EVALUATION OF TETRALOGY OF FALLOT AND ITS ASSOCIATIONS BY MULTI DETECTOR COMPUTED TOMOGRAPHY

Mai Mohamed Ali¹, Laila Ahmad Abdurrahman², Mohamed Hassan Sobhy³, and Aliaa Sayed Sheha⁴

¹Radio-diagnosis specialist, National Heart Institute,
²Professor of Radio-diagnosis, Faculty of Medicine / Ain-shams University,
³Professor of Radio-diagnosis, Faculty of Medicine / Ain-shams University,
⁴Assistant Professor of Radio-diagnosis, Faculty of Medicine / Ain-shams University.

Email: mayoya19892@gmail.com

ABSTRACT

Background: Tetralogy of Fallot (TOF) is the most common cyanotic congenital heart disease (CHD) and represents 10% of all CHD. It needs proper pre surgical evaluation. Multi detector computed tomography (MDCT) has become an essential tool to evaluate the TOF and its associations and extra cardiac vascular abnormalities including the pulmonary arterial tree, major aorto-pulmonary collateral arteries (MAPCAs) and patent ductus arteriosus (PDA).

Results: Multi detector cardiac computed tomography (MDCT), with its superior spatial and temporal resolution, has become a valuable modality in evaluating the cardiovascular complex morphology of TOF, especially the extra cardiac associations as well as the pulmonary artery anatomy and aorto-pulmonary collateral vessels.

Conclusion MDCT proved to be a precious modality for decision-making in TOF patients. MDCT affords many advantages in comparison with echocardiography and it is a non-operator dependent exam. MDCT is excellent in detecting intra-cardiac and extra-cardiac anomalies in pediatric patients with complex CHD such as TOF. It affords comprehensive anatomical information on coronary arteries abnormalities, pulmonary arterial tree development especially distal pulmonary arteries and major aortopulmonary collaterals in fine detail as part of the surgical preparation for TOF & pulmonary atresia.

Keywords: congenital heart disease, tetralogy of Fallot, multi detectors computed tomography, patent ductus arteriosus, major aorto-pulmonary collaterals, pulmonary atresia.

I. BACKGROUND

Tetralogy of Fallot (TOF) is the most common cyanotic congenital heart defect, affecting 3 in 10,000 live births and responsible for 7–10% of all congenital heart disease (¹).

Preoperative imaging is essential to confirm the diagnosis and to differentiate the different types of TOF and evaluate the severity of the chief morphological lesions, associated abnormalities and degree of functional affection that in turn direct proper timing of surgical management either early surgical repair or a staged approach after initial palliative procedure. Anatomical relations of cardiac, coronary and extra cardiac structures, like a right-sided aortic arch, MAPCAs and anomalous coronary anatomy, may change the surgical approach itself (²).

MDCT, with its rapid acquisition speed, high spatial and temporal resolution, and powerful image post-processing techniques, can be done safely and quickly even in small infants. It clearly demonstrates information about the great vessels and coronary arteries and can non-invasively diagnose the complex cardiac anatomy in these patients. It provides superior diagnostic accuracy in assessment of patients with tetralogy of Fallot.
regarding the central and peripheral pulmonary arteries, aortopulmonary collateral vessels as well as in demarcation of the abnormal venous anatomy and veno-atrial connections.  

II. AIM OF WORK

The aim of this study is to assess the role of multi detector CT angiography in evaluation of Tetralogy of Fallot and its cardiac & extra cardiac vascular abnormalities.

III. METHODS

Patients:
- This study was conducted during the period from April 2018 till April 2019. It included 20 patients clinically/ echocardiographically known TOF referred for MDCT examination.

Inclusion criteria:
- Patients diagnosed with TOF by echo.
- Both sexes were included.
- Pediatric age group since (day one to 18 years).

Exclusion criteria:
- TOF Patients with surgical intervention /correction.
- Other cyanotic heart diseases.
- Patients with contraindication to contrast; renal failure or elevated serum creatinine.

Study Tools:
- Full history taking and full clinical examination by referring clinician.
- Laboratory: complete renal function including (serum creatinine level)
- Echocardiography examinations were performed for all patients prior to MDCT.
- All patients have undergone MDCT angiographic examination of the heart.

