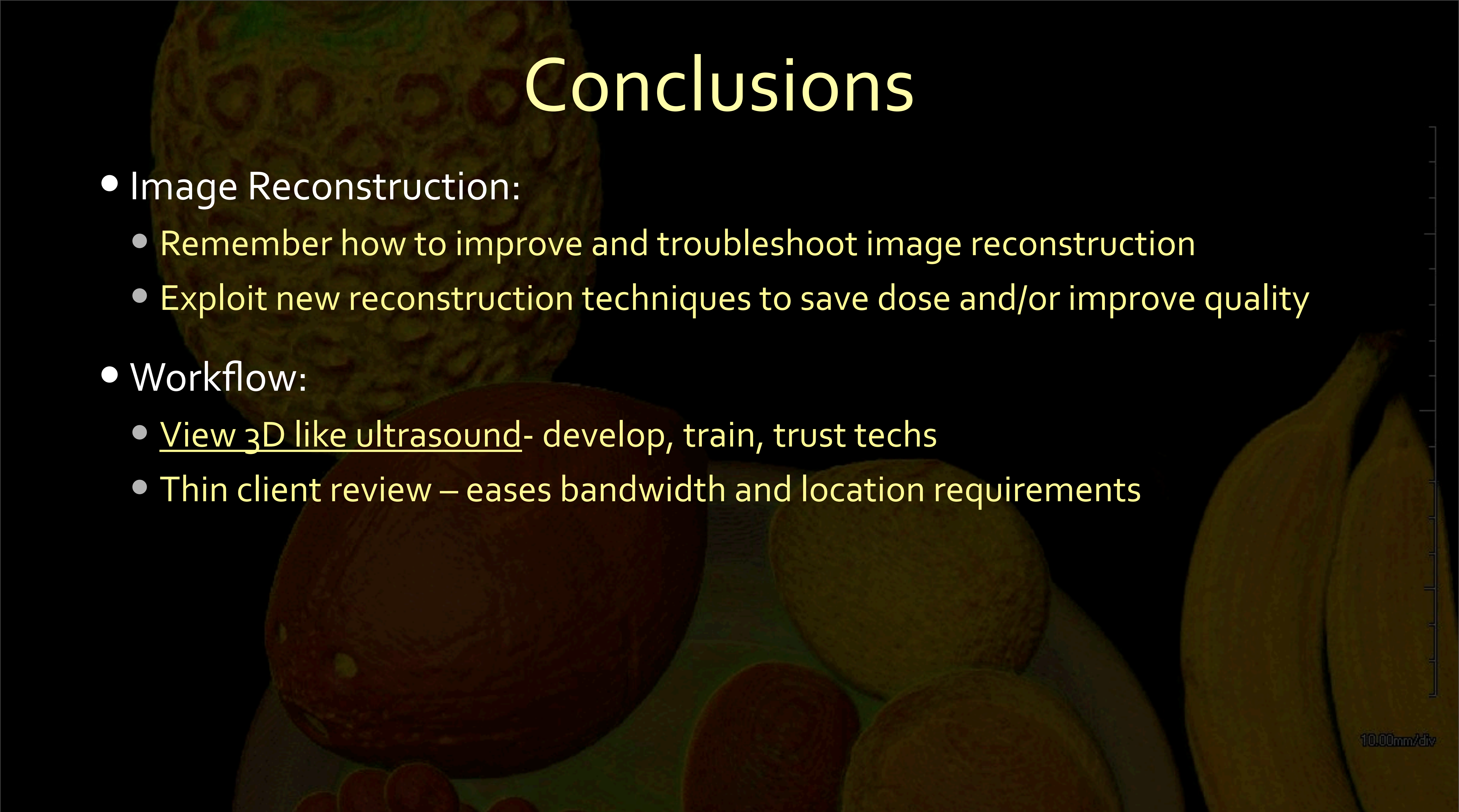

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  - Thin client review – eases bandwidth and location requirements
- Interpretation:
  - Develop a consistent reading algorithm, always have the source (thin) data available
  - Share your results!

THANK YOU!!

