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Computed Tomography Coronary Angiography for Evaluation of Children With Kawasaki Disease

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Objective: We sought to assess the feasibility of computed tomography coronary angiography (CTCA) on a 128-slice, dual source scanner in children with acute and convalescent phase Kawasaki disease (KD).
Materials and Methods: A prospective study of 49 children with KD (12 at presentation and 37 in the convalescent phase) was conducted between November 2013 and April 2015. CTCA was performed with either prospective ($n = 37$) or retrospective ($n = 12$) electrocardiographic gating. A radiologist blinded to clinical profile and echocardiogram evaluated each scan.
Results: Median age (36 boys and 13 girls) was 7 years. Median dose-length product value and median effective CT radiation dose was 32 mGy cm (interquartile range [IQR]: 21-74) and 0.54 miliSieverts (mSv) (IQR: 0.77-3.2) for all scans, and 27 mGy cm (IQR: 18.5-33.75) and 0.48 mSv (IQR: 0.18-1.17) for prospectively triggered scans ($n = 37$). Fourteen subjects (30 coronary segments) showed abnormalities by CTCA including aneurysms ($n = 27$) and stenoses ($n = 3$). In the acute phase ($n = 12$), aneurysms were detected in 5 children (18 segments).
Conclusion: CTCA allows comprehensive evaluation of coronary arteries in children with KD.

Introduction

Echocardiography has hitherto been the imaging modality of choice for assessment of coronary artery aneurysms in children with Kawasaki disease (KD), both during the acute phase and on follow-up.[1] It has several inherent advantages in that it is easily available, is relatively inexpensive and can be repeated as often as required. However, it is highly operator dependent and requires skill, patience and experience in interpreting the images, especially in infants and young children.[2] Further, one can only visualize proximal segments of coronary arteries and changes in the vessel wall are difficult to assess.[3,4] Moreover, the acoustic window for adequate examination becomes limited as the child grows. Catheter angiography, though considered a gold standard for evaluation of luminal abnormalities, is not a valid option in young children in KD as it is invasive, requires general anesthesia, (GA) has a significant radiation exposure and cannot be repeated as often as required.[2,5] Magnetic resonance coronary angiography is technically very challenging to perform and interpret in young children.[6] Moreover, acquisition times are often prolonged (up to 90 minutes) and require GA.[6]

With advances in technology, computed tomography coronary angiography (CTCA) can be developed as a low-radiation imaging paradigm for children with KD.[7-10] Advantages over echocardiography include the ability to visualize middle and distal coronary segments with little or no interobserver variability.[3] Unlike catheter angiography, CTCA is noninvasive and clearly delineates intramural abnormalities. Besides, the measurements of coronary artery abnormalities (CAA) on catheter angiography correlate well with CTCA.[11]

In the present study, we evaluated the feasibility of CTCA for assessment of CAA in children with KD in both the acute and convalescent phases of the disease.

Material and Methods

A prospective study comprising 49 children with KD was conducted between November 2013 and April 2015 at the Department of Radiodiagnosis and Imaging and the Department of Pediatrics, Advanced Pediatrics Centre, Post Graduate Institute of Medical Education and Research, Chandigarh, India. Our Institute is a federally funded, not-for-profit tertiary level hospital in northwest India.

The study protocol was approved by the Institute Ethics Committee and the Departmental Publication Review Board. Written consent was obtained from the parents before performing the procedure.

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Patient Selection

A total of 12 children with newly diagnosed KD who either had an echocardiographic abnormality or had clinically severe disease were evaluated by CTCA. Furthermore, 37 children with KD on follow-up were selected for evaluation by CTCA. The median time from KD onset to imaging was 1.5 years (interquartile range [IQR]: 0.42-3.3).

Patient Preparation

CTCA was performed without sedation or anesthesia in children greater than 5 years. CTCA was done under short anesthesia (ketamine and midazolam) for children less than 5 years. GA was administered to 1 infant in the study. Oral metoprolol (2 mg/kg body weight) was administered to all children 30 minutes prior to CTCA. The aim was not only to achieve a low but also a stable heart rate.

