New Concept in CT Image Reconstruction (ASiR) in The Abdomen

Director of CT
Associate Professor of Radiology
MGH
email: dsahani@partners.org
Disclosures

Research Grant Support from GE Healthcare
Contribution of CT to Medical Radiation

Percentage of Diagnostic Imaging Studies
- 74%
- 17%
- 5%
- 4%

Percentage of Radiation Exposure
- 49%
- 26%
- 14%
- 11%
## Estimated Effective Doses From Typical Abdominal Radiology Exams

<table>
<thead>
<tr>
<th>Examination</th>
<th>Dose (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal radiograph (AP)</td>
<td>0.2-0.6</td>
</tr>
<tr>
<td>Abdominal series (KUB, upright, LLD)</td>
<td>0.6-1.8</td>
</tr>
<tr>
<td>Barium Enema</td>
<td>5-7</td>
</tr>
<tr>
<td>Intravenous Pyelogram</td>
<td>8-10*</td>
</tr>
<tr>
<td>Small bowel follow-through</td>
<td>4-7†</td>
</tr>
<tr>
<td>Abdomen CT</td>
<td>5-7</td>
</tr>
<tr>
<td>Pelvis CT</td>
<td>3-5</td>
</tr>
<tr>
<td>Abdomen and Pelvis CT</td>
<td>8-12</td>
</tr>
</tbody>
</table>

* 4-5 conventional tomograms and 6-9 radiographs  
† including fluoroscopy and spot views
Two Pillars of Radiation Dose Reduction

- Appropriate Utilization
- Optimization of CT Protocols
General Strategies

- Faster gantry rotation reduces radiation dose. However, noise is increased if the other factors are constant.
- Decreasing kVp reduces dose and increases tissue contrast; increasing mAs could reduce noise.
- Off-centering increases dose.
- Splitting scan volumes increases dose.
- Collimation, beam pitch, table speed.
- Automatic exposure control.
- "Extra" images = Extra dose.
Factors Affecting Radiation Dose

DECREASE IN
- Tube current
- Tube potential
- Gantry rotation time *
- Scan length
- Overlap scanning
- Number of scan phases

*Provided other scanning factors are kept constant

INCREASE IN
- Pitch (Table speed) *
- Beam collimation
Low Dose CT Challenges: Image Quality
Low Dose Imaging

• Standard Filtered back projection (FBP) treats projection data as if coming from an idealized system

• ASIR (Adaptive statistical iterative recon.)
  • FBP with added modeled based noise suppression (ASIR Factor)
Technology Overview

• Iterative reconstruction is a time consuming process.
• System optics modeling (orange box) is computationally expensive
• In ASIR, we model only the system statistics (green box) and achieve the dose reduction benefit

Courtesy: Bob Becket, GE Healthcare
Technology Overview

- Raw Data
- System Model
- Cost Function
- MBIR Image
- Data Statistics
- Nonlinear Smoothing
- Optimization (Recon)

Optimal use of spatially-varying statistical model for stable, low noise, and high resolution IQ

Courtesy: Bob Becket, GE Healthcare
Adaptive Statistical Iterative Reconstruction (ASIR)

- Noise reduction reconstruction method to improve the signal-to-noise ratio
- Relies on the accurate modeling of the distribution of noise in the data

Superior Image Quality with Less Noise and 10-80% less dose

Kole et al 2006 Phys Med Biol
ASIR: Noise Index

<table>
<thead>
<tr>
<th>ASIR Selection</th>
<th>Noise Index Adjustment</th>
<th>HIRES</th>
</tr>
</thead>
<tbody>
<tr>
<td>30%</td>
<td>X 1.2</td>
<td>X 1.3</td>
</tr>
<tr>
<td>40%</td>
<td>X 1.3</td>
<td>X 1.4</td>
</tr>
<tr>
<td>50%</td>
<td>X 1.4 (50% Dose)</td>
<td>X 2</td>
</tr>
</tbody>
</table>
How to Apply in Practice

