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

S Miller[1], EB Sviggum MD[1], and CP Favazza PhD[2]

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

Disclosure

- Funding support from Canon Medical Systems, USA

Introduction and Purpose

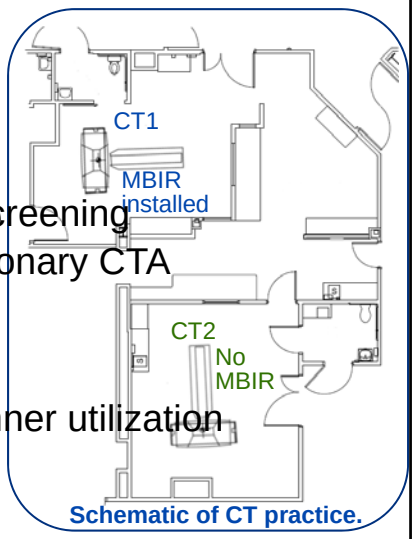
- Fully model based iterative reconstruction (MBIR) algorithms have been shown to improve CT image quality[1], including:
  - Spatial resolution
  - Image noise
  - Artifacts (e.g. beam hardening artifacts)
- MBIR algorithms require longer reconstruction times and more advanced computer hardware[2,3], 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.

1. Liu L. Model-based Iterative Reconstruction: A Promising Algorithm for Today's Computed Tomography Imaging. J Med Imaging Radiat Sci. Elsevier; 2014;45(2):131–136
2. 2. Jensen CT, Telesmanich ME, Wagner-Bartak NA, et al. Evaluation of Abdominal Computed Tomography Image Quality Using a New Version of Vendor-Specific Model-Based Iterative Reconstruction. J Comput Assist Tomogr.
3. 3. Katsura M, Matsuda I, Akahane M, et al. Model-based iterative reconstruction technique for radiation dose reduction in chest CT: comparison with the adaptive statistical iterative reconstruction technique. Eur Radiol. Springer-Verlag; 2012;22(8):1613–1623

Clinical Implementation

- MBIR systems:
  - Routine abdomen
  - Routine chest
  - Low dose lung cancer screening
  - Calcium scoring and coronary CTA
- 3 month survey to assess:
  - Reconstruction times
  - Impact on workflow/scanner utilization

- Toward adopted model-based Iterative Reconstruction (**FIRST**, Canon Medical Systems US)
- Separate MBIR protocol enables simultaneous reconstruction of FIRST and FBP/IR (Adaptive Iterative Dose Reduction—AIDR3D) image data
- FIRST installed on 1 of 2 scanners in our practice

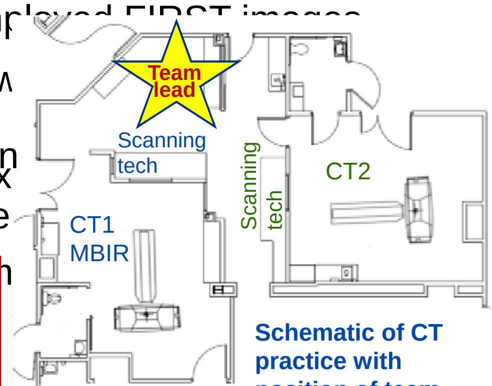


Schematic of CT practice.

Clinical Workflow Modifications

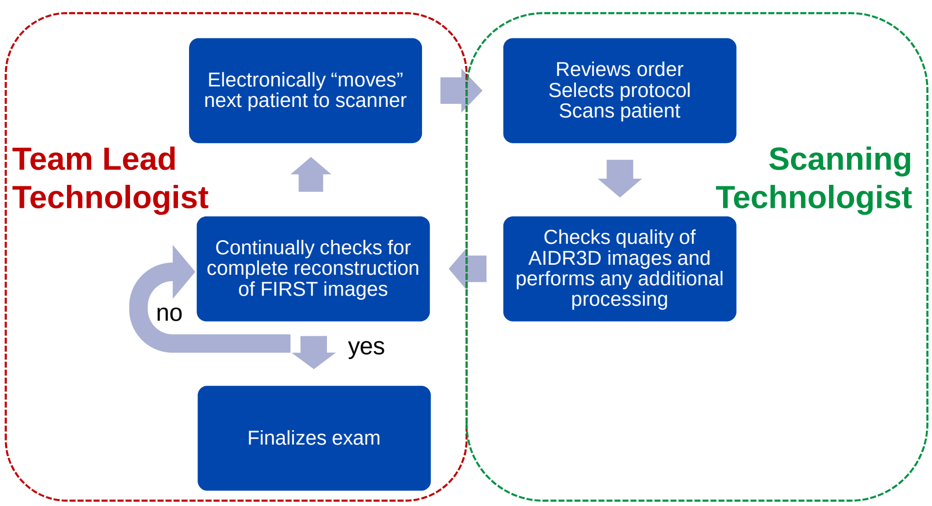
- Additional AIDR3D reconstruction was inserted in all protocols that employed FIRST images
- FIRST reconstruction w... sensitive exams:
  - A duplicate set of ex... created for ED patie...
  - Coronary CTA exam... AIDR3D images for...

