ORIGINAL ARTICLE

Image quality and radiation doses of volumetric 320-row computed tomography angiography with prospective electrocardiogram-gating in the assessment of coronary arteries in neonates and infants

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ABSTRACT

Background: Diagnostic imaging of coronary arteries is required in neonates and infants suspected of congenital or acquired coronary artery anomalies and in pre- and postoperative assessment of complex congenital heart diseases (CHD).

Aim: Our study aimed to evaluate the image quality of volumetric 320-row computed tomography angiography (CTA) with prospective electrocardiogram (ECG)-gating for coronary arteries in neonates and infants with heart diseases, analyze factors influencing image quality and assess a radiation dose related to the procedure.

Methods: The study included 110 CTA performed in neonates and infants with CHD.

Results: CTA was performed in 37 girls and 73 boys at a median (interquartile range [IQR]) age of 3.0 (0.5–5.0) months, median (IQR) body weight of 5 (3.66–6.5) kg, and median heart rate (HR) of 133 (92–150) beats per minute. The orifices of the left coronary artery were visible in 100% of CTA, the orifices of the right coronary arteries were visible in 96%, whereas all coronary segments were assessable in 45% of CTA. Patients with non-diagnostic segments were significantly younger, median (IQR) age of 2.0 (0.21–5.00) months, had lower body weight of 4.6 (3.45–6.07) kg and faster HR of 136.5 (120–150) beats per minute (P <0.05) than patients with diagnostic image quality in all segments (4.0, 2–6 months, 6.0, 4.2–7 kg, and 130; 110–150 beats per minute, respectively; P <0.05).

Conclusions: CTA performed with volumetric 320-row prospective ECG-gating allows for good visibility of the coronary arteries with an acceptable radiation dose. Children aged >15 days, with body weight >4.85 kg and HR <130 beats per minute are good candidates for excellent quality non-invasive CTA of all segments of coronary arteries.

Key words: 320-row computed tomography, coronary artery anomalies, infants, neonates, radiation dosage

INTRODUCTION

Coronary imaging in the early postnatal period and the first months of life is performed in the pre- and postoperative assessment of complex congenital heart diseases (CHD) and when congenital or acquired isolated coronary artery pathologies are suspected. Coronary anomalies accompanying CHD are reported with frequency even over 30% [1, 2]. Preoperative diagnosis of coronary pathology in CHD potentially increases morbidity and mortality and impacts the surgery approach [3–5]. Guidelines of pediatric coronary imaging suggest multimodality management based on age, diagnosis, local capabilities, and site experience, with echocardiography being

WHAT'S NEW?

Diagnostic imaging of coronary arteries is required in neonates and infants suspected of congenital or acquired coronary artery anomalies and in the pre- and postoperative assessment of complex congenital heart diseases. Computed tomography angiography performed with volumetric 320-row prospective electrocardiography-gating allows for good visibility of the coronary arteries in neonates and infants with acquired and congenital heart diseases. Body weight is the strongest factor that influences coronary artery image quality in this age group. Children aged >15 days, with body weight >4.85 kg and heart rate <130 per minute, are good candidates for excellent quality non-invasive computed tomography angiography of all segments of coronary arteries.

the first-line choice, whereas conventional angiography and catheterization are still considered the gold standard [6–8]. Cardiac computed tomography angiography (CTA) is getting wider acceptance also for coronary imaging in children although in neonates and infants it is more challenging due to smaller vessel diameter and body weight, higher heart and respiratory rate, and inability to cooperate. The improvement in computed tomography (CT) technology in several recent years has brought a new generation of high-end scanners and allowed performing fast, non-invasive scanning with the coverage of large volumes of submillimetre isotropic spatial resolution. Volumetric scanning during single lamp rotation in small patients enables to perform free-breathing examinations of wide anatomic ranges (ie. thorax and abdomen in neonates) and decreases or eliminates the need for sedation. ECG-gating with prospective mode and careful definition of scan range results in lower doses of ionized radiation considered a major drawback of CT in the pediatric population [9–12]. Therefore, also neonates and infants can benefit from tremendous CT technical advantages, and CTA with prospective ECG-gating might replace invasive coronary angiography and become an easy, repeatable, first-line method for objective morphological assessment of coronary arteries. This study aimed to evaluate the image quality of volumetric 320-row computed tomography angiography (CTA) with prospective ECG-gating for coronary arteries in neonates and infants with heart diseases, analyze factors influencing image quality and assess the radiation dose related to the procedure.

