Optimizing CTA: Image Post-Processing

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Adjunct Assistant Professor
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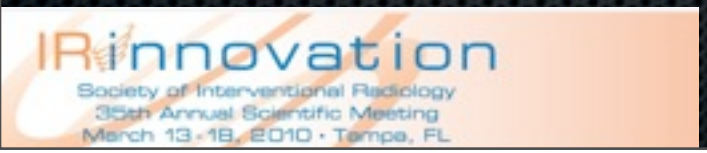

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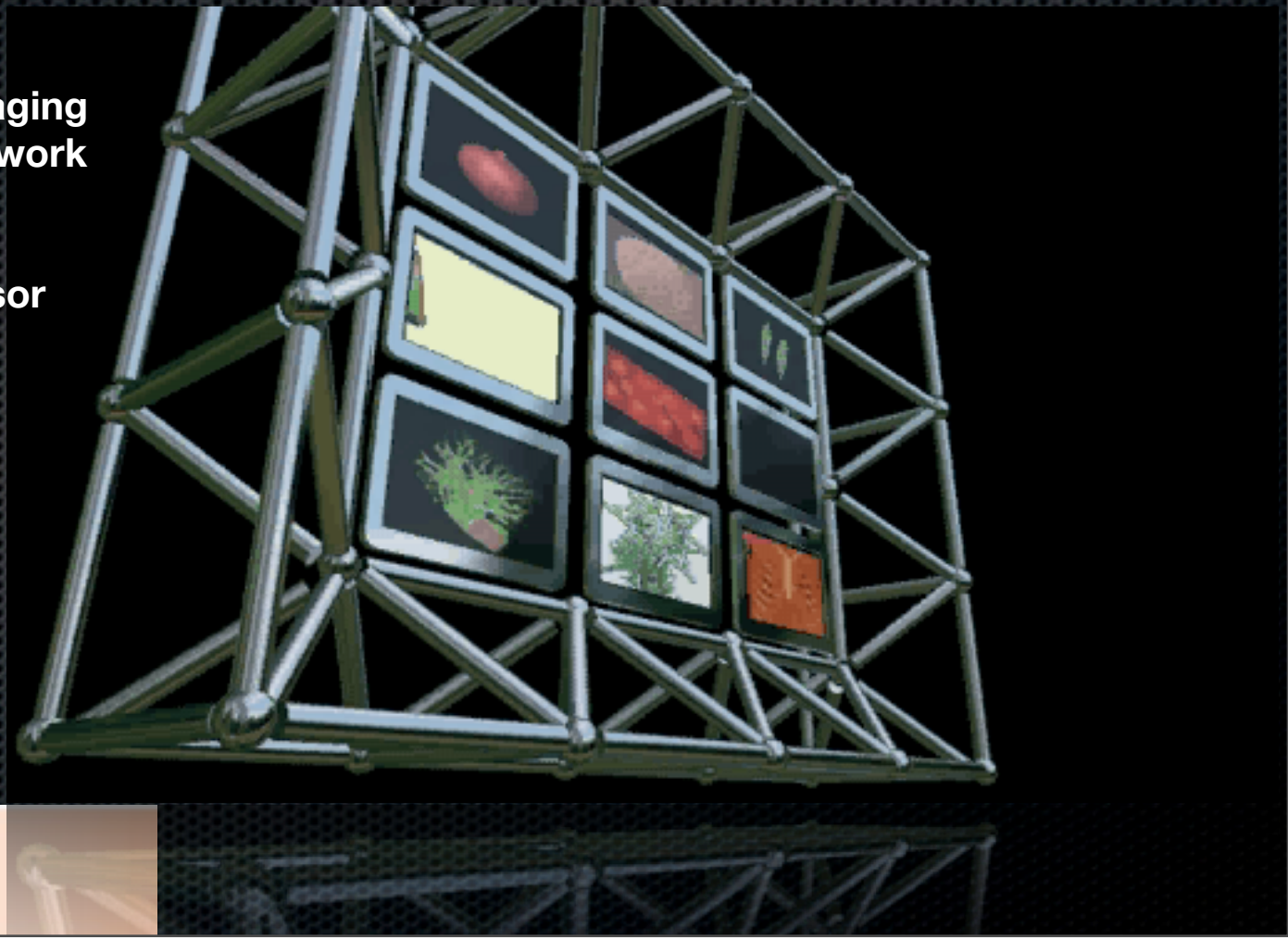

IRinnovation
Society of Interventional Radiology
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Disclosures: None

Online Handouts from Lecture:

stanford.edu/~hallett/SIR2010

Outline

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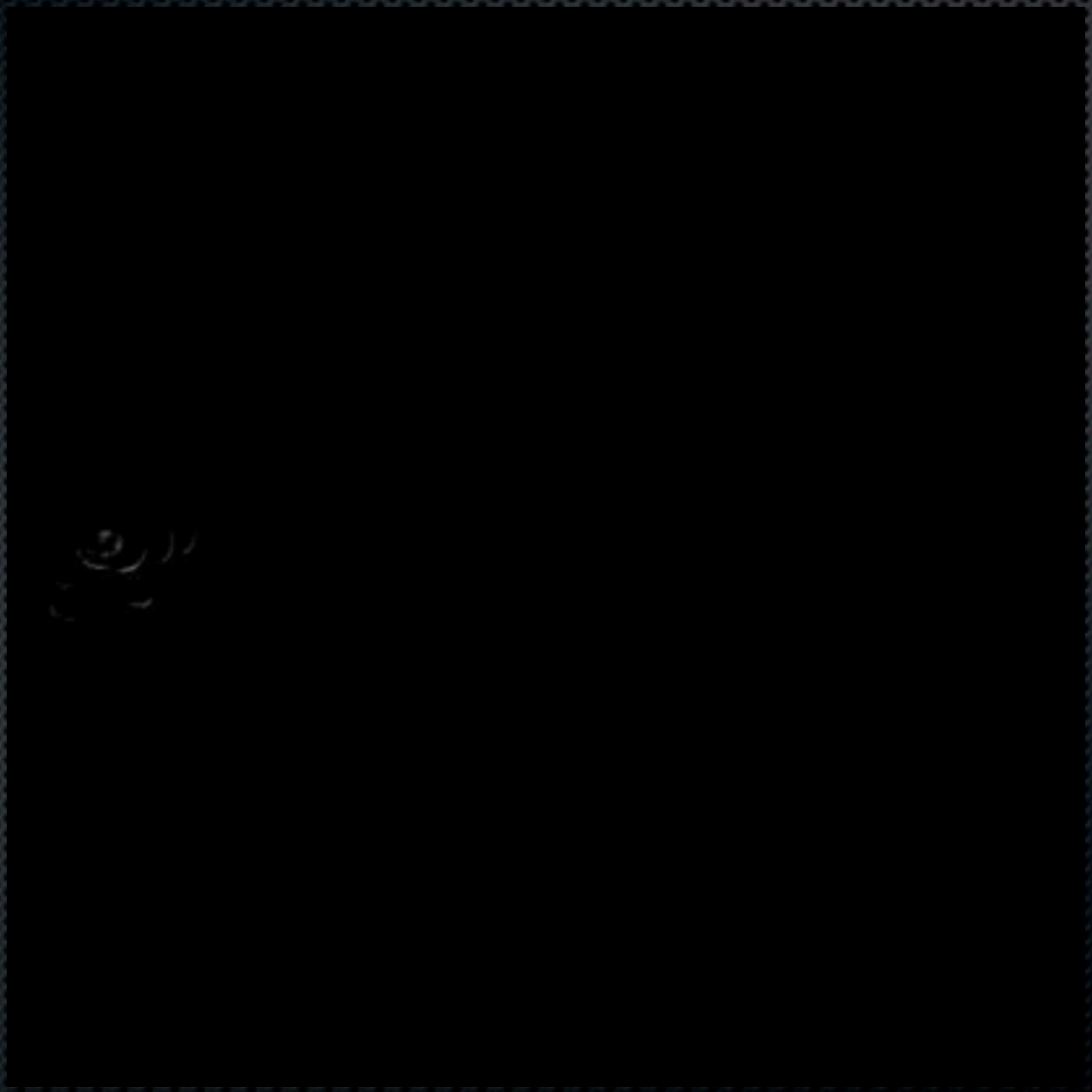
I. Axial image reconstruction tips

II. Post-Processing techniques

- Benefits
- Limitations

Reconstruction and Post-Processing

Reconstruction and Post-Processing



The basic acquired 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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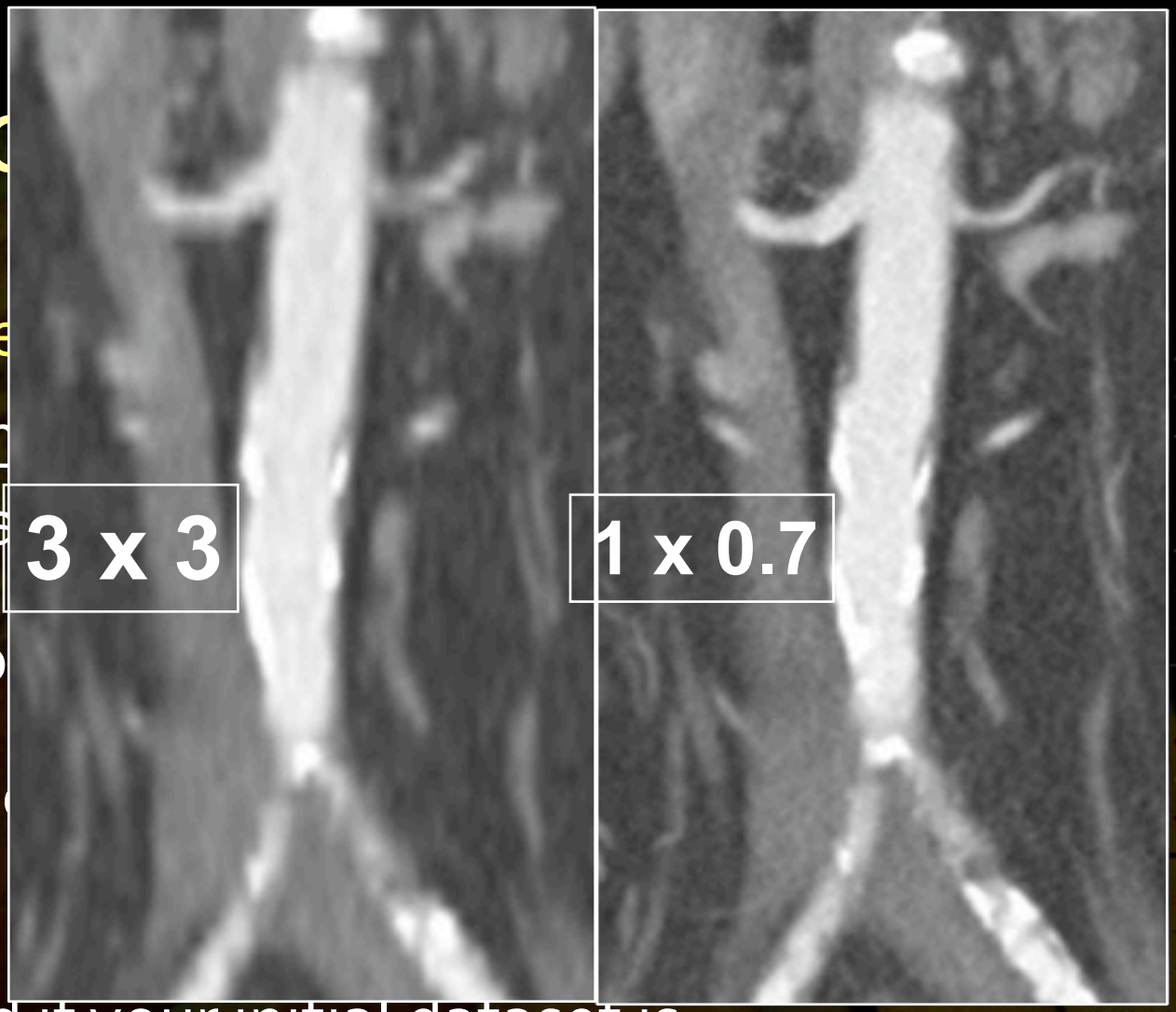

Reconstruction Rule:

Scan thin, reconstruct **thicker**

- Exception:
  - **LARGE** patients: SNR suffers
    - Scan at 140 kV
    - Scan at 1.25 – 2.5 mm **collimation**
    - Slow down gantry rotation
- Thicker recons have higher SNR
  - But: CNR may suffer

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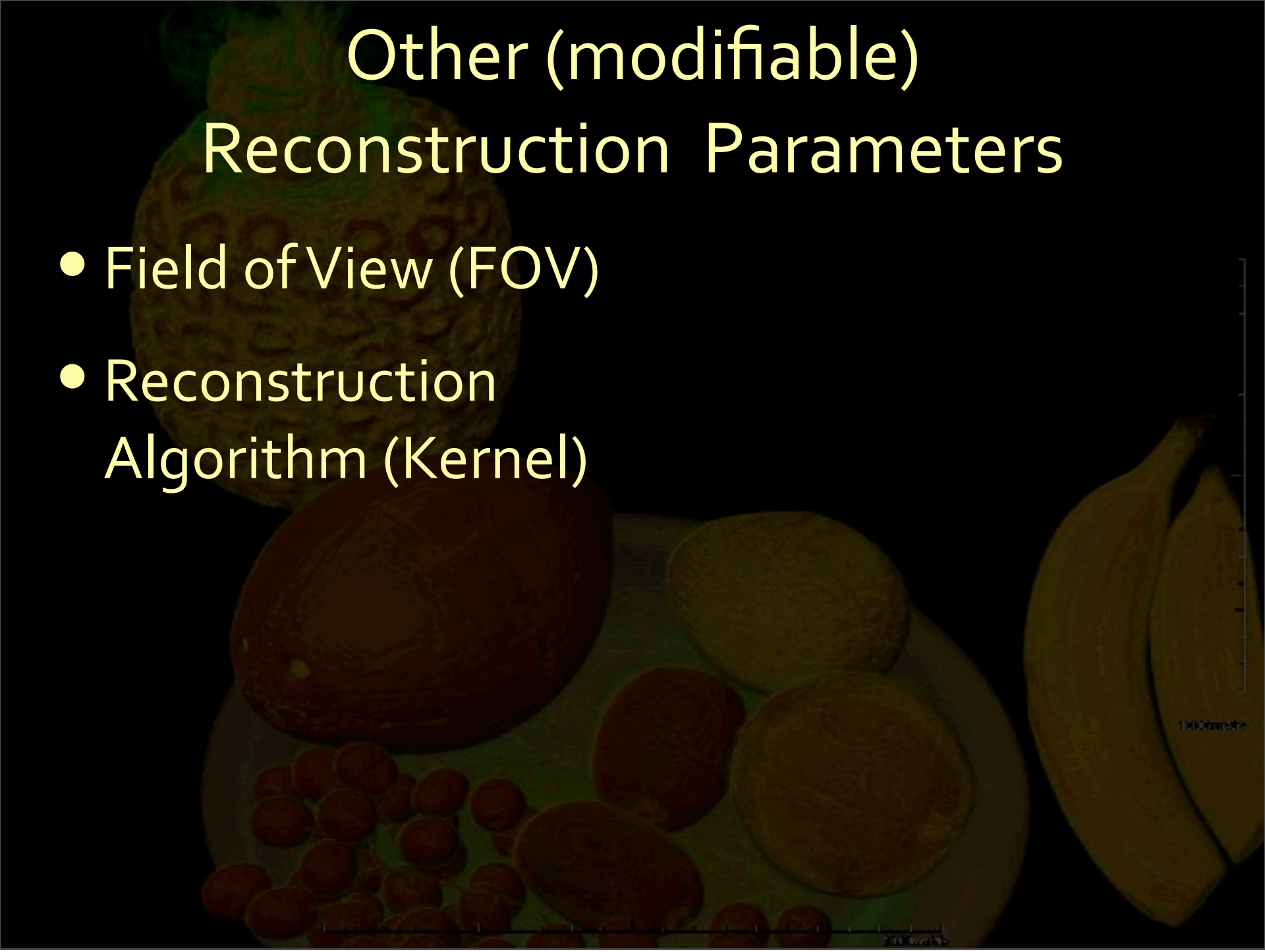
Increase signal, decrease noise, or both!

