CT coronary angiography in Kawasaki disease: current perspectives

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INTRODUCTION

Kawasaki disease (KD) is a common vasculitic disorder in children that preferentially involves the coronary arteries.[1] Coronary artery abnormalities (CAAs) may develop in 15–25% of patients with KD who do not get timely treatment. However, even with appropriate treatment, CAAs can still develop in ~5% of patients.[1] Precise diagnosis of CAAs is important for treatment planning.[1–3]

CAAs are the most important complication of KD and necessitate prompt and accurate diagnosis. While CAAs are more common in proximal segments, these can also occur distally.[1–3] Presence of CAAs in both distal and proximal segments of coronary arteries impacts treatment planning. With time, CAAs may resolve, remodel or persist and may be complicated by thrombosis, steno-occlusive lesions and mural calcifications.[1–3]

There are several imaging techniques for assessment of CAAs. These include 2D-transthoracic echocardiography (2DE), catheter coronary angiography (CCA), magnetic resonance coronary angiography (MRCA) and CT coronary angiography (CTCA).

Role of 2DE in KD

2DE is a simple, non-invasive point-of-care test for detection of CAAs. It is useful for detection of aneurysms in proximal segments of coronary arteries.[1] However, there are several limitations of 2DE. These include operator dependency and interobserver variability, poor acoustic window in older children and difficulty in detection of CAAs in (1) mid and distal segments, (2) coronary artery branches and (3) left circumflex artery. Further, it has limitations in the detection of coronary thrombosis and stenosis.

Role of CCA in KD

CCA is the gold standard for assessing CAAs but is invasive and has significant radiation exposure (5–10 mSv). It also has limitations in assessing mural abnormalities (eg, calcifications) and intramural thrombi. It cannot be repeated readily on follow-up.

Role of MRCA in KD

MRCA has also been studied for evaluation of CAAs in KD. MRCA, however, has lower spatial resolution (ie, image quality) and temporal resolution (ie, scanning speed) as compared with CTCA. Furthermore, MRCA has lengthy scan times (often 45–60 min) and requires anaesthesia support in young children. MRCA has limitations for the assessment of steno-occlusive lesions. It is, however, superior to CTCA for evaluating myocardial perfusion and viability and for assessing coronary arteries with thrombotic aneurysms and calcification.[4]

Role of CTCA in KD: a new imaging paradigm

CTCA is now gradually emerging as an important imaging technique for assessment of coronary arteries in KD. It is comparable to CCA for delineation of CAAs. It is non-invasive, can be easily performed during the acute phase (once the patient has stabilised) and can be readily repeated on follow-up. The procedure can be performed with minimal sedation in children below 5 years and without any sedation in children older than 5. The ability to visualise coronary arteries and their branches over the entire length, with little or no interobserver variability, is a distinct advantage over 2DE. However, at times, it may be difficult to visualise the distal segments of coronary arteries on CTCA, especially in infants and young children. This may be due to the small calibre of coronary arteries and suboptimal image quality due to variability in heart rates. However, with the availability of dual-source and higher detector CT scanners, these limitations are easily addressed. In addition, CTCA also provides temporal change of CAAs (ie, resolution, persistence and remodelling) and accurate delineation of luminal (eg, thrombus within the CAAs and steno-occlusive lesions) and mural (eg, calcifications) abnormalities. While CTCA and 2DE are comparable for imaging proximal segments of coronary arteries, CTCA scores over 2DE for demonstration of distal segments.[2] CTCA is particularly useful in older children and adolescents who have a poor acoustic window for 2DE.[1–3]

High radiation exposure had previously been a hindrance to more widespread use of CTCA in KD. Radiation exposure with CT scanners has always been of concern, especially in infants and young children. However, with the advent of higher detector CT platforms (eg, 128, 256 and 384 slices) and dual-source CT (DSCT) scanners, high-resolution and motion-free images can now be acquired at any heart rate with sub-millisievert radiation exposures.[3] Table 1 lists the proposed indications of CTCA at presentation and on follow-up.