RSNA 2010
PERSONALIZED MEDICINE: In Pursuit of Excellence

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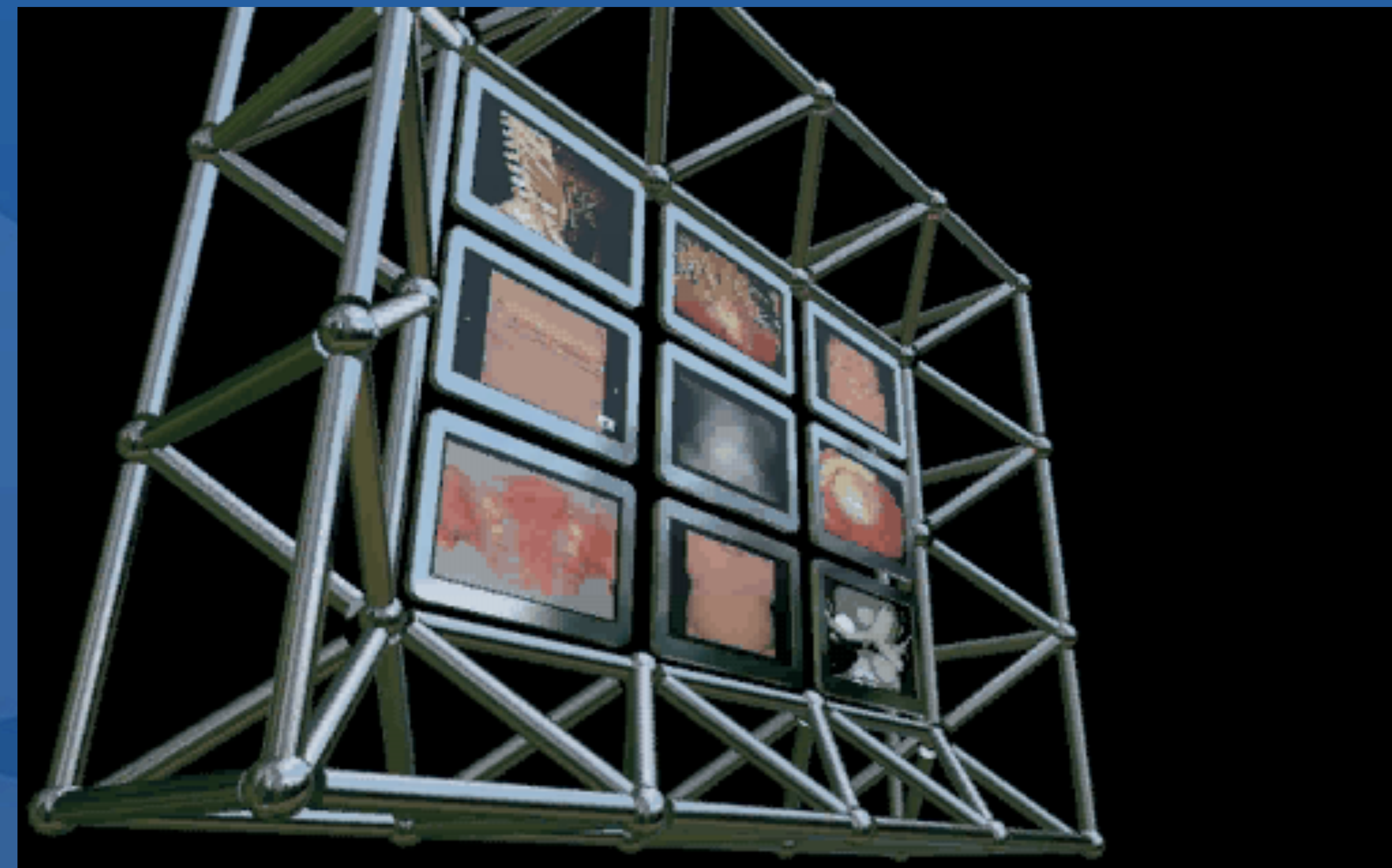

Online Handouts from Lecture:
www.stanford.edu/~hallett

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:
  - http://www.osirix-viewer.com/
  - WIKI: http://osirixmac.com/index.php/Main_Page