Hull and East Yorkshire Hospitals NHS Trust

Standardisation and optimisation of CT protocols using the Philips DoseRight 2.0 automatic exposure control system

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Introduction

- With the increasing use of CT in the UK over the last 30 years, it is essential to ensure all CT protocols are optimised to keep radiation doses as low as reasonably practicable, *consistent with the intended clinical task*. However, the complexity of modern CT equipment can make this difficult to achieve in practice.
- Recent results of local patient dose audits demonstrated discrepancies between two Philips CT scanners that use the DoseRight 2.0 automatic exposure control (AEC) system in the 'automatic' mode of operation.
- The automatic mode can result in drifting dose and image quality performance as it is designed to learn what exposure factors to select based on the interaction of the operator performing the scan and how they adjust factors (where appropriate).
- The aim of this study was to develop a practical technique for configuring the 'manual' mode of operation of the DoseRight system, which fixes the AEC configuration to ensure it does not drift over time. This in turn enables standardisation and optimisation of CT protocols between scanners.

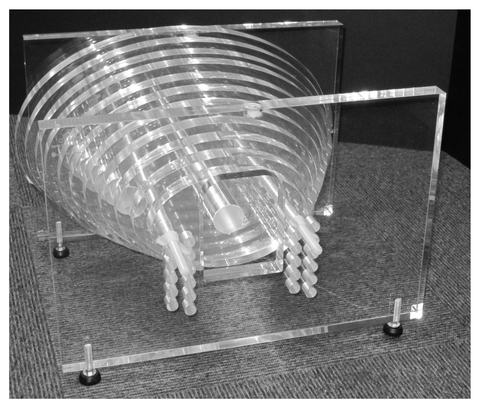


Figure 1. The Leeds Test Objects CT AEC phantom.

Materials & Methods

- Patient dose audits were performed before and after changes were made to all protocols that used the DoseRight AEC system, using the technique described by Wood *et al* [1].
- Large data sets covering a period of six months were extracted from the Radiology Information System for each scanner, and median dose length products (DLP) compared for each protocol. Error estimates were taken as the 95% confidence intervals.
- To create new standardised CT protocols, those that used the DoseRight system were reviewed and settings harmonised as far as possible between equivalent studies on each scanner e.g. reference mAs/slice values, pitch and beam collimation.
- Where protocol settings were found to be different between scanners, the lowest dose settings were used as the basis for the new version of the protocol as no image quality issues had been reported prior to this work (it was assumed the 'low dose' images were fit for clinical purpose).
- The DoseRight system was configured by scanning the fifth largest section of the Leeds Test Objects (Boroughbridge, UK) CT AEC phantom (see Figure 1) to define the 'reference image'. This section of the phantom was found to be representative of typical patient sizes (30.5 cm water equivalent diameter, WED).
- A flow chart of the detailed process for configuring CT protocols is shown in Figure 2.
- After configuration, the full length of the CT AEC phantom was scanned using each of the new protocols, and the standard deviation (image noise) of a central region of interest, plotted as a function of phantom size, was compared for each equivalent protocol to confirm the standardisation of image noise (as well as patient dose).