- Thicker recons have higher SNR
  - But: CNR may suffer

Other (modifiable) Reconstruction Parameters

- Field of View (FOV)
- Reconstruction Algorithm (Kernel)



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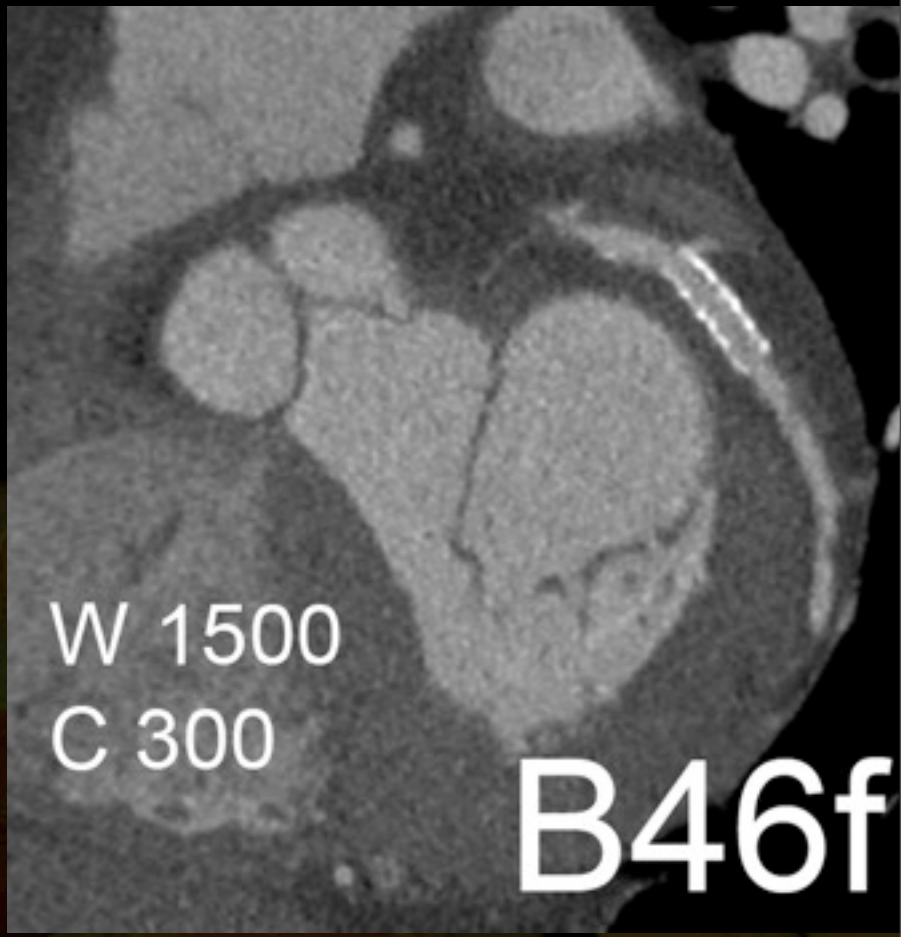

Image Post-Processing

Post-Processing "Alphabet Soup"

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

Reconstruction "Alphabet Soup"

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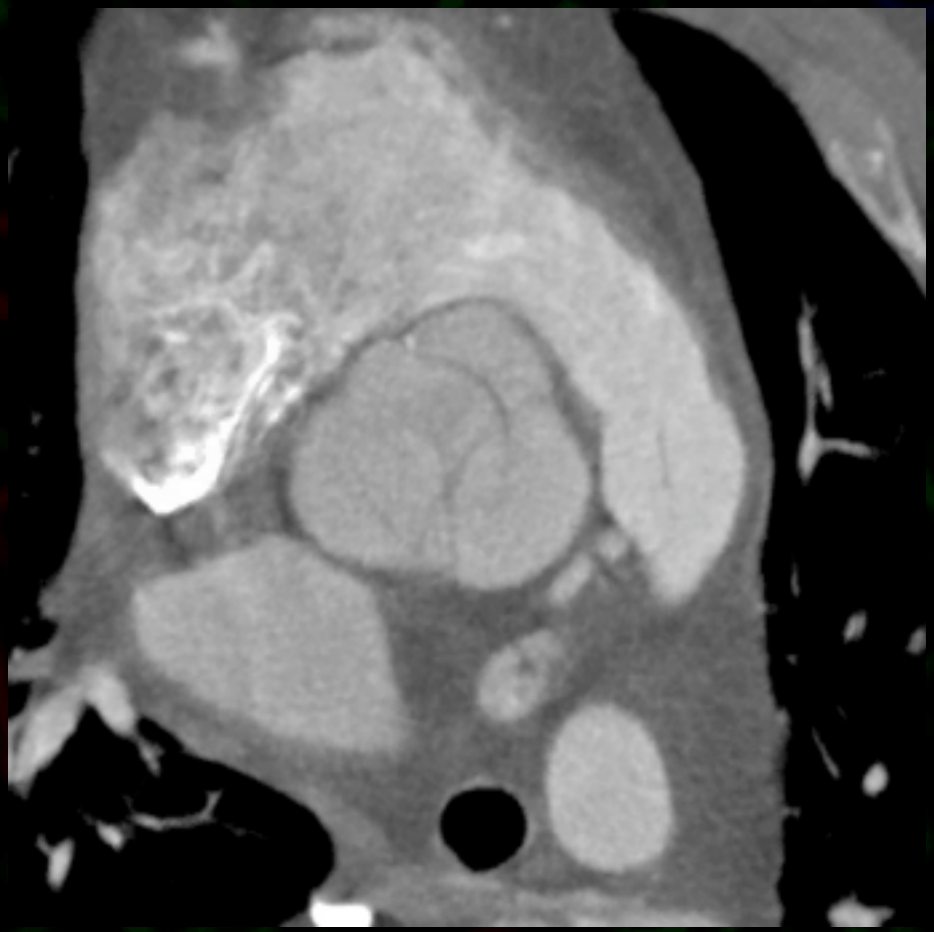
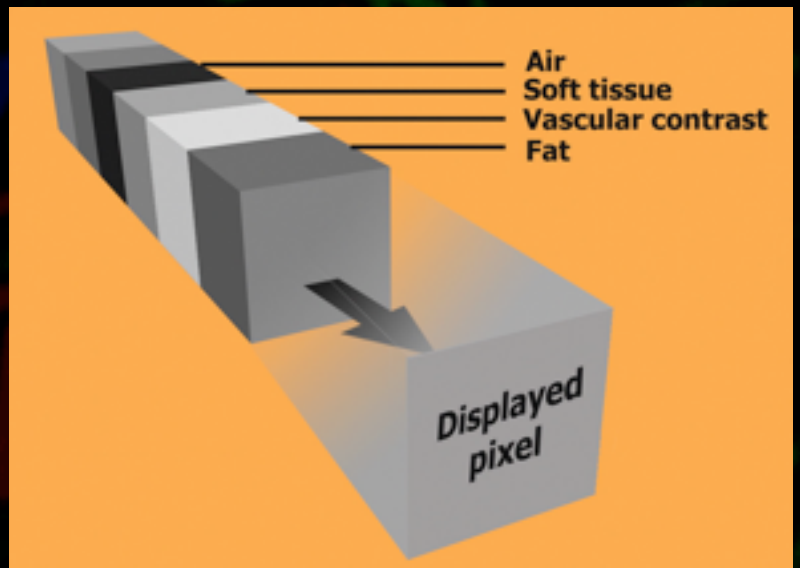


Multi - Planar Reconstruction (MPR)

- A slice of nominal thickness (one voxel)
- *Average pixel value* along the ray
- **BUT:** Only includes a small amount of the scan data, and vessels are curved structures
- USES:
  - Stenosis Measurement
  - Nodule measurement
  - Orthogonal measurements



EXAMPLE: MPR Stenosis Evaluation

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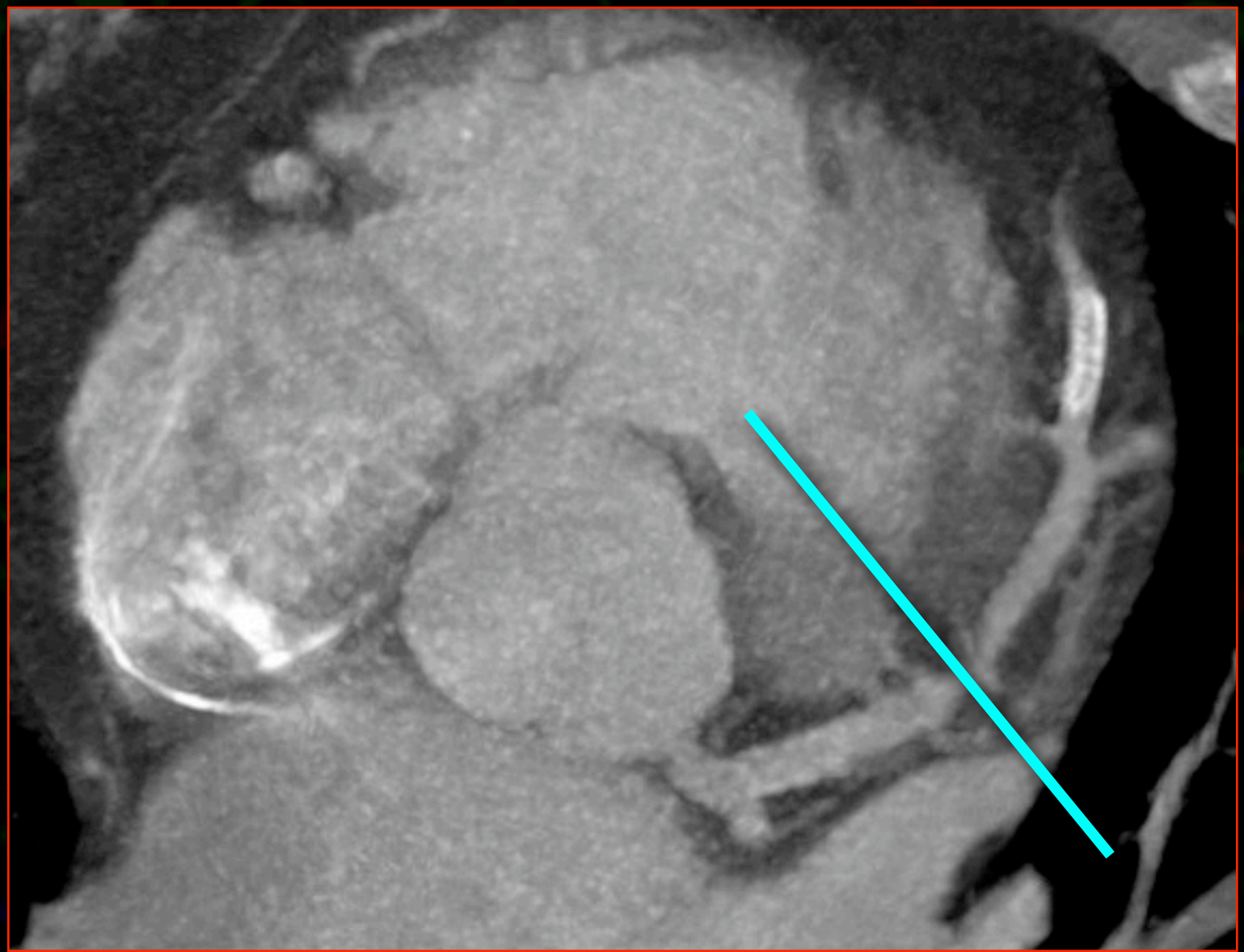
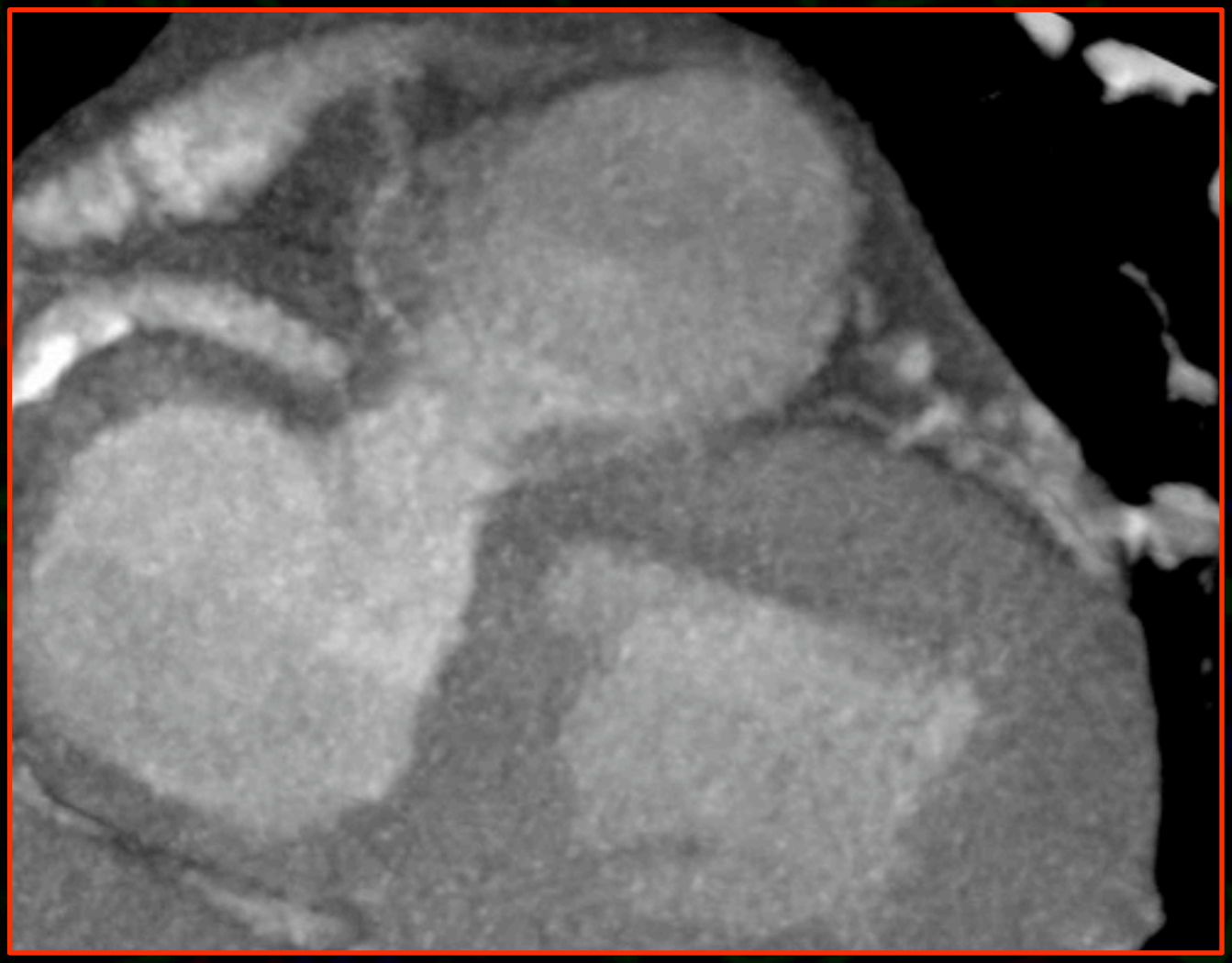


Stenosis Evaluation: MPR cross-section



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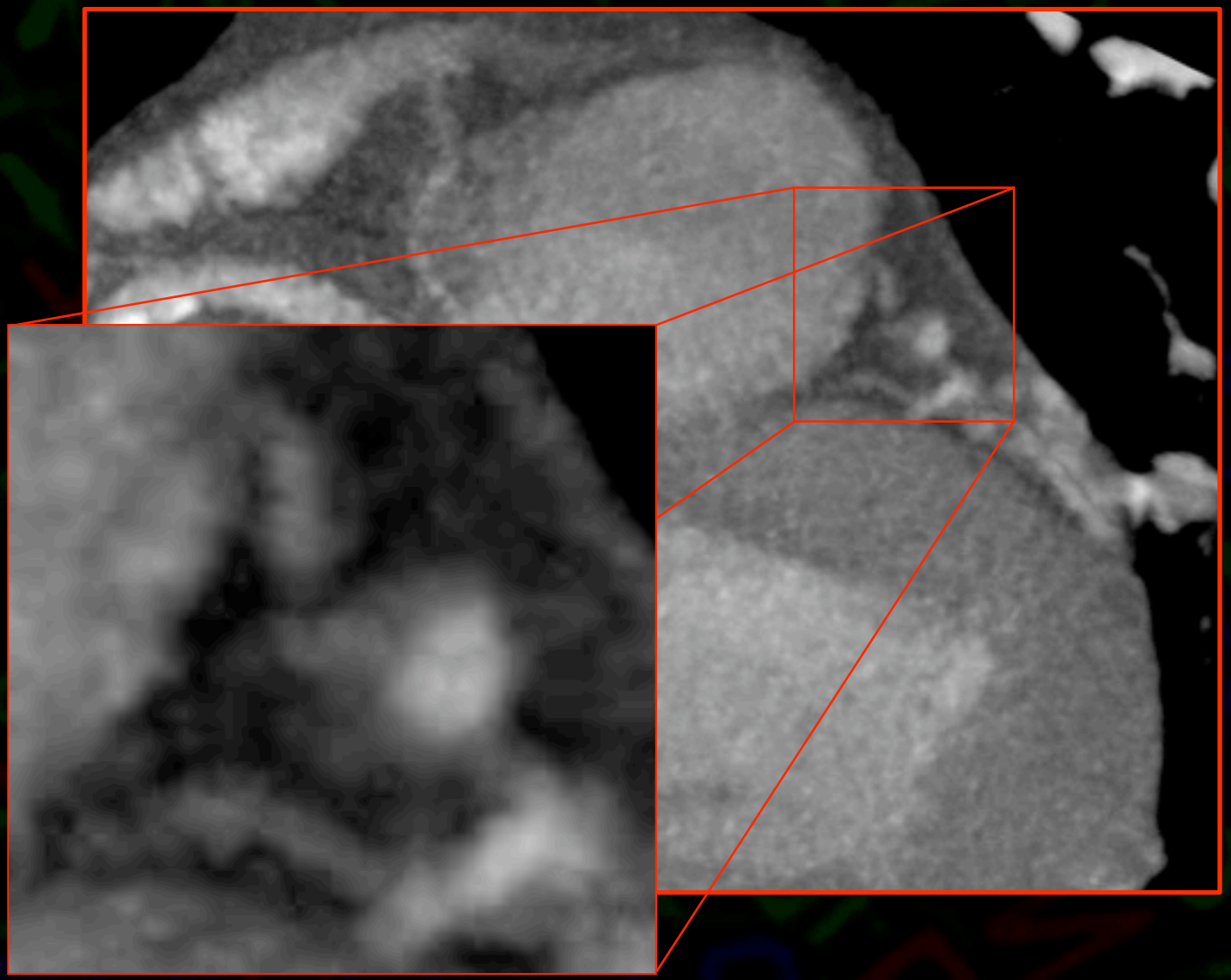

EXAMPLE: MPR - Orthogonal Measurements

- Axial measurements not as precise nor as reproducible as orthogonal measurements
- TIP: Rotate crosshairs perpendicular in 2 planes → 3rd is orthogonal!!
  - Can also auto generate from centerlines

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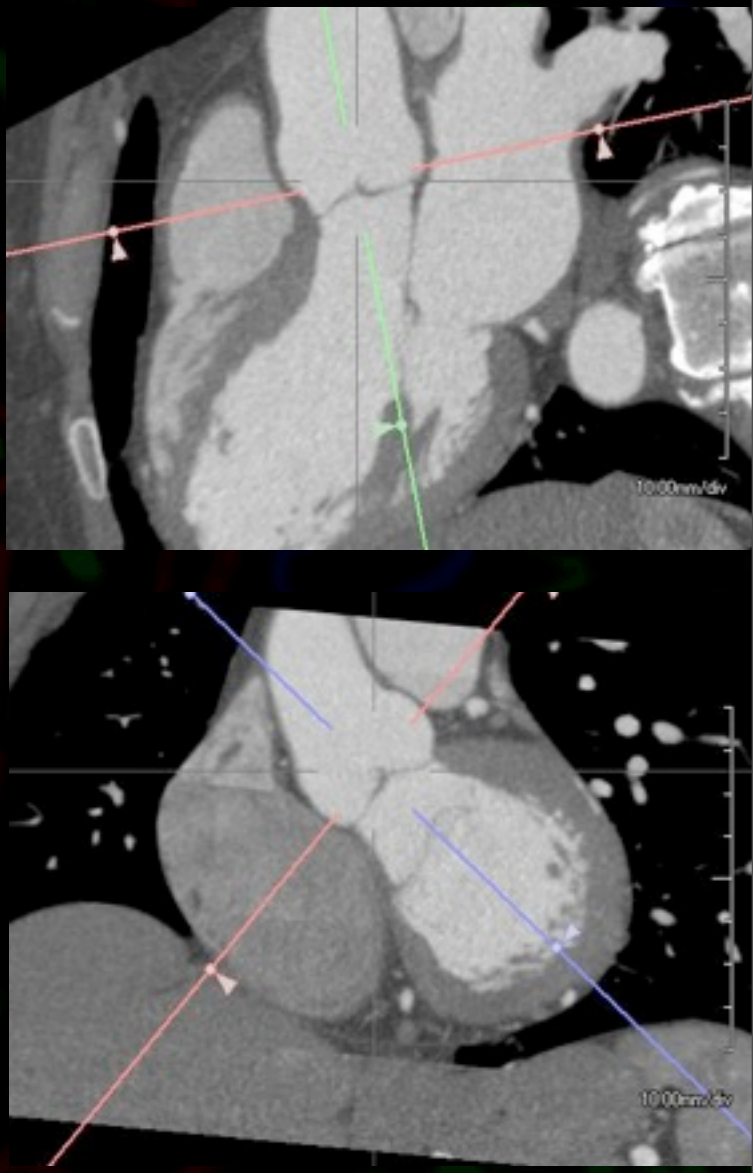

