Comparison between MRI, Echocardiography and Cardiac Angiography in the evaluation of Pulmonary Vascular Anomalies in complex Congenital Heart Disease.

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Abbreviations:

AF: Atrial Fibrillation.

APCs: Aorto-pulmonary Collaterals.

APVD: Anomalous pulmonary venous drainage.

ASD: Atrial septal defect.

BSA: Body Surface Area.

BT: Blalock-Taussig.

CHD: Congenital Heart Disease.

CMR: Cardiac Magnetic Resonance.

CT: Computer Tomography.

CTA : CT angiography

CxR: Chest X-Ray.

DDTA: Diameter of the Descending Thoracic Aorta.

3D: Dimensional.

2DE: 2- Dimensional Echocardiography.

DLPA: Diameter of the LPA.

DRPA: Diameter of the RPA.

ECG: Electrocardiography.

EPI: Echo-planar imaging

FID: Free induction Decay.

FOV: Field Of View.

Gd: Gadolinium.

ICD: Implantable Cardioverter Defibrillator.

IR: Inversion recovery.

LLPV: Left lower pulmonary vein.

LPA: Left Pulmonary Artery.

LUPV: Left upper pulmonary vein.

LV: Left ventricle.

PDA: Patent Ductus Arteriosus.

MPA: Main Pulmonary Artery.

MRA: Magnetic Resonance Angiography.

MRI: Magnetic resonance Imaging.

MR: Magnetic Resonance.

NMR: Nuclear Magnetic Resonance.

PAs: Pulmonary Arteries.

PAVD: Partial Anomalous Venous Drainage.

PA –IVS: Pulmonary atresia with intact inter-ventricular septum.

PA/VSD: Pulmonary Atresia/Ventricular septal defect.

PAPVC:Partial Pulmonary Venous Connection.

RA: Right Atrium.

RF: Radiofrequency

RPA: Right Pulmonary Artery.

RV: Right Ventricle.

RVOT: Right Ventricular Out-flow Tract.

S2: Second heart sound.

SPECT: single photon emission computed tomography.

SSFP: Steady state free precession

SVC: Superior Vena Cava.

T: Teilsa

Tc 99m : Technetium 99.

TEE: Trans-Esophageal Echocardiography.

TGA: Transposition of great arteries.

TOF: Tetralogy Of Fallot.

TTE: Trans- Thoracic Echocardiography.

UCSF: University of California, San Francisco

VEC: Velocity Encoded Cine.

Vs: Versus.

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INTRODUCTION:

Since the discovery of x-rays by Wilhelm Conrad Rontgen over 100 years ago, diagnostic imaging has profoundly influenced the practice of medicine. As a result of discoveries during this period, ultrasonography, nuclear imaging, computed tomography and magnetic resonance imaging, as well as conventional radiography, have assumed a major role in diagnostic medicine. In addition to their traditional role in diagnosis, imaging techniques are becoming an increasingly important factor in innovative treatment methods, and this role is likely to expand. In the current climate of rising health care costs, radiologists and other health care providers who use imaging must increasingly account to health care funders for the cost-effectiveness of imaging in relation to other diagnostic and interventional techniques. They must also assure minimum standards of quality and training, and determine the appropriate role for diagnostic imaging in health care systems of the future [1].

Echocardiography and angiography are the traditional imaging modalities used to diagnose congenital heart disease. Echocardiography with Doppler performs well in defining intra-cardiac anomalies and estimating hemodynamics. However, it is limited by a small field of view, a variable acoustic window, inability to penetrate air and bone, and difficulty in delineating extra-cardiac vascular structures in their entirety. Cardiac catheterization with angiography is an invasive modality that yields important hemodynamic data while clearly defining anatomy in vessels that are accessible to catheterization. However, angiography often gives only indirect information regarding venous connections and arterial anatomy distal to high-grade stenosis or atresia. It also uses high doses of ionizing radiation and is limited by the risks inherent to iodinated contrast material.

Therefore, magnetic resonance (MR) imaging may play a valuable role in bridging the gaps created by echocardiography and angiography, specifically with regard to extra-cardiac arterial and venous anatomy and connections in patients with congenital heart disease. MR imaging can assist in making appropriate decisions in the final evaluation and surgical planning for patients who have previously undergone surgical or other interventional cardiac procedures, especially if vascular access is difficult or undesired (1–3).

Aim of the work:

1. To evaluate the accuracy of MRI in the diagnosis of abnormalities of the pulmonary vessels in comparison with that of cardiac angiography and echocardiography:

- In assessing the confluence (defined as the left and right pulmonary arteries joining centrally), morphology and distribution of the pulmonary arteries.
- To determine the ability of MRI to depict the connections and morphology of the pulmonary veins in patients with congenital heart disease.

2. To evaluate the ability of MRI in identification of major aortopulmonary collaterals (defined as vessels originating from the aorta and supplying the pulmonary parenchyma) and shunts, whether natural or surgical as Blalock-Taussig shunt.

