JACC: CARDIOVASCULAR IMAGING
VOL. 1, NO. 3, 2008

ISSN 1936-878X/08/$34.00
PUBLISHED BY ELSEVIER INC.
DOI:10.1016/j.jcmg.2008.03.006

EDITORIAL COMMENT

CT Angiography in Children: It Is Accurate, But Is it Safe?*

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In this issue of *JACC: Cardiovascular Imaging*, Ou et al. (1) report the results of a large series of children undergoing conventional catheter coronary arteriography (angio) and contrast-enhanced 64-slice multidetector computed tomography (MDCT) for the evaluation of their coronary arteries after performance of the arterial switch operation for D-transposition of the great arteries. One hundred thirty consecutive children (5.6 ± 1.1 years) surviving the arterial switch operation had contrast-enhanced MDCT performed within 24 h before or after angio was performed.

Children were prepared for their examination by a technician, who trained them to hold their breath for 5 to 7 s. All patients (unless contraindicated) received propranolol (1 to 2 mg/kg) 1 h prior to exam to achieve a resting heart rate <80 beats/min.

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The investigators used a standard MDCT acquisition protocol, determining scan delay empirically, by scanning in a continuous, low dose (70 kV, 20 mA) fluoroscopy mode over the ascending aorta. Based upon the measured time to maximum aortic opacification, bolus injection of contrast was performed, and imaging commenced at this time using a low kilovolt dose reduction algorithm (80 kV, range 150 to 350 mA, based upon patient body weight). Examinations were centered over the heart, from the pulmonary trunk to just below the diaphragmatic surface of the heart. Results of these examinations were compared with those obtained at angio.

The duration of MDCT examinations (including analysis) averaged 20 ± 6 min. Using their heart rate control method, mean heart rates decreased from 92 ± 19/min at rest to 74 ± 13/min at examination. The average volume of contrast material used for these examinations was 30 ± 7 cc. No sedation was used, and there were no complications of examination. Average radiation dose for MDCT was 4.5 ± 0.5 mSv. This was significantly greater than that for angio (3.1 ± 1.6 mSv, $p < 0.001$).

Evaluation of angio performed in these children found that 12 (9.2%) of patients had significant coronary lesions, including 6 ostial arterial occlusions and 6 arterial stenoses. Evaluation of CT examinations found interpretable images in 126 (97%) of the patients. Four children were excluded from MDCT analysis. These children were slightly younger (their average age was 4.9 years), their scans obtained at higher heart rate (average of 91/min), and their breath holding inconsistent. No coronary lesions were found at angio in any of these 4 patients. The MDCT examination was able to assess all coronary ostia and proximal arterial segments and correctly detected all 12 patients with significant coronary stenoses identified by angio. Compared with angio, MDCT provided 100% sensitivity, specificity, and negative predictive value for coronary artery lesions. In addition, in those patients with stenotic but nonocclusive coronary artery disease, MDCT demonstrated additional morphologic findings not obtained at angio, providing insight into the mechanism of these stenoses.

This report points out the reliability and safety of MDCT for the evaluation of pediatric patients with coronary heart disease. The 100% accuracy of MDCT in this series is not dissimilar to results reported in adult series. However, the high accuracy was obtained quickly and without complications. Radiation dose for MDCT in these children was greater than that re-

*Editorials published in *JACC: Cardiovascular Imaging* reflect the views of the authors and do not necessarily represent the views of *JACC: Cardiovascular Imaging* or the American College of Cardiology.

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ceived by angiography. Thus, although performed without complication, the children may have been exposed to an unknown, but greater future risk by the MDCT. Therefore, choice of MDCT or angio must also include an assessment of the other, short-term risks of angio, namely sedation, percutaneous arterial puncture, and catheter manipulation.

The risks of MDCT relate to intravenous contrast administration and radiation exposure. Contrast-induced nephropathy is a common cause of renal failure (2). Among individuals without predisposing renal impairment, renal dysfunction is found in between 3.3% and 8% of contrast administrations (3,4). In individuals with pre-existing renal disease or diabetes, this increases to between 12% and 16% (5). Severe anaphylactic reaction to intravenous contrast administration is rare, commonly quoted as between 0.04% (using nonionic contrast media) and 0.22% (using ionic media) (6). Adverse, less severe contrast-related reactions are more common, on the order of 10% to 12% of patients with known contrast allergy and in 15% to 16% in patients with previous contrast reaction (7). Radiation exposure in adults for 64-slice MDCT using dose modulation protocols is about 5.4 to 9.4 mSv (8), greater than seen in this report of a pediatric population.

Complications associated with cardiac catheterization in children are uncommon, occurring in about 8.8% of examinations (9). Reports of the mean radiation dose in angio in adult patients vary widely (10). The United Nations Scientific Committee on the Effects of Atomic Radiation cites 7 mSv as a typical dose (11). In a pediatric population, the median dose for angio was 4.6 mSv (12) greater than that found in this report. We do not have a good measure of the incremental risk of cancer after MDCT examination. Mathematical models provide guidance, but may significantly overestimate risk and thus potentially deny the benefit to many. There are no good biological models, which might cause us to err on the side of accepting examinations at higher dose and expose many to greater risk. In a retrospective study of 674 children catheterized for congenital heart disease, with mean follow-up of 28.6 years (13), 78% of subjects were alive. Eleven malignancies were diagnosed (more than doubling the expected 4.75 malignancies).

Thus, in all patients undergoing angio or MDCT (and especially in children), we are faced with the conundrum of weighing a small chance of low risk, short-term complications against an unknown risk of more severe, later complications (i.e., hematoma or contrast reaction vs. leukemia or lymphoma). If the radiation dose is similar, then it follows that the risk of radiation-related complication is probably nearly the same for angio and MDCT; the significant problem may lie in an increasing number of MDCT exams performed in children. Thus, if our choice of angio versus MDCT is reduced to an assessment of the risk of short-term complication, then the choice of MDCT becomes more attractive.

Certainly research on the effects of low dose radiation must continue. Furthermore, we must adjust our clinical protocols to reflect the known and unknown dangers of radiation exposure in children and adults as well. Nevertheless, it is always prudent be aware of and to minimize radiation dose. This is accomplished by adhering to a philosophy of ALARA (as low as reasonably achievable), tailoring each examination to the individual, by maintaining tight control over X-ray factors during image acquisition (including use of dose modulation protocols), and by limiting the exam to necessary thoracic structures. Pre-examination preparation plays an important role in increasing patient compliance by allowing a successful examination in young, as well as symptomatic patients. Although our understanding of the risks of radiation exposure at MDCT is limited, results such as those of Ou et al. (1) show us that examination can be successfully performed in children and adults, allowing the benefits of examination to outweigh the risks.

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