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CLINICAL STUDY

The first experience with the high-resolution multi-slice CT-angiography in pediatric cardiology in Slovakia

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Abstract: *Objectives:* The high-resolution multi-slice computed tomography angiography (HRMS-CTA) is a new imaging method characterized by a precise isotropic imaging of any cardiovascular system structure. The purpose of this study was to review the first experience with the high-resolution multi-slice HRMS-CTA in pediatric patients with congenital heart defects as well as with acquired cardiac diseases in the Slovak Republic.
Methods: We retrospectively reviewed benefits of HRMS-CTA and its influence on the subsequent choice of the most appropriate management in 20 patients with pulmonary atresia with ventricular septal defect and multiple aortopulmonary collaterals (PA, VSD, MAPCAs) and in 15 patients with different diagnoses with expected benefit from HRMS-CTA in terms of an exact delineation of extra-cardiac vascular structures.
Results: The delineation of the examined extra-cardiac structures was very detailed and clear in all 35 patients. All findings definitely contributed to the choice of the most appropriate management not only in PA, VSD, MAPCAs patients (20), but also in 15 patients with different diagnoses.
Conclusions: HRMS-CTA is a new complementary imaging method with the potential to replace invasive catheterization procedures in large number of patients who need extra-cardiac vascular structure imaging *(Fig. 1, Ref. 18).* Full Text (Free, PDF) *www.bmj.sk.*
Key words: HRMS-CTA imaging, extra-cardiac vascular structures, pulmonary atresia with ventricular septal defect and multiple aortopulmonary collaterals.

The HRMS 64-row detector CTA is one of the most advanced CT technologies available at present. The unique detector enables the CT-scanner to acquire 64 simultaneous slices of 0,4mm width with each 330 milisecond gantry revolution, resulting in a precise isotropic imaging of any region of the body in 5 to 10 seconds (Nikolaou, 2006). This advanced software enables visualization of examined objects in any 2D planes and as well as in 3D layout with the possibility of any sight on the examined object.

Besides the phenomenon of a detailed visualization ability, the additional advantage of HRMS-CTA is its minimal invasiveness (Schönenberger, 2007, Ou, 2007). Efficient HRMS-CTA detector yields an excellent image quality with contrast material dose reduction up to 40 % compared to competitive systems. There is no need for central vein cannulation; the contrast fluid is applied only into the peripheral vein. The majority of pediatric patients do not need anesthesia either. Sedation is needed only when patients are not cooperative, usually younger than 4 years.

All of the above mentioned characteristics prove that HRMS-CTA can be used effectively for imaging of cardiovascular system structures in pediatric patients with congenital heart defects or acquired cardiac diseases (Poon, 2006, Ou, 2007).

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Methods

We decided to try the effectiveness of HRMS-CTA on a group of patients with pulmonary atresia, ventricular septal defect and multiple aorto-pulmonary collaterals (PA, VSD, MAPCAs). PA, VSD, MAPCAs are complex cyanotic congenital heart defects with severe prognosis. An exact delineation of origins, courses and communications of collaterals, delineation of main pulmonary artery and its branches, declaration to pulmonary artery confluence, the McGoon index setting and imaging of right ventricle – to pulmonary artery (RV-AP) conduits is the main key for the appropriate pre-operative and post-operative management of patients with PA, VSD, MAPCAs. Delineation of these anatomic structures echocardiographically yields a low sensitivity and angiocardiography (ACG) often does not bring an exact and clear imaging of the examined structures. These facts authorize the indication of HRMS-CTA in patients with PA, VSD, MAPCAs. A minimal invasiveness of HRMS-CTA in patients with PA, VSD, MAPCAs is accentuated by avoiding multiple selective injection of contrast fluid into each collateral during standard ACG.

With regard to our encouraging results of the HRMS-CTA imaging effectiveness in the group of patients with PA, VSD,

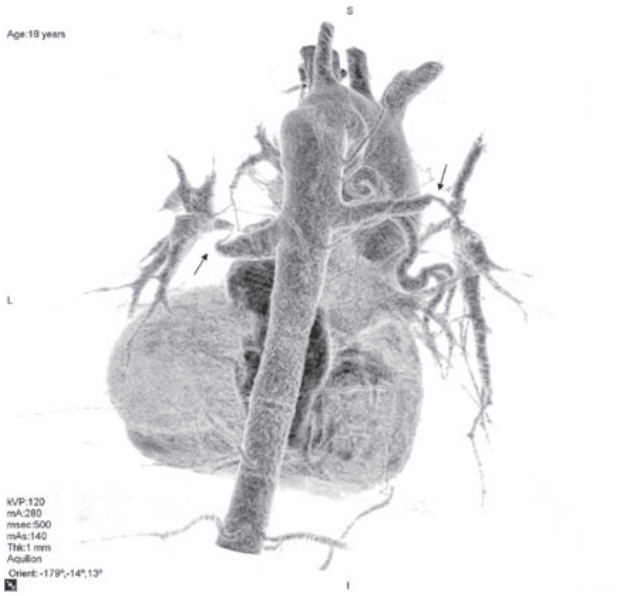

Fig. 1. 3D-HRMS-CTA. Postero-anterior projection in a 18-years old male patient with non-operated PA, VSD, MAPCAs. The arrows point a hemodynamically significant segmental stenosis of two MAPCAs. (segmental stenosis of third MAPCA is impossible to see from this projection) (Original picture was inverted and decolorized for black-and-white printing).

