**ORIGINAL ARTICLE**

**Study of role of MDCT in pulmonary angiography in evaluation of pulmonary arteries patterns in children with tetralogy of fallot**

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**ABSTRACT**

**BACKGROUND:** Tetralogy of Fallot (TOF) is one of the most common congenital cyanotic heart disease and continues to be a major source of morbidity. Our aim is to evaluate the feasibility of computed tomography CT angiography to define the pulmonary arteries abnormalities in Tetralogy of fallot patients. In patients with Tetralogy of Fallot, characterization of anatomy, size and morphology of pulmonary aborisation, which is essential for surgical management. **MATERIALS AND METHODS:** This study was carried out on 38 paediatric patients diagnosed with Tetralogy of fallot. All these patients were underwent CT pulmonary angiography before the corrective surgical intervention. **RESULTS:** CT findings of the pulmonary artery morphology showed: 23 (60.5 %) patients had confluent fair/normal size pulmonary arteries, 12 (31.6%) patients had confluent hypo plastic arteries, 2 (5.3%) patients had absent pulmonary arteries and 1 (2.6%) patient had markedly dilated pulmonary arteries. **CONCLUSION:** With advantage of non invasive nature of MDCT pulmonary angiography with short scanning time and high spatial resolution, CT can provide accurate information about extra cardiac anatomy in patients with Tetralogy of fallot. CT facilitates accurate assessment of the central and peripheral pulmonary arteries.

**Keywords:** MDCT pulmonary angiography, pulmonary arteries, Tetralogy of fallots.

**Introduction**

Tetralogy of Fallot is one of the most common congenital heart disorders. This anomaly account for 10% of all congenital heart disease and has an estimated prevalence of 1 in 2000 birth¹. It is classically characterised by four features which are right ventricular out flow tract obstruction(RVOT) with infundibular stenosis or hypo plastic pulmonary valve and/or hypoplasia of pulmonary artery, ventricular septal defect (VSD), over ridding of aorta and right ventricular hypertrophy which develops only after birth. Other defects may be associated such as cardiovascular defects includes additional VSDs, right sided aortic arch, Pulmonary arterial abnormalities such as pulmonary hypoplasia with or without atresia², atrial septal defect (ASD) termed as pentalogy of fallot, patent ductus arteriosus(PDA), Coronary artery abnormality, persistent left sided superior vena cava. Extra cardiac association may be present in 16% of cases¹ such as congenital lobar emphysema, digeorge syndrome, fetal Rubella syndrome and prune belly syndrome. In approximately 15% of cases it is associated with a deletion of 21q11³. More than 10% of patients with Tetralogy of Fallot have either central or peripheral pulmonary arterial stenosis⁴, therefore precise knowledge of pulmonary arterial anatomy is essential. The variabilities of pulmonary blood supply make this defect heterogeneous and challenging for surgical repair. Plain radiographic films may classically show a "boot shaped" heart with an upturned cardiac apex due to right ventricular hypertrophy and concave pulmonary arterial segment. Most infants with tetralogy of fallot however may not show this finding⁵. Although echocardiography and catheter-directed cardiac angiography are generally accepted as the primary imaging techniques, they have many disadvantages like echocardiography is highly operator dependent and acoustic window limitations exist for evaluating extra cardiac structures. Catheter-directed cardiac angiography is limited by its 2D nature and it has difficulties in simultaneous evaluation of the systemic and pulmonary vascular systems. Due to its invasive nature it has higher complication rate. Procedure requires a larger volume of intravascular contrast material and more frequently requires general anaesthesia. There is also greater radiation dose to the patient. For an excellent surgery, prior detailed information regarding the abnormal anatomy of heart and pulmonary arteries variations must be given to the surgeon. Our aim was to evaluate the feasibility of computed tomography CT.

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angiography to define the pulmonary arteries abnormalities in Tetralogy of fallot patients.

