CT and MRI in Congenital Thoracic Vascular Abnormalities

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Abstract—Echocardiography is often insufficient to evaluate congenital thoracic vascular abnormalities. CT and MRI are excellent imaging modalities for assessment of congenital thoracic vascular anomalies. The main advantages of MRI are absence of radiation exposure and possibility of concomitant flow quantification. The advantages of CT are short examination time, high spatial resolution, possibility of simultaneous evaluation of airways and lung parenchyma. Learning objectives of the lecture: to discuss MRI and CT scanning protocols for evaluation of congenital thoracic vascular abnormalities; to demonstrate imaging findings in patients with congenital thoracic vascular anomalies; to highlight advantages and disadvantages of MRI and CT in evaluation of congenital thoracic vascular abnormalities; to describe current advances in pediatric cardiovascular CT and MRI.

I. INTRODUCTION

Over the last years CT and MRI have become an integral part of the evaluation of congenital thoracic vascular abnormalities since echocardiography alone often cannot resolve the diagnostic problem.

II. MRI AND CT SCANNING PROTOCOLS FOR EVALUATION OF CONGENITAL THORACIC VASCULAR ABNORMALITIES

Generally, non-ECG-gated multidetector computed tomography (MDCT) is sufficient for the assessment of congenital thoracic vascular abnormalities. ECG-gated CT may be necessary when there is a clinical question regarding intracardiac anatomy. Protocols vary from 4-slice CT to dual-source CT. The key points are: using of the strategies for CT dose reduction, reasonable choice of the scan parameters, correct timing of imaging.

Non-contrast MRI often provides essential information about vascular anatomy of the chest. However, gadolinium-enhanced magnetic resonance angiography (MRA) is required in many cases. Phase-contrast MRI is excellent application for flow quantification in patients with coarctation of the aorta, pulmonary branch stenosis, patent arterial duct, partial anomalous pulmonary venous connection. The key points are: reasonable choice of MRI pulse sequences, correct timing of imaging during gadolinium-enhanced MRA.

III. COMMON CONGENITAL THORACIC VASCULAR ANOMALIES

Coarctation of the aorta (Fig. 1)

Coarctation of the aorta is a narrowing of the aortic arch or descending aorta, usually located in the region of the insertion of the arterial duct. CT and MRI allow excellent visualization of the thoracic aorta both in pediatric and adult patients; furthermore, it is possible to quantify gradient across coarctation and collateral blood flow with phase-contrast MRI.

Interrupted aortic arch (Fig. 2)

Interrupted aortic arch is a complete absence of one of the segments of the aortic arch, in most cases associated with ventricular septal defect. Abnormalities of the subclavian and common carotid arteries are frequent. Thymic hypoplasia consistent with the DiGeorge syndrome is common in patients with interruption of the aortic arch between the left common carotid artery and the left subclavian artery.
Interrupted aortic arch. a Volume-rendered image from MRI demonstrates interruption of the aortic arch between the left common carotid artery and the left subclavian artery. b Volume-rendered image from MDCT shows interruption of the aortic arch distal to the left subclavian artery (BT brachiocephalic trunk, LSA left subclavian artery, LCCA left common carotid artery, AA ascending aorta, DA descending aorta, PAD patent arterial duct, RPA right pulmonary artery, LPA left pulmonary artery)

**Left aortic arch with aberrant right subclavian artery (Fig. 3)**

In patients with left aortic arch and aberrant right subclavian artery, the order of branching of the vessels from the aortic arch is right common carotid artery, left common carotid artery, left subclavian artery, right subclavian artery; the right subclavian artery crosses the mediastinum behind the esophagus. Left aortic arch with aberrant (retroesophageal) right subclavian artery rarely causes tracheal compression, but may produce significant dysphagia. Rarely, in cases of right descending aorta and right-sided arterial duct to right pulmonary artery the true vascular ring exists. Vertebral and carotid artery anomalies are common in this category of patients [1].

Common arterial trunk (Fig. 4)

Common arterial trunk (truncus arteriosus) is characterized by the presence of a single great artery providing both pulmonary and systemic circulation; ventricular septal defect is almost always present. Sometimes, it can be impossible to distinguish between common arterial trunk and pulmonary atresia with ventricular septal defect by cross-sectional echocardiography.

**Major aortopulmonary collateral arteries (Fig. 5)**

Major aortopulmonary collateral arteries (MAPCAs) are the vessels supplied blood to the lungs in some of the patients with pulmonary atresia. In contrast to pulmonary atresia with ventricular septal defect, MAPCAs rarely occur in pulmonary atresia with intact ventricular septum [2].

Anomalous pulmonary venous connections (Fig. 6)

In total anomalous pulmonary venous connection, all the pulmonary veins drain into the right atrium or to one or more of its venous tributaries. Partial anomalous pulmonary venous connection is the anomaly in which one or more, but not all the pulmonary veins drain into the right atrium or to one or more of its venous tributaries. Partial anomalous pulmonary venous...
drainage is often associated with the sinus venosus interatrial communication.

**Fig. 6. Anomalous pulmonary venous connections.** a Axial CT image reveals anomalous drainage of the right upper pulmonary vein into the superior caval vein in patient with partial anomalous pulmonary venous connection. b Total anomalous pulmonary venous connection (volume-rendered 3D reconstruction from MDCT). All veins drain anomalously into portal vein system through so-called vertical vein (AA ascending aorta, DA descending aorta, SCV superior caval vein, RPA right pulmonary artery, RUPV right upper pulmonary vein, LUPV left upper pulmonary vein, RLPV right lower pulmonary vein, LLPV left lower pulmonary vein, VV vertical vein, PV portal vein)

IV. ADVANTAGES AND DISADVANTAGES OF MRI AND CT IN EVALUATION OF CONGENITAL THORACIC VASCULAR ABNORMALITIES

The main advantage of MRI is absence of radiation exposure. MDCT is better than MRI for assessment of the airways and lung parenchyma. Other advantages of CT are high spatial resolution and short examination time. In our experience, MDCT is preferred over MRI for evaluation of MAPCAs and anomalous pulmonary venous connections. Inability to assess flow is relative weakness of CT, albeit flow quantification is rarely necessary in patients with congenital thoracic vascular abnormalities.

V. CURRENT ADVANCES IN PEDIATRIC CARDIOVASCULAR CT AND MRI

Over the last few years many improvements in pediatric cardiovascular CT and MRI were made. Thus, dual-source CT angiography has the potential to clearly depict anomalies of the coronary arteries even in neonates and infants [3]. 4D flow MRI is fast and reliable for assessment of collateral blood flow in patients with coarctation of the aorta [4]. Time-resolved contrast-enhanced MR angiography is excellent tool for evaluation of the anatomy of the thoracic vessels [5].

VI. CONCLUSION

Both CT and MRI are the excellent imaging modalities for evaluation of congenital thoracic vascular anomalies. These methods can serve second tier of the imaging modalities in this category of patients.

REFERENCES