CT calcium scoring

CT calcium scoring should be considered on a case-to-case basis in children with KD during follow-up. However, the literature on this aspect is still evolving.[5] Calcium scoring is especially recommended in patients who have developed CAAs at

Table 1 Proposed indications for CTCA in patients with KD

Acute stage	Older children and adolescents who have a poor acoustic window for 2DE.
	Children with a severe disease course (eg, KD shock syndrome, KD with macrophage activation syndrome or symptomatic myocarditis and KD in infants <6 months).
	Children with CAAs on 2DE for confirmation of 2DE findings and children with equivocal 2DE studies.
Follow-up	To document the resolution/progression of CAAs every 3–5 years.
	To monitor distal aneurysms as these cannot be evaluated by 2DE.
	Long-term monitoring for the detection of mural abnormalities.
	Delineation of thrombosis, stenosis and dystrophic calcifications.

CAAs, coronary artery abnormalities; CTCA, CT coronary angiography; 2DE, 2D-transthoracic echocardiography; KD, Kawasaki disease.

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Table 2 Suggested standard operating procedures for CTCA in children with KD

Procedures to be carried out on the day before CTCA	► Detailed 2DE. ► Consent from parents for CTCA and sedation. ► Ensuring availability of resuscitation kit.
Procedures to be done on the day of CTCA	► Nil per orally for 4 hours. ► Patient to be accompanied by 2 resident doctors/fellows. ► Placement of an age-appropriate wide-bore cannula in the right antecubital vein (eg, 24G—infants; 22G—toddlers). ► Single-dose metoprolol tablet (2 mg/kg) to be given 1 hour before the procedure. ► Syrup triclofos (50 mg/kg) to be given 30 min before procedure for young children. ► Intravenous midazolam (0.1–0.2 mg/kg) is given in children who require additional sedation.
Contrast details	► Non-ionic contrast. ► Dose: 2 mL/kg. ► Speed of intravenous contrast injection: depends on size of cannula (24G: 1.5 mL/s; 22G: 2–3 mL/s).
Contrast injection protocol	Automated bolus triggering technique in which scanning gets initiated when the preset Hounsfield unit value of 100 is achieved in the 'region of interest' placed in the descending thoracic aorta.
Radiation optimisation technique during CTCA procedure	► Area coverage: from carina to base of heart; field of view: coverage of heart only. ► 80 kVp is appropriate—this reduces radiation exposure. ► Adaptive ECG triggering with current modulation.
Iterative image reconstruction algorithms	This provides high-resolution images even at low radiation exposure.*

*At our centre we use the following iterative reconstruction algorithms: '*Saffire*' in 128 dual-source CT scanner (Siemens Definition Flash) and '*Admire*' in 192 dual-source CT scanner (Siemens Force).
CTCA, CT coronary angiography; 2DE, 2D-transthoracic echocardiography; KD, Kawasaki disease; kVp, kilovolt peak.

presentation. Coronary calcification in KD is usually confined to CAAs and can develop at varying intervals after the initial KD episode.

Guidelines for radiation optimisation in CTCA

CTCA should be carried out with radiation optimisation and preferably on higher detector CT scanners or DSCT. Radiation exposure can be minimised by limited area coverage and field of view, low tube voltage (most children can be scanned at 80 kV), automatic body adaptive tube current selection, ECG-triggered tube current modulations (ie, adaptive ECG-triggered sequence) and iterative reconstruction algorithms. At our centre, we use 'adaptive ECG-triggered sequence' for data acquisition with image acquisition during 30–80% of the R-R interval (table 2).

Limitations of CTCA

CTCA, however, has a few limitations. Higher slice CT platforms with DSCT scanners are expensive and may not be easily available in all centres. The need for sedation in infants and young children and radiation exposure are other drawbacks of the procedure.[1 4] However, these are minor in comparison to the benefits that accrue from the procedure. In our experience, only mild sedation is required in infants and young children, and there is no need for general anaesthesia.

CONCLUSIONS

CTCA is a useful imaging technique that is complementary to 2DE. CTCA allows detailed evaluation of coronary arteries along their entire course, including branches. Radiation hazard is significantly reduced when performed on present-day advanced CT scanners with radiation optimisation techniques. CTCA also delineates CAAs in distal segments of coronary arteries and their branches—findings that are often missed on 2DE. CTCA is also required for identification of complications (eg, thrombus, stenosis, occlusions and mural calcifications) during follow-up.

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