Low Dose Iterative Reconstructions in the Emergency Ward CT

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Medical Imaging and Physical Sciences (BEFY)
Head of Radiology Department

Universitair Ziekenhuis Brussel
Vrije Universiteit Brussel
Radiology: +/- 180.000 patient contacts / year
Volume CT: +/- 33.000 exams / year

Emergency Ward: +/- 66.000 patients / year
UZ Brussel

Radiology: +/- 180,000 patient contacts/year
Volume CT: +/- 33,000 exams/year

IC (36 beds) Admissions: +/- 1750 patients / year
Use of Advanced Radiology During Visits to US Emergency Departments for Injury-Related Conditions, 1998-2007

Korley et al. JAMA Oct 2010;304(13):1465-1471

Cost
Radiation dose
Time
Patient transport

Benefit???
Quality vs Dose: The Trade off

The straightforward way...

increase # photons, increase patient dose (mAs)

10 mAs

120 mAs

CTDlv = 0,8 mGy

CTDlv = 5 mGy

CTDlv = 10 mGy
Noise suppression

Noise pattern follows Poisson statistics

\[ \text{Noise} \propto \frac{1}{\sqrt{\text{CTDI}_{\text{vol}}}} \]

GE CT750 HD, 120 kVp, \( p = 0.9 \), \( r = 1 \), \( t = 2.5 \text{ mm} \), FOV = 230 mm
Quality vs Dose: The trade off

- Noise Reduction Technique
  - FBP Reconstruction Filters & kernels
  - Smoothing (MPR, …)
  - Reconstruction Techniques
    - Iterative reconstructions
Iterative reconstruction

Image acquisition → sinogram → reconstruction

Goal: reconstruction
Iterative methods: optical model

- Use as much prior knowledge as possible → it reduces the amount of data needed
  - Real Detector
  - Real Focal Spot
  - Cubic Voxel
  - Broad Beam
  - Object Model
  - ...

Low dose iterative reconstructions in the emergency ward CT

Copenhagen  Januari 27th  2012
Generations of CT reconstruction
DOSE >> IMAGE QUALITY

1st Generation
Filtered back Projection (FBP)
- Assumes “perfect” model

2nd Generation
Image Filters & Kernels
- Image space approach
- Filter noise, Application specific

3rd Generation
Statistical Iterative Reconstruction
- Blending technique (FBP + Iterative)
- Models noise (Photon & Electronic)

4th Generation
Full Model Based Iterative Recon
- Models CT system geometry
- Reconstruct more accurate images

Traditional CT Reconstruction
Trade-off Noise vs. Detail
Lower Dose and Preserves Detail
Improves Detail and Lower Dose
The next frontier in Ultra Low Dose CT: Model-based Iterative Reconstruction in the brain, chest and abdomen.

<table>
<thead>
<tr>
<th></th>
<th>True IR</th>
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<td>ASiR (GE), Safire (Siemens), iDose (Philips), AIDR (Toshiba)</td>
<td>IRIS (Siemens), Clarity (nonvendor specific)</td>
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A.K. Hara et al – RSNA 2011 Educational exhibit LL-MSE1081
The next frontier in ULtra Low Dose CT: Model-based Iterative Reconstruction in the brain, chest and abdomen.

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Iterative Reconstruction:

ASiR™

(Adaptive Statistical Iterative Reconstruction)

&

VEO™

(Model Based Iterative Reconstructions)
ASiR (0%.....100%)

GE CT750 HD, 100 kVp, \( p = 0.9 \), \( r = 1 \), \( t = 2.5 \) mm, FOV = 230 mm

Low dose iterative reconstructions in the emergency ward CT

Copenhagen Januari 27th 2012
What about spatial resolution?
ASIR vs. FBP
Effective doses for CT procedures (review over 20 published articles)

<table>
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<tr>
<th>Examination</th>
<th>Average Effective Dose (mSv)</th>
<th>Values Reported in Literature (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>2</td>
<td>0.9–4.0</td>
</tr>
<tr>
<td>Neck</td>
<td>3</td>
<td>...</td>
</tr>
<tr>
<td>Chest</td>
<td>7</td>
<td>4.0–18.0</td>
</tr>
<tr>
<td>Chest for pulmonary embolism</td>
<td>15</td>
<td>13–40</td>
</tr>
<tr>
<td>Abdomen</td>
<td>8</td>
<td>3.5–25</td>
</tr>
<tr>
<td>Pelvis</td>
<td>6</td>
<td>3.3–10</td>
</tr>
<tr>
<td>Three-phase liver study</td>
<td>15</td>
<td>...</td>
</tr>
<tr>
<td>Spine</td>
<td>6</td>
<td>1.5–10</td>
</tr>
<tr>
<td>Coronary angiography</td>
<td>16</td>
<td>5.0–32</td>
</tr>
<tr>
<td>Calcium scoring</td>
<td>3</td>
<td>1.0–12</td>
</tr>
<tr>
<td>Virtual colonoscopy</td>
<td>10</td>
<td>4.0–13.2</td>
</tr>
</tbody>
</table>

*Table 2*
Patient 1: Female 45

- Acute dyspnea, suspicion pulmonary embolism

- Scan Parameters
  - Range 26 cm
  - Ni: 30
  - 100KV
  - ASiR: 50%
  - CTDIv 7.44 (mGy)
  - E 2.7 (mSv)
Patient 2: male 36

- Right Costolumbar Colic Pain
  → Urolithiasis?