Patient preparation:
- Explanation of the study to patients or his/ her caregiver. Obtaining informed consents were taken by the patient's parents or caregivers before CT examination.
- Fasting about 4 – 6 hours before the study.
- Adequate hydration was advised for at least 4 hours before contrast.
- Checking kidney function was done via serum creatinine.
- Measuring patient body weight for calculation of amount of contrast media, measures for contrast allergy were available.
- Measuring patient height & weight to calculate body surface area.
- Administration of intravenous cannula in the antecubital vein.
- I.V sedation was used in 20 patients before CT procedure via the anesthesiologist.
- Qualified medical monitoring was available during the examination.
Patient position:
The patient was positioned supine in middle of the gantry. ECG leads were put on his chest wall. Neonates and infants below 6 months could be with arms at their side or above their head for image acquisition, positioning the arms above their head was preferable; and patients above 6 months of age were positioned with their arms above their head when possible.

Procedure duration:
The study took 10-15 minutes.

Method of CT examination:
CT study was performed by using MDCT 64 dual source Siemens.

The radiation dose was kept to minimum by reducing the kilo voltage and tube current appropriately.

Scan range: Data acquisition was done from the inlet of thorax to the level of the diaphragm.

Retrospective ECG gating was applied utilizing low dose protocol in all cases complying with ALARA (As Low As Reasonably Achievable) principle in form of Kvp reduction and automatic modification of the CT tube current according to patient weight. As the majority of pediatric group had high heart rate, difficulties in breathing control so we used retrospective gating to get good quality reconstructed images & to avoid cardiac motion artifacts that partially degrades the reconstructed images so as not to miss an abnormality and to avoid repetition of the study and repetitive patient radiation exposure.

A preliminary scout image was obtained.

Contrast agent: non-ionic contrast agent calculated according to the patient’s weight, with a maximum dose of 1 ml/kg in flow rate 1 to 1.5 ml/sec followed by saline 1 ml/kg in flow rate 1 ml/sec by dual mechanical power injector.

- Scanning initiation was triggered by identification of a density of 100-150 HU in the ascending aorta.
- Cardiac examination was performed. Sequential series of images were acquired in arterial and subsequent phase of enhancement to make sure of opacification of both sides of the heart and all extra-cardiac vessels.

Image post processing and interpretation:
- All axial images were transferred to a separate dedicated workstation for image post processing and 3D reconstruction.
- All axial cuts were reconstructed in the coronal and sagittal views. Furthermore, a variety of high quality 2D reformatted and 3D reconstructed images were created that aided in the understanding of complex cardiovascular anatomy.
- MDCT data were reviewed to obtain all clinically relevant information using a combination of 3D maximum intensity projections (MIP), volume rendering (VR), multi planar (MPR) and curved planer reformations (CPR) were produced at various angles of views.
- The results were correlated with echocardiography.

Statistical Analysis
Data were collected, revised, coded and entered to the Statistical Package for Social Science (IBM SPSS) version 23. The quantitative data with non-parametric distribution were presented as median with inter-quartile range (IQR) and ranges. Also qualitative variables were presented as number and percentages.
The comparison between groups regarding qualitative data was done by using Chi-square test and/or Fisher exact test when the expected count in any cell found less than 5.

Kappa statistic was used to compute the measure of agreement between two methods of investigations. Kappa’s over 0.75 is considered excellent, 0.40 to 0.75 is fair to good, while below 0.40 is poor.

The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant as the following:

- P-value > 0.05: Non significant (NS)
- P-value < 0.05: Significant (S)
- P-value < 0.01: Highly significant (HS)

IV. RESULTS

Demographic Data:
- This study included 20 patients, their ages ranged from nine months to 18 year old. The mean age was 2 years. There was 13 (65%) females and 7 (35%) males.

Feature of Classic TOF:

PS, RV hypertrophy, VSD & aortic over-riding:

- The classic morphological features of TOF are include PS, aortic over-riding & RV hypertrophy were all found by CT & ECHO in 20 cases. That shows perfect agreement between the two modalities as (Table 1) & (Fig. 1).

