Paediatric Dose Reduction and Image Quality

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The majority of this work was undertaken as part of MSc Thesis of Helen Dixon.
Introduction

Paediatric CT protocols result in a higher effective dose to children when compared to adults due to:

※ Choice of protocol:
  1. Adult Protocol – Settings not corrected
  2. Child Protocol – Reduced slice width

Children are also more radiosensitive than adults
Protection of Radiosensitive Organs

Bismuth Rubber

- In-plane shielding of radiosensitive organs i.e. breast tissue, thyroid and eyes.
- Partial attenuation of the X-ray beam, particularly the softer photons, reduces the dose to the underlying radiosensitive tissue.
Previous Work


- Consistent Skin Dose Reduction of 30% to 40%
- Artefacts were noted in all four studies.
Hein et al.

- A study on radiation dose and image quality of low-dose CT scans of the paranasal sinuses with eye lens protection:
  - Patients referred due to sinusitis;
  - Dose reduction of 40% is possible;
  - HU at the surface of eye protected with bismuth is 240HU but dramatically reduces to 18HU at a depth of 5cm; and
  - Hardly perceptible artefacts in images using a bone window. Streak artefacts in soft tissue window.
A study on radiation dose and image quality of paediatric CT using in-plane paediatric breast shields.

- Fifty consecutive female patients referred for CT scans of either the chest or the abdomen.
- A foam layer was inserted between the bismuth rubber and the patient in an attempt to reduce scattered radiation artefacts.
- The diagnostic image was assessed Qualitatively by a Radiologist and the effect of noise was assessed Quantitatively by one of the team.
- Both forms of analysis determined there to be no difference between shielded and non-shielded image quality.
Aims of Aberdeen Study

• Confirm magnitude and consistency of skin dose reduction using Bismuth Rubber using on all three CT Scanners in Grampian.

• Investigate the affect of Compton Scatter on the diagnostic image quality and develop Fricke’s technique of inserting a foam pad between the bismuth rubber and skin to ease positioning and reduce radiation scatter entering the patient.
## CT Scanners in Study

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Model</th>
<th>Generation</th>
<th>Focus-axis distance (mm)</th>
<th>Minimum mAs product</th>
<th>Total filtration (mm)</th>
<th>Al equivalent filtration (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Siemens</td>
<td>Somatom Plus 4</td>
<td>3rd</td>
<td>570</td>
<td>38</td>
<td>1.4Al + 1.2 Ti</td>
<td>10mm</td>
</tr>
<tr>
<td>GE</td>
<td>LightSpeed Plus</td>
<td>3rd</td>
<td>541</td>
<td>10</td>
<td>4.0Al</td>
<td>4mm</td>
</tr>
<tr>
<td>Philips</td>
<td>AVE1</td>
<td>3rd</td>
<td>606</td>
<td>30</td>
<td>3.5Al + 0.1Cu</td>
<td>7mm</td>
</tr>
</tbody>
</table>
Experimental Technique – Skin Dose

- Three rows of thermo-luminescent dosimeters
- Identical scan parameters for both shielded and unshielded chest and head phantoms
Experimental Technique – Image Quality

The following images were taken to assess image quality:

**Chest**
- No Shielding
- Shielding on Skin
- Shielding and Foam
- Shielding and Air Gap

**Head**
- No Shielding
- Shielding on Skin
- Shielding and Foam
- Shielding and Goggles
- Shielding, Foam & Goggles
## Results – Skin Dose

### Chest

<table>
<thead>
<tr>
<th>Scanner</th>
<th>Average Dose Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Philips AVE1</td>
<td>48%</td>
</tr>
<tr>
<td>Siemens Somatom Plus 4</td>
<td>35%</td>
</tr>
<tr>
<td>GE Lightspeed Plus</td>
<td>41%</td>
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</tbody>
</table>

### Head

<table>
<thead>
<tr>
<th>Scanner</th>
<th>Average Dose Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Philips AVE1</td>
<td>37%</td>
</tr>
<tr>
<td>Siemens Somatom Plus 4</td>
<td>36%</td>
</tr>
</tbody>
</table>
Results – Chest Image Quality

No Shielding

Shielding on Skin – Poor Image Quality

Shielding and Foam – Comparable to No Shielding

Shielding and Air Gap – Comparable to No Shielding
Results – Head Image Quality

No Shielding

Shielding on Skin
Poor Detail

Shielding on Foam
Better Detail

Shielding & Goggles
Better Detail

Foam & Goggles
Better Detail
Conclusions

This study concluded that:

• Significant skin dose reduction of over 35% for both head and body imaging, consistent with published literature, was achievable using Bismuth Rubber.
• Bismuth rubber creates scatter artefacts that affect clinical diagnosis. However, image quality analysis is inappropriate in a phantom.
• More image quality analysis with phantom data is required to justify clinical trial.
Acknowledgements

- I am grateful for the assistance I received from the Radiographers at Aberdeen Royal Infirmary (ARI) and Dr. Grays Hospital in Elgin.

- I would also like to acknowledge the help of Dr. Maggie Brooks, Consultant Radiologist, at ARI for subjectively assessing the image quality.
References

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