Implementing a fully model based iterative reconstruction algorithm in a high volume CT practice

S Miller¹, EB Sviggum MD¹, and CP Favazza PhD²

1. Department of Radiology, Mayo Clinic Health System-Eau Claire, WI
2. Department of Radiology, Mayo Clinic, Rochester, MN

Disclosure

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Introduction and Purpose

- Fully model based iterative reconstruction (MBIR) algorithms have been shown to improve CT image quality, including:
  - spatial resolution
  - image noise
  - artifacts (e.g. beam hardening artifacts)

- MBIR algorithms require longer reconstruction times and more advanced computer hardware, which historically has precluded widespread adoption.

- Purpose: Improve image quality through clinical use of MBIR by adapting our CT imaging workflow in our high volume practice without loss of efficiency.

Clinical Implementation

- MBIR systems:
  - Routine abdomen CT
  - Routine chest CT
  - Low dose lung cancer screening
  - Calcium scoring and coronary CTA

- 3 month survey to assess:
  - Reconstruction times
  - Impact on workflow/scanner utilization
Clinical Workflow Modifications

- Additional AIDR3D reconstruction was inserted in all protocols that employed FIRST images.
- FIRST reconstruction was avoided for time-sensitive exams.
- A duplicate set of exams were created for ED patients.
- Coronary CTA exams were configured to use AIDR3D images for calcium scoring.

Use of team lead technologist to:
- Electronically move patients
- Manage clinical schedule and assign exams to each scanner
- Continually checks for complete reconstruction of FIRST images
- Finalizes exam

Basic Clinical Workflow with Team Lead

Electronically "moves" next patient to scanner

Team Lead Technologist

Continually checks for complete reconstruction of FIRST images

Scanning Technologist

Reviews order

Selects protocol

Scans patient

Checks quality of AIDR3D images and performs any additional processing

Finalizes exam
Quality improvement of MBIR images

- Artifact reduction
  - Example: streaking and truncation with MBIR incorporated in Agatston score (TeraRecon)
  - AIDR3D - FC86 (Sharpest kernel) FIRST-Lung Algorithm
    - Sharper images without significant noise penalty
    - Example: scar tissue more evident with MBIR
  - Image processing
    - Example: Small coronary calcification incorporated in Agatston score (TeraRecon) for MBIR images only
  - AIDR3D - FC12: score 7.73 FIRST-Cardiac Sharp: score 17.3

Results: Clinical Workflow Modifications

- 1st image reconstructed with AIDR3D
  - FIRST was avoided for time-sensitive exams
    - duplicate ED protocols and use of AIDR3D for calcium scoring of coronary CTAs
    - Team lead responsible for finalizing exams
      - Allowed scanning technologist to move to the next patient and concentrate on next exam.
      - Helpful during times of high throughput with possible FIRST backlog build-up.
Results: Scanner Utilization with MBIR

- Scanner utilization with and without FIRST
  (Data obtained during weekdays from 7am-5pm)

Comparison of utilization for the same scanner over the 2 different exam periods:

<table>
<thead>
<tr>
<th>Review Period</th>
<th>Number of Exams</th>
<th>Mean Exam Time (mins)</th>
<th>Median Inter-Exam Time (mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1 2017: w/o FIRST</td>
<td>1668</td>
<td>4.93</td>
<td>28.58</td>
</tr>
<tr>
<td>Q1 2018: w/ FIRST</td>
<td>1707</td>
<td>5.22</td>
<td>6.89.26</td>
</tr>
</tbody>
</table>

Comparison of utilization of 2 scanners over the same quarter:

<table>
<thead>
<tr>
<th>Scanner</th>
<th>Number of Exams</th>
<th>Number of Exams Using MBIR</th>
<th>Percentage of MBIR Exams</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT1 With FIRST</td>
<td>1707</td>
<td>493</td>
<td>29%</td>
</tr>
<tr>
<td>CT2 Without FIRST</td>
<td>1239</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Conclusions

- With appropriate modifications to the clinical workflow, image quality improvements from MBIR using FIRST can be achieved without scanner utilization penalties, despite relatively longer reconstruction times.

On-going and Future Work

- Broader deployment across clinical exams, first targeting exams that could possibly benefit the most, e.g., pelvis exams that suffer streaking and beam hardening artifacts.
- Investigate and compare Canon’s “Volume” reconstruction with axial reconstruction → possibly reconstruct “Volumes” only.
- Examine the pace of completed exams and its impact on the Radiologist workflow. With phased deployment, multiple exams (FIRST and non-FIRST exams) could be completed in bunches and hinder Radiologist workflow.