Objective evaluation and optimization of new CT procedures performed with MDCT (above 64-detectors)

**PhD Candidate:** Iliya Dyakov, City Clinic Hospital, Sofia, Bulgaria  
**Chief Scientific Investigator:** Dr. Simona Avramova - Cholakova, City Clinic Hospital, Sofia, Bulgaria  
**Remote Mentor:** Dr. Isabel Castellano, The Royal Marsden Hospital, London, UK
• To develop and implement methods for quality control, phantom and patient dosimetry for 64-DCT and 320-DCT used for a number of clinical applications.

• To develop methods for the optimisation of clinical protocols together with radiologists and to formulate a general algorithm for CT optimisation.
Tasks

• Establishment of Quality Assurance program;

• Suitable dosimetry for wide beam CT;

• Implement an optimization approach for selected examination;
The departments

“St. Ekaterina” University Hospital

Aleksandrovska University Hospital

City Clinic University Hospital
CT systems

Aquilion ONE, Toshiba medical systems

Optima 660 J, General Electric

Aquilion 64, Toshiba medical systems
Quality assurance program

- CT alignment lights
- Image slice width
- Tube voltage accuracy and precision
- HVL measurement
- Image noise
- CT numbers accuracy
- CT numbers uniformity
- High contrast resolution
- Low contrast resolution
- CTDI display calibration
- CTDI for common clinical protocols
- Helical system performance (z-sensitivity phantom);
- Assessment of MTF;
Narrow beam CT dosimetry

- Standard method–100 mm ionization chamber and 140 mm phantom

In air measurements

In phantom measurements
Wide beam CT dosimetry

- IEC method – use the same equipment;

- AAPM method - small volume chamber long >450 mm phantom;

\[
\text{CTDI}_{100,(N\times T)} = \text{CTDI}_{100,\text{ref}} \times \left( \frac{\text{CTDI}_{\text{free-in-air},N\times T}}{\text{CTDI}_{\text{free-in-air,ref}}} \right)
\]
Wide beam CT dosimetry

- Standard approach:
  - underestimates CTDI_{air} with 73% and CTDI_{w} with 38 % (Aquilion one) when compare with IEC method;
  - applicable for beam wide ≤ 40 mm;
- AAPM method:
  - different metrics and equipment - equilibrium dose constant and equilibrium dose-pitch product;
  - Equilibrium dose-pitch product is equal to CTDI_{∞}, but not to CTDI_{100};
  - These metrics could not be compared with the standard metrics!
- IEC method:
  - does not include scatter radiation outside chamber length;
  - but still more appropriate for routine dosimetry.
Do we need optimization?!

- High patient dose
- Variation of patient dose

![Graph showing patient dose variation]

<table>
<thead>
<tr>
<th>Examination</th>
<th>1991</th>
<th>2003 SSCT</th>
<th>2003 MSCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiography</td>
<td>73.6</td>
<td>6.7</td>
<td>7.6</td>
</tr>
<tr>
<td>Fluoroscopy</td>
<td>20.3</td>
<td>21.1</td>
<td>12.4</td>
</tr>
<tr>
<td>CT</td>
<td></td>
<td></td>
<td>45.9</td>
</tr>
</tbody>
</table>

Elly Castellano
What shall we do?!

- Optimization team;
  - radiologist;
  - radiographer;
  - medical physicist.

- Decide which examination to optimize!
CT Urography

- Four phases;
- Standard protocol:

<table>
<thead>
<tr>
<th>beam width</th>
<th>kV</th>
<th>mA</th>
<th>rot.time</th>
<th>range</th>
<th>D_FOV</th>
<th>slice thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5x64</td>
<td>120</td>
<td>R</td>
<td>0.5</td>
<td>420</td>
<td>335.9 (L)</td>
<td>5 mm</td>
</tr>
</tbody>
</table>

- Optimization approaches:
  - kV reduction;
    Coppenrath E et al (2006);
  - Reduction of mAs;
    Tack D, et al 2003;
  - Reduction of phases;
    Walter J, Caoili EM, Cohan RH, et al., 2005

- Patient doses were reviewed when changing the kV from 120 to 100 and 80;

- Objective assessment – calculation of CNR and FOM:
  \[ \text{CNR} = \frac{\text{HU}_{\text{object}} - \text{HU}_{\text{background}}}{\sigma_{\text{background}}} \]
  \[ \text{FOM} = \frac{\text{CNR}^2}{\text{CTDI}_{\text{vol}}} \]

- Subjective assessment – the images were reviewed by two different radiologists.
  Three point scale was used:
  1. Images with excellent diagnostic quality; 2. Images with adequate diagnostic quality; 3. Images not appropriate for good diagnostic.
### CT Urography

#### Comparison

- **120 kV** protocol to patient cohort:
  - 34% reduction in CTDIvol.
  - No difference in image noise (SD);
  - 33% reduction in CNR and 22% reduction in FOM;

<table>
<thead>
<tr>
<th>Protocol</th>
<th>CTDIvol</th>
<th>CNR</th>
<th>SD</th>
<th>FOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>80 kV</td>
<td>3,2</td>
<td>25,2</td>
<td>35,2</td>
<td>24,1</td>
</tr>
<tr>
<td>120 kV</td>
<td>3,1</td>
<td>16,8</td>
<td>34,5</td>
<td>18,8</td>
</tr>
</tbody>
</table>

#### Diagrams

- **Noise vs. Effective diameter [mm]**
- **CTDvol vs. Effective diameter [mGy]**
CT Urography

- Most of the images obtained with 120 kVp protocol were rated with 1.
- The images obtained with low kVp protocol were rated with 2.
- All of them were adequate.
CT Urography

Reduction of phases

Combined phase – double bolus technique!

Maheshwari et al.

venous phase- standard protocol

venous phase- split-bolus protocol
CT Urography

Reduction of phases

Combined phase – double bolus technique!

excretory phase- standard protocol

excretory phase- split-bolus protocol
Thank you!

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