- Scan Parameters
  → Range 49
  → 100KV
  → CTDIv 4,7(mGy)
  → E 3,6 (mSv)

- Recon parameters
  → Ni: 50 (30)
  → ASIR: 70% (50%)
Patient 3: male 33

- Polytrauma
  - Hit by car on bicycle
  - Patient in vacuum mattress

- Total body CT
  - Dry head
  - Dual contrast COW to ankle

- DMPR
  - Brain Ax + Sag
  - Total Body Ax + Cor

- Scan Parameters
  - Range 230 mm +1700 mm
  - 120KV
  - CTDIv 67,6 + 10,9(mGy)
  - E 19,7 (5,8 + 13,9) (mSv)
  - Ni: 6.4 + 28
  - ASiR: 50% + 50%
Low dose iterative reconstructions in the emergency ward CT

Copenhagen Januari 27th 2012

Face Profiel

1.25 mm
5 mm
0.625 mm
5 mm
2 mm
3 mm
2 mm
Low dose iterative reconstructions in the emergency ward CT
Copenhagen
Januari 27th
2012

Face Profiel
20 mm MIP

I ❤️ SAGITTALS
2 mm

20 mm MIP
Patient 4: male 33

- Polytrauma
  - Jumper from 3th floor
  - Patient on Spine Board and head blocks

- Total body CT
  - Dry head
  - Dual contrast COW to ankle

- DMPR
  - Brain Ax + Sag
  - Total Body Ax + Cor

- Scan Parameters
  - Range 210 +1700
  - 120KV
  - CTDIv 60.4 + 9.2(mGy)
  - E 17.1 (4.9 + 12.2) (mSv)
  - Ni: 6.4 + 28
  - ASiR: 50% + 50%
Low dose iterative reconstructions in the emergency ward CT
VEO – *impact on image noise*

![Graph showing the impact of VEO on image noise vs relative radiation dose.](image-url)
Ultra Low dose VEO (0.4 mSv): Noise Reduction

FBP Reconstructions

VEO
VEO in Emergency Ward

Chest CT with Veo – Empyema 3y

FBP-images 2010
Low Dose

Veo-images 2011
Low dose
VEO in Emergency Ward

Chest CT with Veo – Empyema 3y

FBP-images 2010
Low Dose

Veo-images 2011
Low dose
Low dose iterative reconstructions in the emergency ward CT

### VEO in Emergency Ward

**Chest CT with Veo – Empyema 3y**

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<th>FBP-images 2010</th>
<th>Veo-images 2011</th>
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<tr>
<td>Low Dose</td>
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**Exam Description: CT THORAX MEDIASTINUM**

**Dose Report**

<table>
<thead>
<tr>
<th>Series</th>
<th>Type</th>
<th>Scan Range (mm)</th>
<th>CTDIvol (mGy)</th>
<th>DLP (mGy⋅cm)</th>
<th>Phantom cm</th>
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<tbody>
<tr>
<td>1</td>
<td>Scout</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>2</td>
<td>Helical</td>
<td>1205.250-530.310</td>
<td>2.01</td>
<td>56.80</td>
<td>Head 16</td>
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**Total Exam DLP:** 56.80

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**Total Exam DLP:** 27.69
Emergency Radiology Courses

TRAUMA RADIOLGY
7TH NORDIC COURSE
MAY 21ST - 24TH, 2012
HELSINKI, FINLAND
TRAUMA IMAGING FROM TOP TO TOE
FOCUS ISSUES
NORDIC FORUM www.nordictraumarad.com
TRAUMA & EMERGENCY RADIOLOGY

ASER 2012 Annual Scientific Meeting and Postgraduate Course
September 12 - 15, 2012
New Orleans Marriott
New Orleans, Louisiana
Take to work messages

- Increasing use of CT in the EW in relatively young patients
- Radiation Dose↓, Noise↑: Iterative reconstructions

- **ASiR™:** - Low Dose – Preserves spatial resolution
  - Fast Reconstruction technique

- **VEO™:** - Low Dose – Spatial Resolution
  - Opportunites in Ultra Low Dose CT
  - Slower Reconstruction Technique
  - Temporary drawback
Thank you for your attention

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