HYPOTHESIS:

Evaluation of the anatomy of the central pulmonary artery is critical to the surgical management of children with obstructive lesions of the right ventricular outflow tract. Although cineangiography has long been the reference standard for imaging of the central pulmonary arteries the invasive nature of cineangiography and the inability to visualize the central pulmonary arteries in some patients has led to a search for alternative imaging techniques. Echocardiography, CT and more recently MR imaging have been investigated as possible substitutes or corroborative techniques in the evaluation of the pulmonary arteries in patients with right ventricular obstructive lesions. MR imaging in multiple non-orthogonal planes allows better visualization of complex anatomy. Flow void on spin-echo images and rich intravascular signal on gradient echo images allow differentiation of vessels and blood pool from soft-tissue structures and the tracheo-bronchial tree. Contrast media are not needed for MR imaging.

MRI is a completely non-invasive modality that provides excellent delineation of the anatomy, and flow of cardiovascular structures in any orientation in the thorax as a result of the natural contrast derived from flowing blood. MRI greatly enhances surgical planning and can even obviate cardiac catheterization for the definitive diagnosis in most forms of congenital heart disease. MRI combined with echocardiography may be the safest and most cost-effective method for preoperative and postoperative assessment of many forms of congenital heart disease.

MRI provides an excellent modality for visualization of palliative systemic-pulmonary shunts, such as the Blalock-Taussig shunts, they are well seen on transverse or coronal MR images. The size and patency of these shunts and the site of anastomosis with the pulmonary arteries can be assessed.

Regarding pulmonary venous anomalies, PAPVC is clearly displayed by transverse MRI. MRI very clearly outlines the course of the four pulmonary veins and identifies the morphology of each vein.

Our purpose is to conduct a combined and comparative study evaluating the efficacy of MRI, echocardiography and angiography in determining pulmonary artery size, identifying MAPCA's, and identifying the pulmonary vein connection and morphology with a high degree of accuracy.

If supported by increased co-operation between Cardiologists and Radiologists, MRI will grow into a useful non-invasive imaging tool that, together with echocardiography, will obviate the need for invasive catheter studies for diagnostic purposes.

Literature review

The emergence of noninvasive imaging techniques for the definitive diagnosis and monitoring of cardiovascular disease has greatly altered cardiac imaging in the past 25 years. The practice of cardiac imaging in 1975 was centered on conventional radiography and angiography, but, in the past 2 decades, noninvasive techniques have substantially replaced catheterization and angiography. In the past decade, magnetic resonance imaging has been gradually assuming more importance in cardiovascular diagnosis [2].

The definitive diagnosis of cardiovascular disease is now accomplished for the most part by using noninvasive imaging techniques. Several noninvasive cardiovascular imaging techniques have emerged during the past 25 years and have greatly altered the practice of cardiac imaging [2].

Although many changes have transpired in cardiovascular imaging in the past 25 years, it is important to recognize how reticent physicians are to change and how slowly new technologies were adapted for the complicated thoracic imaging conditions caused by the confounding effects of respiratory and cardiac motion. Echocardiography in a primitive form was introduced in the mid 1950s for the diagnosis of mitral stenosis and left-atrial tumors. It was not until the early 1970s that the use of echocardiography became widespread. Radionuclides for the evaluation of cardiac disease were shown to be feasible in the late 1940s but did not come into widespread clinical use until the early 1970s. The long persistent bias that existed toward the need for invasive techniques prior to surgery has disappeared so that now many patients undergo surgery without cardiac catheterization and angiography [2].

Chapter 1

Diagnostic modalities:

- **Chest Radiography**:

The initial work-up of children and adults with suspected congenital heart disease (CHD) usually includes a posteroanterior (PA) and lateral chest radiograph. Occasionally the radiograph will be the first study to alert the radiologist and the clinician to the possibility of a congenital cardiac defect or great-vessel anomaly. This simple and inexpensive examination remains a first-line test for patients with suspected CHD[168].

The chest radiograph quickly illustrates gross cardiac and mediastinal contours, pulmonary vascularity, pathologic calcification, and the presence of certain indwelling metallic devices. It also provides an assessment of cardiac size, cardiac configuration, and position of the aortic arch. The situs of the abdomen and thorax can usually be determined. Thoracic cage anomalies associated with CHD and postoperative changes may also be detected. The chest radiograph continues to be an invaluable tool for following the patient with surgically treated CHD[168].

- **Echocardiography**:

Transthoracic echocardiography (TTE) remains a first-line imaging examination in children and adults with suspected CHD. This test has long been established as a clinically useful diagnostic modality for CHD in children, often eliminating the need for cardiac catheterization in uncomplicated lesions. Although adults present certain technical problems related to the need for lower frequency transducers, limited acoustical windows, and postoperative changes, this examination