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

Previous papers: Hopper KD et al (1997),
Hopper KD et al (2001),
Hein E et al (2002) and
Fricke BL et al (2003).

- 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.

Fricke et al.

- 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.

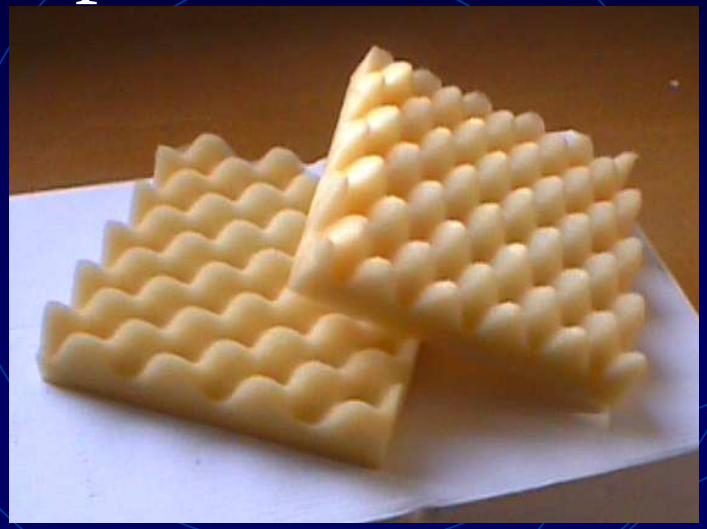
CT Scanners in Study

Manufacturer	Model	Generation	Focus-axis distance (mm)	Minimum mAs product	Total filtration (mm)	Al equivalent filtration (mm)
Siemens	Somatom Plus 4	3rd	570	38	1.4Al + 1.2 Ti	10mm
GE	LightSpeed Plus	3rd	541	10	4.0Al	4mm
Philips	AVE1	3rd	606	30	3.5Al + 0.1Cu	7mm

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

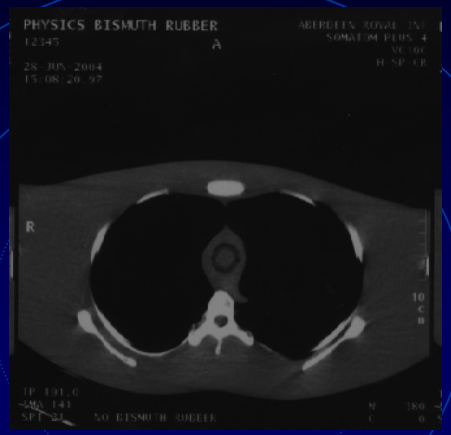
Chest

Scanner	Average Dose Reduction
Philips AVE1	48%
Siemens Somatom Plus 4	35%
GE Lightspeed Plus	41%

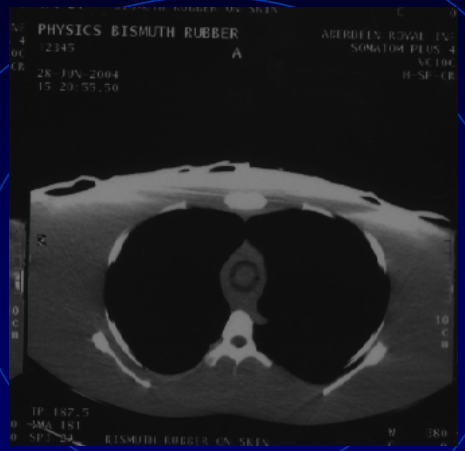
Head

Scanner	Average Dose Reduction
Philips AVE1	37%
Siemens Somatom Plus 4	36%

Results – Chest Image Quality

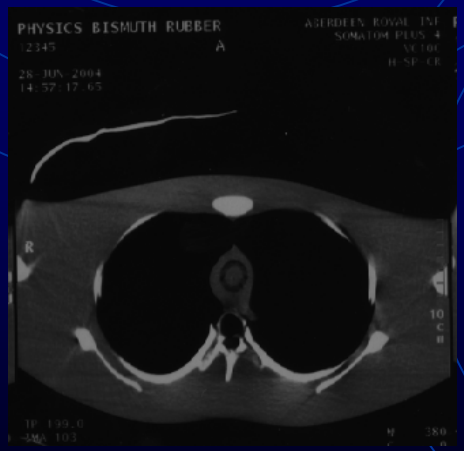


No Shielding

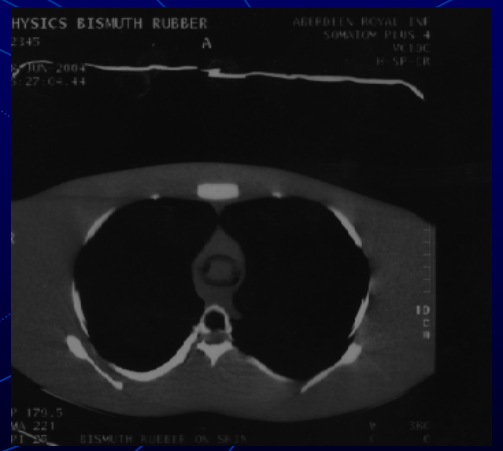


Shielding on Skin –

Poor Image Quality

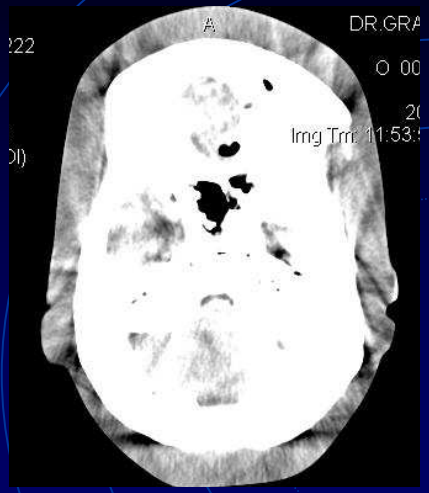


Shielding and Foam –
Comparable to No Shielding



Shielding and Air Gap –
Comparable to No Shielding

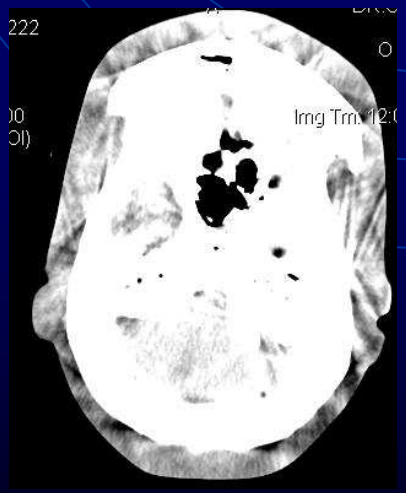
Results – Head Image Quality



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.

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