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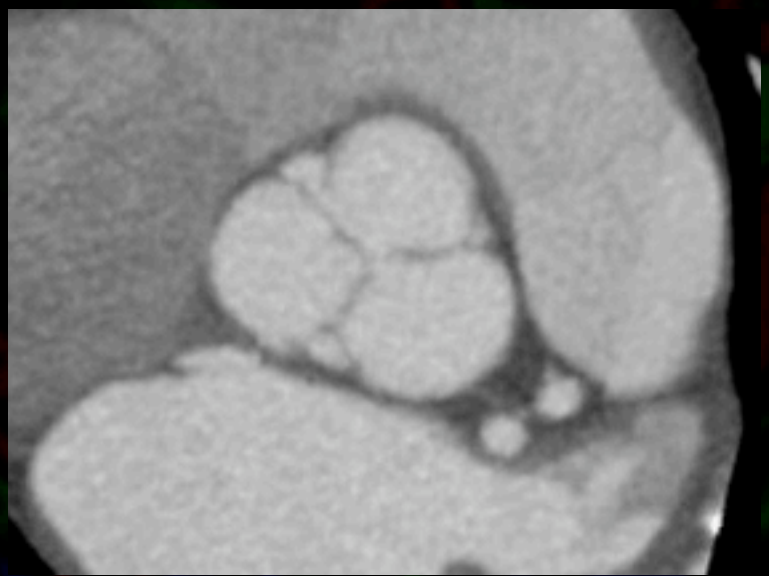
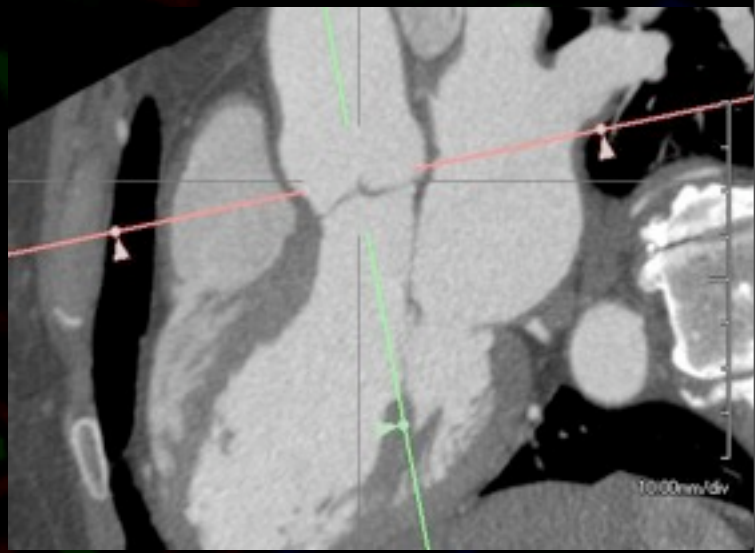
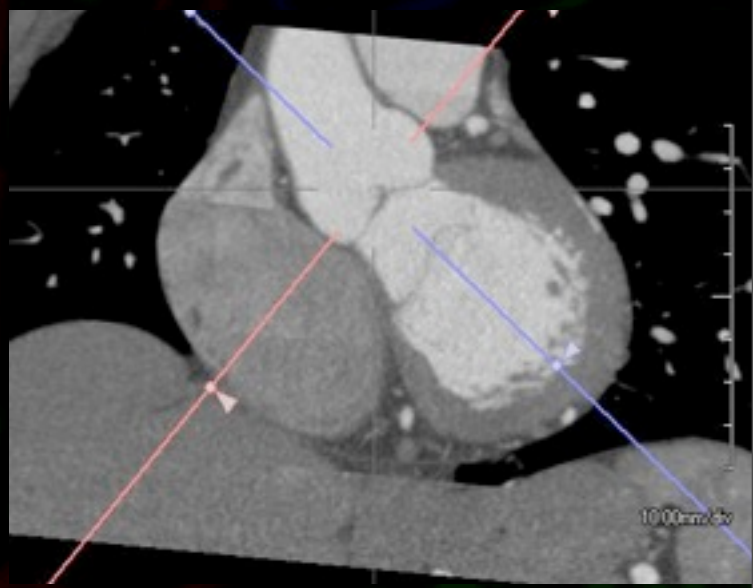
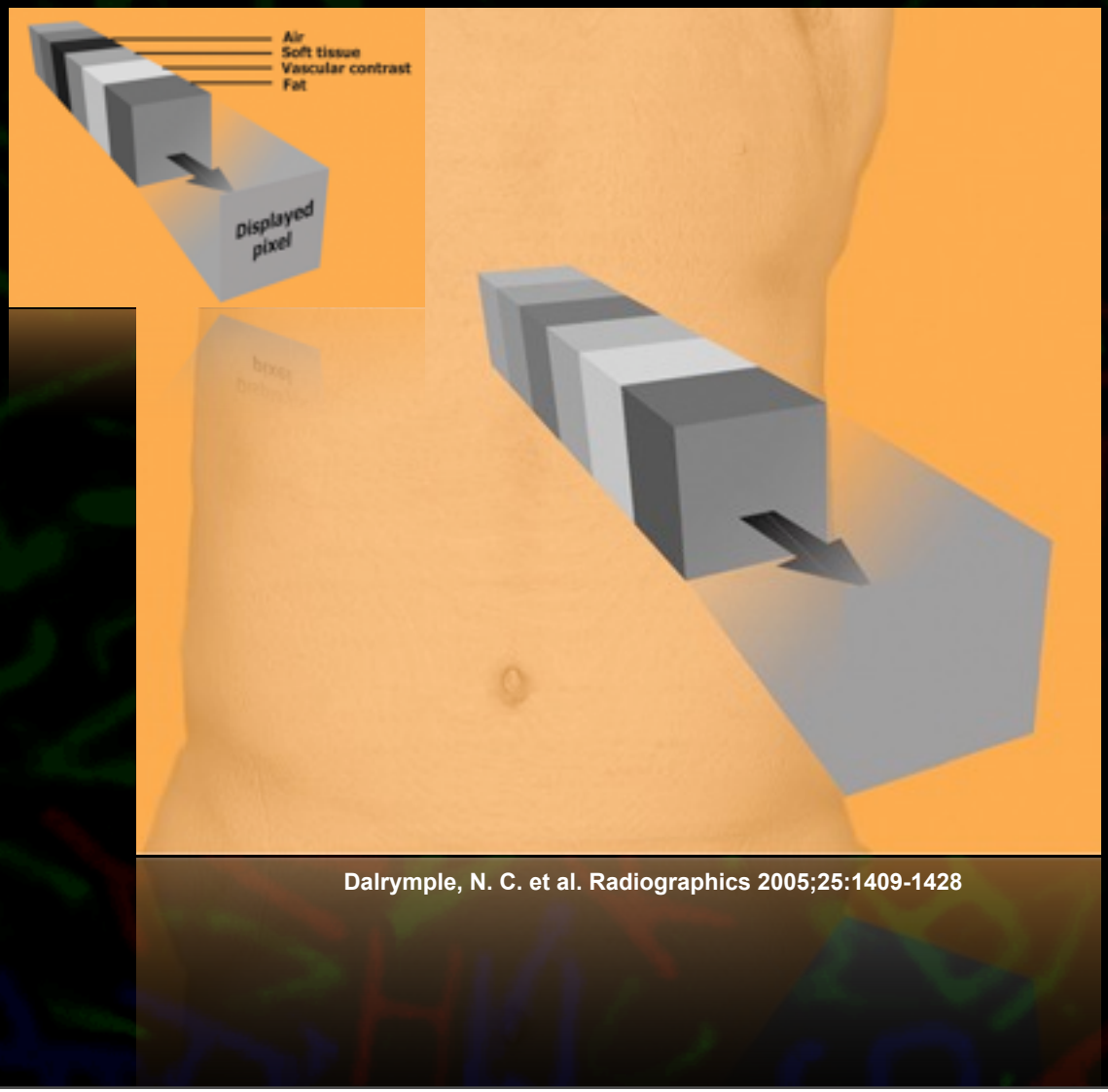






Average Intensity Projection (AIP)

= "Thick MPR", "Raysum"

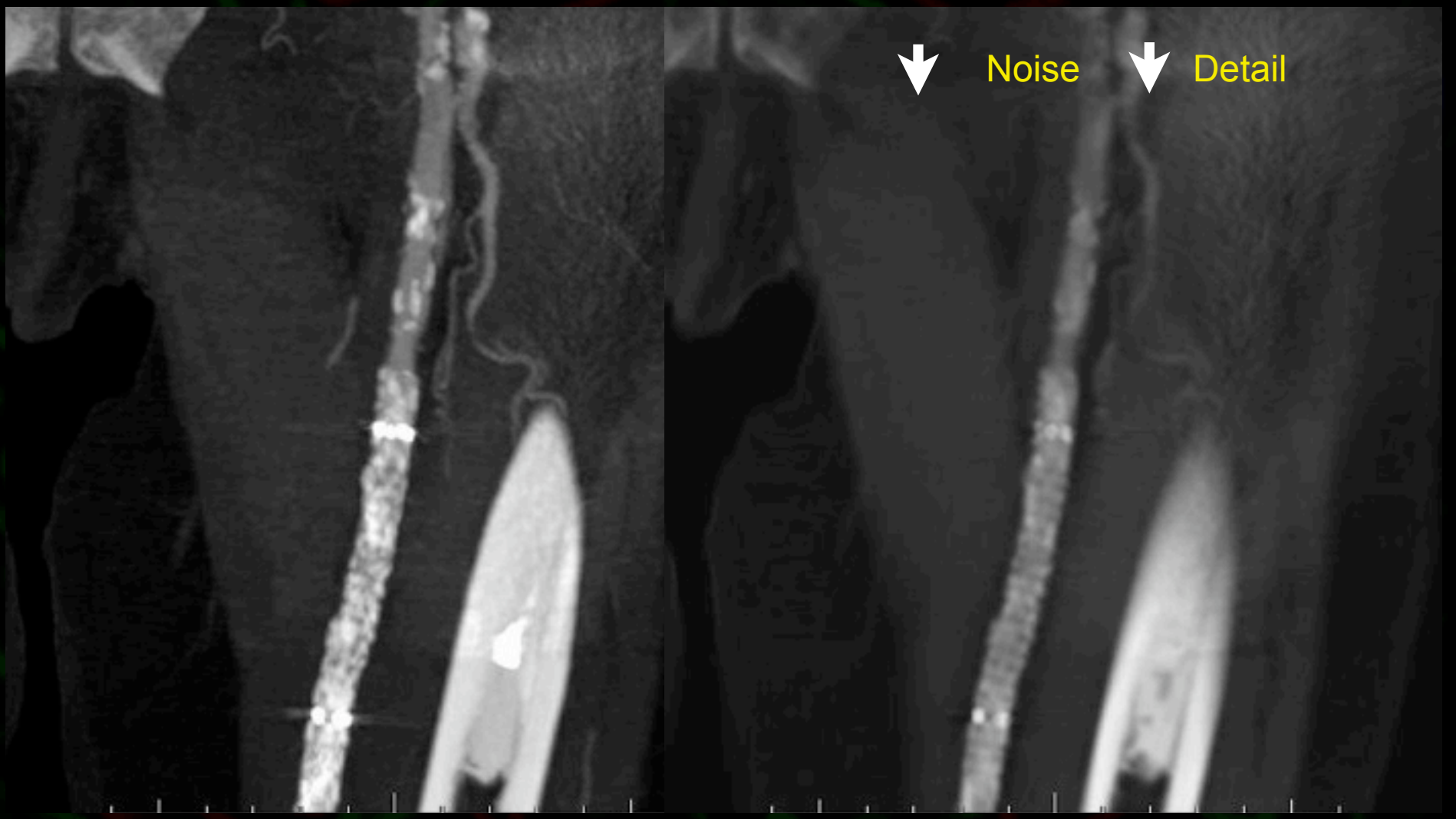


Dalrymple, N. C. et al. Radiographics 2005;25:1409-1428

- Average intensity along ray
- Decreased noise vs. MIP and MINIP
- Decreased edge detail
- Good to "salvage" studies when primary recons have too much noise

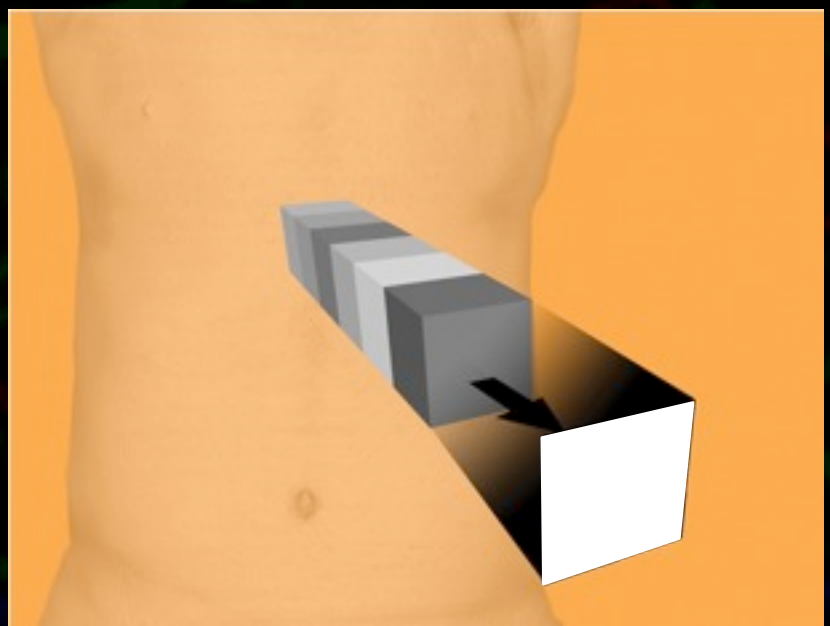
10 mm MIP

10 mm AIP


10 mm MIP
10 mm AIP
Noise
Detail

Maximum Intensity Projection (MIP)

- Voxel along ray with maximal HU value displayed
- Vessel/background contrast ↑
- Details are better seen



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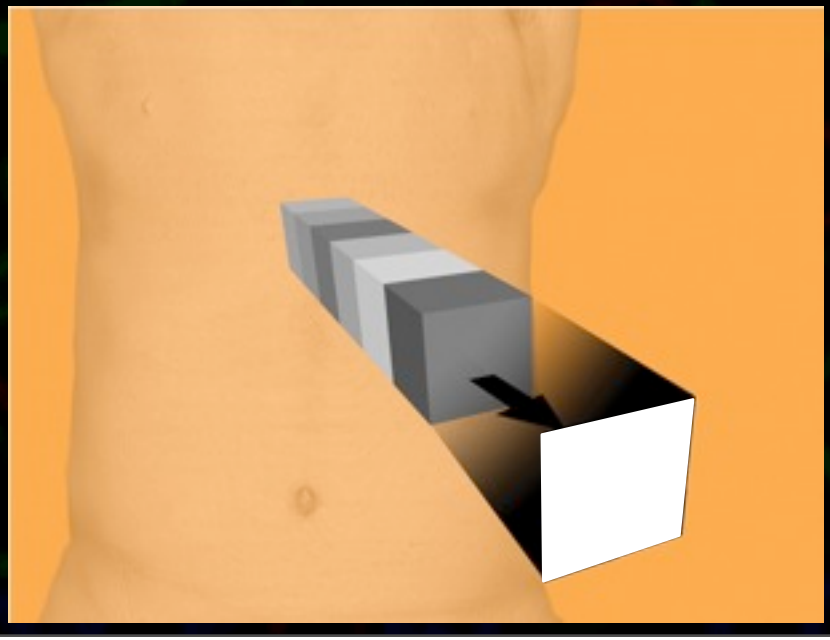

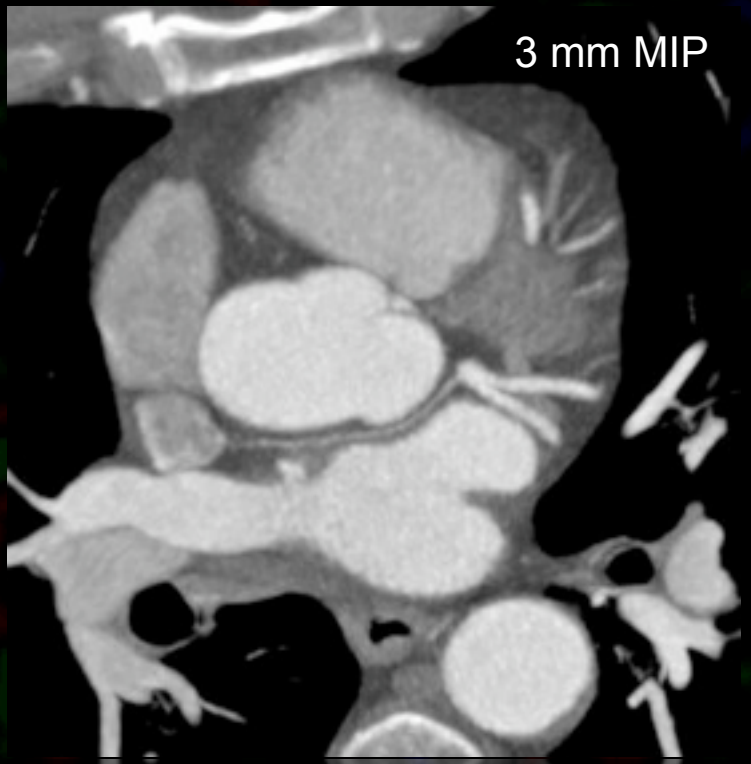

MIP Limitations

- Overlap:
  - Bones / Metallic clips
  - Vascular Calcium
- Intra-luminal defects may not be visible
- Noise (additive)
- Over-Estimation of stenosis
  - from background noise, W/L