- There were 7 cases showing no PS by CT & echo, 6 cases of them were diagnosed with pulmonary atresia while one case showed absent pulmonary valve only.

Table (1): Shows the number of cases with PS, aortic over-riding & RV hypertrophy by CT & ECHO. Results are expressed as frequency and percentages.

<table>
<thead>
<tr>
<th></th>
<th>Echo</th>
<th>CT</th>
<th>Test value*</th>
<th>P-value</th>
<th>Sig.</th>
<th>Kappa agreement (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSD</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>0</td>
<td>0.0%</td>
<td>0</td>
<td>0.0%</td>
<td>0.000</td>
<td>1.000 NS 1.000 - 1.000</td>
</tr>
<tr>
<td>Positive</td>
<td>20</td>
<td>100.0%</td>
<td>20</td>
<td>100.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>7</td>
<td>35.0%</td>
<td>7</td>
<td>35.0%</td>
<td>0.000</td>
<td>1.000 NS 1.000 - 1.000</td>
</tr>
<tr>
<td>Positive</td>
<td>13</td>
<td>65.0%</td>
<td>13</td>
<td>65.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overriding</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>0</td>
<td>0.0%</td>
<td>0</td>
<td>0.0%</td>
<td>0.000</td>
<td>1.000 NS 1.000 - 1.000</td>
</tr>
<tr>
<td>Positive</td>
<td>20</td>
<td>100.0%</td>
<td>20</td>
<td>100.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RV hypertrophy</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>0</td>
<td>0.0%</td>
<td>0</td>
<td>0.0%</td>
<td>0.000</td>
<td>1.000 NS 1.000 - 1.000</td>
</tr>
<tr>
<td>Positive</td>
<td>20</td>
<td>100.0%</td>
<td>20</td>
<td>100.0%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P-value >0.05: Non significant (NS); P-value <0.05: Significant (S); P-value< 0.01: highly significant (HS)
Fig. (1): Shows the number of cases with PS, aortic over-riding & RV hypertrophy by CT & ECHO. Results are expressed as frequency and percentages.

As regards TOF associations:

Pulmonary atresia:

- CT & ECHO could detect 6 out of 20 cases of pulmonary atresia (30%).

- There were perfect agreement between CT & ECHO in detection of pulmonary atresia as shown in (Table 2), Yet; CT was superior in giving detailed information about the pulmonary atresia with fully detailed description of PA subtypes as followed:
  - Three cases showed absent MPA with confluent RPA&LPA (type II).
  - One case showed absent MPA & RPA with present LPA (type III).
  - Two cases showed absence of MPA, RPA & LPA (grade IV).

Table (2): Shows the pulmonary atresia as detected by CT & ECHO, results are expressed as frequency and percentages

<table>
<thead>
<tr>
<th>Pulmonary atresia</th>
<th>Echo No.</th>
<th>%</th>
<th>CT No.</th>
<th>%</th>
<th>Test value*</th>
<th>P-value</th>
<th>Sig.</th>
<th>Kappa agreement (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative</td>
<td>14</td>
<td>70.0%</td>
<td>14</td>
<td>70.0%</td>
<td>0.000</td>
<td>1.000</td>
<td>NS</td>
<td>1 (1.000 - 1.000)</td>
</tr>
<tr>
<td>Positive</td>
<td>6</td>
<td>30.0%</td>
<td>6</td>
<td>30.0%</td>
<td>0.000</td>
<td>0.000</td>
<td>NS</td>
<td>1 (1.000 - 1.000)</td>
</tr>
</tbody>
</table>

P-value >0.05: Non significant (NS); P-value <0.05: Significant (S); P-value< 0.01: highly significant (HS)

As regards MAPCS:

- There are 7 cases associated with MAPCAs were detected by CT while ECHO detected only one case with P value =0.018 & kappa = 0.178.

- This denoting poor agreement between CT & ECHO as regards MAPCAs detection, so CT is superior than ECHO in MAPCAs detection as shown in (Table 3).

Table (3): Shows the MAPCAs as detected by CT & ECHO, results are expressed as frequency and percentages

<table>
<thead>
<tr>
<th>VSD</th>
<th>PS</th>
<th>RV hypertrophy</th>
<th>Over riding aorta</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>
As regards Coronary artery anomalies:

- CT could detect only one case of anomalous origin of coronary arteries as the coronary arteries seen arise by single artery from right coronary sinus with pre pulmonic course of LAD (pre RVOT course) & retro aortic course of LCX. This case was missed by ECHO.

