Potential dose optimisation in paediatric digital radiography

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Overview

Current paediatric imaging guidelines apply to film-screen radiography whilst clinical practice is now predominately digital radiography (DR).

- Background
- Methodology
- Results
- Conclusions and Recommendations
Background

- European guidelines on quality criteria for diagnostic radiographic images in paediatrics are only available for conventional film-screen radiography. At present they recommend:
  - the use of an anti-scatter (AS) in patients > 6 months (including AP spine, Abdomen)
  - additional copper 0.2mm (Cu) filtration for all patients\(^1\).

- Tube potentials of 60-80kVp (chest), 65-90kVp (AP spine) and 65-85kVp (Abdomen) were also recommended\(^1,2\).
Aims

- To determine if scatter removal techniques in paediatric imaging are necessary when examining the chest, abdomen and spine with a DR system.

- To determine the optimum tube potentials using a caesium iodide image receptor (predominantly used in DR flat panel detectors).

- To propose optimised techniques for paediatric imaging with DR and estimate the potential dose saving achievable.
AS grid and AG techniques

Figure 1. Anti-scatter grid technique

Figure 2. Air-gap technique
Image acquisition

- Three techniques studied:
  (i) AS grid in situ
  (ii) no AS grid \[^{4,5}\]
  (iii) no AS grid and a 15 cm air-gap (AG) between object and detector\[^{6}\].

- Newborn, 5, 10 and 15 year old.

- Images acquired of the chest, abdomen and lumbar spine (AP view) at 50-100kVp.

- With and without 0.2 and 0.4mm Cu filtration\[^{7}\].
Image quality and dose assessment

- Image quality was assessed by measuring signal-to-noise ratio (SNR) as the corrected mean pixel values divided by standard deviation (noise) in regions of interest e.g. over mediastinum, abdomen, lumbar spine.

- Effective dose ($E$) calculated using PCXMC montecarlo software and used in figure of merit (FOM) calculations as $(\text{SNR}^2/E)$.

- $\text{FOM}_{89}$ - measurement used to assess dose optimisation, i.e. considering both image quality (SNR) and radiation dose ($E$).
Results overview

- Highest SNR and FOM was achieved without scatter removal (AS grid or AG) for newborn to 10 year old phantoms ($E$ savings 35 - 55%).

- For the 15 year old phantom the AG had comparable SNR and FOM values from 55 - 85kVp ($E$ savings 25 - 50%).

- For all anatomical regions optimal tube potentials were:
  - 70 - 80kVp - newborns
  - 70 – 90kVp - 5-15 year olds

- Additional 0.2mm Cu filtration demonstrated up to 45% E reduction.
Image quality

Figure 5. SNR for newborn chest with and without anti-scatter techniques

Figure 6. SNR for 15 year old chest with and without anti-scatter techniques
Dose optimisation

Figure 7. Figure of merit effective dose for 5 year old spine with and without anti-scatter techniques

Figure 8. Figure of merit effective dose for 15 year old abdomen with and without anti-scatter techniques
Additional Cu filtration

Figure 9. Figure of merit effective dose for 15 year abdomen with and without additional 0.2mm and 0.4mm Cu filtration
Conclusion

- Better image quality was achieved using no scatter removal method on most projections. However, a 15cm AG is more effective for dose optimisation in AP lumbar spine and abdomen for children > 10 years.

- Approximately 50% dose reduction is achievable on a DR system using
  - 70-90kVp
  - no scatter removal technique (except >10 years use a 15 cm AG)
  - additional 0.2mm Cu filtration on a DR system
References


[3] ATOM dosimetry phantoms Model 701-706, CIRS, VA, USA.