Contrast Injection Protocol

Nonionic contrast (Omnipaque 350, GE Healthcare, Ireland) 2-4 mL/kg was injected at a rate of 4 mL/s (through 20G cannula) for children greater than 5 years, and 1.5-2.5 mL/s for infants and children less than 5 years, in the right antecubital vein. This was followed by a saline push with a dual head power injector. The acquisition was carried out using the bolus tracking technique with the circular region of interest set at the level of the descending thoracic aorta with threshold attenuation value of 100 HU.

CTCA Technique

CTCA was carried out on a second generation dual-source CT 128-slice scanner (SOMATOM Definition Flash, Siemens, Erlangen, Germany) with the following parameters: temporal resolution—75 milliseconds, gantry rotation time—0.28 seconds, slice thickness—0.6 mm. The scan was conducted in a craniocaudal direction from just below the carina to the diaphragm. At the beginning of the study, we used retrospective-triggered electrocardiogram (ECG)-synchronized CT scanning for data acquisition as we had the apprehension that prospective gating might be inappropriate for the anticipated high heart rates in small children. We soon realized that it was feasible to carry out the same procedure with prospective-triggered ECG-synchronized CT scanning. The latter scanning protocol was carried out in 37 patients, and this enabled us to achieve low radiation exposures without compromising image quality. Adaptive prospective ECG-gating with full tube current was performed between 30% and 80% R-R interval (to obtain both systolic and diastolic images).

Scanning parameters were customized to ensure minimal radiation exposure (Table 1). The dose parameters of peak kilovoltage (kVp), milli-ampere second (mAs), and volume CT dose index were adjusted according to body size-adapted protocols that include body weight and cross-sectional area. Automatic Care kV was switched off and adjusted to 80 kVp in all children except for 4 subjects for whom it was reduced further to 70 kVp. These modifications, along with care-dose 4D tube current modulation, enabled us to reduce further the effective radiation dose. The lowest kVp and mAs values that ensured optimal image quality with minimum possible radiation exposure were selected. The mAs values ranged between 48 and 220. Effective CT radiation dose estimates were calculated by multiplying dose-length product (DLP) value and an appropriate conversion factor provided by the CT manufacturer (0.026, 0.018, and 0.014 for $\leq$ 1 year, 5-10 years, and $>$ 10 years, respectively).

Postprocessing

Postprocessing was done on a dedicated Syngo.via workstation (Siemens, Germany) for reconstruction of the coronary arteries. Curved multiplanar reconstructions, maximum intensity projections, and volume rendered images were reviewed by the lead author (M.S.) who was blinded to details of clinical profile and echocardiography findings. A second radiologist (P.G.) correlated CTCA data with clinical data.

Assessment of Coronary Arteries

Coronary arteries were evaluated using the 13 segment model proposed by the American Heart Association (AHA).[12] Side

TABLE 1
Scan acquisition protocol

CTCA parameters	Details
Scan area	Floor of carina to base of heart
Data acquisition technique	Bolus tracking technique (region of interest in the ascending aorta with preset of 100 HU)
Scan delay	5 s after achievement of 100 HU
Kilo-voltage	80 kV
Tube current	Automatic exposure control system-based tube current modulation (Care-DOSE; Siemens Medical Solutions)
ECG gating	Adaptive prospective ECG-gating with full tube current between 30% and 80% R-R interval (to obtain both systolic and diastolic images)
Detector collimation	2 × 64 × 0.6 mm
Slice acquisition	2 × 128 × 0.6 mm by means of a *z*-flying focal spot
Gantry rotation time	280 ms
Temporal resolution	75 ms
Reconstructed slice thickness	0.75 mm with a reconstruction increment of 0.5 mm
Image window	Soft-tissue convolution kernel (B26f)
Image postprocessing	Syngovia (Siemens Medical Solutions). Images constructed in multiplannar, maximum intensity projection and volume rendering along with axial data set.
Contrast injection protocol	Dual head pressure injector with saline flush (saline flush for 5 s at same flow rate of contrast)
Calculation of contrast volume	Flow rate × (scan time + scan delay*) *Fixed at 5 s
Contrast flow rates	24G cannula: 1.5 mL/s (2-4 mL/kg) 22G cannula: 2.5–3 mL/s (2-4 mL/kg) 20G cannula: 4 mL/s (2-4 mL/kg)
Beta-blocker	5 mg/kg oral 30 min prior to scanning. Intent was to stabilize rather can reduce heart rate.