As regards PDA:

- CT could detect 6 cases with PDA (P <0.009 and kappa = 0.00) while none of them could be detected by ECHO (Table 4) & (Fig. 2).

- CT is superior to echo in PDA detection.

Table (4): Shows the PDA as detected by CT & ECHO, results are expressed as Frequency and percentages:

<table>
<thead>
<tr>
<th></th>
<th>Echo</th>
<th>CT</th>
<th>Test value*</th>
<th>P-value</th>
<th>Sig.</th>
<th>Kappa agreement (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDA</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>20</td>
<td>100.0%</td>
<td>14</td>
<td>70.0%</td>
<td>7.059</td>
<td>0.009</td>
</tr>
<tr>
<td>Positive</td>
<td>0</td>
<td>0.0%</td>
<td>6</td>
<td>30.0%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P-value >0.05: Non significant (NS); P-value <0.05: Significant (S); P-value < 0.01: highly significant (HS)

As regards other associations such as aberrant SCA, ASD & AV canal

- CT detected 4 cases of aberrant SCA. That weren’t detected by echo (Table 5) & (Fig.3).

- CT can differentiate them into 3 cases of left aberrant SCA & 1 case of aberrant right SCA

- Both echo & CT detected 1 case associated with AV canal.

- Echo detected 5 cases of ASD while CT could detected 4 of them.

Table (5): Shows the aberrant SCA, ASD & A-V canal as detected by CT & ECHO, results are expressed as frequency and percentages:

<table>
<thead>
<tr>
<th></th>
<th>Echo</th>
<th>CT</th>
<th>Test value*</th>
<th>P-value</th>
<th>Sig.</th>
<th>Kappa agreement (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>abn lt SCA</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>20</td>
<td>100.0%</td>
<td>16</td>
<td>80.0%</td>
<td>4.444</td>
<td>0.035</td>
</tr>
<tr>
<td>Positive</td>
<td>0</td>
<td>0.0%</td>
<td>4</td>
<td>20.0%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P-value >0.05: Non significant (NS); P-value <0.05: Significant (S); P-value < 0.01: highly significant (HS)
As regard other associations right sided aortic arch, double aortic arch & persistent left SVC:

- CT detected 10 case of right sided aortic arch while echo detected only 3 (P value 0.018 & kappa = 0.100) (Table 6) & (Fig. 4).

- CT detected 3 cases of persistent left SVC while echo detected only one of them.

- The CT also detected 2 case of double aortic arch while echo detected only one.

Table (6) shows the right sided aortic arch, persistent left SVC & double aortic detected by CT & ECHO, results are expressed as frequency and percentages.
Fig. (4): shows the right sided aortic arch, persistent left SVC& double aortic detected by CT & ECHO, results are expressed as frequency and percentages

As regards other associations minor APCs, other VSD& retro BCV

- CT detected 7 cases of minor APCs & 2 cases of retro aortic course of BCV but all that cases were missed by echo.

- The CT detected 2 cases of other VSD while echo detected one of them as shown in (Table 7) & (Fig. 5).

Table (7) shows the minor APCs, other VSDs & retro aortic BCV detected by CT & ECHO, results are expressed as frequency and percentages

<table>
<thead>
<tr>
<th></th>
<th>Echo</th>
<th>CT</th>
<th>Test value*</th>
<th>P-value</th>
<th>Sig.</th>
<th>Kappa agreement (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>minor APCs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>20</td>
<td>100.0%</td>
<td>13</td>
<td>65.0%</td>
<td>8.485</td>
<td>0.004</td>
</tr>
<tr>
<td>Positive</td>
<td>0</td>
<td>0.0%</td>
<td>7</td>
<td>35.0%</td>
<td>0.360</td>
<td>0.549</td>
</tr>
<tr>
<td>other VSD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>19</td>
<td>95.0%</td>
<td>18</td>
<td>90.0%</td>
<td>0.360</td>
<td>0.549</td>
</tr>
<tr>
<td>Positive</td>
<td>1</td>
<td>5.0%</td>
<td>2</td>
<td>10.0%</td>
<td>2.105</td>
<td>0.147</td>
</tr>
<tr>
<td>retro BCV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>20</td>
<td>100.0%</td>
<td>18</td>
<td>90.0%</td>
<td>2.105</td>
<td>0.147</td>
</tr>
<tr>
<td>Positive</td>
<td>0</td>
<td>0.0%</td>
<td>2</td>
<td>10.0%</td>
<td>2.105</td>
<td>0.147</td>
</tr>
</tbody>
</table>
V. DISCUSSION

