Original paper

Multidetector computed tomographic angiography in evaluation of neonates with suspected extracardiac congenital heart disease: experience in Vilnius University Hospital Santariškių Klinikos

Mindaugas Matačiūnas a,b,*, Ingrida Zelekiene a,b, Lina Gumbiene c,d, Virgilijus Tarutis c,d, Algirdas Tamošiūnas a,b, Aleksandras Laucevičius c,d

a Department of Radiology, Nuclear Medicine and Medical Physics, Faculty of Medicine, Vilnius University, Vilnius, Lithuania
b Centre of Radiology and Nuclear Medicine, Vilnius University Hospital Santariškių Klinikos, Vilnius, Lithuania
c Clinic of Cardiac and Vascular Diseases, Faculty of Medicine, Vilnius University, Vilnius, Lithuania
d Centre of Cardiology and Angiology, Vilnius University Hospital Santariškių Klinikos, Vilnius, Lithuania

* Corresponding address: Mindaugas Matačiūnas, Department of Radiology, Nuclear Medicine and Medical Physics, Faculty of Medicine, Vilnius University, M.K. Čiurlionio 21, Vilnius 03101, Lithuania.
E-mail: mindaugas.matacianas@santa.lt (M. Matačiūnas).

Summary

The aim of this study was to determine the frequency of extracardiac pathology in neonatal patients with suspected congenital heart disease referred to undergo multidetector computed tomography (MDCT) angiography in Vilnius University Hospital Santariskiu Klinikos. The safety of MDCT angiography (intravenous contrast media volume injected, scanning time and exposure to ionising radiation) was also evaluated.

Patients and Methods: During the period of 2006–2012, in Vilnius University Hospital Santariskiu Klinikos 186 pediatric patients were referred to undergo MDCT angiography of whom 71 were neonates with suspected complex congenital heart disease (CHD) and extracardiac pathology.

Results: Sixty nine (97.2%) of referred neonates were found to have extracardiac pathology (36 had extracardiac vascular pathology only, 4 – extracardiac non-vascular pathology only and 29 – both extracardiac vascular and non-vascular pathology). In 47 patients diagnosis of extracardiac pathology was verified intraoperatively. Remainder (n = 24) of the group were not operated (12 patients died because of hemodynamic instability and inoperable complex CHD, 9 patients were scheduled for later surgery, in 3 patients surgery was not indicated). Mean contrast media volume used was 4.18 ± 1.03 ml, mean scanning time was 1.07 ± 0.77 s and mean effective radiation dose was 2.8 ± 0.69 mSv. No adverse reactions or complications were observed.

Conclusions: MDCT angiography is accurate and safe method in diagnosis of complex congenital heart disease with extracardiac pathology.

Keywords: neonate, complex congenital heart disease, multidetector computed tomographic angiography

Introduction

Precise evaluation of intracardiac and extracardiac vascular anatomy in suspected neonatal congenital heart disease (CHD) is important for effective management strategies. Bedside neonatal echocardiography allows comprehensive evaluation of intracardiac defects. Limitations of echocardiography are well known: dependence on operator experience, poor imaging window due to lung, rib cage interference, and poor visualisation of extracardiac structures [1]. Thus, cardiac catheterization often remains the gold standard for the complete diagnosis of CHD. However, longer procedure time, difficult vascular access and complications related to cardiac catheterization (including arrhythmia, bleeding, heart perforation, cardiac tamponade, thromboembolism, shock, hypoxemia and vessel occlusion) remain a major concern for performing the procedure [2]. Multidetector computed tomographic (MDCT) angiography could provide comprehensive non-invasive information on intracar-
diac and extracardiac vascular and non-vascular anatomy in one imaging session.

**Patients and methods**

During the period of 2006–2012, in our institution MDCT angiography was performed in 186 pediatric patients of whom 71 were neonates (thereafter “patients”) with suspected complex CHD and extracardiac pathology. Prior to the scan, possible adverse effects of contrast medium injection and radiation exposure were thoroughly explained to the patients’ parents, who gave informed signed consent. Intravenous sedation was used and during the scan all patients were free-breathing. MDCT scanner General Electric LightSpeed VCT XT (GE Healthcare, Milwaukee, Wisconsin, USA) was used with the following scanning parameters: collimation 64 × 0.625 mm, pitch 1.375, tube voltage 80 kV, tube current up to 375 mAs. Non-ionic iodinated contrast medium (1 ml per 1 kg of body weight) was injected via peripheral vein with a rate of 1 ml per second. We used one scanning phase with optimal enhancement of the heart chambers and major thoracic vessels. Bolus tracking technique was used for the initiation of the scan. Statistical analysis was done using SPSS version 16 for Windows (SPSS, Inc.) Descriptive statistics was used; continuous variables were expressed as mean and standard deviation (SD), and categorical variables were expressed as percentages.

**Results**

MDCT angiographic images were of adequate quality in all 71 patients. Fifty one (71.8%) patients were first week neonates, 20 (28.2%) were 8 or more days old. Weight of study participants ranged from 2.6 kg to 6.7 kg and mean weight (±SD) was 3.9 kg (±0.61). Images of 69 (97.2%) patients revealed 137 extracardiac pathologic findings. Spectrum of extracardiac pathology is presented in Table 1.

