Radiation Dose Measurements for Pediatrics and Co-patients During Micturating Cystourethrography

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Presentation outlines

- Introduction
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- Discussion
- Conclusions

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Introduction

Micturating cystourethrography (MCUG / MCU) or voiding cystourethrography (VCUG) is the definitive method of assessing the lower urinary tract.

MCUG accounts 40% of all fluoroscopic procedures performed on children in Europe (Schneider 2001, Hardy & Boynes 2003)
Introduction

- It is particularly valuable for the assessment of vesicoureteric reflux (VUR).

- Urinary Tract Infections (UTI) incidence during childhood has been estimated to be 8% for girls and 2% for boys with an incidence of VUR were estimated to be 52%

(EUR 16261, 1996)
Introduction

MCUG involves unavoidable radiation dose to the pediatric patients as well as to the co-patient, i.e. individuals helping in the support, care and comfort of the children during the examination.
Introduction

- Continuously there has been an increase in the number of radiological procedures.

- The application of the concept of justification to these procedures is not fulfilled yet.

- In Sudan, Diagnostic reference levels is not adopted yet.
Introduction: Patient protection

Principles of radiation protection
- Justification-√
- Optimization-√
- Dose limitation-X

In Practice:
- Un-justified examinations are ≈20-50%
- Optimization can bring down patient doses by about 50%
  [J. Malone, 2008]

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Objectives

(i) Determine the Entrance surface dose (ESD), organ and thyroid surface dose, effective dose ($E$) and its related risks.

(ii) evaluate the technique applied in order to reduce patient and co-patient dose.

(iii) compare the results with previous available literature.
Materials and Methods

TLD Material

I. The dosemeter used in this work consists of TLD-GR-200 chips, circular type.

II. TLDs were calibrated under reproducible reference condition using Toshiba Rotande model (T6-6TL-6) against ionization chamber PTW.CONNY II.
TLD Calibration

Sulieman et al, BJR 2007
The TLD signal was read using an automatic TLD reader (Fimel PCL3, France) in an atmosphere of inert nitrogen.
Materials and Methods

- **Time –temperature profile (TTP)** which divided into:
  - **(i) Pre-heat temperature**: (pre-readout) is done by heating to 155°C to ensure consistency of the reading, and to remove unwanted peaks.
  - **(ii) Acquisition**: the signal is acquired up to 260°C with heating rate 1°C/s to get the glow curve.
Materials and Methods: X-Ray machine

- An under couch fluoroscopy unit and over couch intensifying screen (Toshiba, KXO-15E, Toshiba corporation, Japan) was used.

- The minimum tube filtration was 2.5 mm aluminium. The kV and mA ranges are (40-150 and 20- 640) respectively. Last image hold capability is available.

- The machine was constructed in 2003.

- The machine had already passed the routine quality control tests performed by Sudan Atomic Energy Commission.
MCUG Procedure

- Radiographic images were taken as follows:
  a. Scout radiograph of the kidneys and bladder before contrast is instilled.
  b. Right and left oblique views of the bladder when full to show the vesicoureteral regions.
  c. Urethra while voiding.
  d. Post void radiograph of the bladder and kidneys.

More radiographs may be taken when an abnormality is noticed.
Patient and co-patient dosimetry

A total of 33 children were examined at Radiology department, Soba University Hospital, Khartoum.

Radiation doses were measured by directly placing a labeled TLD envelope on the patient’s skin over the skin at the centre of the field of view (FOV) and over the thyroid.

Co-patient dosimetry, two groups of TLDs were used: one at the level of the chest above the lead apron (0.5 mm thick lead equivalent), and the second at the level of the waist under the lead apron.
Entrance surface dose (ESD) was used to estimate the organ equivalent dose ($H$) using software provided by the National Radiological Protection Board (NRPB-SR279).
Results

- Thirty three children, 7 (21%) were girls and 26 (79%) were boys, with age range (0.13 - to 10 years) were examined.