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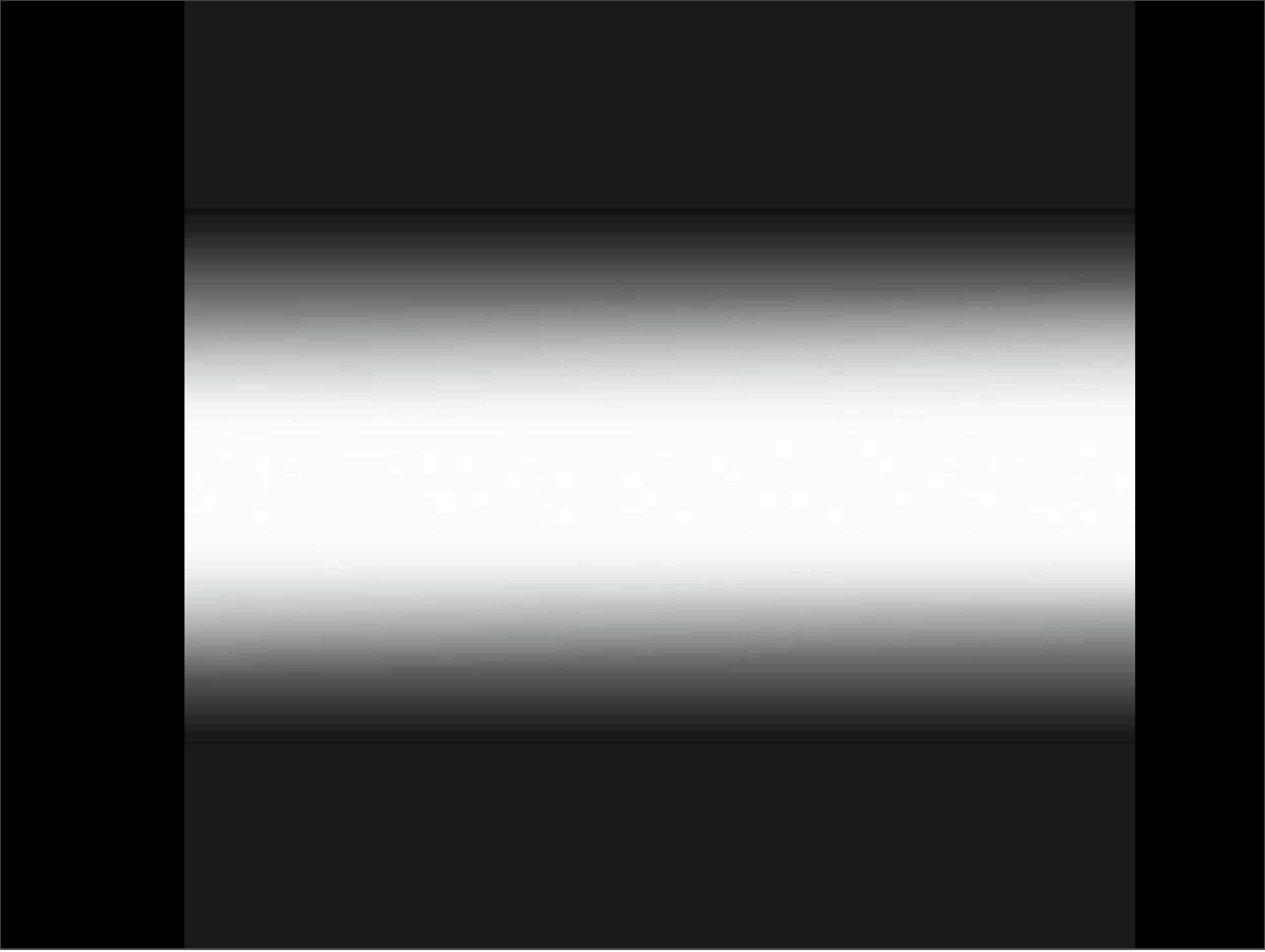
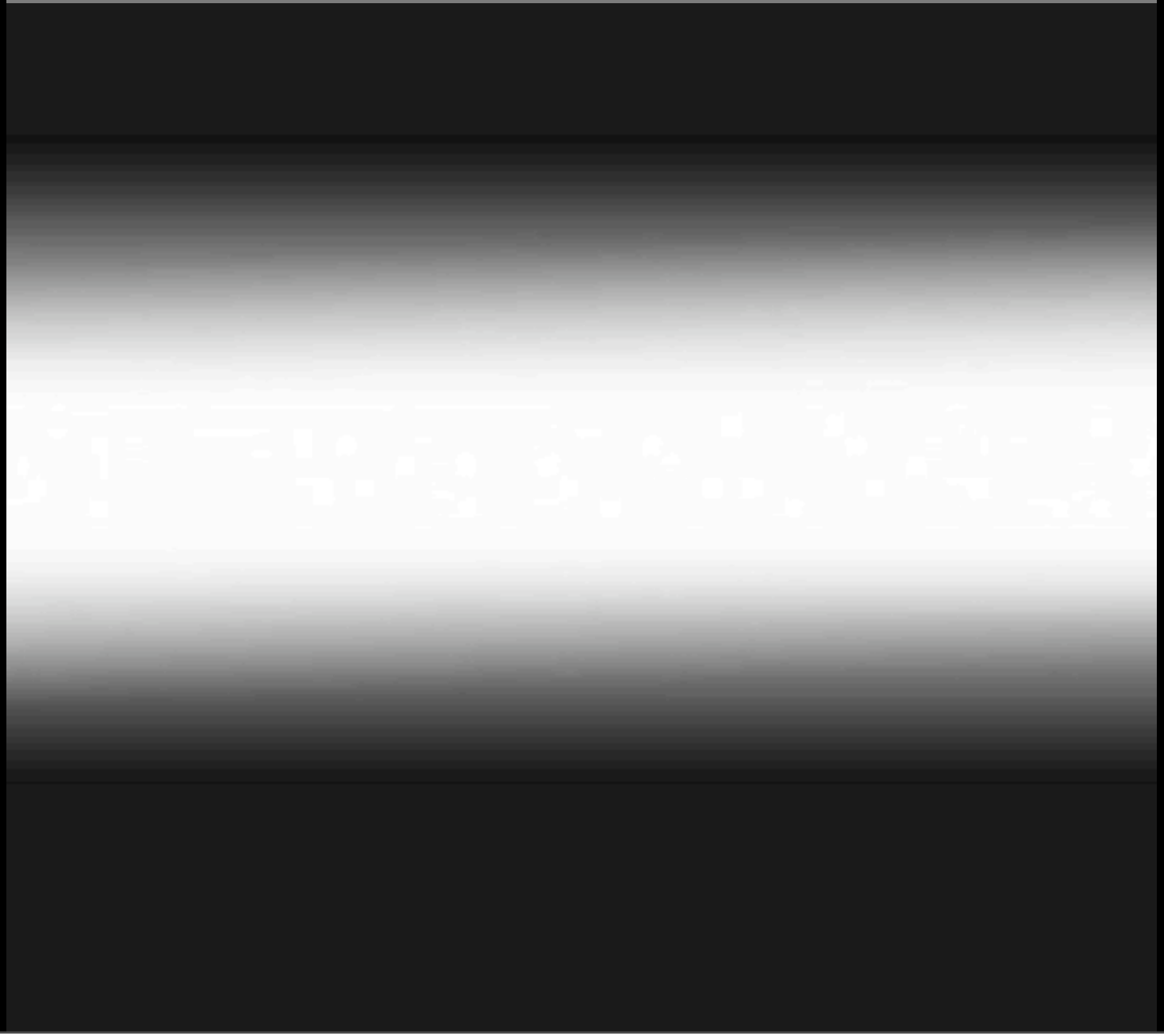


MIP: Over-Estimation of Stenosis



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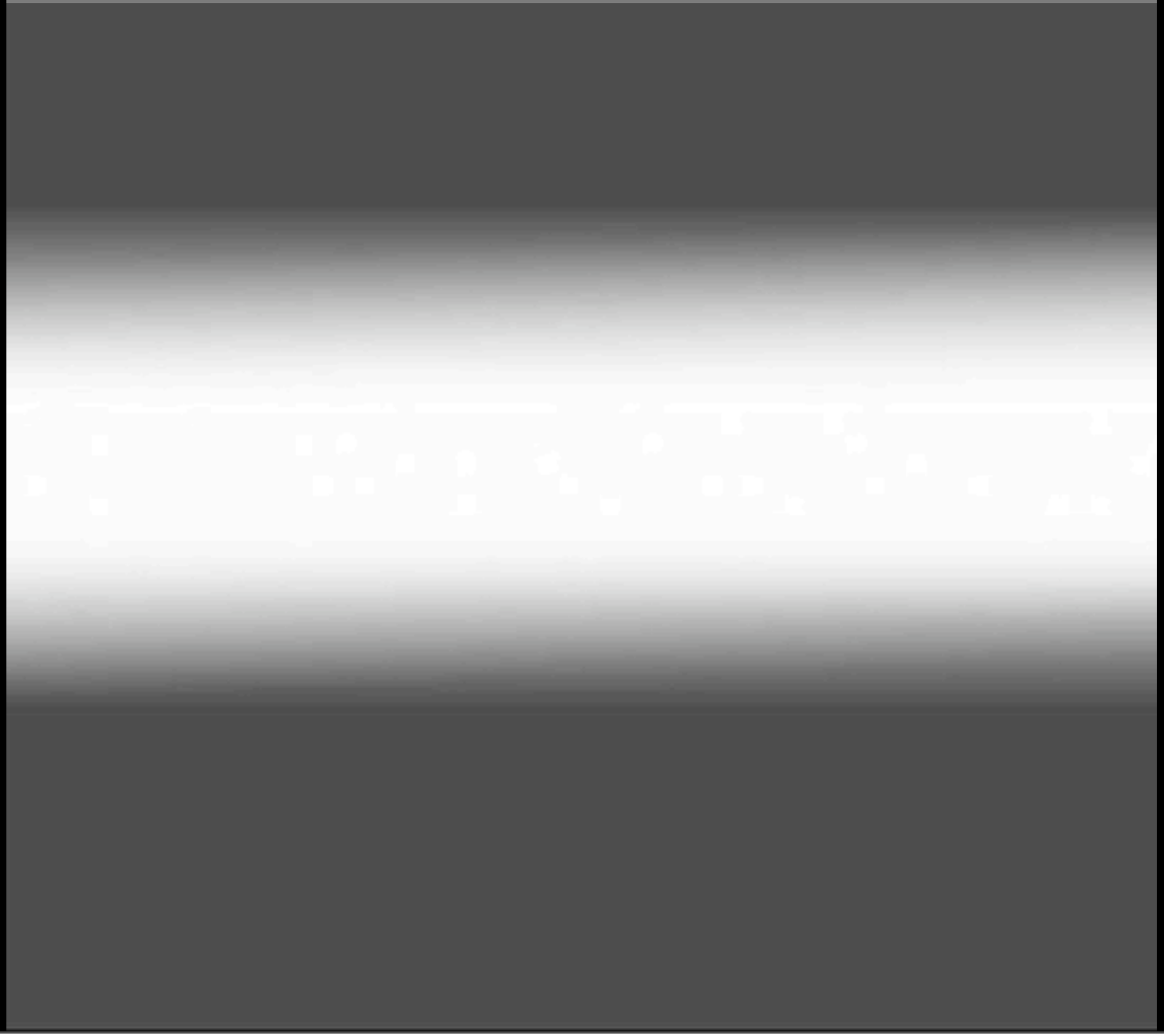

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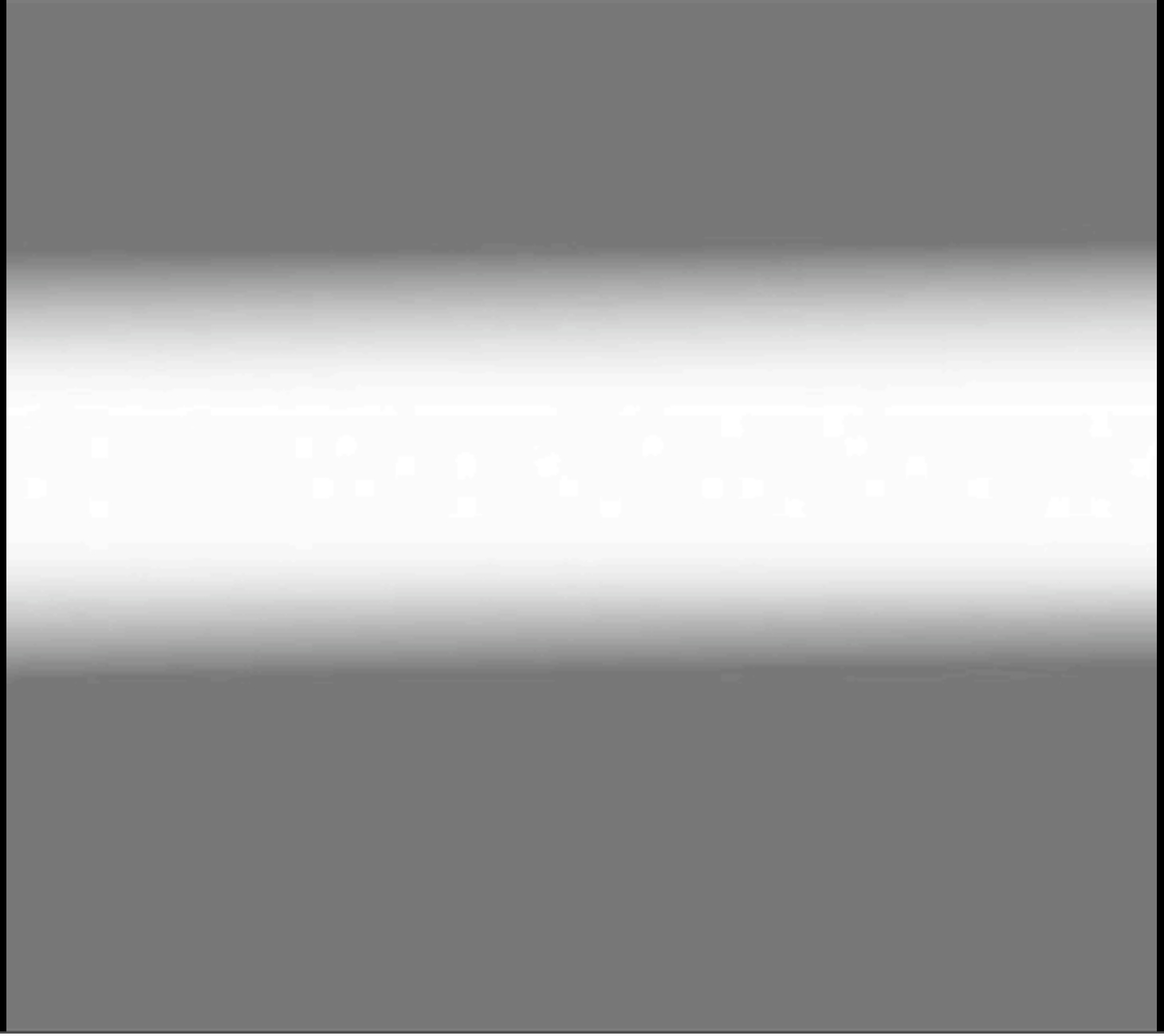
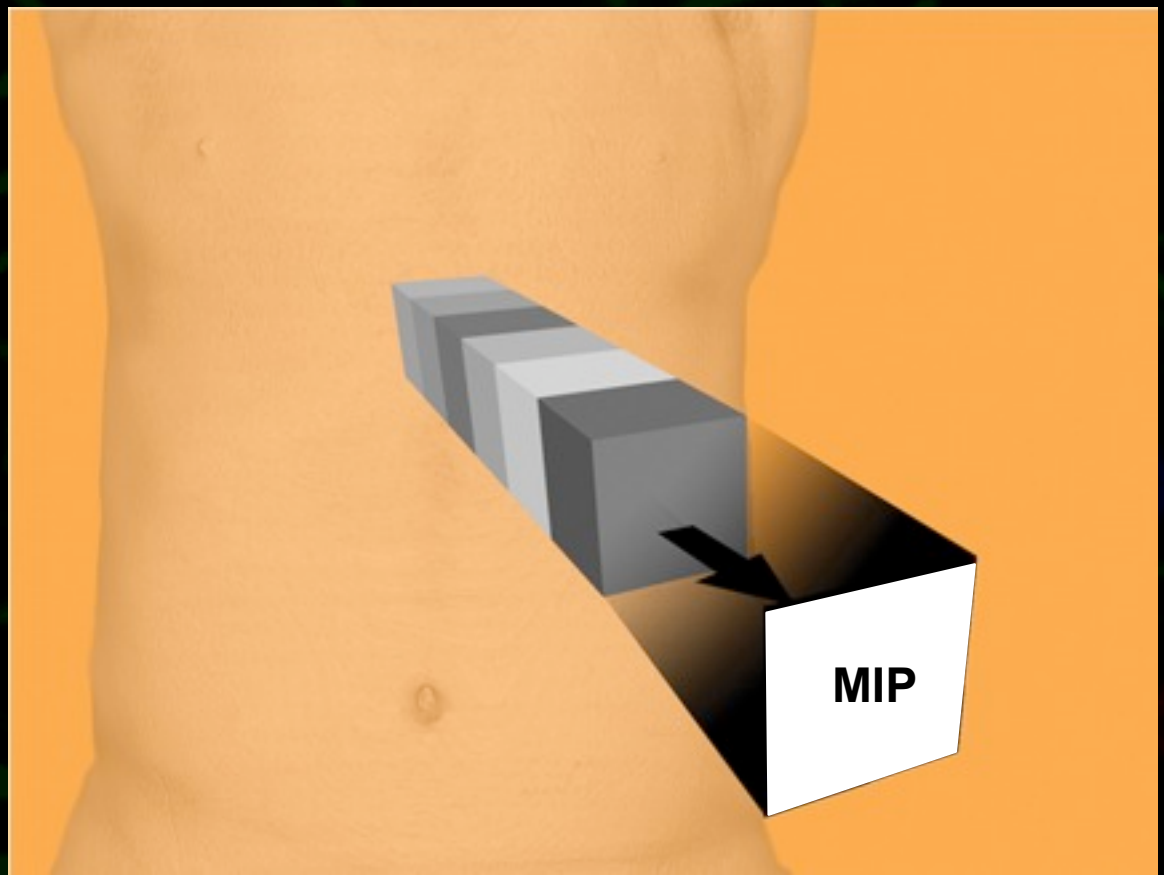
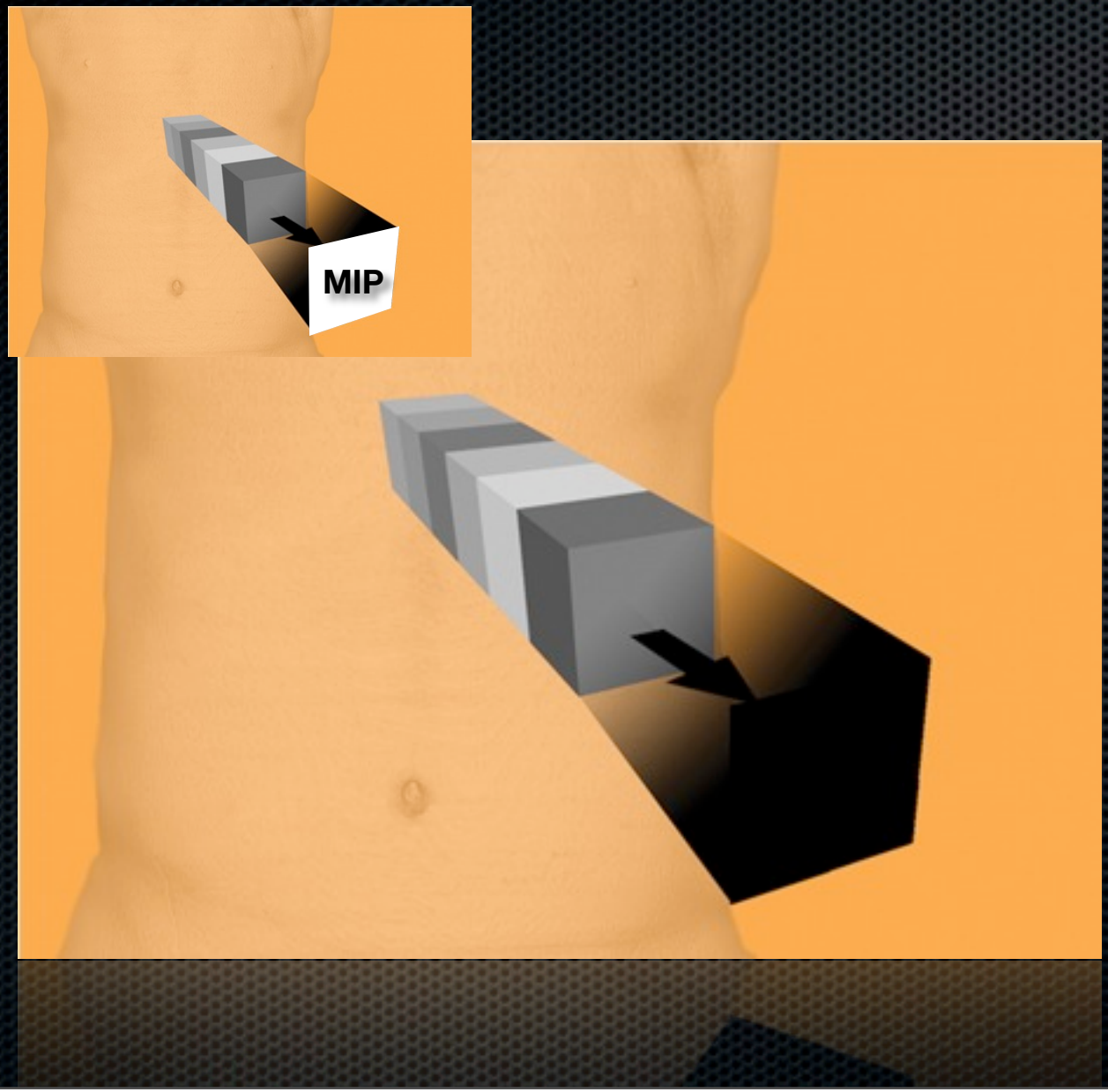