METHODS

The study included 110 consecutive CTA performed in 32 months (from March 2016 to October 2018) according to our local diagnostic management algorithm in neonates and infants (age ranges from 1st day till the end of the 12th month) with congenital and acquired heart diseases. For all CTA examinations, informed consent was obtained from parents or legal guardians. This study was approved by the local ethics board. The studies were performed using a 320-row scanner (Aquilion One, Canon Medical Systems) with prospective ECG-gating and target CTA scan mode designed to guarantee radiation dose before scanning, which allowed setting one rotation exposure window. Due to the high heart rate (HR) of our patients, the end-systolic (40%) phase was selected as the target phase and a range of 10% of the R–R cycle was available for reconstructions. Scanning was performed with volumetric mode, one gantry rotation covering up to 16 cm by 320-row area detector with spatial resolution of 0.5 mm. The time of one gantry rotation was 350 ms, and images were reconstructed from half time rotation, from one heart beat with the temporal resolution of 175 ms. All patients were free-breathing during scanning, younger babies were fed and safely wrapped to perform scanning with no sedation; older patients (infants) required short sedation supervised by the anesthetic team.

The tube voltage of 80 kV, automatic tube current modulation, and iterative reconstruction AIDR 3D (Adaptive Iterative Dose Reduction 3D) were applied for all studies. CTA was acquired with intravenous administration of warmed, iso-osmolar (iodixanol, Visipaque) or low-osmolar contrast agents (iomeprol, Iomeron 300 or iopromide, Ultravist 300) at the dose of 1–3 ml/kg, with the rate of 0.5–1.5 ml/s, depending on the size of intravenous access catheter (22–26 G; peripherally inserted central catheter [PICC]) and demanded length of bolus duration. Scanning was triggered automatically with the bolus tracking technique or manually after visual estimation of the contrast opacification in the region of interest by a supervising radiologist.

Raw data were analyzed with a dedicated cardiac application (Cardiac Analysis, Philips Intelispace Portal, Koninklijke Philips N.V.), and multiplanar and volumetric reconstructions were obtained.

The volumetric computed tomography dose index ($CTDI_{vol}$) and dose–length product (DLP) of each examination based on 32 cm phantom were recorded and compared with data from literature and with European reference dose levels for pediatric chest computed tomography examinations.

The coronary artery image quality was assessed using a four-point scale (0–3 points) based on coronary segmental anatomy (proximal, middle, and distal segments) as follows: 0 points — assessment of coronary arteries impossible; 1 — ostium and the proximal segment of the left and/or right coronary artery was visible; 2 — ostia, proximal and middle segments of coronary arteries assessable; 3 — ostia, proximal, middle and distal segments of coronary arteries well visible.