MAPCAs, HRMS-CTA was indicated for delineation of extracardiac vascular structures also in patients with different diagnoses with the assumed benefit of HRMS-CTA in the diagnostic process.

Results

From January to August 2007, 20 patients with PA, VSD, MAPCAs underwent HRMS-CTA, out of which 10 patients had not been surgically treated and 10 patients had had surgery before consisting of forming a continuity between RV and AP, VSD closure and unifocalizations and/or ligation of MAPCAs. In the group of non-surgically-treated patients, HRMS-CTA contributed to detection of localized stenosis of MAPCAs in 4 patients. With regard to HRMS-CTA findings, a complete correction was contraindicated with the possibility of later catheterization intervention in 5 patients. Based on HRMS-CTA finding, 1 patient is considered for a complete correction.

A short clinical case of a 18-year-old male patient with PA, VSD, MAPCAs with no native pulmonary arteries is an example of the effective use of HRMS-CTA in the group of non-surgically-treated patients with PA, VSD, MAPCAs.

The patient's pulmonary blood flow was preserved by 3 MAPCAs arising from descendent aorta exclusively. This finding was revealed by ACG at the newborn age. Central cyanosis progressed, the level of NYHA increased from NYHA II to NYHA III and the patient experienced series of syncopes during previous months due to increased blood viscosity. The assummed pathophysiological cause of clinical worsening was the progression of MAPCAs stenosis. Subsequently the HRMS-CTA was indicated to prove the hypothesis. The HRMS-CTA finding confirmed our assumption. The 3 MAPCAs arising from descendent aorta with segmental stenosis in their course were delineated (Fig. 1). Based on this finding, a stent was implanted into the segmental narrowing of the aortopulmonary collateral (APCA) with limitated perfusion. The reason of the limited perfusion was prevention of pulmonary hypertension in lung segments supplied through this collateral. In the 3-month interventional follow-up, a reduction of central cyanosis, increase of capillary oxygen saturation from 72 to 83 %, NYHA improvement from NYHA III to NYHA II and no syncopes were present. The patient is currently on the "waiting list" for a stent implantation into the stenotic segment of another APCA. Further improvement in oxygenation and NYHA classification is expected after the planned intervention.

In the group of 10 surgically treated patients, HRMS-CTA contributed to the delineation of stenosed pulmonary artery branches with possible dilatation of these stenotic segments either by an invasive balloon angioplasty or by implantation of an appropriate stent in 4 patients. Residual hemodynamically significant collaterals, possible to close by coils, were delineated in 2 patients. Thrombosed collaterals were visualized in 2 patients and appropriate post-operative findings with temporarily no need of intervention were found in 4 operated patients with PA, VSD, MAPCAs.

A short clinical case of a surgically treated male patient with PA, VSD, MAPCAs is presented as an example of the effective use of HRMS-CTA in the group of surgically treated patients with PA, VSD, MAPCAs.

So far, a 10-year-old patient has undergone two surgical repairs. The first one consisted of construction of RV–AP conduit, VSD closure and unifocalization of MAPCAs at the age of 10 months. The second one included exchange of an old calcified, stenosed RV–AP conduit for a new one. He did not thrive enough and the oxygen saturation slowly decreased from 97 % to 92 % in the course of previous 6 months. There were no changes in NYHA I and no central cyanosis during physical effort present. Echocardiography detected 10–25 torr gradient in the proximal part of the right pulmonary branch (RPA), no gradient in RV–AP conduit and no tricuspidal regurgitation (TI). Subsequently, HRMS-CTA was indicated and focused on hemodynamic significance of RPA stenosis. The HRMS-CTA revealed hemodynamically borderline 45–50 % stenosis of proximal part of RPA. No invasive treatment was indicated for the time being. The patient will be regularly examined by a children cardiologist with the focus on the following: 1) a potential worsening in clinical manifestation, 2) changes in oxygenation parameters and 3) a potential worsening of echocardiographic parameters; progression of TI and predominantly the increase of RPA gradient. The next HRMS-CTA is indicated in one year. If the progression of RPA stenosis is present, a balloon dilatation or stent implantation will be indicated.

HRMS-CTA was also used in 15 patients with different diagnoses designed for imaging of extra-cardiac vessel structures.