the anti-MIP.....



Minimum Intensity Projection (MinIP)



Like MIP, but minimum voxel value along ray depicted

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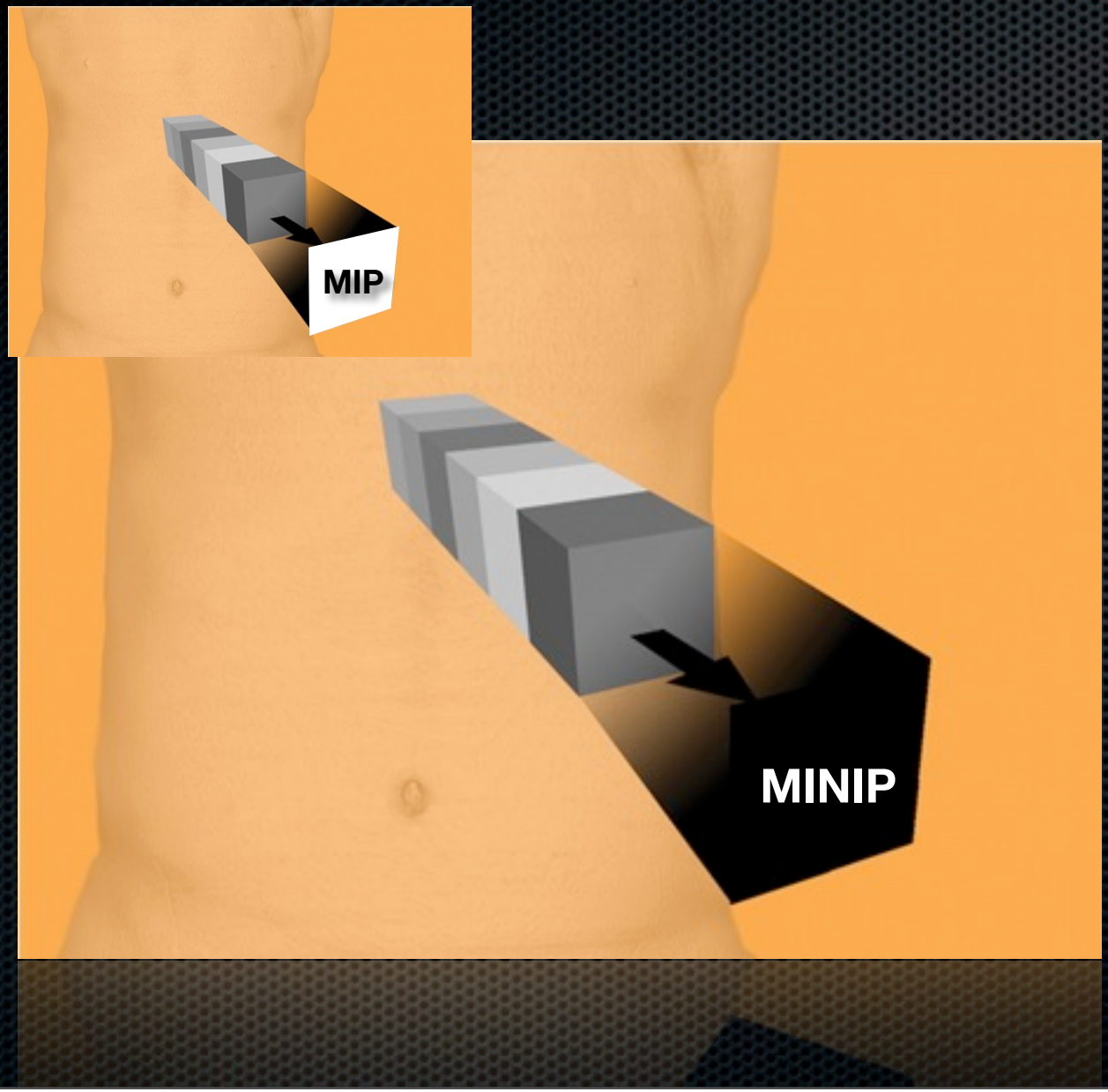

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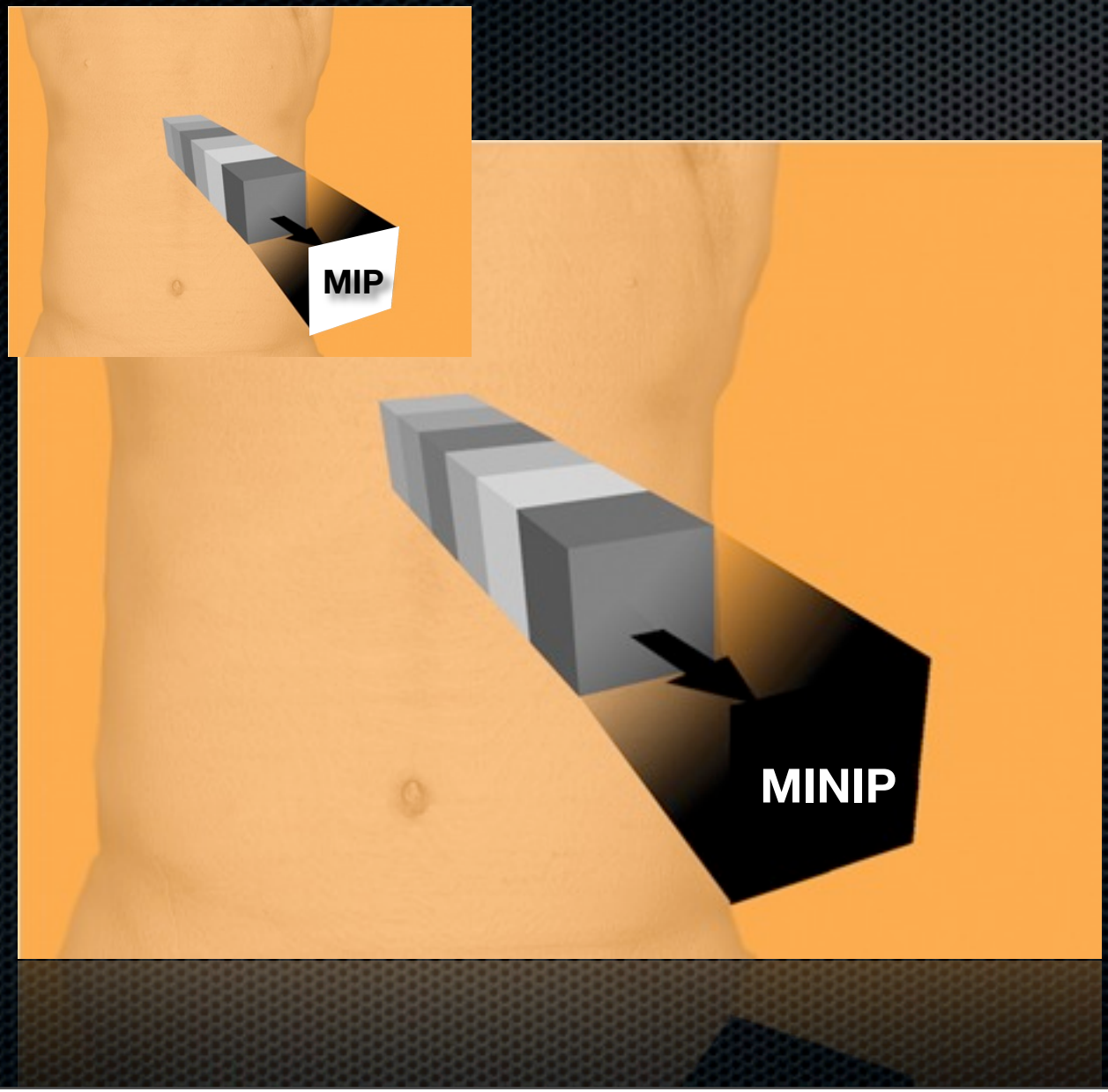

Uses:

Lungs

Central airways, air trapping

Cardiac Valves

5-20 mm slab; 4D review

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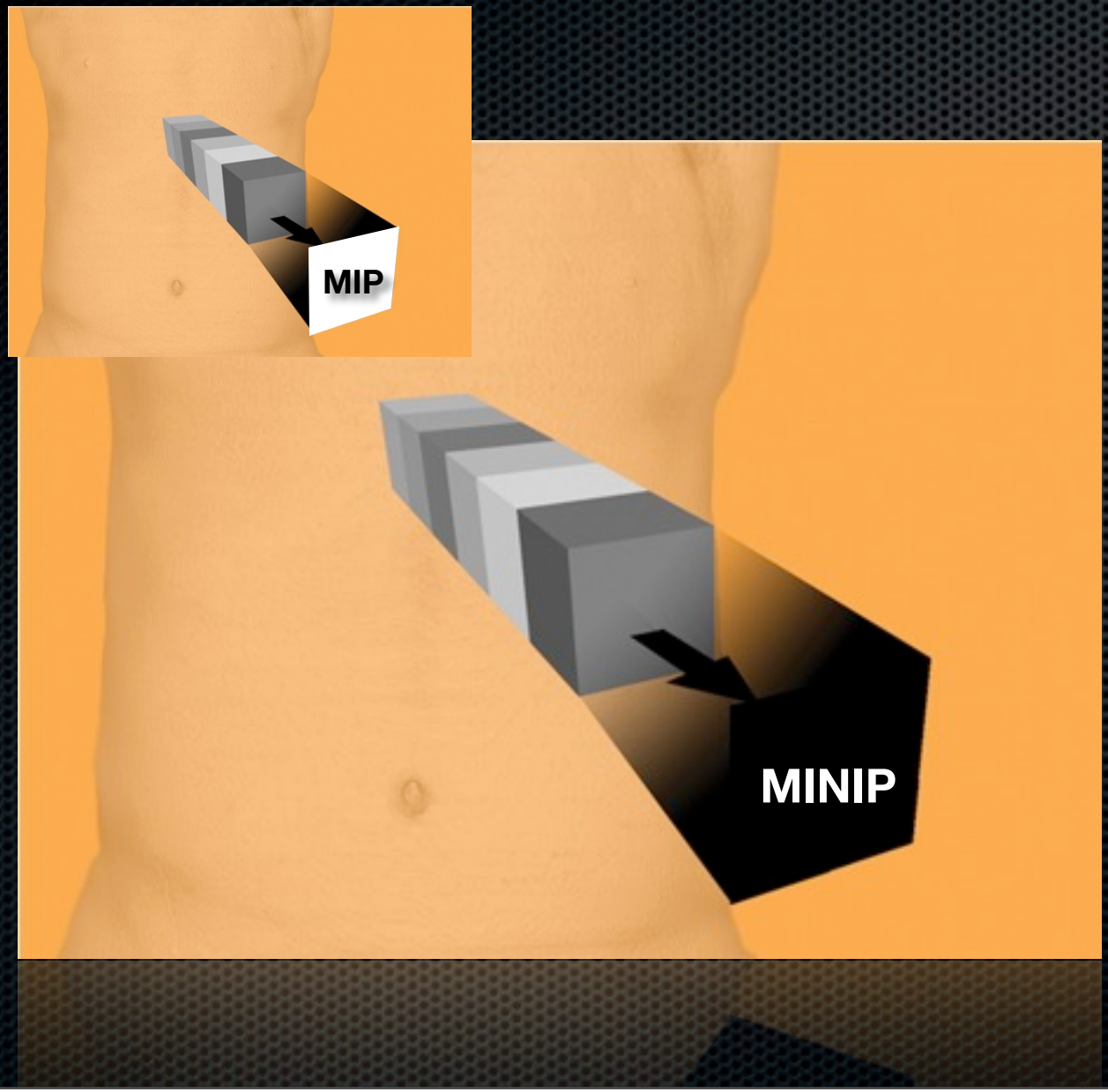

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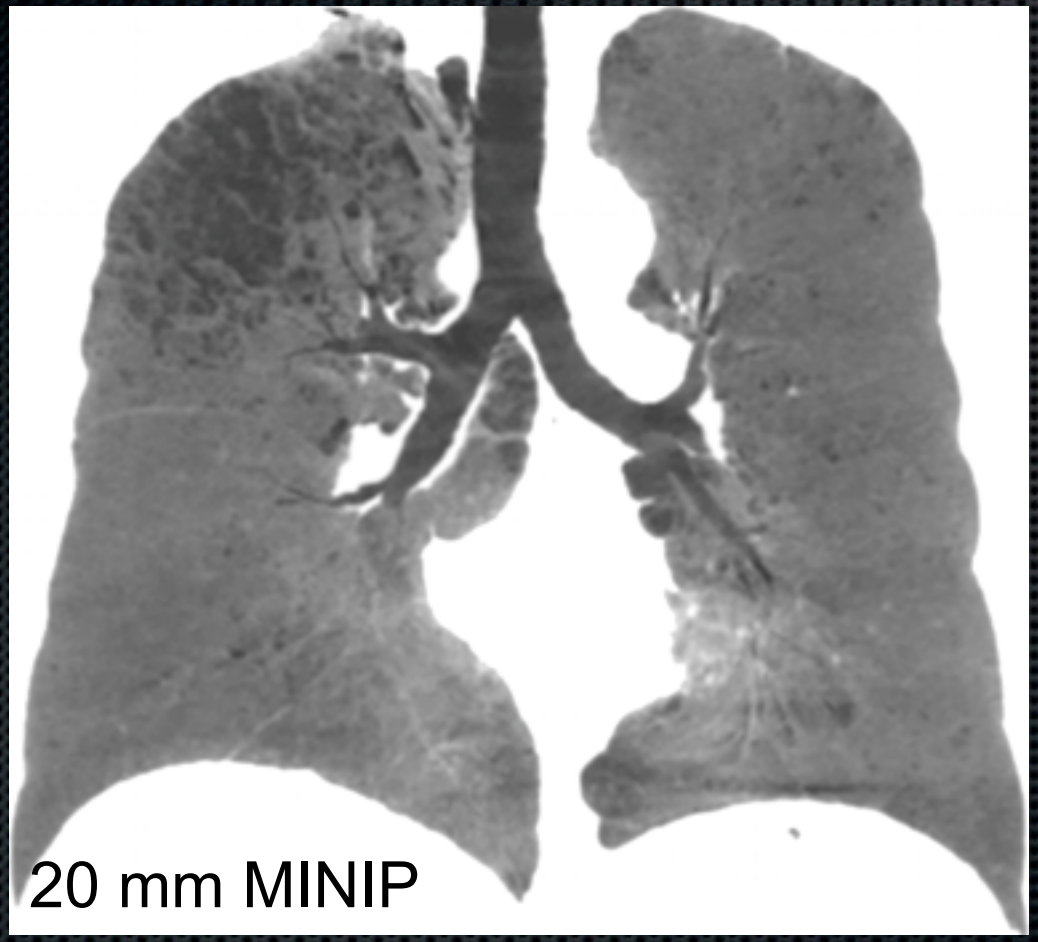