<table>
<thead>
<tr>
<th>Extracardiac pathology</th>
<th>Number of patients, n</th>
<th>Percentage of patients, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patent arterial duct</td>
<td>50</td>
<td>70.4</td>
</tr>
<tr>
<td>Coarctation of aorta/arch</td>
<td>20</td>
<td>28.2</td>
</tr>
<tr>
<td>Hypoplasia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulmonary pathology</td>
<td>14</td>
<td>19.7</td>
</tr>
<tr>
<td>Bronchial pathology</td>
<td>13</td>
<td>18.3</td>
</tr>
<tr>
<td>Anomalous drainage of pulmonary veins</td>
<td>8</td>
<td>11.3</td>
</tr>
<tr>
<td>Anomalies of systemic veins</td>
<td>8</td>
<td>11.3</td>
</tr>
<tr>
<td>Tracheal compression</td>
<td>6</td>
<td>8.5</td>
</tr>
<tr>
<td>Pleural pathology</td>
<td>6</td>
<td>8.5</td>
</tr>
<tr>
<td>Major aortopulmonary collaterals</td>
<td>5</td>
<td>7.0</td>
</tr>
<tr>
<td>Interrupted aortic arch</td>
<td>4</td>
<td>5.6</td>
</tr>
<tr>
<td>Other tracheal pathology</td>
<td>2</td>
<td>2.8</td>
</tr>
<tr>
<td>Aortopulmonary window</td>
<td>1</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Four patients had 4 extracardiac pathologies, 16 patients – 3 extracardiac pathologies, 24 patients – 2 extracardiac pathologies, 25 patients – 1 extracardiac pathology. In 2 patients MDCT angiography showed no extracardiac pathology.

In 47 patients diagnosis of extracardiac pathology was confirmed intraoperatively. Remainder (n = 24) of the group were not treated surgically (12 patients died because of hemodynamic instability and inoperable complex CHD, 9 patients were scheduled for later surgery, in 3 patients surgery was not indicated).

Mean contrast media volume used was 4.18 ± 1.03 ml. Mean scanning time was 1.07 ± 0.77 seconds. Exposure to ionising radiation was evaluated using conversion coefficient of 0.039 [3,4] and mean effective dose was 2.8 ± 0.69 mSv.

**Discussion**

Primary evaluation of congenital cardiac abnormalities traditionally relies on echocardiography and conventional angiography, both of them having potential limitations. Echocardiography is an operator-dependent study, limited by a small acoustic window and patient movement. Conventional angiography is an invasive procedure with an inherent risk of catheter complication such as vessel damage, bleeding, stroke, and infection. During angiography, overlapping of the pulmonary and systemic circulation often provides a confusing picture given complex anatomy. Another limiting factor of particular significance in young children is radiation dose and contrast administration during catheterization procedures [5]. MDCT angiography allows rapid evaluation of the heart as well as the lungs, great vessels, and airways. Coupled with high spatial resolu-
Figure 1. Distribution of extracardiac vascular and non-vascular pathology (left vertical light blue axis and colorful columns correspond percentage of particular congenital cardiac defect in three patient groups: first – with only extracardiac vascular pathology, second – with only extracardiac non-vascular pathology, third – with both extracardiac vascular and non-vascular pathology; right vertical black axis and black columns correspond number of patients in each patient group; AA – aortic arch, ACO – aortic coarctation, Ao-PA – aortopulmonary, APVD – anomalous pulmonary venous drainage, ASV – anomalies of systemic veins, PDA – patent ductus arteriosus.

Magnetic resonance imaging (MRI) has been an alternative imaging method to cardiac catheterization and echocardiography for patients who need evaluation of cardiac disease [5]. However, MRI requires long scan time and effective sedation during noisy scanning. Mechanical ventilation, electrocardiographic monitoring equipment, or infusion pumps are often incompatible with the strong magnetic field. The application of MRI to the critically ill patient is therefore impractical. MDCT, on the other hand, is fast and efficient, with very short scan times, and is not associated with the presence of strong magnetic fields [8]. Mean scan time (±SD) in our study was 1.07 ± 0.77 seconds and this is comparable to results of other studies [10].

In infants and neonates, contrast volume is an important consideration because of the low blood volume of the patient and the hypertonicity (and potentially detrimental cardiac effects) of even nonionic monomeric contrast media [11]. Mean weight of our study population was 3.9 kg and mean contrast media volume was 4.18 ml resulting in a mean contrast volume of 1.07 ml per kg of body weight. Authors report 2–4 times higher volumes (2–3 ml/kg up to 4 ml/kg) of contrast media used during cardiac catheterisation [2,11].
For diagnostic cardiac catheterizations, a median effective dose of 4.6 mSv was found. Therapeutic procedures resulted in a higher median effective dose of 6.0 mSv because of the prolonged use of fluoroscopy [12]. Radiation burden using MDCT ECG-gated cardiac imaging ranges from 2.17 to 3.41 mSv, limiting its use to complex CHD and as a problem solving technique [13]. Our average effective dose was in this range (2.8 ± 0.69 mSv). However, using newer techniques and applying prospective gating on a second generation DSCT it is possible to achieve marked dose reduction with an effective dose of only 0.26 ± 0.6 mSv (i.e. equivalent annual background dose) [14].

**Limitations**

We acknowledge the following limitations of the study. Despite high accuracy of MDCT angiography in operated patients, the findings were not compared to golden standard – cardiac catheterisation. However, recent reports indicate the potential of MDCT angiography to provide robust alternative to invasive cardiac catheterisation [8]. Autopsy for patients with lethal outcome was not performed.

In conclusion, MDCT angiography is an accurate, safe and fast method in diagnosis of complex congenital heart defects with extracardiac pathology in neonates.

**References**


