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

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0800-1000
Disclosures: None

Online Handouts from Lecture:

www.stanford.edu/~hallett

Choose “SIR 2011”
I. Image reconstruction
II. Post-processing techniques
III. Workflow / Interpretation
Outline

I. Image reconstruction
II. Post-processing techniques
III. Workflow / Interpretation
(Modifiable) Image reconstruction parameters

1. Raw Data Reconstruction Mathematics
2. Individual Slice / Patient Characteristics
3. Field of View
4. Kernel
(Modifiable) Image reconstruction parameters

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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

- **Iterative Reconstruction** (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 *computationally expensive*

Iterative Reconstruction

- Up to 50% dose reduction 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:
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)


<table>
<thead>
<tr>
<th></th>
<th>FBP</th>
<th>40% ASIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density, HU</td>
<td>718.6</td>
<td>719.3</td>
</tr>
<tr>
<td>SD (noise)</td>
<td>52.3</td>
<td>38.5</td>
</tr>
</tbody>
</table>
(Modifiable) Image reconstruction parameters

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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
(Modifiable) Image reconstruction parameters

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Effect of changing FOV

• Standard CT image:
  • 512x512, FOV = 30 cm
  • Pixel size ~ 0.35 mm²

• Small FOV:
  • 512x512, FOV = 15 cm
  • Pixel size ~ 0.10 mm²

• BUT: “Isotropic” voxels easier to obtain at thicker slice / larger FOV
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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 (Raysum)
- CPR
- VR
- BPI-VR
- 4-D
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<thead>
<tr>
<th>Major Uses</th>
<th>Advantages</th>
<th>Disadvantages</th>
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<tbody>
<tr>
<td><strong>MPR</strong></td>
<td></td>
<td></td>
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<tr>
<td>Stenosis, vessel wall analysis</td>
<td>Accurate for stenosis, nodule, orthogonal measurements</td>
<td>Limited spatial relationships</td>
</tr>
<tr>
<td>Lung nodule measurement</td>
<td>Calcification, stent evaluation</td>
<td>Limited display if curving vessel</td>
</tr>
<tr>
<td>Orthogonal Measurements</td>
<td>“Thick MPR”: salvage noisy datasets</td>
<td></td>
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<tr>
<td><strong>MIP</strong></td>
<td>Depicts course of small and/or poorly enhancing vessels</td>
<td>Vessel, bone, visceral overlap</td>
</tr>
<tr>
<td>(MINIP)</td>
<td>Object - background contrast</td>
<td>Limited stent, calcium evaluation</td>
</tr>
<tr>
<td>Angiographic overview, contextual with adjacent structures</td>
<td></td>
<td>Stenosis Overestimation</td>
</tr>
<tr>
<td>Lung nodule detection (coronal STS)</td>
<td></td>
<td>NOISE IS ADDITIVE!!</td>
</tr>
<tr>
<td>Valves, Airways (MINIP)</td>
<td></td>
<td></td>
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<tr>
<td><strong>CPR</strong></td>
<td>Best for mural stenosis, occlusions, calcifications, stents</td>
<td>Distortion of extra-vascular structures</td>
</tr>
<tr>
<td>Flow lumen, vessel wall analysis</td>
<td>Slice through display (perpendicular to CPR)</td>
<td>Dependent on accurate centerline (Needs Oversight)</td>
</tr>
<tr>
<td>Curved Objects</td>
<td></td>
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| **VR**    | - Best for complex relationship display  
            - Valves  
            - Vessel Origins  
            - EVAR, DSX, etc | **Opacity transfer function and operator dependent**  
                         **No accurate measurements** |
| **BPI-VR**| - Angiographic overview, contextual with adjacent structures  
            - Pre-procedural planning  
            - Valves, vessel orifices, DSX flaps | - **WOW factor** |

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Caveat for MIP: Effect of Background Noise on apparent stenosis
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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

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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

• Image Reconstruction:
  • 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
Conclusions

• **Image Reconstruction:**
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  • Improve and troubleshoot image reconstruction
  • Remember inherent advantages, limitations, and differences in each type of image display

• **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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Choose “SIR 2011”

Special Thanks:

TeraRecon

Vital Images
Further Reading:

- **Image Reconstruction:**
  - Parrish FJ, *AJR* 2007; 189:528-534
Further Reading

- **CTA Workflow:**
Further Reading

- **CTA Interpretation Strategies:**
  - Ferencik, M. Radiology 2007;243:696-702
  - Pugliese, F. et al. Radiographics 2006;26:887-904

- **OSIRIX (Free Image Viewer for MAC):**