Tetralogy of Fallot (TOF) is the most common cyanotic congenital heart defect, affecting 3 in 10,000 live births and responsible for 7–10% of all congenital heart diseases (1).

Almost all pediatric patients born with TOF can now expect to survive to adulthood because of advances in its surgical treatment. TOF with extra cardiac vascular anatomical information, particularly of the coronary and pulmonary arteries, is crucial for surgeons in the formulation of surgical strategies. The effective imaging modalities are required to provide a thorough preoperative anatomic description of the associated extracardiac vascular anomalies in pediatric patients with TOF in order to improve surgical planning and outcomes (3).

Transthoracic Echocardiography is the first-line option for depicting complex CHD. Combined with Doppler flow imaging, TTE is preferred in the diagnosis of intra cardiac anomalies. However, its small acoustic window, low spatial resolution, and operator-dependent nature are inherent limitations that affect its diagnostic performance in identifying extra cardiac vascular anomalies (4).

MDCT, with its rapid acquisition speed, high spatial and temporal resolution, and powerful image post-processing techniques, can be done safely and quickly even in small infants. It clearly demonstrates information about the great vessels and coronary arteries and can non-invasively diagnose the complex cardiac anatomy in these patients. It provides superior diagnostic accuracy in assessment of patients with tetralogy of Fallot regarding the central and peripheral pulmonary arteries, aortopulmonary collateral vessels as well as in demarcation of the abnormal venous anatomy and veno-atrial connections (3).

The current study was done to highlight the role of multi detector CT angiography in evaluation of patient with TOF & its extra cardiac vascular abnormalities.

This study included twenty patients clinically /echocardiographically known TOF. including 13 females (65%) and 7 males (35%). The age of patients ranged between nine months to 18 years. However, the majority of patient population lied below the age of four years.

Patients were referred for cardiac MDCT after Echo was done and we assessed the agreement between Echo and MDCT.

As regards the classic features of Tetralogy of Fallot;
All patients in our study had ventricular septal defect, overriding of the aorta, variable degree of pulmonary stenosis and hypertrophy of right ventricle. The classical morphologic features of TOF were equal by CT to echocardiography.

This agrees with what was reported by Wang et al., 2007 (5), who reported that the morphologic characteristics of TOF by MDCT were equal to ECHO. CT angiographic imaging findings proved to be of pronounced additional value to ECHO findings.

As regards the pulmonary arteries abnormalities:
In our study, MDCT could diagnose & differentiate the different subtypes of pulmonary artery atresia in 6 cases (3%). No cases with pulmonary vascular abnormality were missed by CT modality.

This is in agreement with Nakhla, 2015 (6), who concluded there total agreement (100%) between echocardiography and CT in diagnosing pulmonary atresia but CT was superior in giving detailed information about the pulmonary atresia with fully detailed description of PA subtypes.

In spite of good agreement between MDCT & ECHO noted in our study in detection of pulmonary atresia; the MDCT could answer the main questions regarding TOF with PA; to detect obviously the obstruction level and to detect sources of pulmonary blood flow.

Regarding the six patients who suffered from TOF/PA; two patients had absence of central pulmonary branches and both lungs are supplied via MAPCAs only, while three patients had atresia of the pulmonary artery trunk alone & one patient had absence of MPA & RPA.

This is in agreement with Lin et al., 2012 (7), who showed that MDCT is valuable in pulmonary arteries evaluation. This involves recognizing all sources of pulmonary blood flow (native pulmonary arteries and MAPCAs), that is considered chief objectives in imaging TOF with pulmonary atresia patients. These involve determining the presence and size of native pulmonary arteries when ECHO findings are indeterminate.

