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Original Work

Accuracy of different imaging modalities prior to biventricular repair in Tetralogy of Fallot

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ABSTRACT: The aim of the present study was to determine the diagnostic accuracy of non-invasive tests in patients with Tetralogy of Fallot prior to biventricular repair, and the need of invasive angiocardiography in specific subgroups. A retrospective analysis was performed for paediatric patients with Tetralogy of Fallot who underwent biventricular repair in three consecutive months. Patients were divided into two groups according to their age: below and above 5 years. We compared the findings of different imaging modalities (e.g. echocardiography, multi-detector Computed Tomography (CT) and invasive angiocardiography) to intraoperative findings to determine their accuracies in different subgroups. Results showed that echocardiography is reliable for preoperative imaging, especially in younger children (sensitivity=71.43%) and its findings are 'moderately' concordant with intraoperative findings (kappa=0.439). For patients above 5 years of age, its sensitivity (29.41%) declines and findings are 'poorly' concordant with intraoperative findings (kappa=0.093). With addition of multi-detector CT, the findings of non-invasive means are 'perfectly' concordant with the intraoperative findings (kappa=1) in children below 5 years and 'moderately' concordant with those (kappa=0.4) in children above 5 years. The findings of CT are 'moderately' concordant with those of invasive angiocardiography (kappa=0.4). Tetralogy of Fallot patients below 5 years can directly be subjected to surgery with work-up including detailed echocardiography only. If anatomy is not clearly delineated, CT helps and invasive angiocardiography is not essential. In patients above 5 years, CT has an important role in defining anatomy. The need for catheterization is limited to hemodynamic evaluation of prior shunt and embolization of aorto-pulmonary collaterals.

KEY WORDS: ***Tetralogy of Fallot; Pulmonary artery; Aorto-pulmonary collaterals; Echocardiography; Computed Tomography; Invasive angiocardiography***

INTRODUCTION

Tetralogy of Fallot (TOF) is a common congenital anomaly and accounts for 7-11% of all congenital heart diseases.[1,2] Surgical correction is by closure of the ventricular septal defect (VSD) and relief of right ventricular outflow tract (RVOT) obstruction, when patients are young. Accurate preoperative assessment of pulmonary artery (PA) anatomy, aorto-pulmonary collaterals (APCs), status of prior surgically created shunt, coronary artery anomaly, additional VSD and patent ductus arteriosus (PDA) is essential prior to biventricular repair.
Echocardiography is used as the primary non-invasive modality for diagnosis in most centers, provided there is no aorto-pulmonary shunt, favorable proximal PA anatomy, no suspicious coronary artery over RVOT, no APC seen. This condition accounts for most of the cases. Cardiac

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catheterization with invasive angiocardiography is indicated when the PA anatomy cannot be defined clearly on echocardiography, previous palliative aorto-pulmonary shunt leading to PA distortion, suspicious coronary artery origin/course or as a part of therapeutic procedures e.g. embolization of APCs.

Computed Tomography (CT) has the advantages of easy availability and very short scanning times.[3,4] Contrast–enhanced multi-detector CT angiography allows precise timing for accurate extracardiac arterial and venous imaging.[3,4] The major advantages of CT are its excellent submillimeter spatial resolution and contrast-to-noise ratio.[5] The ability to produce static images of the heart and great vessels as well as three-dimensional reconstructions has revolutionized this technique.[5] Multi-planar reformation decreases the inherent disadvantage of CT image acquisition exclusively in the transaxial plane.[3] Multi-detector CT angiography is useful in demonstrating the PA anatomy, along with the significant APCs.[3,6,7] Gadolinium-enhanced Magnetic Resonance Imaging (MRI) angiography is a feasible, fast and accurate technique for identification of all sources of pulmonary blood flow in patients with complex PA anatomy. It can better delineate small collaterals but it needs to be performed under general anaesthesia for small children.[8]

This study was aimed to determine the diagnostic accuracy and impact of the systematic use of non-invasive tests such as, echocardiography and multi-detector CT in preoperative paediatric patients with TOF and to determine the need for cardiac catheterization and invasive angiocardiography in patients of specific subgroups.

METHODOLOGY

Study Design

After ethical clearance from the institutional ethical committee (UNMICRC/CARDIO/2013/23), a retrospective analysis was performed for paediatric patients (below 18 years) with TOF who underwent biventricular repair in three consecutive months. Patients were divided in two groups according to their age: below 5 years and above 5 years of age.

