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Computed Tomography / Tomodensitométrie

High-Resolution Computed Tomography Examinations for Chronic Suppurative Lung Disease in Early Childhood: Radiation Exposure and Image Quality Evaluations With Iterative Reconstruction Algorithm Use

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Abstract

Purpose: High radiosensitivity of children undergoing repetitive computed tomography examinations necessitates the use of iterative reconstruction algorithms in order to achieve a significant radiation dose reduction. The goal of this study is to compare the iDose iterative reconstruction algorithm with filtered backprojection in terms of radiation exposure and image quality in 33 chest high-resolution computed tomography examinations performed in young children with chronic bronchitis.
Methods: Fourteen patients were scanned using the filtered backprojection protocol while 19 patients using the iDose protocol and reduced milliampere-seconds, both on a 64-detector row computed tomography scanner. The iDose group images were reconstructed with different iDose levels (2, 4, and 6). Radiation exposure quantities were estimated, while subjective and objective image qualities were evaluated. Unpaired *t* tests were used for data statistical analysis.
Results: The iDose application allowed significant effective dose reduction (about 80%). Subjective image quality evaluation showed satisfactory results even with iDose level 2, whereas it approached excellent image with iDose level 6. Subjective image noise was comparable between the 2 groups with the use of iDose level 4, while objective noise was comparable between filtered backprojection and iterative reconstruction level 6 images.
Conclusions: The iDose algorithm use in pediatric chest high-resolution computed tomography reduces radiation exposure without compromising image quality. Further evaluation with iterative reconstruction algorithms is needed in order to establish high-resolution computed tomography as the gold standard low-dose method for children suffering from chronic lung diseases.

Résumé

Objet : Le recours à des algorithmes de reconstruction itérative permet de considérablement réduire la dose de rayonnement à laquelle sont exposés les enfants dont la radiosensibilité est élevée lors d'examens tomodensitométriques répétitifs. La présente étude avait pour objectif de comparer la radioexposition et la qualité d'image associées à l'algorithme de reconstruction itérative iDose et à la rétroprojection filtrée, dans le cadre de 33 examens de tomodensitométrie thoracique haute résolution réalisés chez de jeunes enfants atteints de bronchite chronique.
Méthodes : Quatorze patients ont été soumis à un protocole de rétroprojection filtrée et dix-neuf, à un protocole iDose avec réduction du réglable des milliampères-secondes. Tous les protocoles ont été exécutés à l'aide d'un appareil de tomodensitométrie à 64 barrettes. Les images du groupe iDose ont été reconstruites à différents niveaux iDose (2, 4 et 6). Les valeurs de radioexposition ont été estimées, et la qualité des images a été évaluée de façon subjective et objective. Enfin, l'analyse statistique des données a reposé sur des tests *t* pour échantillons indépendants.
Résultats : L'application iDose a permis de considérablement réduire la dose efficace (environ 80 %). Après évaluation subjective, la qualité d'images a été jugée satisfaisante (même au niveau iDose 2), voire excellente au niveau iDose 6. Les deux groupes ont affiché des résultats comparables au chapitre de la mesure subjective du bruit image quand il y avait recours au protocole iDose de niveau 4. Pour ce qui est de la

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mesure objective du bruit image, les images produites par rétroprojection filtrée et par reconstruction itérative de niveau 6 ont également affiché des résultats comparables.

Conclusions : Le recours à l'algorithme iDose dans le cas d'une tomodensitométrie thoracique haute résolution chez l'enfant réduit la radioexposition sans nuire à la qualité d'image. Il convient toutefois d'étudier davantage les algorithmes de reconstruction itérative avant de pouvoir définir la tomodensitométrie haute résolution comme la modalité à faible dose par excellence chez les enfants atteints de pneumopathies chroniques.

Key Words: High-resolution computed tomography; Iterative reconstruction; iDose; Dose reduction; Chronic suppurative lung disease; Children

Computed tomography (CT) is a very useful tool in everyday practice, with new clinical applications continuously being identified. However, potential cancer risks do exist from associated ionizing radiation, in particular for children, who are growing organisms with a longer lifetime than adults to manifest possible radiation outcomes [1,2]. In fact, recent studies have shown positive association between radiation exposure from CT scans and leukaemia or brain tumours in pediatric patients [3]. Therefore, the particularity of this population has raised the need to minimize the radiation exposure of children undergoing CT examinations, without affecting the diagnostic outcome.

Several techniques for radiation dose reduction have been introduced so far, including the use of automatic tube current modulation and the decrease of the acquisition settings according to the patient's attenuation characteristics [4,5]. However, the reduction of current or tube voltage as a dose reduction technique may be responsible for diagnostic unreliability because of increased image noise.

Iterative reconstruction (IR) algorithms constitute a recently applied in medical practice CT image reconstruction technique with an advantage over the so far widely used filtered backprojection (FBP) reconstruction algorithm, as they decrease image noise and artifacts through multiple repetitive reconstructions [6]. Specifically, the noisiest measurements are given low weight in the iterative process and as a result they contribute very little to the final image. Therefore, consequent reduction of noise and artifacts in reconstructed image allow radiologists to significantly diminish exposure settings without compromising image quality [6].

So far, there are a limited number of publications concerning radiation exposure in pediatric CT examinations with the use of IR and even lower concerning the chest region [7−9]. Therefore, the purpose of this study is to evaluate radiation exposure reduction and image quality in chest high-resolution CT (HRCT) examinations for children in need for repetitive radiological examinations, such as young children suffering for chronic suppurative bronchitis. This study is performed with the use of the iDose^4 (Philips Healthcare, Cleveland, OH) IR algorithm compared to the standard FBP reconstruction algorithm at different iDose levels (parameter used to define the strength of the IR technique in reducing image noise). Additionally, the optimum kilovolt peak (kVp), milliampere-seconds (mAs), and iDose^4 level combination will be determined in order to achieve a diagnostically accepted outcome.

Methods

The present cohort study had the approval of our hospital ethics committee.

Patient Population

We retrospectively reviewed preschool and preadolescent school-aged pediatric patients under the age of 10 years old, who underwent chest HRCT examinations for chronic suppurative lung disease before and after the installation of iDose^4 IR algorithm in our Radiology Department. For reasons of homogeneity of our patient samples, only children weighing up to 30 kg were included in this study. This threshold was chosen based on published growth charts, according to which 30 kg is the average weight of children under the age of 10 years [10].

The retrospective review showed that a total number of 14 children underwent the specific examination between 2010 and 2012 using the standard FBP reconstruction algorithm (FBP protocol group). Among those children, 11 showed prolonged wet cough, with 2 of them having pathological findings in plain radiography, whereas 3 had recurrent infections of the lower respiratory system.

After the installation of iDose^4 in our Department, 23 pediatric patients of the same age group underwent chest HRCT examination for chronic suppurative bronchitis using the IR algorithm (iDose protocol group) between March 2012 and December 2014. For technical reasons and mainly because of poor cooperation and severe motion artifacts, 4 of them were excluded from the study. Therefore, a total number of 19 pediatric patients were included in the iDose protocol group, 17 of which showed prolonged wet cough, 1 recurrent pneumonia within the last 2 years, and 1 right middle lobe syndrome.

Exact weight, age, and sex were recorded for all the pediatric patients included in the study (Table 1).

Acquisition Protocol

All the HRCT examinations were performed in a 64-slice multidetector CT (MDCT) scanner (Brilliance, Philips Healthcare, Cleveland, OH).

The FBP protocol group was scanned with 80 kVp and 120-220 mAs settings, whereas pediatric chest HRCT examinations with iDose algorithm (the iDose protocol group) were