Materials and Methods
This study was carried out on 38 paediatric patients of U.N. Maheta Hospital, Civil Hospital Campus Ahmedabad. Study group includes patients under 12 years of age group diagnosed with Tetralogy of fallots with various types of pulmonary arterial anomalies. In our study group minimum age of patient was 2 month old and maximum age of patient was 10 years old. All study group patients underwent CT pulmonary angiography for evaluation of accurate information about cardiac as well as extra cardiac anomalies in patients with Tetralogy of fallot before the corrective surgical intervention. Study period was between October 2012 to April 2013 were included in our study. CT pulmonary angiography was done on 128 slice MDCT scanner. The imaging data analysed were the level of the pulmonary stenosis and sizes of the pulmonary arteries. CT data was compared to surgical findings. Protocol for CT pulmonary angiography: MDCT and newer scanners yield images with better temporal and spatial resolution, greater anatomic coverage per rotation, more consistent enhancement with a lesser volume of intravascular contrast material, and higher-quality 2D reformation and 3D reconstruction owing to acquisition of an isotropic data set. Rapid imaging with these CT scanners requires less patient sedation than older-generation CT. Paediatric CT pulmonary angiography requires no or mild sedation with ketamine (0.5 ml/kg) and midazolam (1 mg/kg). Non ionic contrast (iohexol 350 mg%) was injected by iv route through peripheral vein, dose of contrast given was 1.5 ml/kg. Pressure injector was used to administer the contrast at a rate of 1-2 ml/sec. Real-time contrast bolus tracking, in which repetitive low-dose images were obtained every 1–3 seconds at the level of pulmonary artery after the contrast injection. Diagnostic image acquisition was started manually as soon as contrast was visualised in vascular structures of the mediastinum (pulmonary arteries or any other vascular structure in case of anomalous vessels). The second phase of image acquisition was done immediately after the completion of first scan. The images acquired were of 3 mm thickness (0.6 collimation) with reconstruction done in 1 mm thickness. Syngo software version VA 40 was used for data analysis in our study.

Results

Table 1: Level of pulmonary stenosis (N=38)

<table>
<thead>
<tr>
<th>Type</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infundibular stenosis</td>
<td>17</td>
<td>44.7</td>
</tr>
<tr>
<td>Valvular stenosis</td>
<td>3</td>
<td>7.9</td>
</tr>
<tr>
<td>Valvular and infundibular stenosis</td>
<td>5</td>
<td>13.1</td>
</tr>
<tr>
<td>Pulmonary atresia</td>
<td>11</td>
<td>28.9</td>
</tr>
<tr>
<td>Absent pulmonary valve</td>
<td>2</td>
<td>5.3</td>
</tr>
</tbody>
</table>

Out of 38 paediatric age groups patients data were collected and analyzed. Results show excellent demonstration of different types of pulmonary arteries anomalies in patients with tetalogy of fallots. Out of 38 paediatric patients the most common level of stenosis is infundibular stenosis which is 44.7% while least common type is absent pulmonary valve which is 5.3%.

Table 2: Pulmonary artery morphology (N=38)

<table>
<thead>
<tr>
<th>Type</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absent pulmonary arteries</td>
<td>2</td>
<td>5.3</td>
</tr>
<tr>
<td>Confluent hypoplastic pulmonary arteries</td>
<td>12</td>
<td>31.6</td>
</tr>
<tr>
<td>Fair/normal size pulmonary arteries</td>
<td>23</td>
<td>60.5</td>
</tr>
<tr>
<td>Markedly dilated pulmonary arteries</td>
<td>1</td>
<td>2.6</td>
</tr>
</tbody>
</table>

CT findings of the pulmonary artery morphology, most of the patients showed confluence normal size pulmonary arteries (60.5%) while minimum patient shows markedly dilated pulmonary arteries (2.6%). Mc goons ratio: It is measured as diameter of the right pulmonary artery at the pre branching point plus that of the left pulmonary artery divided by diameter of aorta at the level of diaphragm. If it is more or equal to 1.2 then it is favourable for complete repair and if it is less than 0.8 then it is inadequate for complete repair.

Table 3: Mc Goons ratio (N=38)

<table>
<thead>
<tr>
<th>Type</th>
<th>No.</th>
<th>%</th>
</tr>
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<tbody>
<tr>
<td>&lt;0.8</td>
<td>3</td>
<td>7.8</td>
</tr>
<tr>
<td>&gt;0.8 to &lt;1.2</td>
<td>3</td>
<td>7.8</td>
</tr>
<tr>
<td>&gt;or=1.2</td>
<td>32</td>
<td>84.2</td>
</tr>
</tbody>
</table>

Out of 38 paediatric patient Mc goons ratio was favourable in 84.2% patients so this group of patients were adequate for complete surgical repair.