<table>
<thead>
<tr>
<th>Body Weight</th>
<th>Routine NI</th>
<th>Low Dose NI</th>
<th>ASIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;135 lbs</td>
<td>28</td>
<td>36</td>
<td>30%</td>
</tr>
<tr>
<td>136-200 lbs</td>
<td>32</td>
<td>40</td>
<td>30%</td>
</tr>
<tr>
<td>&gt;201 lbs</td>
<td>35</td>
<td>42</td>
<td>30%</td>
</tr>
</tbody>
</table>
ASIR Selection and Image Quality
### ATTENUATION VALUES AND ASIR

<table>
<thead>
<tr>
<th>ASIR</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>106.9</td>
<td>15.1</td>
</tr>
<tr>
<td>10</td>
<td>106.8</td>
<td>13.8</td>
</tr>
<tr>
<td>20</td>
<td>106.7</td>
<td>12.5</td>
</tr>
<tr>
<td>30</td>
<td>106.7</td>
<td>11.3</td>
</tr>
<tr>
<td>40</td>
<td>106.7</td>
<td>10</td>
</tr>
<tr>
<td>50</td>
<td>106.6</td>
<td>8.8</td>
</tr>
<tr>
<td>60</td>
<td>106.6</td>
<td>7.5</td>
</tr>
<tr>
<td>70</td>
<td>106.5</td>
<td>6.4</td>
</tr>
<tr>
<td>80</td>
<td>106.5</td>
<td>5.3</td>
</tr>
<tr>
<td>90</td>
<td>106.5</td>
<td>4.4</td>
</tr>
<tr>
<td>100</td>
<td>106.5</td>
<td>3.7</td>
</tr>
</tbody>
</table>

**Mean HU:** No significant difference

**Standard Deviation (SD):** 10 ASIR increment - 0.7HU reduction, (p<0.001)
ASIR Application

Low dose Low Contrast: Routine Abd-Pel CT/Venous phase

Lower ASiR (20-40%)

Low dose high contrast: CTA /Stone/CTC

High ASiR 50-60% or greater
23 yrs old with Crohn’s Disease. Baseline and FU CT exam

40% ASIR

55% Dose Reduction

Radiation Dose – 11.6mSv

Radiation Dose – 5.1 mSv
Kidney Stone

July 2 2007

Feb 26 2009

60%
ASIR

263 lbs

81%

DLP 744
11.16 mSv

DLP 138
2.07 mSv

DLP 5

Kidney Stone
Liver Donor - CTC

FBP

ASIR-60%
### CTA

<table>
<thead>
<tr>
<th></th>
<th>NI</th>
<th>Low dose scans</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NI</td>
<td>ASIR</td>
</tr>
<tr>
<td>Non contrast</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>Arterial study</td>
<td>28</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40</td>
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<tr>
<td>Delays</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>Routine CT Protocol</td>
<td>% Dose Reduction</td>
<td>CTA Protocol</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>*Routine Abdomen</td>
<td>21-58%</td>
<td>CT AAA (3 phase)</td>
</tr>
<tr>
<td>*Stone disease</td>
<td>23-81%</td>
<td>*CTA – Donors (3phase)</td>
</tr>
<tr>
<td>*CT Enterography</td>
<td>6-58%</td>
<td>CT PE/DVT</td>
</tr>
</tbody>
</table>

*presented at RSNA 2009
Large Body Habitus

FBP

260lbs

ASIR

15 mSv

8.9 mSv
Do’s and Dont’s of ASIR

Do’s

Apply ASIR technique after corresponding dose reduction

In multiphasic examinations, apply higher ASIR levels on noncontract studies

In patients undergoing multiple examinations, increase ASIR incrementally on follow up studies

Dont’s

Do not apply higher (> 50 %) ASIR technique on low contrast diagnostic exams
Summary

Low dose CT scans with ASIR technique allows substantial radiation dose reduction for abdominal CT examinations of varying indications.

ASIR enabled CT scans provide diagnostically acceptable image quality comparable to or better than FBP enabled CT scans.

Dual benefits of improved Image Quality and dose for patients with large body habitus

The radiation dose benefits are particularly beneficial in patients undergoing multiple CT scans or multi-phase exams.