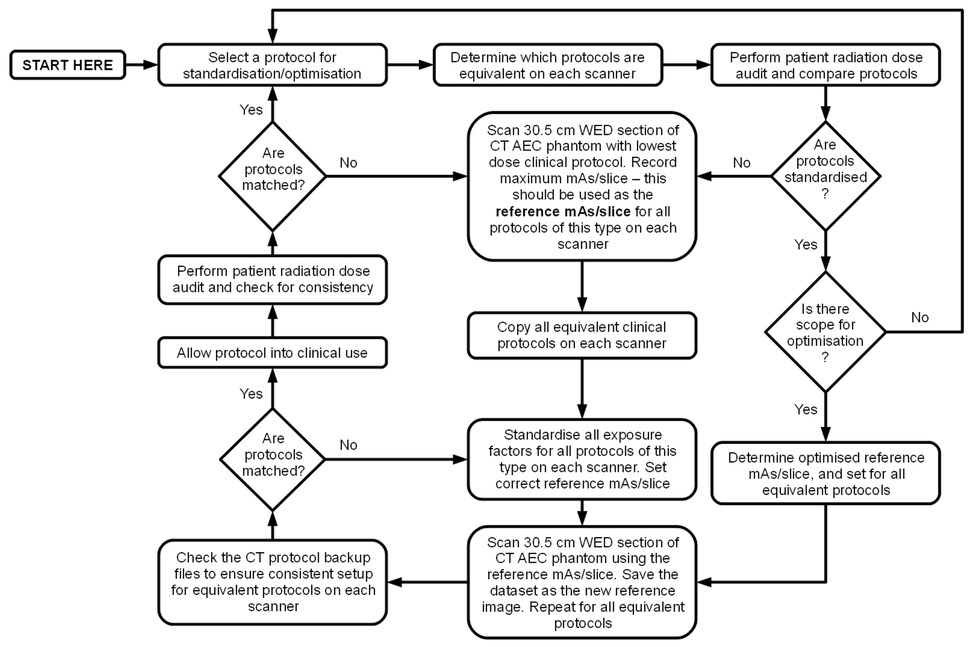


Figure 2. A flow chart demonstrating the process used to standardise and optimise CT protocols on the Philips Brilliance CT scanners with DoseRight 2.0.

Results & Discussion

- Figure 3 shows the comparison of patient doses and image noise for the chest-abdomen-pelvis protocol that was created on both CT scanners.
- In 2012, typical patient DLP was about 20% higher on the 16 slice system, but this has now been configured to match the 40 slice scanner with a corresponding match in image quality demonstrated in Figures 3(b) & (c).
- Figure 4 shows a comparison of average patient doses for a much wider range of CT protocols on the 16 slice system compared with the 40 slice scanner.
- The poor correlation between the doses observed on the two systems in 2012 demonstrates the discrepancy in protocol setup that resulted from the use of the automatic 'learning' mode of the DoseRight AEC system.
- In 2014, the correlation between protocol setup is much better, with a straight line fit showing a gradient close to unity (i.e. a 1:1 relationship between the doses on each scanner), and a much better fit (R^2 = 0.98, compared with 0.77 in 2012).
- As a result of this work, the average DLP per examination (i.e. the average dose for all scanners undertaking that procedure) performed on these CT scanners has been reduced, without any adverse impact on the diagnostic acceptability of the resulting images.
- The use of phantom derived reference images acts as an aid to optimisation as the standard of 'image quality' that the user defines will remain consistent over time, and will only change if the user takes action to adjust protocol settings if they feel it can be further optimised.