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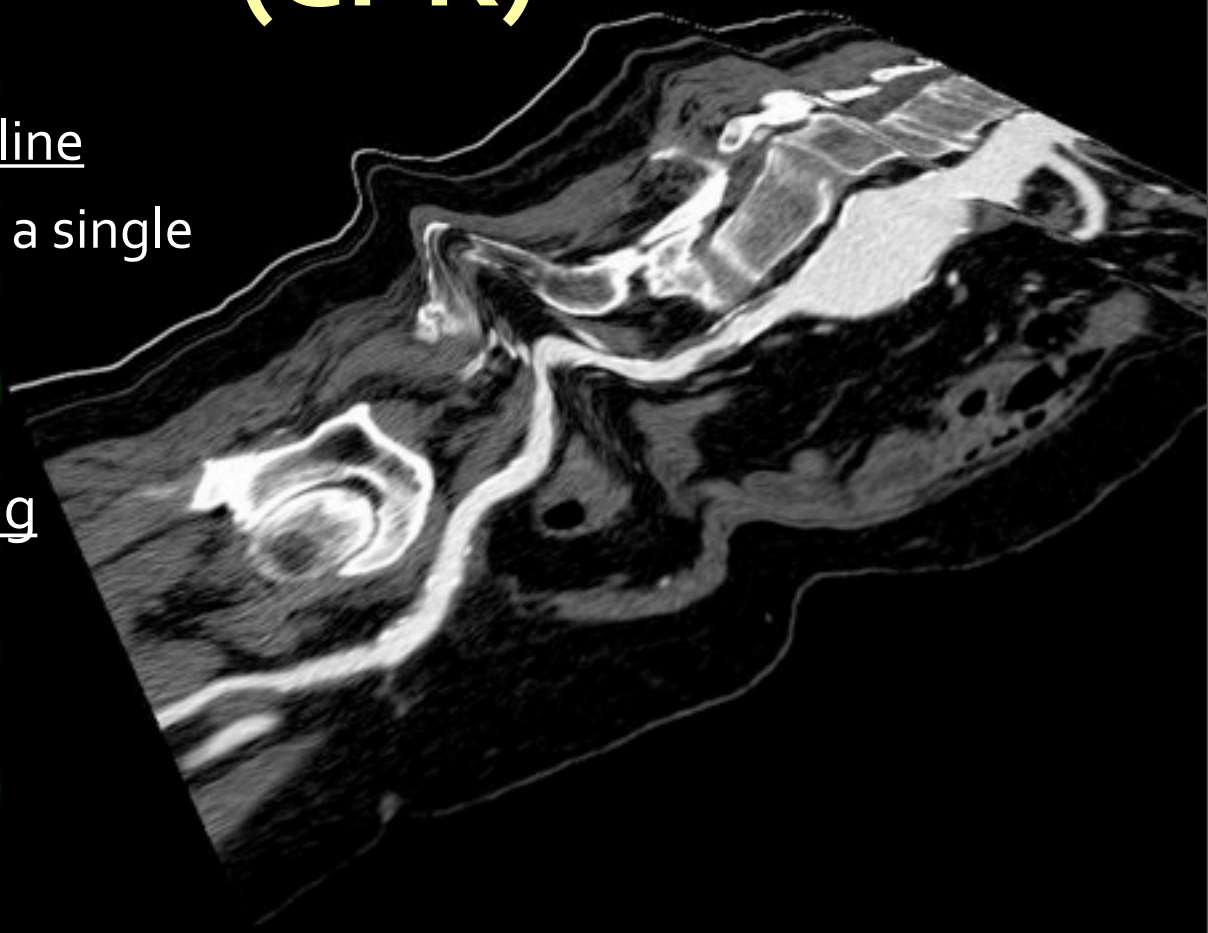
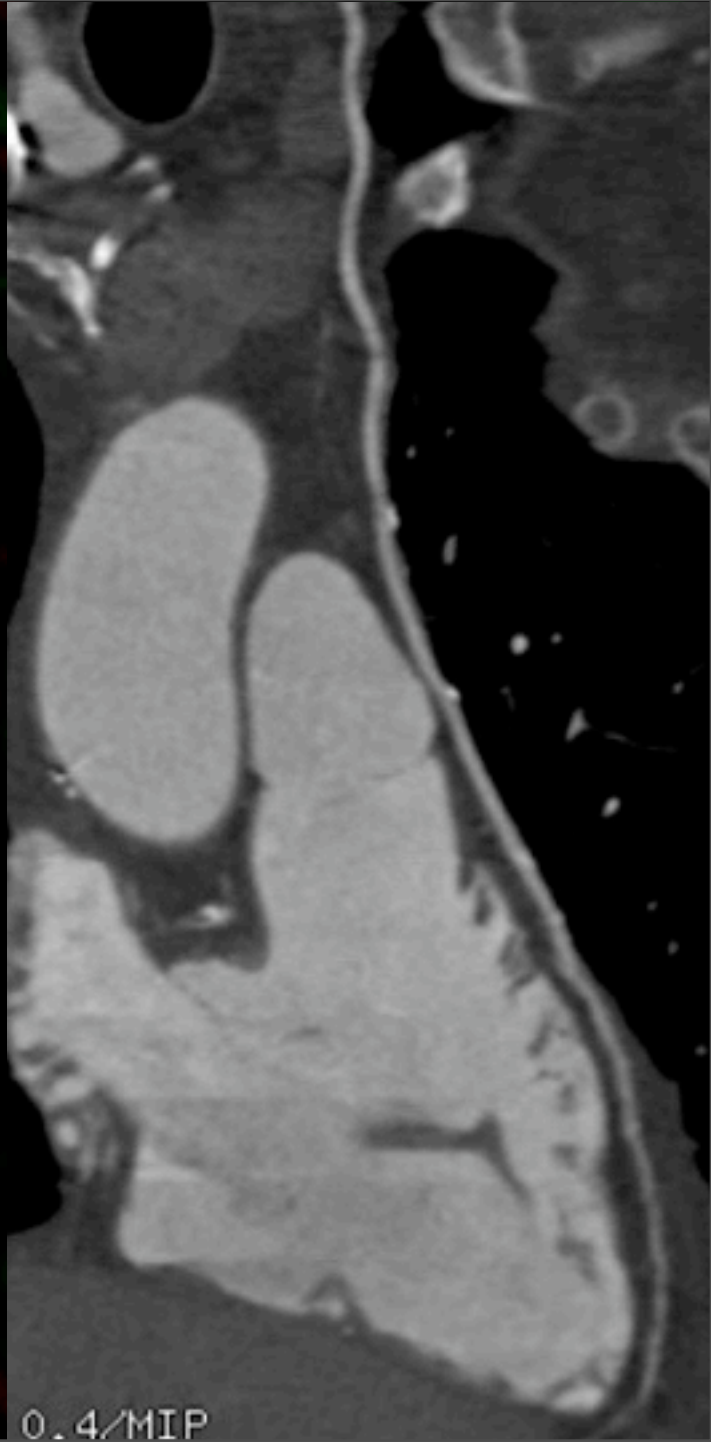
Curved Planar Reformation (CPR)

- MPR generated along an arbitrary (**curved**) line
  - Usually a vessel centerline
  - get WHOLE VESSEL in a single plane
- Best to evaluate wall abnormalities along long segments of vessels:
  - Stents
  - Calcium
  - Soft plaque
  - Ulcers



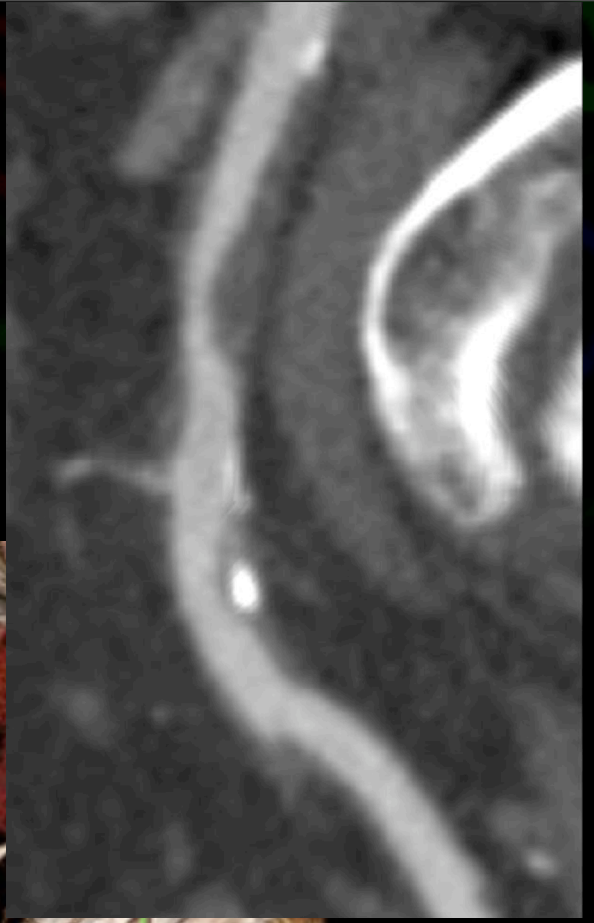
CPR = Curved MPR

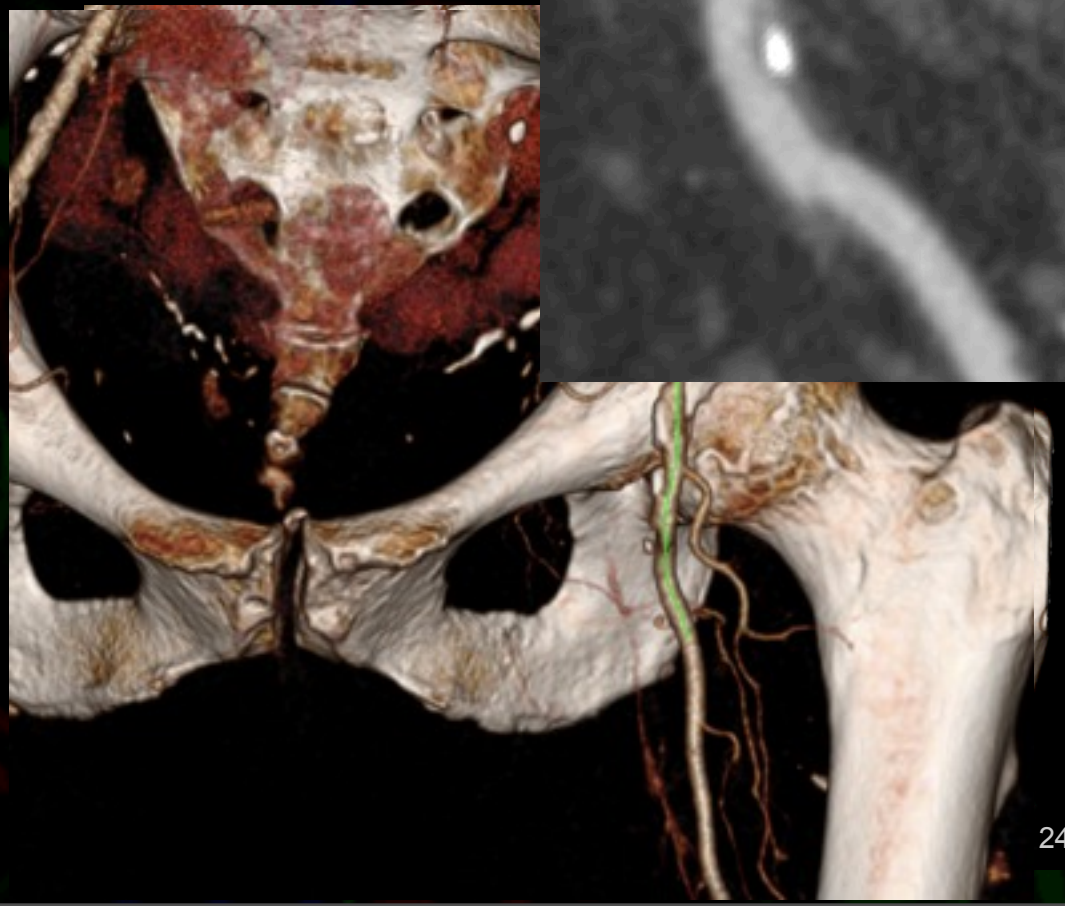
LIMA-LAD BPG



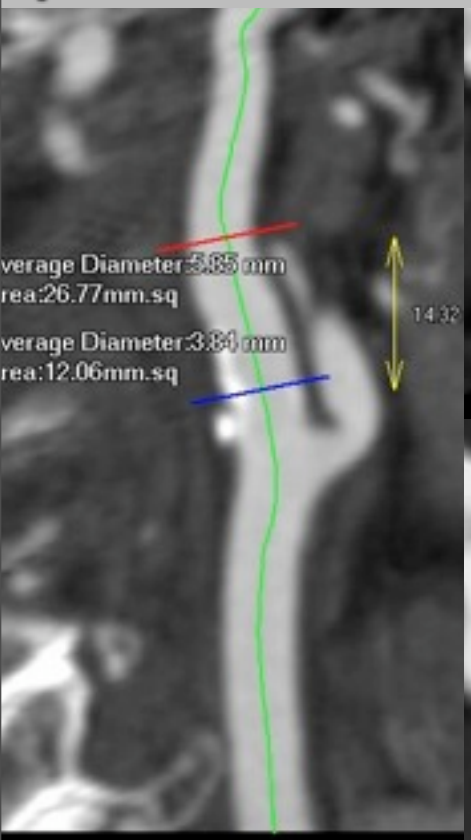
CPR = Curved MPR

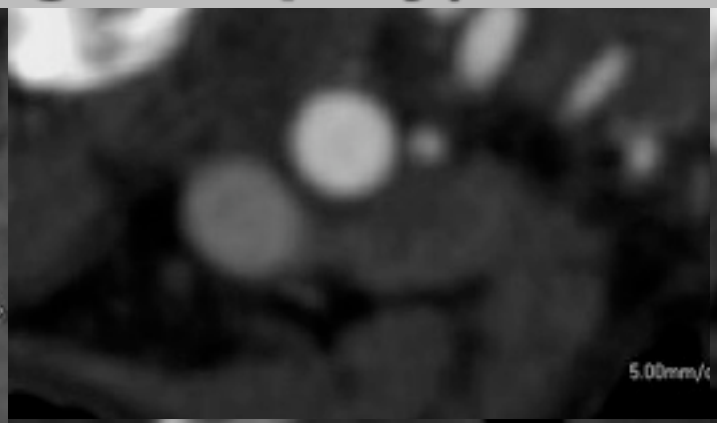
Eccentric CFA stenosis from mixed plaque

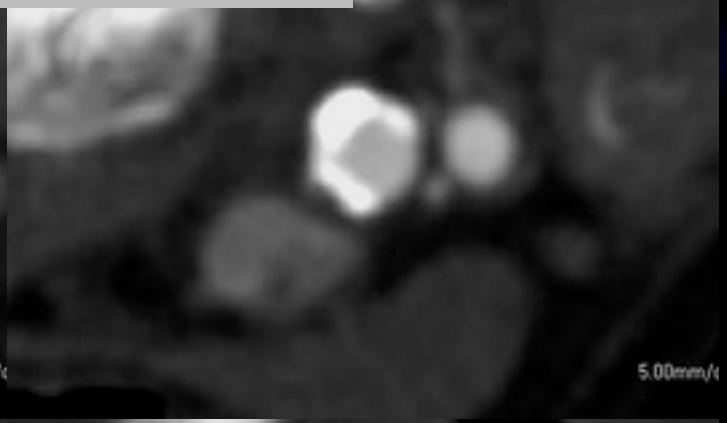


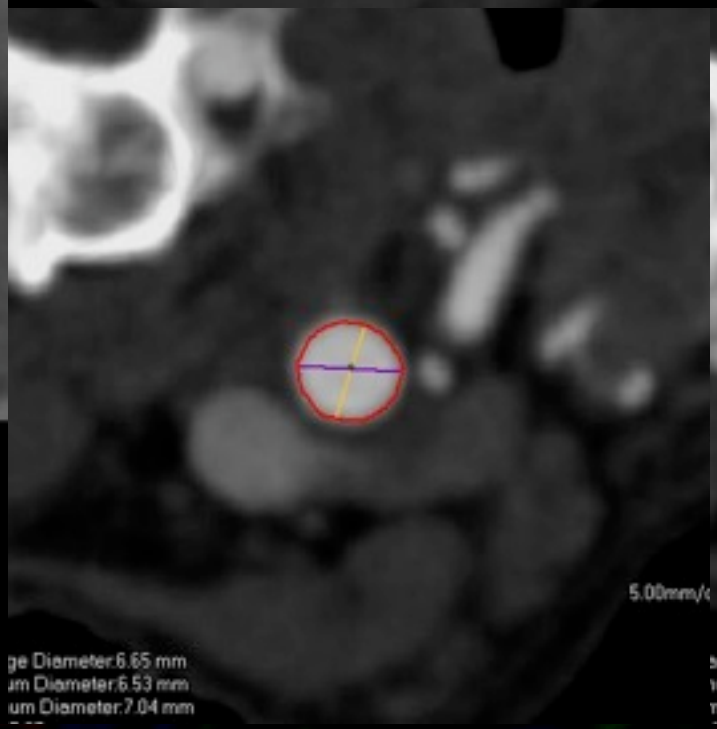


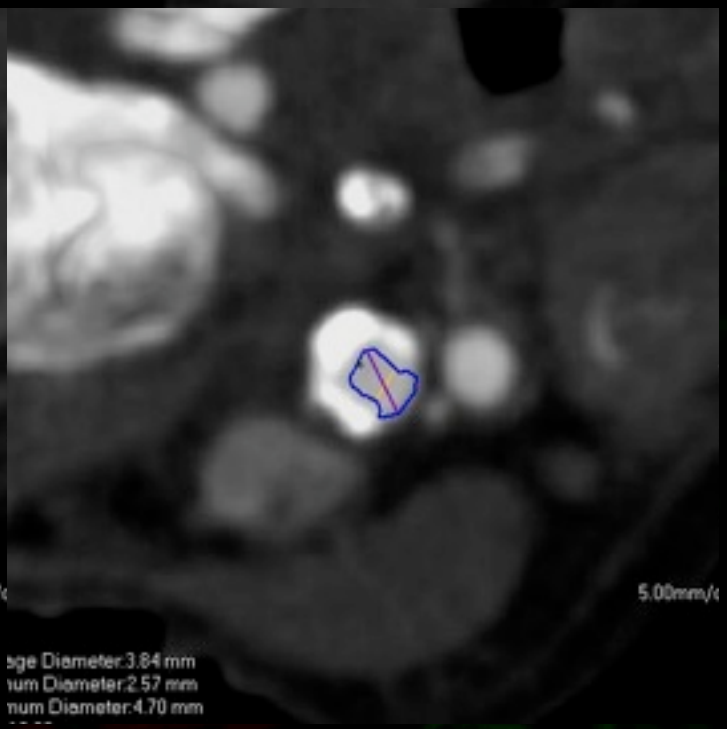
CPR - Orthogonal Measurements (slice through display)











