Comparison of Standard-Dose and Reduced-Dose Expiratory MDCT Techniques for Assessment of Tracheomalacia in Children

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Rationale and Objectives: The aim of this study was to assess the effects of radiation dose reduction on the assessment of the tracheal lumen on expiratory multidetector computed tomographic (MDCT) images of pediatric patients referred for evaluation for tracheomalacia (TM).

Materials and Methods: The hospital information system was used to retrospectively identify 20 standard-dose and 20 reduced-dose paired inspiratory and expiratory MDCT studies performed for the evaluation of suspected TM in pediatric patients (aged ≤ 18 years). The reduced-dose technique used a 50% reduction of the tube current for the expiratory portion of the study compared to the standard-dose technique. Two experienced pediatric radiologists, who were blinded to the tube current of the study, reported their levels of confidence for measuring the tracheal lumen using a four-point scale ranging from zero (no confidence) to three (highest level of confidence). The difference in confidence level between the two groups of studies was analyzed using the Mann-Whitney *U* test. The percentage of radiation dose reduction using the reduced-dose technique in comparison to the standard-dose technique was estimated using anthropomorphic thorax phantoms. The presence or absence of TM (≥50% expiratory reduction in tracheal cross-sectional luminal area) on MDCT imaging was compared to bronchoscopic results for the subset of 32 patients who underwent both procedures.

Results: A high level of confidence was reported for measuring the tracheal lumen on MDCT imaging for both standard-dose (median, 3.0) and reduced-dose (median, 3.0) expiratory sequences (P = .80). The total radiation dose of the paired inspiratory-expiratory computed tomographic (CT) exam was decreased by 23% with the reduced-dose technique. TM was diagnosed by CT imaging in seven patients who underwent standard-dose and six patients who underwent reduced-dose paired inspiratory and expiratory MDCT studies. CT results for the presence or absence of TM were concordant with the results of bronchoscopy in all 32 patients who underwent both procedures.

Conclusion: The radiation dose of paired inspiratory-expiratory CT imaging can be reduced by 23% while maintaining similar diagnostic confidence for assessment of the tracheal lumen compared to a standard-dose technique in pediatric patients. Thus, a reduced-dose technique is recommended for evaluating TM in children.

Key Words: Multidetector CT; MDCT; tracheomalacia; radiation dose reduction; children.

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Tracheomalacia (TM), a condition characterized by excessive expiratory collapse due to weakening of the tracheal wall and supporting cartilage, is the most common congenital anomaly of the central airways and a cause of potentially significant morbidity (1–6). Recently, paired inspiratory and expiratory multidetector computed tomographic (MDCT) imaging has been shown to be highly accurate in diagnosing TM in both children and adults (7–13). However, a potential disadvantage of this technique is that dual-phase (ie, inspiratory and expiratory phases) computed tomographic (CT) imaging is associated with up to twice as much radiation exposure as a single-phase CT acquisition. Such exposure is particularly concerning for pediatric patients, who are more susceptible than adults to the potentially harmful effects of ionizing radiation (14–16).

A previous study in adult patients showed that tube current can be reduced for the expiratory phase of MDCT studies while maintaining a high level of confidence in assessing the tracheal lumen for TM (17). However, to our knowledge, there is no published information regarding the use of a reduced-dose MDCT technique for the evaluation of TM in children. Because pediatric CT parameters are already

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routinely adjusted by patient age or weight, as well as by the use of automated tube current modulation, it is uncertain whether further dose reduction is possible while maintaining diagnostic confidence. Therefore, the purpose of this study was to evaluate the influence of a reduced-dose technique on the confidence levels of radiologists in assessing the tracheal lumen on paired inspiratory and expiratory MDCT exams of pediatric patients with clinically suspected TM.

MATERIALS AND METHODS

Patient Population

This retrospective study was approved by our institutional review board, which waived the requirement for informed consent. Patient confidentiality was protected according to guidelines of the Health Insurance Portability and Accountability Act.

