Optimisation of the pediatric pelvis radiographic examination

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Purpose

The use of digital radiography has increased rapidly over recent years. Digital radiographic modalities have seen a considerable increase in their application within diagnostic imaging centres. However, recommendations for optimal digital radiographic exposure parameters do not exist and therefore the potential for un-optimised practices exists. Digital modalities have a huge potential to reduce dose while maintaining image quality at a high level. The larger DQE value, a linear response to X-ray radiation and a wider dynamic range all contribute to the potential for the delivery of lower radiation doses by digital systems. Such features facilitate optimisation, however there are a number of optimisation strategies that need to be investigated.

It is universally accepted that paediatric patients have a higher sensitivity to the effects of ionising radiation than adults. It is of paramount importance that the radiation dose delivered to paediatric patients is as low as is reasonably possible, diagnostic efficacy taken into account. Two cost-effective optimisation methods are the use of additional beam filtration and the use of variable kVp techniques. Such optimisation programmes have the potential to reduce effective dose (E) delivery whilst producing images of suitable diagnostic image quality. The aim of this investigation was to identify the optimum exposure parameters, kVp and depth of Copper filtration that should be used for this paediatric examination.
Methods and Materials

The results are defined for 1, 5 and 10 year old patients and for direct radiography (DR) and computed radiography (CR) modalities. Current radiographic exposure settings within paediatric imaging departments for the pelvis radiographic examination range from 45-55kVp for a one year old patient, 50-60kVp for a 5 year old patient and 65kVp- 85kVp for a 10 year old patient. No centre uses Copper filtration routinely for this radiographic examination.

Image quality based on European Quality Criteria and effective dose calculation were made using anthropomorphic phantoms. Low contrast detail detectability was assessed on a psychophysical basis using a CDRAD test tool. Dose recordings were performed by an inbuilt DAP meter and all readings were converted to $E$ using a PCXMC Monte Carlo simulation programme.
Images for this section:

**Fig. 0:** experimental set up

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Results

This study advocates the use of additional Copper filtration during paediatric pelvic X-ray examinations for all age groups tested. The recommended exposure factors for the 1 year old DR pelvis examination are 55kVp with 0.3mmCu. This results in a 41.75% lower E result at 55kVp without any filtration present. If current imaging protocols are used for comparison, the recommended exposure parameters would result in a reduction of E by 25.47% at 45kVp, 29.45% at 50kVp and 29.45% at 55kVp.

The recommended exposure factors for 1 year CR examination are 40kVp with 0.3mm Cu. This would result in a 108.01% decrease in E over 40kVp without filtration present. If current imaging protocols are used for comparison, the recommended exposure parameters would result in a reduction of E by 51.92% at 45kVp, 54.5% at 50kVp and 62.99% at 55kVp.

For the 5 year old DR examination 90kVp with 0.3mm Cu is recommended resulting in a 116.5% reduction in E over 90kVp without any filtration present. Comparing this to current practice, the recommended exposure parameters would result in a reduction of E by 24.34% at 55kVp and 28.87% at 60kVp.

Similarly for the 5 year CR examination the choice of 45kVp with 0.3mm Cu results in an E reduction of 13.37% over 45kVp without any filtration present. Comparing this to current practice there is a decrease of 31.04% in E at 55kVp and 35.8% at 60kVp.

The 10 year DR examination should be performed at 65kVp with 0.2mm Cu, resulting in a 22.86% reduction in E 65kVp without any filtration present. Again reduction in E in comparison to current practice of 30.59% at 65kVp, 92.03% at 75kVp and 47.44% at 85kVp is observed.

The recommended exposure factors for a 10 year old CR examination are 50kVp with 0.3mm Cu. The E delivery at this exposure setting is 58.39% lower than at 50kVp without any filtration present. If current imaging protocols are used for comparison, the recommended exposure parameters would result in a reduction of E by 48.05% at 65kVp, 57.31% at 75kVp and 62.29% at 85kVp.

It can be seen that considerable dose savings are attainable when exposure factors as outlined are adopted for this paediatric X-ray examination.
Fig. 0: Example of the pattern of results seen across many of the phantom experiments

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Conclusion

These results and all other results from this study and the testing of hypotheses brings us to the following conclusions:

1. Although a patient study is needed to validate these results, considerable dose savings are attainable through optimisation of exposure parameters;

1. There is no evidence for not implementing additional beam filtration for paediatric examinations on the grounds of reduced image quality. The low contrast detail rendition of digital acquisition systems is unaffected by changes in the applied beam energy and by the application of additional beam filtration;

1. Not implementing additional Cu filtration on the grounds of characteristic radiation emission from the filter increases the overall effective dose delivered to the patient is unfounded. Spectral analysis has shown that despite such characteristic radiation existing, it is of such a negligible value that it can be disregarded, as it would not have sufficient energy to travel the recommended source to image detector distance for this examination (Casey, 2006);

1. Current thinking on higher kVp reducing $E$ has been questioned. In order to efficiently measure the true $E$ reduction capacity of increased kVp, the exposure to the detector must be kept constant for all of the beam energies used. This facilitates direct comparisons to be made for both $E$ and image quality analysis. By employing such a methodology a more accurate estimation of $E$ results has been obtained and the effect of increasing kVp has been shown (see Fig. 3.13, p129 as an example of this process);

1. The need for revised international paediatric exposure criteria for digital examinations is urgent. The results from this investigation have shown that the current CEC Guidelines for Paediatrics (1996b) poorly reflect optimised practice for DR and CR and the use of ESD and DRL’s need revision also. With more diagnostic imaging facilities using digital modalities the potential for un-optimised practices is great in the absence of such recommendations;

1. The need for an awareness of these results to be brought to the collective radiological society is large;
1. Further studies on other radiographic examinations based on similar methodologies are recommended;

1. CEC Guidelines for Paediatrics (1996b) do not apply to CR and DR, they do not reflect optimised practice;

1. Optimised practice can reduce $E$ up to 116.5% for DR and 108.01% for CR. Every effort should be made to implement this immediately.
References

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