Stenosis (Minimum):53.53%
Stenosis (Average):34.39%
Area Stenosis:54.97%

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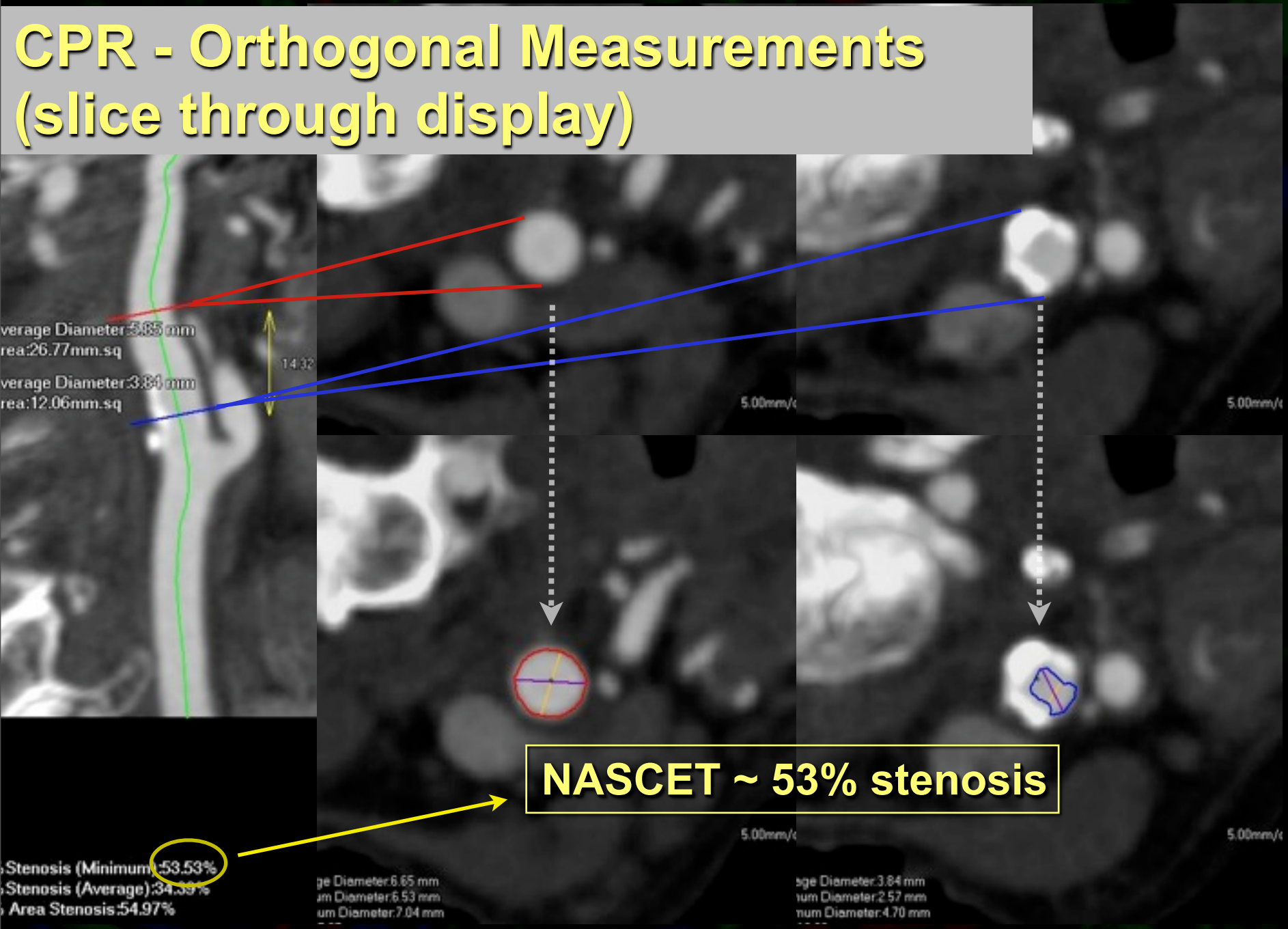
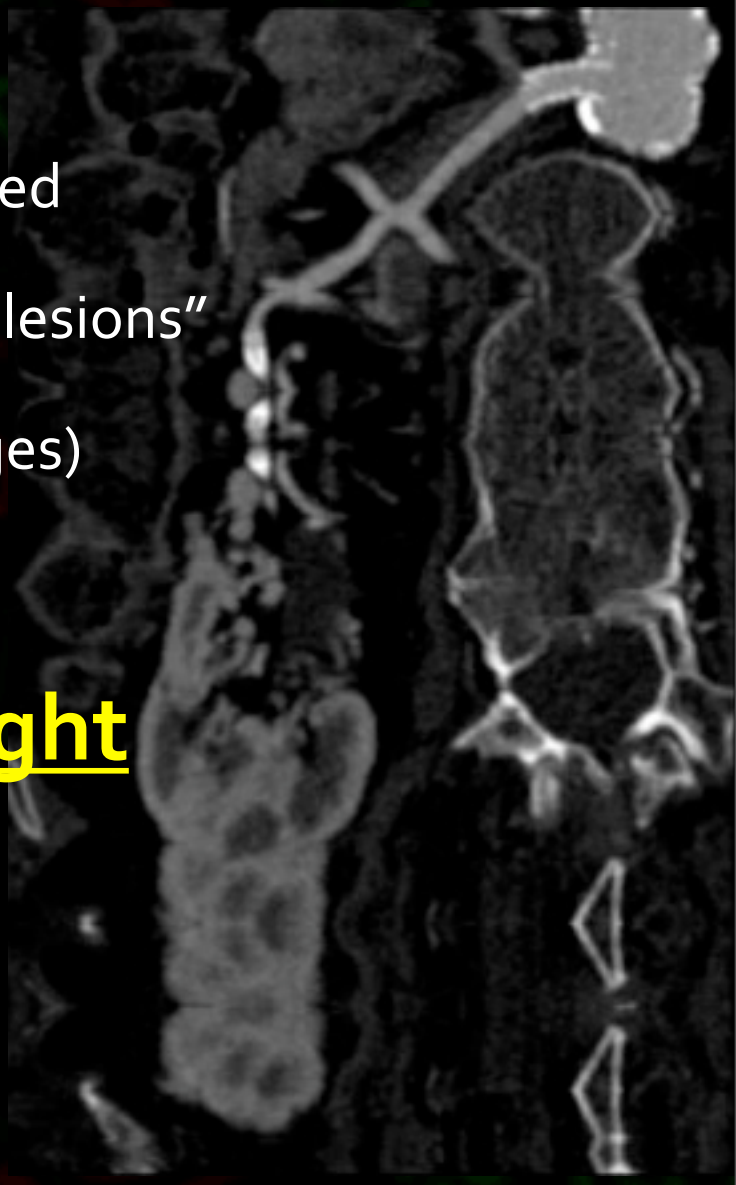


Curved MPR Limitations



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- Cannot be used alone (need source images)
- Time consuming if manual generation
- **Still needs RT / MD oversight**

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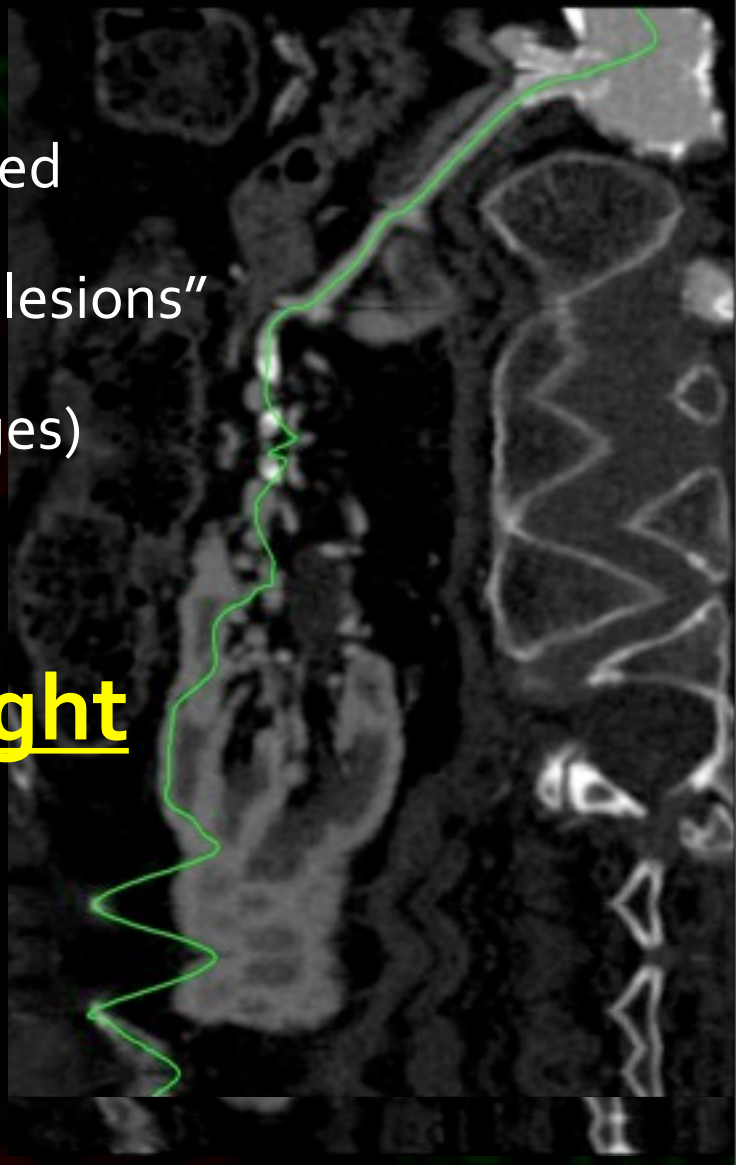

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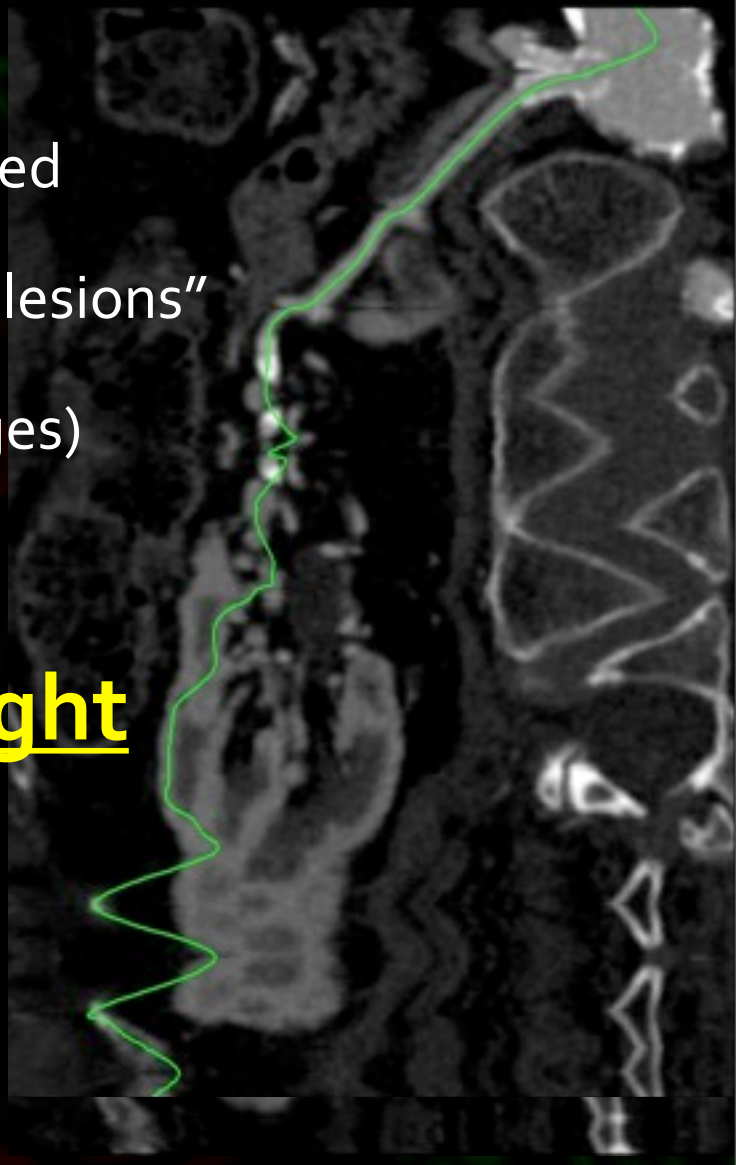
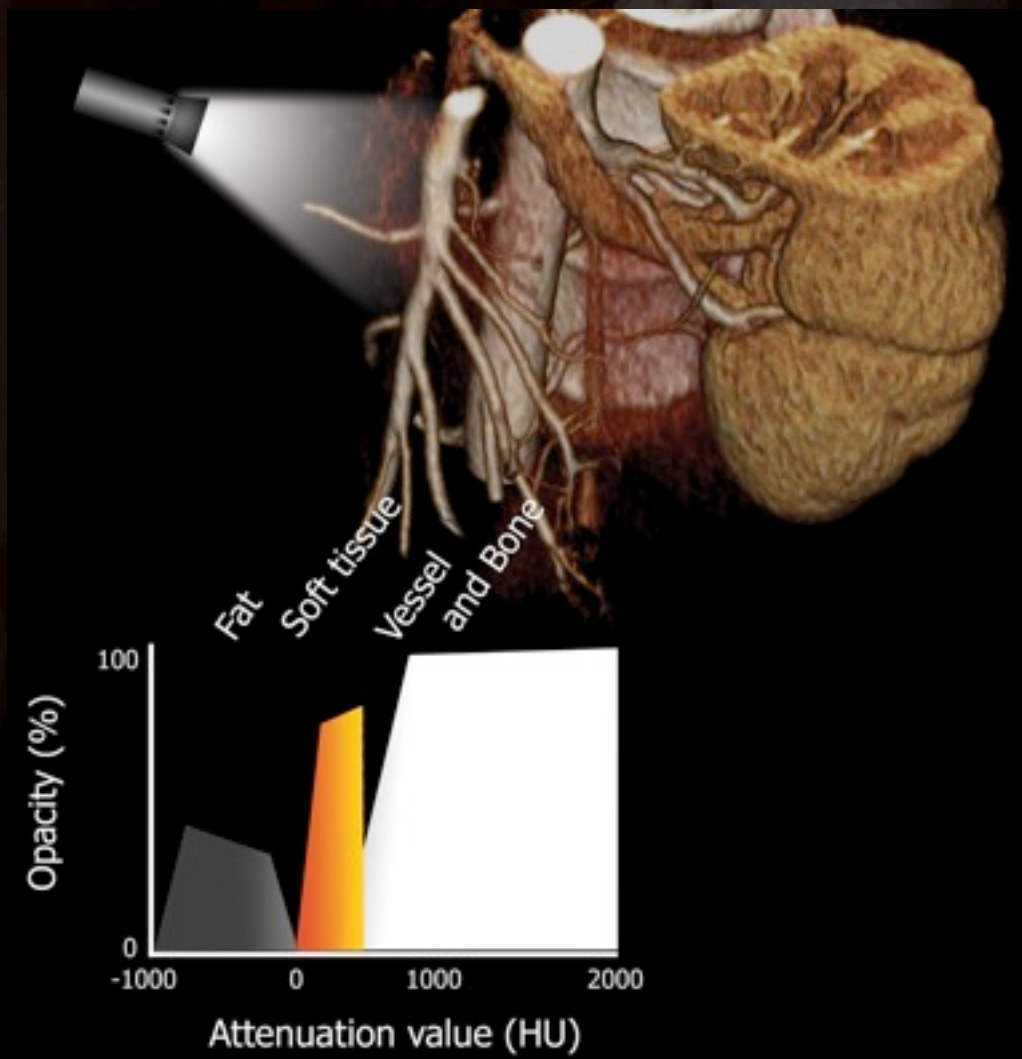


Volume Rendering (VR)