Two patients with a functional single-ventricle circulation underwent HRMS-CTA. The first one was a 5-year-old patient with hypoplastic left heart syndrome as well as interruption of vena cava inferior (IVC). He underwent the third stage of reconstruction including forming of an incomplete Fontan circulation (Kawashima operation – anastomosis of IVC extension via vena azygos to RPA). The patient suffered from a prolonged oxygen desaturation to 80 % and NYHA II.

The assumed cause of oxygen desaturation was the presence of pulmonary arteriovenous malformations formed as a consequence of lower hepatic factor inflow to pulmonary vascular system due to an anomalous junction of hepatic veins with the right atrium. HRMS-CTA delineated this anomalous hepatic vein drainage, the distance between supraphrenic part of hepatic vein confluence and pulmonary artery branch; it also delineated multiple pulmonary arteriovenous malformations. The conduit was implanted between hepatic vein confluence and right pulmonary branch following this HRMS-CTA finding, which could lead to the restriction of pulmonary arteriovenous malformation and decline in oxygen desaturation.

Pulmonary arteriovenous malformations were also diagnosed in detail by HRMS-CTA in the second patient with a functional single-ventricle circulation.

HRMS-CTA verified the suspicion of "subclavian steal syndrome" in 1 patient and excluded a hemodynamically significant coarctation of aorta in another patient. HRMS-CTA confirmed the assumption of a hemodynamically significant stenosis of pulmonary artery branches in all 5 patients with Tetralogy of Fallot after the complete correction. The effect of HRMS-CTA was acknowledged within the process of differential diagnosis of arterial hypertesion in 6 infants. The vascular cause of arterial hypertesion was excluded and hemodynamically significant stenoses of renal and splanchnic arteries were delineated in 2 and 4 patients, respectively.

Discussion

Our intention to use HRMS-CTA in patients with PA, VSD, MAPCAs is supported by positive results of clinical studies focused on comparison of effectiveness of HRMS-CTA to ACG within the pre-operative and post-operative management of patients with PA, VSD, MAPCAs. HRMS-CTA delineated pulmonary artery branches, RV-AP conduits, origins, courses, and communications of collaterals in 8 patients with PA, VSD, MAPCAs with 100 % sensitivity, in comparison to standard ACG (Greil, 2006). An excellent HRMS-CTA imaging quality within the pre- and post-operative management of patients with PA, VSD, MAPCAs was demonstrated on the following three examples: firstly, comparable findings of AP sizes imaged by HRMS-CTA and AP sizes measured during the surgery; secondly, an exact visualization of MAPCAs and their space relation to close anatomic structures pre-operatively, and finally, a detailed delineation of unifocalized MAPCAs post-operatively (Paul, 2002).

Our intention to use HRMS-CTA in patients with Fontan circulation for hepatal veins and pulmonary arteriovenous malformations delineation is supported by an effective HRMS-CTA imaging of these structures in several studies (Zwicker, 1990, Almeida, 2004, Kojima, 1998). A precise HRMS-CTA delineation of coronary anomalies and pulmonary artery stenosis contributes valuably for planning the operative procedure on the patients with Tetralogy of Fallot (Wang, 2007). More studies showed an excellent HRMS-CTA imaging quality of aorta and its branches, which authorized our indication for HRMS-CTA in patients with suspected malformations of these structures (Smith, 2006, Castorina, 2007, Haidary, 2007, Ferrari, 2007).

We also expect a priceless benefit of HRMS-CTA in our institution in the field of coronary anomalies imaging (abnormal origins and courses of coronary arteries, or left coronary to right ventricle fistula), due to the phenomenal HRMS-CTA results in coronary arteries abnormalities delineation in number of studies (Ou, 2007, Ou, 2006, Singh Nijjar, 2007, Marini, 2007).

Conclusions

HRMS-CTA is a new imaging method fully utilizable in pediatric cardiac patients in a large spectrum of diagnoses requiring a precise isotropic imaging of extra-cardiac vascular structures predominantly. In these cases, HRMS-CTA complements echocardiography and ACG and eventually replaces ACG in a large number of patients. The additional advantage of HRMS-CTA compared to ACG is its minimal invasiveness. On the other hand, the drawback of HRMS-CTA is its inability to set hemodynamic parameters. The first patients submitting to HRMS-CTA in our institution were the ones with PA, VSD, MAPCAs. HRMS-CTA imaged extra-cardiac vascular structures in detail in all 20 patients, both non-operated as well as operated. The results of HRMS-CTA substantially contributed to choice of the most appropriate management in all 20 patients. With regard to the excellent HRMS-CTA imaging abilities in patients with PA, VSD, MAPCAs, HRMS-CTA was used with encouraging results of imaging resolution in patients with different diagnoses where the extra-cardiac vascular structure delineation was required. Based on the above mentioned results, we intend to use HRMS-CTA as a standard delineating method indicated for a precise imaging resolution of extra-cardiac vascular structures.

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