- Of the 33 children, 15 (45.5%) patients had positive VUR and 18 (54.5) patients had negative VUR
Results

Table 1. Patient body characteristics, screening time and number of radiographic images (Mean and the range in the parentheses) were presented.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>n</th>
<th>Patient age (year)</th>
<th>Height (m)</th>
<th>Weight (Kg)</th>
<th>BMI (Kg/m²)</th>
<th>Screening time (minute)</th>
<th>No. of Images</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>33</td>
<td>4.21 (0.13-10)</td>
<td>0.96 (0.5-1.5)</td>
<td>13 (3-35)</td>
<td>13.40 (6.45-21.05)</td>
<td>2.8 (1.1-9)</td>
<td>5 (3-8)</td>
</tr>
</tbody>
</table>
## Results

Values of the ESD and thyroid surface doses (mGy)

<table>
<thead>
<tr>
<th>Patient</th>
<th>Mean</th>
<th>Minimum</th>
<th>Median</th>
<th>3rd quartile</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESD</td>
<td>5.51</td>
<td>0.39</td>
<td>4.75</td>
<td>8.89</td>
<td>16.12</td>
</tr>
<tr>
<td>Thyroid</td>
<td>0.30</td>
<td>0.13</td>
<td>0.24</td>
<td>0.27</td>
<td>1.53</td>
</tr>
</tbody>
</table>

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## Results

Values of co-patients' radiation doses (mGy) and effective dose (mSv)

<table>
<thead>
<tr>
<th>Co-patients</th>
<th>Mean</th>
<th>Minimum</th>
<th>Median</th>
<th>3rd quartile</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective dose</td>
<td>0.21</td>
<td>0.15</td>
<td>0.20</td>
<td>0.23</td>
<td>0.38</td>
</tr>
</tbody>
</table>

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Discussion

Patient body characteristic data.

1. The mean screening time (1-9 min) was comparable to previously reported values (0.4 to 8.9 min) (Ward, 2006).

2. The mean number of radiograph per MCUG examination was ranged from 3 to 8 radiographs, which is lower than in previous studies (Ward, 2006).
Exposure factors

- The exposure factors (kVp, mA) for all patients were comparable to exposure factors reported in previous studies.

- High kVp increases the scatter radiation thus also the patients' dose, while decreasing the contrast of the image.
No significant correlation was found between patient dose, patient characteristics, and exposure factors.

Radiation dose depend on the complexity of the procedure and staff experience.

Variations in patient morphology and exposure factors influence the patient dose and image contrast.
### Patient absorbed and effective dose

<table>
<thead>
<tr>
<th>Author</th>
<th>Age (year)</th>
<th>BMI (Kg/m²)</th>
<th>Screening time (Minutes)</th>
<th>No. of Radiographic images</th>
<th>ESD (mGy)</th>
<th>Effective dose (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present study</td>
<td>4.21</td>
<td>13.40</td>
<td>2.8</td>
<td>5</td>
<td>5.51</td>
<td>0.22</td>
</tr>
<tr>
<td>Suleiman et al [2007]</td>
<td>0.02-2</td>
<td>15.35</td>
<td>0.75</td>
<td>1.18</td>
<td>1.13</td>
<td>0.20</td>
</tr>
<tr>
<td>Perisinakas et al [2005]</td>
<td>0-1</td>
<td>16.9</td>
<td>0.73</td>
<td>6.3</td>
<td>NR</td>
<td>(0.12–1.67)a (0.15–1.45)b</td>
</tr>
<tr>
<td>Fotakis et al [2003]</td>
<td>NR</td>
<td>NR</td>
<td>3</td>
<td>NR</td>
<td>4.58</td>
<td>(0.76+-/0.28)a (0.86+-/0.31)b</td>
</tr>
</tbody>
</table>

**NR: not reported, a: girls, b: boys**

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Co-patients dose

It is clearly considered that the radiation dose inside the lead apron is insignificant.

The lead aprons are old and required further assessment.

Co-patient results are comparable with study published by Sulieman et al [2007],

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Discussion

- MCUG procedure was performed by: Radiologists (rare), Technologist (frequently) and fellows (some times).

- No written protocol was available.

- Dose optimisation techniques were applied.
Factors influencing patient Dose

- Beam Quality
  - KV, Filtration, anode material and angle.
- Dose rate
  - mA.
- Exposure Time
- Size of x-ray field and body region irradiation.
- Requirements on image quality.
- Skill of radiography and radiologist.
Conclusions

- The dose delivered to the patient in MCUG is high compared to the most of previous studies.

- The co-patient dose is well within established safety limits, in the light of the current practice.

- The results of this study provide baseline data to establish reference dose levels for MCUG examination in very young patients in Sudan.

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Thank you for your attention