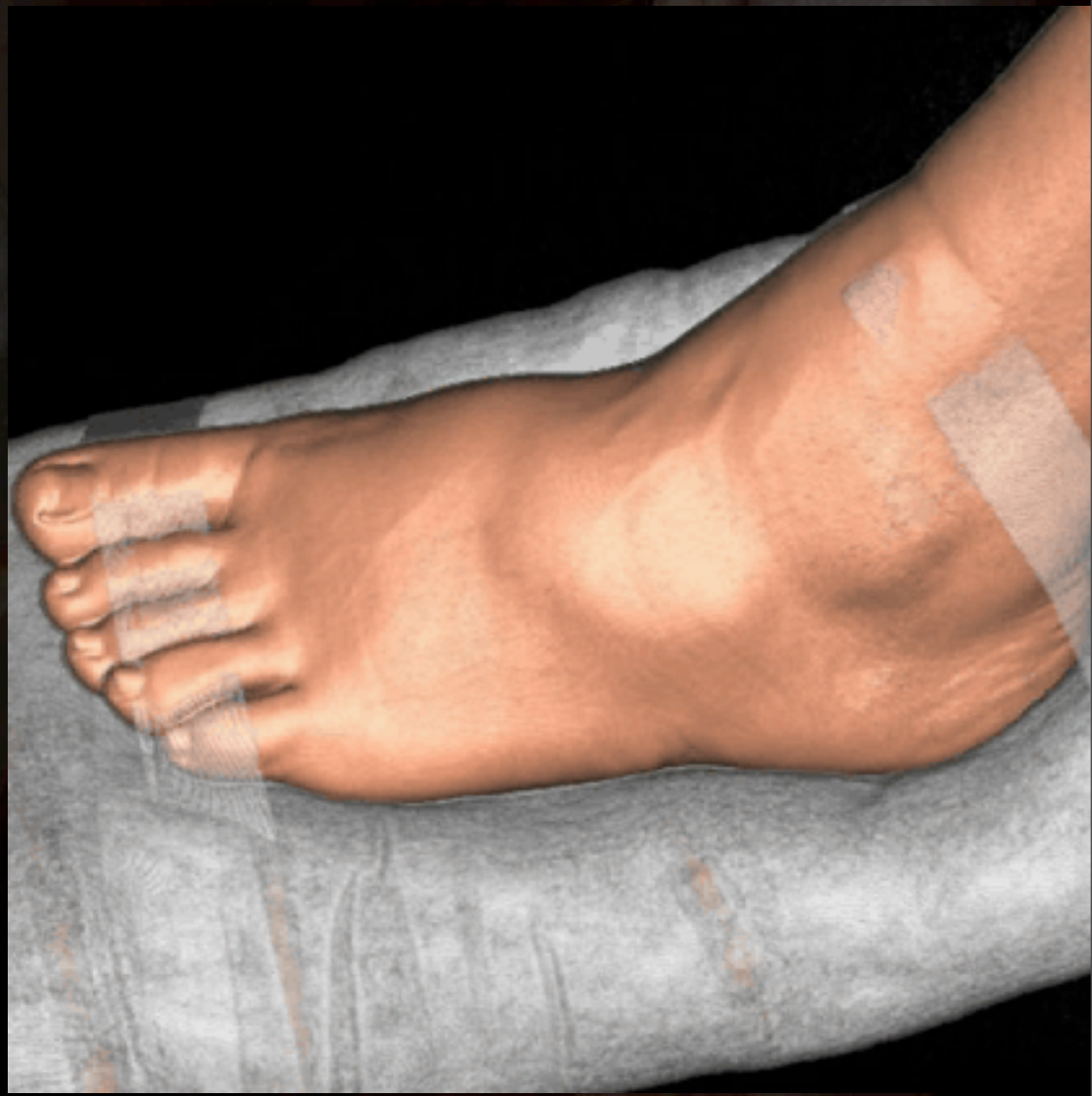
- Originally developed for motion picture animation
- Assigns color and opacity value (0-100) to voxels along artificial line of sight
  - Multiple voxels can contribute to the output image (unlike MIP, MINIP)

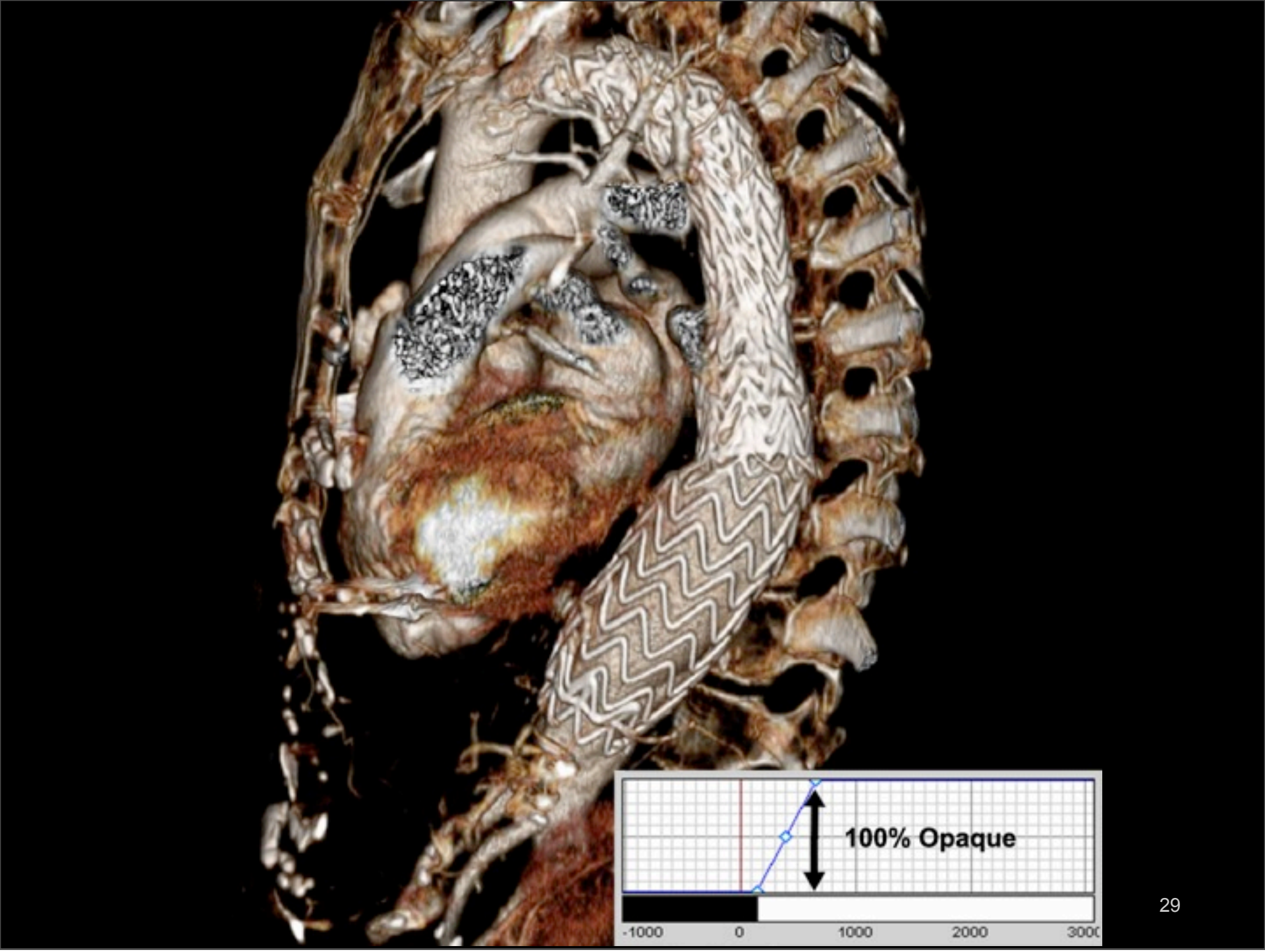
- Can use geometric functions to assign colors
- "Opacity Ramp": curve that describes relative opacities and colors
- Changing the ramp -> changes displayed tissues
- All data may be used
  - computer processing requirements much greater than MIP/ MPR, etc.



Dalrymple, N. C. et al. Radiographics 2005;25:1409-1428

- Can use geometric functions to assign colors
- "Opacity Ramp": curve that describes relative opacities and colors
- Changing the ramp -> changes displayed tissues
- All data may be used
  - computer processing requirements much greater than MIP/ MPR, etc.

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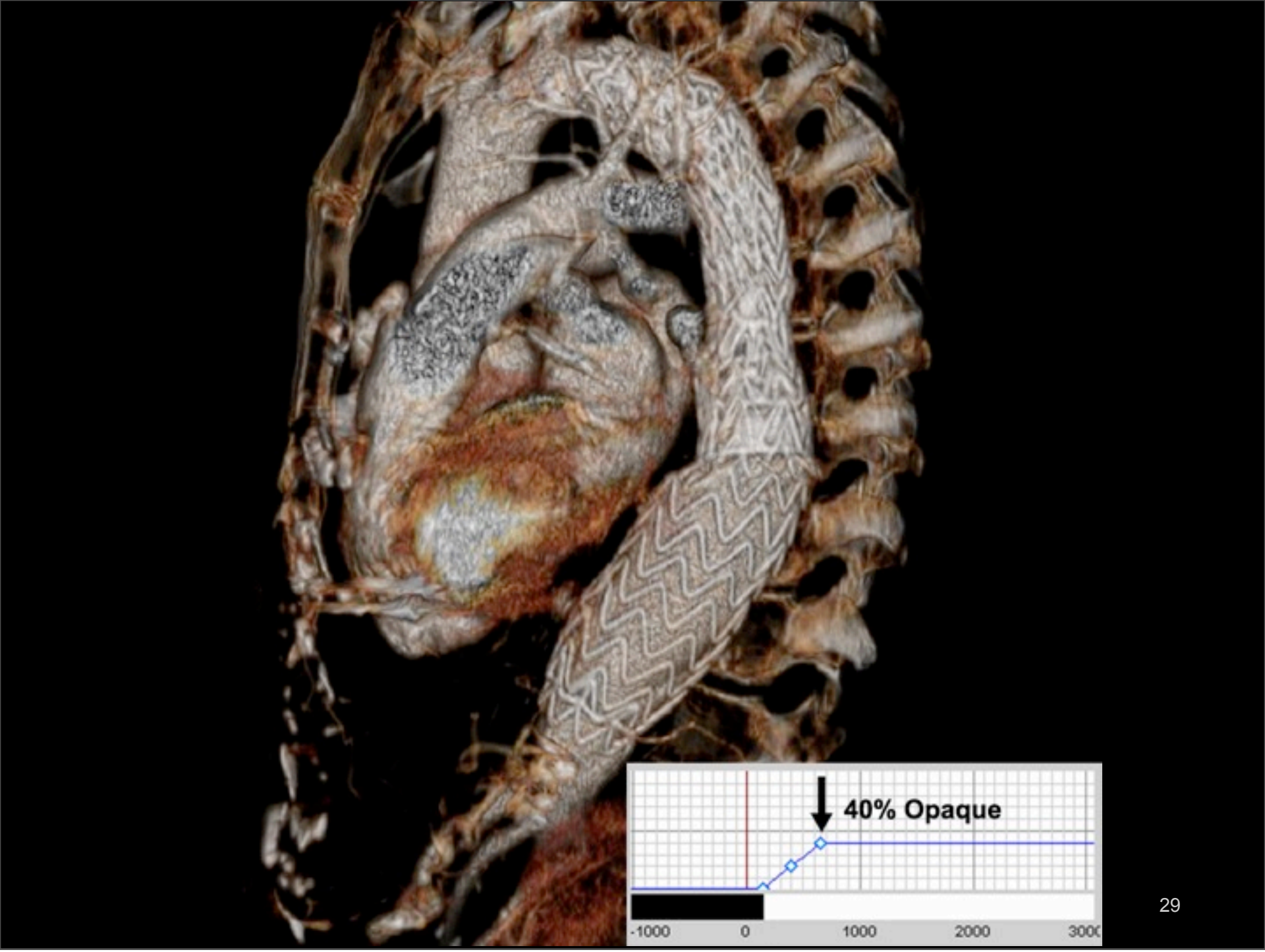
0
1000
2000
3000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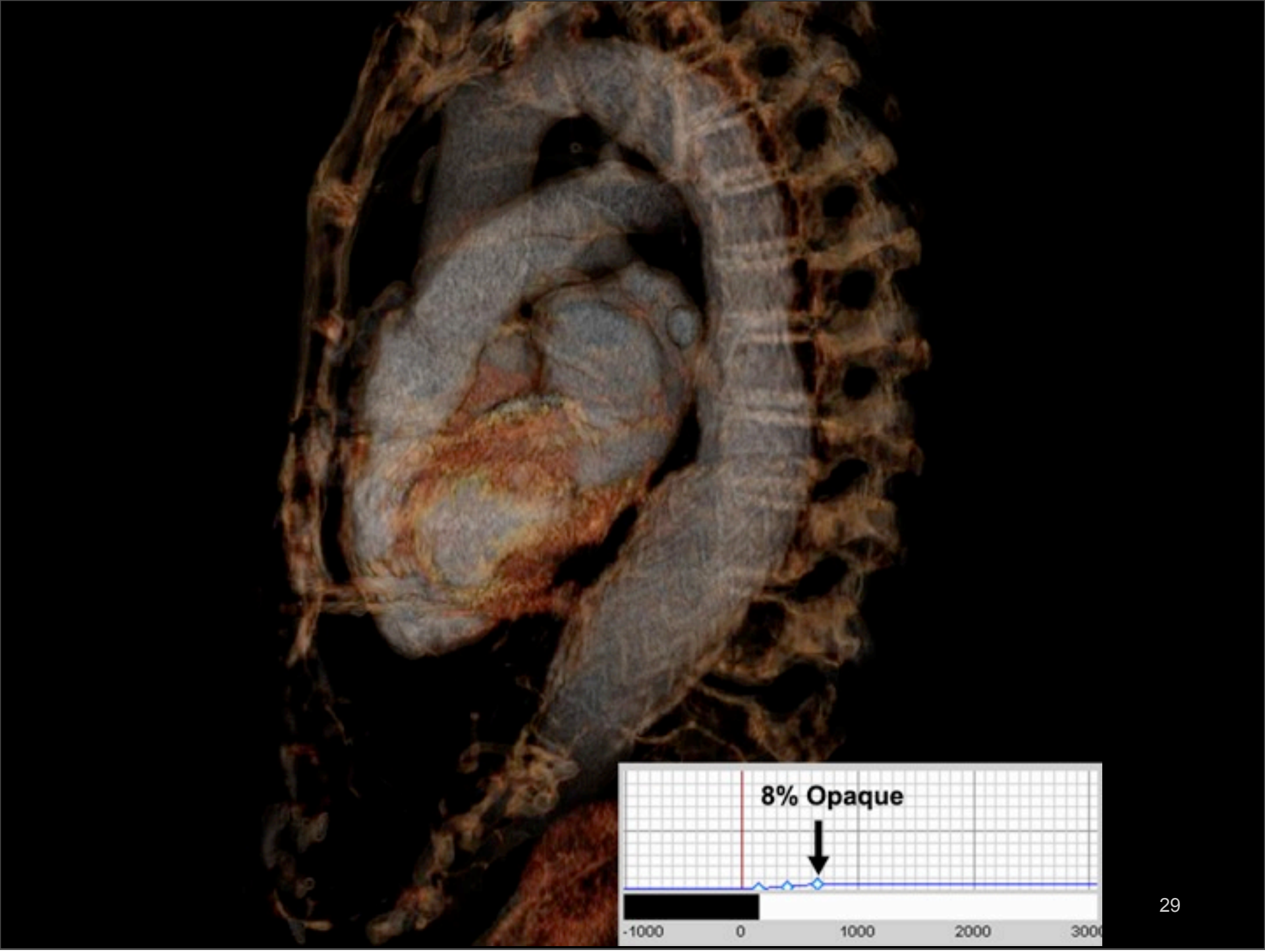
8% Opaque
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0
1000
2000

Uses for VR

- Rapid communication of large amount of data in a few images
  - Surgical planning
  - Surrounding anatomy
- Cardiac / Vascular Interpretation
  - Allows quick overview, directs more detailed evaluation
  - Saves time

IN SUMMARY:

	Major Uses	Advantages	Disadvantages
MPR	Flow lumen, vessel wall analysis	•Best for stenosis, occlusions, calcifications, stents	•Limited spatial relationships •Limited display if curving vessel
MIP	Angiographic overview, contextual with adjacent structures	•Depicts course of small and/or poorly enhancing vessels	•Vessel, bone, visceral overlap •Limited stent evaluation •Limited by calcium •No accurate measurements
CPR	Flow lumen, vessel wall analysis	•Best for stenosis, occlusions, calcifications, stents •Curved objects well seen	•Distortion of extra-vascular structures •Dependent on accurate centerline
VR	Angiographic overview, contextual with adjacent structures	•Structural overview •Best for complex relationship display •**WOW** factor	•Opacity transfer function dependent •No accurate measurements

THANK YOU!!

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Geoff Rubin, MD
Justus Roos, MD

Online Handouts from Lecture:
www.stanford.edu/~hallett/SIR2010

THANK YOU!!

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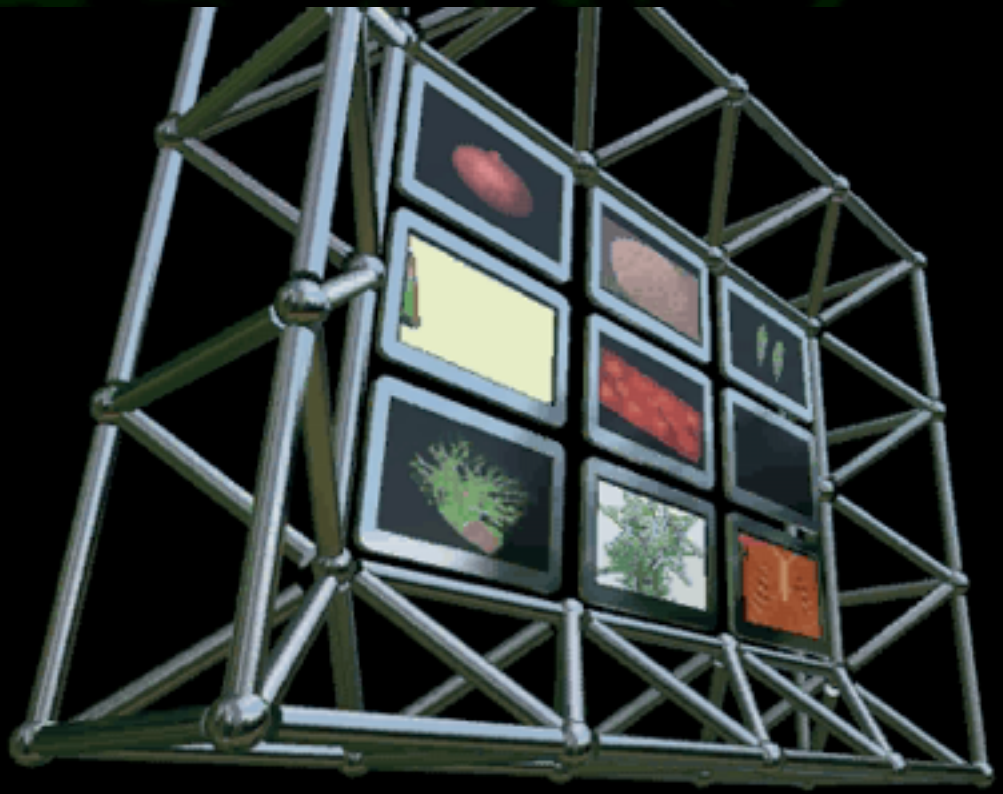

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