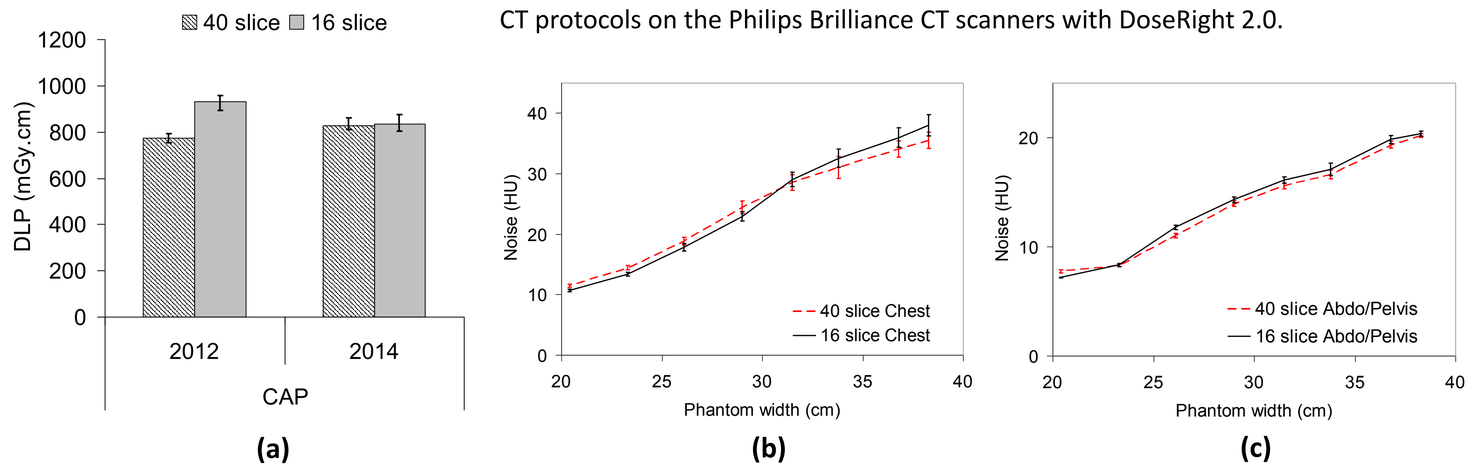


Figure 3. (a) A comparison of patient dose audit results for the chest-abdomen-pelvis protocol on the 40 slice and 16 slice Philips Brilliance CT scanners in 2012 (before) and 2014 (after). (b&c) A post optimisation comparison of image noise for the two phases of the new CAP protocol on each scanner. Both patient dose and image noise are now matched between scanners.

Conclusions

- A technique has been developed that allows the optimisation and standardisation of CT protocols on scanners that use the Philips DoseRight version 2.0 AEC system.
- By configuring the scanner to use a manual reference image that is defined by scanning a uniform PMMA elliptical phantom, it has been demonstrated that matched protocols can be created on multiple scanners, which do not then drift over time.
- This may allow optimisation of DoseRight for a range of anatomical and patient size specific protocols with different size reference phantoms.

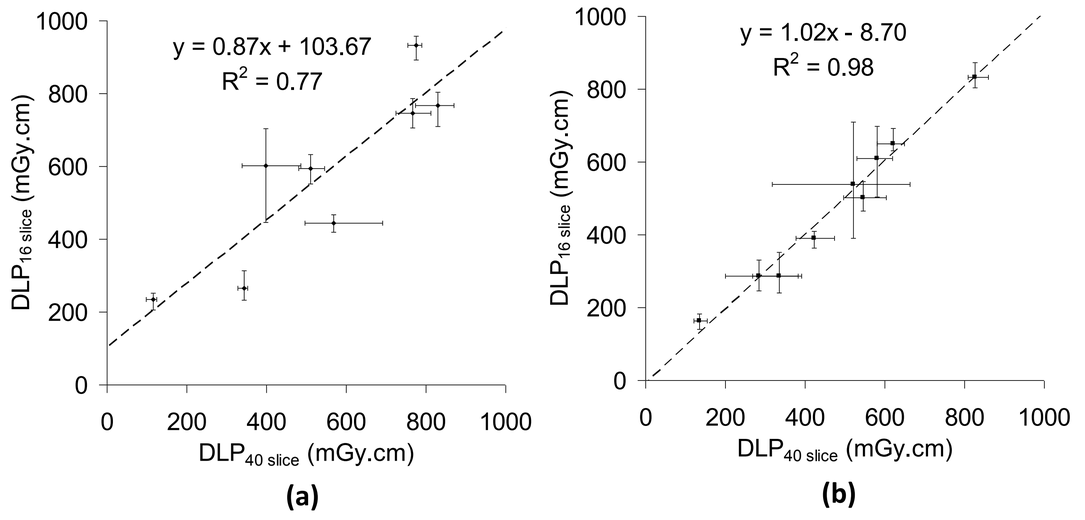


Figure 4. A plot of median dose for common examinations performed on the 16 slice scanner compared with the equivalent protocol on the 40 slice system in (a) 2012 and (b) 2014. Error bars are defined by the 95% confidence intervals, and a straight line fit has been determined.

References

1. Wood TJ, Davis AW, Moore CS, Beavis AW and Saunderson JR 2012 Validation of a large scale audit technique for CT dose optimisation. *Radiat. Prot. Dosim* **150** 427-433.
2. Wood T J, Moore C S, Stephens A, Saunderson J R and Beavis A W. A practical method to standardise and optimise the Philips DoseRight 2.0 CT automatic exposure control system. *J. Radiol. Prot.* (accepted: 29 April 2015).

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