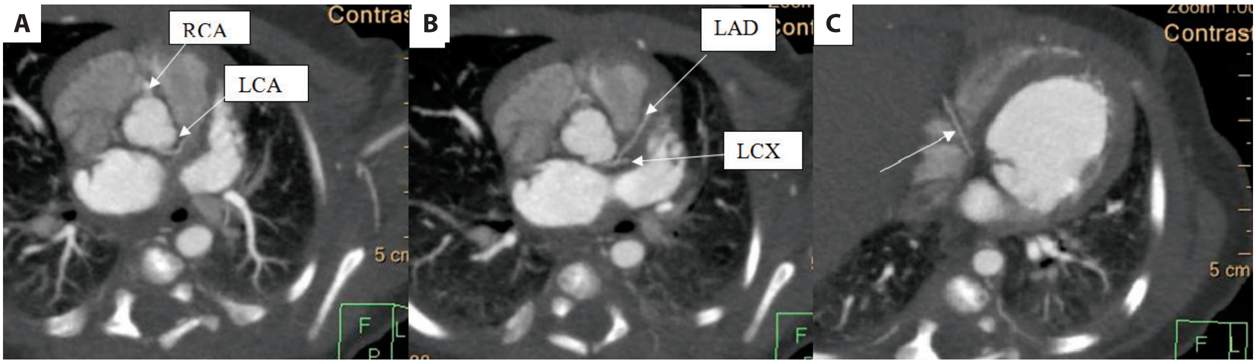

Figure 1. Assessment of coronary artery image quality according to the scale. Computed tomography angiography of free-breathing, non-sedated 5-week-old patient suspected of coronary anomaly; HR, 150–170/min; CTDIvol 2.3 mGy; DLP 14.10 mGy×cm. **A.** The ostia of the left (LCA) and the right (RCA) coronary artery are clearly visible –1 point. **B.** The orifices and middle segment of coronary arteries are visible. The left main coronary artery division into the anterior descending (LAD) and circumflex (LCX) artery is easily appreciated — 2 points. **C.** The ostia, middle segments and distal segments of coronary arteries are visible, arrow points at the distal segment of RCA in the atrioventricular groove — 3 points

The maximum score for the best image quality of coronary arteries was 3 points. Figure 1 presents the quality assessment scale of coronary arteries' image. The image quality of coronary arteries was compared between two groups: a group of CTA with good diagnostic image quality of all segments of coronary artery (Group = 3) and a group of CTA with at least one segment of non-diagnostic image quality (Group <3). The impact on coronary artery image quality of parameters such as age, body weight, heart rate, and radiation dose was assessed.

Statistical analysis

The statistical analysis was performed to define predictors of good image quality.

Continuous variables and scores of image quality were expressed as the mean, standard deviation (SD), and categorical variables as percentages. Continuous variables with normal distributions were compared using Student's t-test. Other numerical were expressed as the median and interquartile range (IQR). The Kolmogorov-Smirnov test was used to identify continuous variables with a skewed distribution which were then compared using the Mann-Whitney U test. Categorical variables were compared using the chi-square or Fisher's exact test and presented as percentages. Clinical parameters and radiation doses were subjected to univariate and multivariable regression analysis. Receiver operating characteristic (ROC) analysis was used to (1) determine the area under the curve (AUC) for selected clinical (age, heart rate, body weight) and CT parameters (CTDI) in the prediction of the occurrence of good quality images of all segments of coronary arteries and (2) to determine the optimal cut-off for the selected (age, HR, body weight) parameter in relation to the diagnostic imaging of all segments of coronary arteries. For all performed tests *P*-values of <0.05 were considered significant. Analyses were performed using the STATISTICA 13 data analysis software system (TIBCO Software Inc., CA, US) and MedCalc 18.0.

RESULTS

A total of 110 CTA were performed in 37 girls and 73 boys with an initial diagnosis of congenital or acquired heart diseases (Table 1). The median (IQR) age of patients was 3.0 (0.5–5.0) months, median body weight 5.0 (3.66–6.5) kg, and heart rate (HR) 133 (92–150) beats per minute. All examinations were performed on free-breathing patients, and in 30% of patients, no sedation was used. The scanning range resulted from an indication for the examination and covered from 6 to 16 cm of the patient's thorax. The median (IQR) dose indexes CTDIvol and DLP were 1.9 (1–4.8) mGy and 16.95 (7.7–38.6) mGy×cm, respectively. Detailed group characteristics are presented in Table 2. The mean (SD) coronary artery score for all examinations was 2.2 (0.74) points. The orifices of LCA were visible in 100% of CTA; the orifices of RCA were visible in 96%; the orifice and middle segments in 82.7%, whereas all coronary segments were assessable in 45% of CTA. CTA with non-diagnostic segments (Group <3) was performed in significantly younger patients with a median (IQR) age of 2.0 (0.21–5.00) months, with lower body weight of 4.6 (3.45–6.07) kg, and a faster HR of 136.5 (120–150) beats per min (*P* <0.05) than CTA with diagnostic image quality in all segments (Group = 3) 4 (2–6) months, 6.0 (4.2–7) kg and 130 (110–150 beats per minute; *P* <0.05). Radiation doses showed no significant differences between the groups. Table 3 presents a detailed comparison of both groups. Clinical parameters and radiation doses were subjected to univariable and multivariable analysis. Univariable regression logistic analysis revealed that age and body weight significantly influenced coronary artery image quality (odds ratio [OR], 1.20; 95% confidence interval [CI], 1.05–1.37; *P* = 0.004 and OR, 1.25; 95% CI, 1.02 – 1.53; *P* = 0.024, respectively), while the heart rate showed only a trend (OR, 0.98; 95% CI, 0.96–1.00; *P* = 0.057). Multivariable regression analysis showed that body weight was the predictor of good image quality (OR, 1.18; 95% CI, 1.01–1.39; *P* = 0.017). The optimal cut-off points for a good quality image of all segments of coronary arteries in the