Until July 2007, our radiology department used a "standard-dose" paired inspiratory-expiratory technique for all pediatric patients referred for CT imaging for suspected TM. As described in detail later, this technique used the same standard age-based and weight-based tube currents for both the inspiratory and expiratory sequences, along with the use of dose modulation, which is customary in our practice.

Beginning in August 2007, on the basis of available published literature in adults and in an animal model of similar size to a pediatric patient (17,18), we began routinely using a "reduced-dose" clinical protocol that decreased the tube current by 50% for the expiratory phase of MDCT imaging in an effort to maintain radiation doses that were as low as reasonably achievable.

This study was a retrospective evaluation of paired inspiratory and expiratory MDCT studies performed in routine clinical practice before and after the implementation of this reduced-dose technique for pediatric patients at a tertiary children's hospital. All pediatric patients who underwent paired inspiratory and expiratory MDCT studies for the evaluation of clinically suspected TM, on the basis of clinical signs and symptoms as determined by their referring physicians, between the dates of December 2004 and April 2009 were included.

We used our hospital information system to retrospectively and randomly identify 20 pediatric patients (aged ≤ 18 years) with clinically suspected TM who underwent paired inspiratory and expiratory MDCT studies using the reduced-dose technique between August 2007 and April 2009. This group represented our study population. We also identified a comparison group of 20 pediatric patients who were imaged with the standard-dose paired inspiratory and expiratory MDCT technique for clinically suspected TM between December 2004 and July 2007. As described in detail in "Statistical Analysis," the number of patients in each subgroup (n = 20) was determined by a power analysis calculation to ensure 85% power for detecting dose-related differences. For both groups of patients, age, gender, and clinical signs and symptoms were recorded from a review of medical records.

MDCT Imaging Technique

Patient Preparation

Sedation and intubation.—Before each MDCT study, a dedicated pediatric anesthesiologist and CT nurse assessed the patient's ability to tolerate the procedure without general anesthesia and intubation. At our institution, infants and younger children (aged ≤ 5 years) who cannot follow the verbal instructions for paired inspiratory and expiratory MDCT imaging are sedated and intubated, whereas older children (aged > 5 years) are generally able to undergo MDCT imaging without sedation and intubation. Of the 20 patients who underwent MDCT studies with the standard-dose technique, 17 (age range, 1 month to 4.3 years) were sedated and intubated, while the remaining three patients (age range, 6–15.8 years) successfully underwent MDCT studies without sedation and intubation. Of the 20 patients who underwent MDCT studies with the reduced-dose technique, 18 (age range, 2 weeks to 4.8 years) were sedated and intubated, while the remaining two patients (8 and 12 years) successfully underwent MDCT studies without sedation.

Intravenous contrast material.—All MDCT studies were performed with nonionic contrast medium (320 mg I/mL), with a contrast dose of 2 mL/kg (not to exceed 4 mL/kg or 125 mL).

MDCT Technical Factors

Type of MDCT scanner.—All studies (n = 40) were performed using one of our department's two MDCT scanners, a 16-row-detector scanner (n = 5) (LightSpeed 16; GE Medical Systems, Waukesha, WI) and a 64-row-detector scanner (n = 35) (Sensation 64; Siemens Medical Solutions, Erlangen, Germany). In the study group, all 20 studies were performed using the 64-row-detector scanner. In the comparison group, 15 of the 20 studies (75%) were performed using the 64-row-detector scanner, and the remaining five studies (25%) were performed using the 16-row-detector scanner.

MDCT parameters.—The protocol consisted of imaging at two different phases of respiration: the end-inspiration phase (ie, imaging during suspended end-inspiration) and the end-expiration phase (ie, imaging during suspended end-expiration). In infants and young children (n = 35) who required general anesthesia and intubation, the end-inspiration and end-expiration phases of CT scanning were performed by alternatively applying and withholding positive pressure ventilation during inspiration and expiration, respectively (7,8,19). In cooperative older pediatric patients (n = 5) who were able to follow breathing instructions, both end-inspiratory and end-expiratory MDCT scanning was performed without intubation or sedation.

CT parameters included 0.6-mm detector element size (64-detector scanner) and 1.25-mm detector element size (16-detector scanner) in the z direction; high-speed rotation,

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