As regards MAPCAs & Minor APCs:
In our study, marked discrepancy was noted between the echocardiographic and MDCT findings as regards MAPCAs &minor APCs detection. 7 cases were detected by MDCT, yet the ECHO missed 6 cases of them. Two patients had MAPCAs which were the source of pulmonary blood flow as they had pulmonary atresia. MDCT could obviously define their size, course, detect any degree of stenosis along their course & define the relationship of these collaterals to the tracheobronchial tree and surrounding structures.

This agreed with Hu et al., 2017 (3), who stated that as regards MAPCAs, ECHO could only detect relatively the large ones, while MSCT could clearly visualize their number, origin, and supplied lung segments whatever the size of these vessels. Moreover, MSCT could afford an informative view of MAPCAs and their relationships with the large airways, which could aid in surgical planning.

Zakaria et al., 2011 (8), in their study reported that the complex pulmonary artery anatomy, MAPCAs and pulmonary atresia in TOF patients is certainly described by CT.

As regards the PDA:
In our study, six patients (30%) were diagnosed with PDA. CT had a superior role in detecting PDA, as ECHO failed to detect it. MDCT could obviously show the shape, length and size as well as the precise location of PDA.

Morgan-Hughes et al., 2003 (9), reported that CT could describe in detail PDA and permit assessment of its size and morphologic criteria. They measured the diameter of PDA, combining 3D reconstruction and volume rendering afforded full data for duct assessment.

As regards the aortic abnormalities:
In our study, CT detected 10 cases of right sided aortic arch while ECHO detected 3 cases of them. MDCT detected two cases of double aortic arch while only one was detected by echo, four cases of aberrant SCA & 2 cases of retro-aortic course of BCV, all of which were not detected by ECHO.
Hu et al., 2017 (3), stated that MDCT was of higher importance in the visualization of aortic artery and valve abnormalities in comparison with ECHO; MDCT was better in detecting anomalies of the pulmonary artery and valve, as well as deformities of the aorto-pulmonary vessels.

One of the findings in our study was persistent left SVC detected by MDCT; which was seen in three patients (15 %) with one of them detected by echo.

Hu et al., 2017 (3), stated that MDCT was superior to ECHO in showing associated extra cardiac vascular abnormalities.

As regards the coronary abnormalities:

In our study, a case of anomalous origin of coronary arteries as the coronary arteries were seen originating from a single artery from right coronary sinus with pre pulmonic course of LAD (pre RVOT course ) with retro aortic course of LCX, these findings were missed by ECHO which is of major surgical importance.

This agrees with Abd El-Rahman et al., 2017 (10), who reported that ECHO failed to diagnose the only case of the coronary artery anomalies detected by MDCT in their study.

VI. STUDY LIMITATIONS

This study has some limitations. First, MDCT scans exposes pediatric patients to ionizing radiation. Therefore, we took several effective measures to minimize the radiation dosage. Second, we did not study the postoperative features and outcomes with a long term follow-up. And finally, the relatively small number of the studied group with the need to involve larger number of patients in future studies for the validation of our findings.

VII. CONCLUSION

MDCT proved to be a precious modality for decision-making in TOF patients; MDCT affords many advantages in comparison with echocardiography, MDCT is a non-operator dependent exam. MDCT is excellent in detecting intra-cardiac and extra-cardiac anomalies in pediatric patients with complex CHD such as TOF.

It affords comprehensive anatomic information on pulmonary arterial tree development especially distal pulmonary arteries and major aortopulmonary collaterals in fine detail as part of the surgical preparation for TOF & pulmonary atresia.

Confident detection and exclusion of coronary or extra cardiac vascular abnormalities is possible with MDCT and when the abnormality is present high level of accuracy of its anatomic description can be achieved.

So, recommendation of this study is to perform ECG gated MDCT as a routine preoperative investigation for patients with TOF and other congenital heart disease to avoid surgical surprise or unexpected coronary or extra cardiac vascular anomalies missed by ECHO & to get adequate detailed information about the pulmonary arteries & MAPCAs for determining treatment planning and predicting clinical outcome.

REFERENCES