Table 1. Indications for computed tomography angiography in neonates and infants in the study group

Diagnosis	Neonates (n = 34)	Infants (n = 76)	Total (n = 110)
Tetralogy of Fallot	1	20	21
Coarctation of aorta	14	5	19
Hypoplastic left heart syndrome	3	6	9
Vascular rings	2	6	8
Transposition of great arteries	2	5	7
Pulmonary atresia	3	4	7
Cardiomyopathies	—	6	6
Pulmonary veins stenosis	—	5	5
Partial/ total anomalous pulmonary vein return	1	4	5
Congenital coronary arteries anomalies	1	3	4
Pulmonary stenosis	2	1	3
Double outlet right ventricle	1	2	3
Supravalvular aortic stenosis	—	2	2
Hypoplastic aortic arch	1	1	2
Interruption of aortic arch	2	—	2
Tricuspid atresia	—	2	2
Kawasaki disease	—	2	2
Double inlet right ventricle, VSD	—	1	1
Unroofed coronary sinus; VSD	—	1	1
Extrapulmonary sequestration	1	—	1

Abbreviations: CTA, computed tomography angiography; VSD, ventricular septal defect; n, number of computed tomography angiographies

Table 2. Patient demographics and cardiac computed tomography scan parameters

Patients' characteristics	
Age, months, median (IQR)	3.0 (0.5–5.0)
Body weight, kg, median (IQR)	5.0 (3.66–6.5)
Neonates, n (%)	34 (31)
Infants, n (%)	76 (69)
Sex (F/M), n (%)	37/73 (34/66)
Sedation, n (%)	Total 77 (70) Neonates 7 (20) Infants 70 (80)
HR, beats/min, months, median (IQR)	133 (92–150)
Contrast agent volume, ml, mean (SD)	8.5 (2.75)
CDTIvol, mGy, median (IQR)	1.9 (1–4.8)
DLP, mGy×cm, months, median (IQR)	16.95 (7.7–38.6)

Abbreviations: CTDIvol, volumetric computed tomography dose index; DLP, dose length product; HR, heart rate; n, number of computed tomography angiographies; SD, standard deviation

study group analyzed for age, body weight, and HR were 0.53 months, >4.85 kg, and ≤130/min — Table 4. Prominent conus branches, preventricular branch from right RCA, and anomalous origin and proximal course of LCA were the most frequent coronary artery pathologies diagnosed on CTA. Other pathologies included anomalous origin and course of main branches of coronary arteries, coronary artery high takeoff, coronary-pulmonary artery fistula and coronary-ventricular fistulae, duplication of the left anterior descending artery, the origin of the RCA from the pulmonary artery, postoperative stenosis of the left main coronary artery, and aneurysm of the RCA. Table 5 presents all coronary anomalies and variants diagnosed with CTA in the study group. Figure 2 presents an example of complex coronary pathology diagnosed with CTA.

Table 3. Comparison of computed tomography angiography with good quality of all coronary segments (Group = 3) and with non-diagnostic segments (Group <3)

Parameter	Group <3 (n = 60)	Group = 3 (n = 50)	*P*-value
	Median (IQR)	Median (IQR)	
Age, months	2.00 (0.21–5.00)	4.00 (2–6)	0.003
Body weight, kg	4.6 (3.45–6.07)	6.00 (4.2–7)	0.007
HR, beats/min	136.5 (120–150)	130 (110–150)	0.045
CTDIvol, mGy	1.9 (1.6–2.2)	1.9 (1.6–2.1)	0.52
DLP, mGy×cm	16.2 (14.3–23.4)	17.65 (13.6–21)	0.93

Abbreviations: see Table 1 and 2

Table 4. The optimal cut-off points for good quality image of all segments of coronary arteries in the analyzed group for age, body weight, heart rate and volumetric computed tomography dose index

Variable	AUC	Sensitivity	Specificity	Cutt off point	*P*-value
Age, months	0.66	88.09	38.33	>0.53	0.002
Body weight, kg	0.65	72.00	58.33	>4.85	0.005
HR, beats per minute	0.61	59.18	62.07	≤130.00	0.039
CTDI, mGy	0.54	90.00	20.00	≤2.40	0.520