Discussion

MDCT pulmonary angiography can be used to characterize numerous pulmonary arterial congenital anomalies in patient with Tetralogy of fallot. CT pulmonary angiography facilitates accurate assessment of the central and peripheral pulmonary arterial anomalies. Echocardiography is limited in the evaluation of branch pulmonary arteries because of the presence of surrounding gas-containing lung. CT pulmonary angiography is useful when the pulmonary arteries are not well seen at echocardiography and the presence, confluence, patency, or calibre of the pulmonary arteries must be established before definitive surgical repair. Oblique reformatted images can be used to establish accurate measurements of the luminal diameter of the pulmonary arteries. There is excellent demonstration of level of stenosis on MDCT, whether it is infundibular stenosis (Figure 1), valvular stenosis (Figure 2) or both (Figure 3). MDCT pulmonary angiography used to depict various types of pulmonary arterial anomalies in patient with Tetralogy of fallots such as absent pulmonary artery, Confluent hypoplastic artery (Figure 5), fair/normal size pulmonary artery (Figure 6) or markedly dilated
pulmonary arteries (Figure 7). In our study pulmonary artery infundibular stenosis was the most common type of stenosis and absent pulmonary valve was least common type while according to Sharma SN study, showed a total of 61 pulmonary artery stenosis, 32 being severe (52%), 17 moderate (28%) and 12 mild (20%). Bifurcational stenosis were the most common (58%), followed by stenosis of the main pulmonary trunk, the right or the left pulmonary arteries (36%), combined central and peripheral stenosis (9.8%), and isolated peripheral pulmonary artery stenosis (3.2%). Nine patients (14.7%) showed segmental stenosis involving both the right and left pulmonary arteries and three of them (4.9%) had atresia of the left pulmonary artery. In our study 60.5% patient had fair or normal size pulmonary artery and 31.6% patient had hypoplastic pulmonary artery. While according to PA Kasar study, 33.9% patients had nonconfluent or hypoplastic pulmonary arteries and 57% had adequate pulmonary artery anatomy. This corresponds to our study.

**Figure 1:** Sagittal pulmonary CT angiography image shows Infundibular stenosis

**Figure 2:** Sagittal pulmonary CT angiography image shows pulmonary valvular stenosis

**Figure 3:** Sagittal pulmonary CT angiography image shows both Infundibular and Pulmonary valvular stenosis

**Figure 4:** Sagittal pulmonary CT angiography image shows absent pulmonary valve

**Figure 5:** Axial pulmonary CT angiography image shows Confluent hypoplastic Pulmonary arteries

**Figure 6:** Axial pulmonary CT angiography image shows Fair /normal size Pulmonary arteries.

**Figure 7:** Axial pulmonary CT angiography image shows markedly dilated Pulmonary arteries.

CT pulmonary angiography depicts the pulmonary arteries in the obstructing lesions of the right ventricular out flow as in Tetralogy of Fallots with pulmonary atresia. CT can be used to accurately visualize centrally diminutive but patent atretic pulmonary arteries. CT also depicts pulmonary arteries not detected at cardiac catheterization. After surgery or shunt placement, CT is useful for non invasive assessment of pulmonary arterial
growth and stenosis. Large aortopulmonary collateral vessels provide blood flow to the lungs in tetralogy of fallot with pulmonary atresia. Central pulmonary arteries may be atretic or entirely absent they can accurately visualized by CT\(^9\). Proximal interruption of the right or left pulmonary artery may be indistinguishable from pulmonary hypoplasia in chest radiograph. This type of anomaly found in association with tetralogy of fallots and the side of interruption is typically opposite to the aortic arch. CT findings include complete absence of the meditational portion of pulmonary artery, contra lateral pulmonary hyper inflation and ipsilateral shift of meditational structure\(^12\). Tetralogy of fallot with pulmonary atresia termed pseudotruncus arteriosus is a severe variant in which there is complete obstruction of the right ventricular out flow tract causing an absence of pulmonary trunk during embryonic development. In these individuals, blood shunts completely from the right ventricle to the left where it is pumped only through the aorta. The lungs are perfused via extensive collaterals from the systemic arteries, and sometimes also via the ductus arteriosus. Pulmonary arterial abnormalities pulmonary hypoplasia with or without atresia particularly important in determining treatment. Primary repair is now the preferred treatment and is usually performed at the time of diagnosis. Shunts are now days only performed as a palliative procedure in inoperable cases or to bridge patients until repair can be carried out, typically in the setting of pulmonary arterial hypoplasia. A number of surgical shunt procedure have been devised that aim to increase pulmonary blood flow using a systemic arterial supply. There are various types of shunt operations used like blalock-taussig operation, Waterston-cooley, Potts and Davidson shunt operation\(^13\). Surgical correction involve closer of ventricular septal defect and relief of pulmonary stenosis.

**Conclusion**

With the advantage of non invasive nature, multi detector scanner, 3D and 2D reconstruction, short scanning time and high spatial resolution, CT pulmonary angiography can provide accurate information about extra cardiac anatomy in patients with Tetralogy of fallot. Thus MDCT pulmonary angiography has excellent role in accurate assessment of various patterns of pulmonary arteries anomalies and levels of pulmonary stenosis thus play an important role in surgical management.

**References**