Optimization of Paediatric CT Examinations

An Approach to Minimize Absorbed Dose to Patients with Regard to Image Quality and Observer Variability

AKADEMISK AVHANDLING

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I. Ledenius K, Gustavsson M, Johansson S, Stålhammar F, Wiklund LM and Thilander-Klang A. *Effect of tube current on diagnostic image quality in paediatric cerebral multidetector CT images.*
Br J Radiol. 82 (2009), 313–320

II. Ledenius K, Svensson E, Stålhammar F, Wiklund LM and Thilander-Klang A. *A method to analyse observer disagreement in visual grading studies: example of assessed image quality in paediatric cerebral multidetector CT images.*
Br J Radiol. 83 (2010), 604–611

III. Ledenius K, Stålhammar F, Jönsson M, Boström H, Thilander-Klang A. *Optimization of noise index in paediatric abdominal computed tomography images.*
Submitted to European Radiology.

IV. Ledenius K, Båth M, Stålhammar F, Wiklund LM and Thilander-Klang A. *Estimating the variability in optimization by repeating a study on paediatric cerebral CT examinations.*
Submitted to British Journal of Radiology.

V. Ledenius K, Stålhammar F, Wiklund LM, Fredriksson C, Forsberg A and Thilander-Klang A. *Evaluation of image-enhanced paediatric computed tomography brain examinations.*
Radiat Prot Dosimetry. 139 (2010), 287–292

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Abstract

The absorbed dose to paediatric patients is important bearing in mind the increased risk of radiation-induced cancer due to exposure to X-rays at young ages. Questions have also been raised of whether a CT examination of the paediatric brain might lead to a reduction in cognitive function. Considering the difference in anatomy and thus in X-ray attenuation, children have a special need in CT image quality and require separate scanning protocols and thus separate optimization from adults.

The overall aim of the work described in this thesis was to find an optimization approach to minimize the absorbed dose to paediatric patients undergoing CT examinations, while maintaining the diagnostic image quality and taking into account observer variability. In a first study, the effect of reducing the tube current on the diagnostic image quality was evaluated for paediatric cerebral CT examinations using the non-parametric statistical method of inter-scale concordance. The observer variability was evaluated by means of Svensson's method in a second study. The approaches in these two studies were then combined in a third study to optimize the noise index in abdominal paediatric CT examinations. The aim of the fourth study was to estimate the variability in the results when using inter-scale concordance. A post-processing 2D adaptive filter, claiming to enable reductions in radiation exposure, was investigated in the third study, and in a separate fifth study.

Artificial noise was added to copies of raw data of paediatric CT examinations in order to simulate a reduction in radiation exposure without having to expose paediatric patients to further scans. When the adaptive filter was tested, all images were created in duplicate: one set being post-processed. All images, including the images duplicated for test-retest assessments were evaluated blindly and randomly by three (two in one study) observers using a software viewing station. The radiologists assessed the image quality visually by grading the reproduction of high- and low-contrast structures and overall image quality on a 4-point rating scale.

For the cerebral CT examinations reductions in radiation exposure were possible for patients 1 to 10 years old. It was possible to further reduce the radiation exposure for shunt-treated patients. The original image quality for patients under 6 months of age was found to be inadequate. Noise index 11 was sufficient for a routine abdominal examination for patients aged 6 to 10 years, noise index 12 was considered sufficient for patients aged 11 to 15 years. The variability in results was less than 20 % between two cerebral studies regarding routine CT examinations. The post-processing filter enabled reductions in radiation exposure of approximately 15 % for some age groups.

The approach used in this work enabled the inter-scale relations between radiation exposure and diagnostic image quality to be determined for paediatric cerebral and abdominal CT examinations. Observer variability was also evaluated and a minimum radiation exposure to paediatric patients was suggested. Applying the approach to post-processed images indicated a possible reduction in radiation exposure to paediatric patients.

Keywords: Computed Tomography, Paediatrics, Radiation Dosage, Computer Simulations, Nonparametric Statistics, Observer Variation, Radiographic Image Enhancement

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