Abbreviations: AUC, area under the curve; other — see Table 2

Table 5. Coronary anomalies and variants diagnosed with computed tomography angiography in the study group

Coronary anomalies and variants	Number	General diagnosis
Prominent conus branch from RCA	5	TOF
Perventricular branch from RCA	2	TOF
LCA from right sinus and prepulmonary course	1	TOF
Coronary fistula	1	TOF
LCA ectasia	1	TOF
RCA from pulmonary artery	1	HLHS
Separate orifices of LAD and LCX	2	HLHS
Persistent coronary sinusoids	5	PA; HLHS; cardiomyopathy
LAD duplication	1	PA
LCA high take off	1	PA
RCA from LCA, preaortic course	1	TGA
LMCA postoperative stenosis; conus branch from LCA	2	TGA
CX from RCA	2	TGA; coronary variant in pt with VSD
Atypical relations of proximal branches	1	TA
Single LCA	1	TAPVR
RCA from LCX	1	coronary variant in patients with VSD and ASD
RCA high take off	1	isolated coronary anomaly
LCA and RCA high takeoff	1	IAA
RCA aneurysm	1	Kawasaki disease
Total	31	

Abbreviations: RCA, right coronary artery; LCA, left coronary artery; LMCA, left main coronary artery; LCX, left circumflex; LAD, left anterior descending; CX, circumflex; TOF, tetralogy of Fallot; HLHS, hypoplastic left heart syndrome; PA, pulmonary atresia; TGA, transposition of great arteries; pt, patient; VSD, ventricular septum defect; TA, tricuspid atresia; TAPVR, total anomalous pulmonary venous return; ASD, atrial septal defect; IAA, interrupted aortic arch

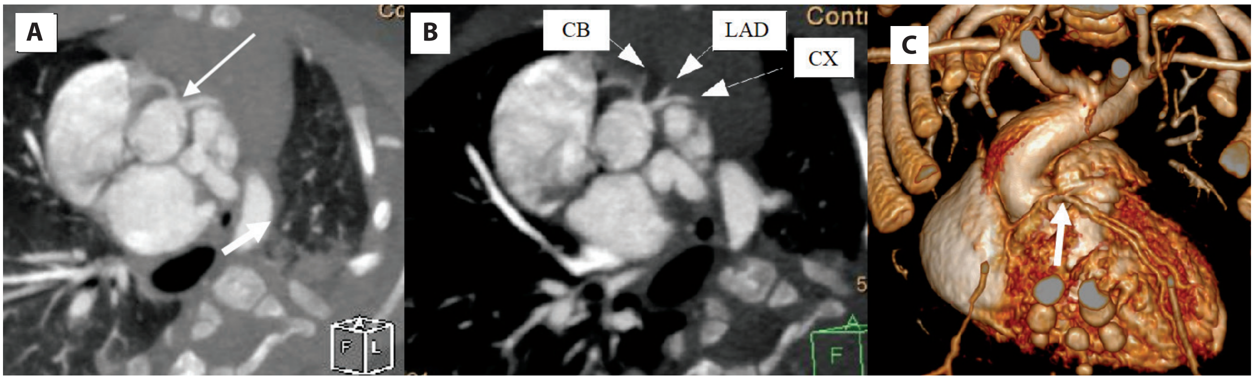

Figure 2. Computed tomography angiography in 2-month-old patient with tetralogy of Fallot and coronary anomaly. HR 109/min; CTDIvol 2.1mGy, DLP 17 mGy×cm. Image quality score 3. **A.** Right and left coronary arteries arise from the right sinus of Valsalva (arrow) **B.** The right coronary artery gives prominent conus branch (CB); the left coronary artery divides into the left anterior descending artery (LAD) and circumflex artery (CX). LAD duplicates and together with CX crosses the right ventricle outflow tract. **C.** Volumetric reconstruction; the thick arrow points at the CX and duplicated LAD crossing the right ventricle outflow tract