- New team lead technologist:
  - Electronically move patients
  - Manage clinical schedule and assign exams to each scanner
  - ***Finalize exams in EMR to cue Radiologist***



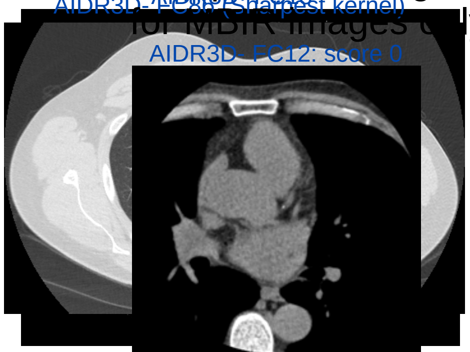
Schematic of CT practice with position of team lead.

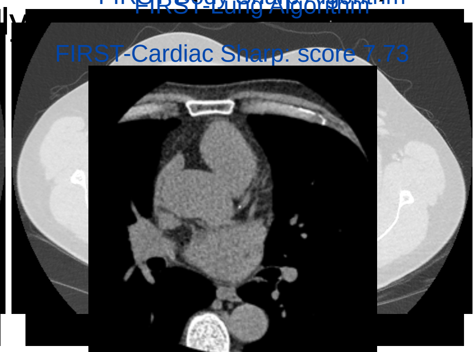
Basic Clinical Workflow with Team Lead



Quality improvement of MBIR images

- Sharper images without significant noise penalty
  - Example: ... incorporated in Agatston score (TeraRecon) for MBIR images only





MAYO CLINIC

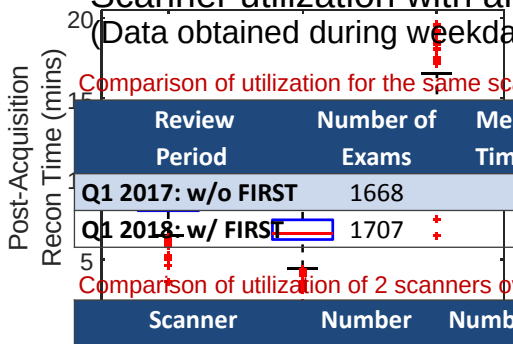
Results: Clinical Workflow Modifications

- 1st image reconstructed with AIDR3D
  - Enabled quick review of images. These data were not sent for permanent archiving.
  - Preferred over vendor's "InstaView" option, as this option is incompatible with a "helical skip," i.e. prematurely ending the scan.
- FIRST was avoided for time-sensitive exams: duplicate ED protocols and use of AIDR3D for calcium scoring of coronary CTAs
  - Separate set of ED protocols avoided issues where relatively longer wait times are not well-tolerated.
  - Use of AIDR3D for calcium scoring for coronary CTA exams allowed for expeditious imaging of the remainder of the exam.
- Team lead responsible for finalizing exams
  - Allowed scanning technologist to move to the next patient and concentrate on next exam.
  - Provided image data to send for review if they were unexpectedly and urgently needed.
  - Helpful during times of high throughput with possible FIRST backlog build-up.

MAYO CLINIC

Results: FIRST Reduction in MBIR Scanner Utilization with MBIR

- Scanner utilization with and without FIRST (Data obtained during weekdays from 7am-6pm)



Comparison of utilization for the same scanner over the 2 different quarters:

Review Period	Number of Exams	Mean Exam Time (mins)	Median Inter-Exam Time (mins)
Q1 2017: w/o FIRST	1668	4.93	28.58
Q1 2018: w/ FIRST	1707	5.22	29.26

Comparison of utilization of 2 scanners over the same quarter:

Scanner	Number of Exams	Number of Exams Using MBIR	Percentage of MBIR Exams
CT1- With FIRST	1707	493	29%
CT2-Without FIRST	1239	0	0

Conclusion and Future Work

- 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.
- 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.
- 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.