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ORIGINAL ARTICLE

Optimization of the pediatric head computed tomography scan image quality: Reducing dose with an automatic tube potential selection in infants

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KEYWORDS
Pediatric head CT scan;
Automatic tube potential selection;
Radiation exposure;
Image quality

Summary
Purpose: The objective of our study was to evaluate the impact of an automatic tube potential selection (ATPS) on the delivered dose and image quality in unenhanced head computed tomography (CT) scans of infants.
Materials and methods: Unenhanced head CT scans were acquired before and after the introduction of an ATPS in full automatic mode in two groups of 20 patients under one year of age. The delivered dose (CDTIvol) as the quantitative (contrast-to-noise ratio) and qualitative (based on the European CT criteria) image quality were compared on the supra- and infratentorial regions by three senior pediatric radiologists. Mann—Whitney and Fisher exact tests were performed. An interobserver Fleiss's kappa agreement was calculated for each criterion.
Results: The use of an ATPS allowed a significant reduction in the delivered dose (−21%, $p = 0.0005$) with no significant difference of the contrast-to-noise ratio in supra- (−5%, $p = 0.21$) and infratentorial regions (+16%, $p = 0.96$). In all cases, dose reduction was obtained with the same value of 100 kV. It maintained a good qualitative image quality (e.g., differentiation between gray and white matter in supra-tentorial region: $p = 0.470$). The interobserver Fleiss's kappa agreements were good to excellent.

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Conclusion: ATPS is a tool that can significantly reduce the delivered dose by choosing the most appropriate tube voltage while maintaining image quality in unenhanced head CT scans of infants.
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Introduction

Computed tomography (CT) is an extremely valuable diagnostic tool, and its use has rapidly increased over the past decade [1]. We must be vigilant, particularly for children: the increasing risks of leukemia and brain cancer are linked to an increase in radiation exposure, even probably at low dose [2,3]. At high doses, age at exposure greatly affects lifetime risk [4]. But it is still desirable to base decisions on clinical utility for the patient without resorting to individual cancer risk estimation [5]. Head and cervical CT scans represent 60% of the CT examinations done in children under 5 years of age [6]. Efforts are made to conduct only strictly indicated examinations. With our new 64-section CT scanner and standard acquisition protocol, image quality has been good in daily examinations, with delivered dose lower compared to the national diagnostic reference levels [7]. However, difficulty in interpretation was sometimes encountered, particularly on the children under 1 year of age, due to a subjectively lower image quality. In infants, brain structures are small and the differentiation between gray and white matters is poor. Appropriateness of the scan (proper indication, no other technique such as ultrasound or magnetic resonance imaging (MRI) available) associated with technique adjusted to the age and size of the child (optimization) are important considerations [8—10]. In concert with the Image Gently CT program improvement [8] and practice of ALARA [11], we focused our attention on optimizing the image quality of the unenhanced head CT scan in this particular population.

Iterative reconstruction and automatic exposure control (CareDose4D™) can significantly improve the reference image quality in a pediatric anthropomorphic whole body phantom [12]. Automatic tube potential selection (ATPS) (CARE kV™, Siemens Healthcare, Forchheim, Germany) is designed to automatically choose the most appropriated tube voltage and to accordingly adjust intensity to deliver the lowest dose achievable while preserving a constant contrast-to-noise ratio (CNR) [13]. The estimated dose is calculated based on a specific tube current time product curves for all of the voltage levels to determine the optimal dose efficiency. Using CARE kV™ requires first that the users pick a reference voltage, quality reference mAs, and a number from 1 through 12 reflecting the type of study that they are going to perform (i.e. unenhanced, CTA, etc.).

The purpose of this study was to evaluate the impact of an automatic tube potential selection during an optimization process of the image quality of unenhanced head CT scans in two groups of 20 infants.

Table 1 Acquisition and reconstruction parameters predefined for unenhanced head CT acquisition on the 2 groups.

	Group 1	Group 2
Automatic tube potential selection (CARE kV)	Inactivated	Activated[a]
Automatic exposure control (Caredose 4D)	Strong	Strong
Quality reference mAs	400	400
Rotation time	1 s	1 s
Pitch	0.8	0.8
Collimation	128 mm × 0.6 mm	128 mm × 0.6 mm
Strength of iterative reconstruction (SAFIRE)	S3	S3
Slice thickness reconstruction	2 mm	2 mm
Reconstruction filter	J30	J30

[a] CARE kV was activated with cursor at position 3 and minimum kilovoltage achievable fixed at 80 kV.

Materials and methods

Study description

The local institutional review board approved this single center prospective study. Three senior pediatric radiologists blindly and successively examined 40 patients (2 groups of 20 patients) under 1 year of age who underwent unenhanced head CT scans with a 64-section multidetector row CT scanner (Somatom AS+, Siemens AG, Forchheim, Germany) from December 2014 to March 2015. The indications of the CT scan were trauma, seizures, and acute headache in emergency. Patients were not sedated. We evaluated the impact of an ATPS on both delivered doses, as well as the qualitative and quantitative measures of brain CT image quality.

Scanning protocols

A lateral scout image with 100 kVp and 35 mA was obtained to define the scan area prior to helical CT imaging. The acquisition and reconstruction parameters are given in Table 1. All CT scans were operated with 1-s rotation time, 230-mm field of view, pitch of 0.6 and collimation of 128 mm × 0.6 mm. Automatic intensity modulation was always activated with quality reference mAs at 400 mAs

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