DISCUSSION

In the era of high-end CT scanners and their wider availability in clinical practice, CTA with prospective ECG-gating seems to be a perfect tool for diagnostic imaging of coronary arteries in patients in all age groups. Our study confirmed that CTA performed with 320-row ECG-triggered volume scanning allows for excellent visibility of proximal and middle segments of the coronary arteries in neonates and infants with a diagnosis of heart diseases. Since 2016 cardiac CTA in our center has been performed with prospective ECG-gating as data from the literature suggested its benefits in cardiovascular imaging in children, including acceptable radiation doses [9–10, 13]. The majority of recently published studies on coronary image quality and diagnostic accuracy with the novel CT technology and prospective ECG-gating in neonates and infants come from Asian countries. Most recent studies including a significant number of patients were published by Goo et al. [14] on 101 patients with median age of 4 days (range 0 days–10 months) and HR 120–160 beats/min and Gao et al. [15] on 102 infants of mean age of 2.9 months, mean body weight of 4.14 kg, and HR of 129 beats/min. Those studies were performed with the use of a dual-source CT scanner and a 64-slice CT scanner with prospective ECG-triggering mode, respectively. Although the use of a 320-row wide detector system for pediatric cardiac CT has been reported since 2010, selective assessment of coronary arteries with prospective ECG-gating was only performed by Tada et al. in 2016 and Yamasaki et al. in 2018 [9, 10, 13, 16, 17]. Tada et al. analyzed a group of 28 children with mean age of

16.8 months, mean body weight of 7 kg, and mean HR of 111 beats per minute, and Yamasaki et al. [16, 17] studied 60 CTA performed in patients with median age of 2 months (range 10 days–19 months), mean body weight of 4.8 kg, and mean HR of 129 beats/min. To our knowledge, this is the first European analysis of coronary arteries image quality in the youngest patients with prospective ECG-gated 320-row CT. We included a total number of 110 CTA, 30% of them were performed in neonates, including premature ones. The HR of our patients was high, mean 134 beats/min (range 92–170 beats/min). All patients were free-breathing; in the neonatal group, 80% of patients were examined without sedation. Although neonates seem to be the target group for decreasing or eliminating sedation due to their inherent long periods of rest after feeding, it appears possible to perform volumetric one-lamp rotation scanning without sedation in younger infants too. In our group, the oldest child examined without sedation was 4 months old with body weight of 8.5 kg**.**

We assessed coronary artery image quality with a simple scale based on coronary segmental anatomy as in pediatric patients most relevant pathologies are of coronary origin, the course of proximal and middle segments, and its relation to great arteries. The precise assessment of artery lumen in pediatric patients is not of concern in most cases, unless in Kawasaki disease [18–20].

Our data confirm the possibility of excellent visualization of proximal (100% for LCA, 96% for RCA) and middle segments (82.7%) of coronary arteries with 320-row prospective ECG-gated CTA. Assessment of RCA is usually more demanding due to its natural course over the free wall of the right ventricle and greater mobility (20). Using 320-row CT systems, Tada et al. [16] reported diagnostic rates of 93% and 83% for proximal and middle segments of LCA and RCA, respectively. Yamasaki et al. [17] assessed the proximal and middle segment of coronary arteries with a 4-point scale (scale range 0–4 points) and reported a mean coronary score of 2.6 for all examinations. In our group, it was possible to assess also distal segments of coronary arteries in 45% of patients. One of the previous studies with a 64-row scanner and retrospective ECG-gating reported an overall detection ability rate of 100% for proximal and 73% for distal segments of coronary arteries for 12 neonates with HR <140 beats/min [21]. The use of a dual-source scanner with retrospective ECG-gating provided satisfactory delineation in 91% of LCA and 84% of RCA in 32 infants [19]. Prospective ECG-gating along with an increased number of rows allowed for an increase in the detection rate of proximal segments of coronary arteries from 90% to 99% for proximal RCA; for distal segments detection rates reached from 51 to even 81% [11, 15, 22].

Important factors that affect the coronary image quality on CTA in neonates and infants investigated in previous studies can be divided into patient related and procedure related. Those attributed to the patients were age, body weight, HR, and HR variability, whereas those related to the procedure were the mode of ECG-gating (retrospective vs. prospective; sequential vs. high pitch spiral), the mode of iterative reconstructions (hybrid or full iterative), and also aorta attenuation, average image contrast, image noise, signal-to-noise and contrast-to-noise ratios [11, 15–17, 19, 23–25]. Coronary image quality was considered to be adversely related to younger age, lower body weight, and faster HR [16–17, 21, 24]. Yamasaki et al. [17] confirmed previous reports in adults demonstrating a significant correlation between the coronary score and coronary attenuation. It seems obvious that vessel assessment on CTA is possible only with its optimal opacification. In our study, we focused on patient related factors, and we found that the strongest predictor of excellent coronary image quality in our group was body weight (OR, 1.18; 95% CI, 1.01–1.39; p = 0.017). It is consistent with findings from studies on 320-row scanners by Tada et al. and Yamasaki et al. [16, 17]. In our study, the cut-off point for body weight of patients with good image quality for all segments of the coronary artery was 4.85 kilograms (AUC, 0.65), like those reported by Yamasaki et al. and lower than published by Tada et al. [16, 17]. Both authors reported that HR showed no statistical significance between diagnostic and non-diagnostic groups, which mirrors our experience. Moreover, Tada et al. [16] showed that also HR variability was not significantly related to a decline in image quality. The authors explained it with the possibility of 320-row CT to obtain image data without table movement and no difference in R-R intervals along the z-axis. Kanie et al. [24] suggested that in children younger than 6 years, as opposed to adults, spatial resolution may influence the quality of a coronary image to a greater degree than temporal resolution. It allows us to believe that high HR and even HR variability should not limit the use of high-end scanners in imaging coronary arteries in very young patients with very high and variable HR. Very interesting are the findings from the latest publications on the possibility of synthetic ECG-gating in patients younger than 3 years, in whom image quality of main coronary trunks was not inferior to those acquired with patients' ECG [26]. Authors emphasized that synthetic ECG-gating allows radiologists to omit inconveniences connected with electrode placement (such as waking-up of sedated patients) and the need for prolonged sedation or even the need to postpone studies. Even more important seems to be the possibility of performing easy, repeatable examination in patients with HR variability. In our center we place ECG- electrodes in advance of sedation, to avoid waking up. Moreover, in neonates and infants, we use MRI-safe, carbon-fiber ECG-electrodes to avoid image quality degradation from metallic element artifacts.

With the use of prospective ECG-gating mode, not only superior visibility of cardiac structures, including coronary artery, was reported but also a reduction in the radiation dose [9, 11, 13]. Radiation dose indexes were significantly lower for prospective gating vs. retrospective gating. Mean CTDIvol and effective dose reported decreased from

5.6 mGy to 1.88 mGy and from 4.06 mSv to 1.36 mSv, respectively [11]. To compare radiation doses for different types of scanners, it is advised to use dose indexes CTDIvol and DLP. An effective dose is calculated by multiplying dose index DLP by a specific coefficient and is useful for comparison between different methods based on ionized radiation [27, 28]. The effective dose reported with the use of prospective ECG-gated CTA in neonates and infants is low, even at the submilisivert level [10, 13, 15–17]. With advanced forward projected, model-based iterative reconstruction solutions, it is possible to achieve CTA dose levels close to those of diagnostic levels of pediatric chest radiographs [25]. In our study, mean values for dose indexes CTDIvol and DLP reported based on the 32-cm phantom were 2.0 mGy and 18.30 mGy×cm, respectively and when adjusted to the 16-cm phantom, they were similar to those reported by other users of 320-row scanners [16, 17]. Mean values of dose indexes from our analysis do not exceed the values of the European Diagnostic Reference Levels for thoracic CT in children with body weight <10 kg published in 2018 by the European Commission on Radiation Protection [29].

Our study had several limitations. First, it was a single-center study of retrospective nature. Second, our study was mainly based on a subjective scoring system for image quality, and evaluation was made by one unblinded, experienced radiologist. Third, the diagnostic accuracy was not fully validated with conventional angiography or during open-heart surgery. In our center, conventional angiography is performed if hemodynamic data are required or when morphological data from CTA are inconclusive. CTA findings were confirmed in 14 from 16 patients in whom data on coronary arteries from conventional angiography or surgical findings were available.

In conclusion, CTA performed with volumetric 320-row prospective ECG-gating allows for good visibility of the coronary arteries in neonates and infants with acquired and congenital heart diseases with an acceptable radiation dose. Body weight is the strongest factor that influences coronary artery image quality in this age group. Children aged >15 days, with body weight >5 kg and HR <130/min are good candidates for excellent quality non-invasive CTA of all segments of coronary arteries.

Article information

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