Inclusion Criteria:

1. Paediatric patients (below 18 years) with TOF
2. Paediatric patients with TOF with prior history of aorto-pulmonary shunt awaiting bi-ventricular repair

Exclusion Criteria:

1. Paediatric patients with Tetralogy of Fallot with history of allergic reaction to iodinated contrast material

Echocardiography

Two-dimensional echocardiogram (iE33 xMATRIX, Philips Healthcare, Andover, USA) was performed by two paediatric cardiologists in all patients. Branch PAs and APCs were evaluated in suprasternal and high parasternal views. Proximal coronary arteries were evaluated in parasternal short axis view in all patients. Patients were also evaluated for additional VSD in apical 4-chamber and parasternal long-axis views. Ductus arteriosus was imaged in suprasternal and parasternal short-axis views. After echocardiography, patients were further evaluated in one of four ways based on the decision of physicians and operating surgeons:

1. Catheterization and invasive angiocardiography
2. Multi-detector CT
3. Catheterization and Multi-detector CT both
4. No further work-up

Catheterization and Invasive angiocardiography: Invasive angiocardiography (Philips Medical systems, Nederland B.V.) included right ventriculogram in postero-anterior and lateral views to evaluate right ventricular function, RVOT and PA anatomy. PA sizes were measured at prebranching levels and Z–scores were calculated using Detroit data with calculation of body surface area using Haycock formula. Crossing of the pulmonary valve with the catheter was avoided to prevent precipitation of a hypercyanotic spell. Left ventriculogram was performed in left anterior oblique view to evaluate function and look for an additional VSD. Aortic and subclavian artery angiograms were performed for PDA and APCs. In patients with prior aorto-pulmonary shunts, shunt angiogram and pressure measurements were undertaken. Anatomical and haemodynamic data were reviewed and confirmed by two expert paediatric cardiologists.

Multi-Detector CT: CT was performed with 128-slice CT scanner machine (Somatom definition AS+, Siemens Healthcare, Malvern, USA). An overall of 1.5 - 2 ml/kg contrast material [Omnipaque (Iohexol); GE Healthcare, Shanghai, China] was administered with a dual-chamber mechanical power injector (Medtron, Germany) at rate of 1– 2.5 ml/sec via a peripheral vein. Gantry rotation time was 330 ms with the use of a halfscan algorithm for image reconstruction. Collimation was 0.6 mm. Tube voltage was 80 or 100 kV at a current of 60-100 mAs, which was estimated by automated tube current modulation by the device. Out bolus tracking was performed for timing. Radiation dose was reduced using automated dose reduction- CARE dose 4D technique (Siemens Healthcare, USA). Out of these initially obtained raw-data sets, standardized image reconstructions

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were performed. All acquired CT images were transferred to a dedicated CT three dimensional-postprocessing workstation (Syngovia, Siemens Healthcare, Malvern, USA). The review of axial images was followed by maximum intensity projections and multi-planar reformation, adjusted to the long axis of the structure of interest to obtain accurate measurements. Volume rendered technique reconstruction was done for the three dimensional visualization of complex anatomy. Branch PA sizes were measured at prebranching levels and Z-score were calculated. Pulmonary stenosis, APCs, status of prior surgically created shunt and ductus arteriosus were also evaluated. All evaluations were performed by two expert cardiac radiologists.

Statistical Analysis

Findings, e.g. PA anatomy (hypoplasia, stenosis, non-confluence etc.), APCs, status of prior surgically created shunt, coronary artery anomalies (esp. major vessel anterior to RVOT), additional VSD and PDA; which were evaluated on echocardiography, invasive angiocardiography and CT were compared to intraoperative findings.

Sensitivity, specificity, precision and accuracy of each imaging modality were calculated for different age groups, keeping the intra-operative findings as 'gold standard' for all anomalies except for APCs, for which invasive angiocardiography was considered as 'gold standard'. Concordances between findings from imaging modalities and intraoperative findings as well as amongst different imaging modalities were calculated and strengths of agreements were shown using Cohen's kappa. Strength of agreement was considered 'poor' when kappa was < 0.2, 'fair' when kappa was 0.2 to 0.4, moderate when kappa was 0.4 to 0.5, good when kappa was > 0.6 and 'perfect' when kappa was 1. Numbers of patients in different age groups having discordant findings on particular imaging modalities from intraoperative findings were compared using chi-square test. All statistical calculations were performed using Graphpad Prism (Graphpad Software, Inc. La Jolla, USA) except approximate significance of agreement, which was calculated with SPSS software (Version 20, Chicago, USA). A p-value of less than 0.05 was considered to be indicating statistical significance.

RESULTS

Sixty paediatric patients (38 male, 22 female) underwent biventricular repair in the study period (**Table-1**). An echocardiogram was performed in all the patients. Fifty two (86.67%) patients had undergone invasive angiocardiography and multi-detector CT was performed in 14 patients (23.33%). Amongst these, ten patients (16.66%) had both invasive angiocardiography and CT; while in four patients (6.67%), surgery was done on the basis of echocardiography alone.

Thirty six patients (60%) were below 5 years. Five patients of this group (13.89%) had PA hypoplasia and/or stenosis on surgery (**Table-1**) which were defined on pre-operative echocardiography. Four patients below 5 years (11.11%) had non-confluent pulmonary branches. Amongst these four, echocardiography detected non-confluence in three patients and in the other one, the suspicion of non-confluence on echocardiography was confirmed on CT. **Figure 1** shows normal sized confluent pulmonary artery branches on invasive angiocardiography (A) and CT (B).

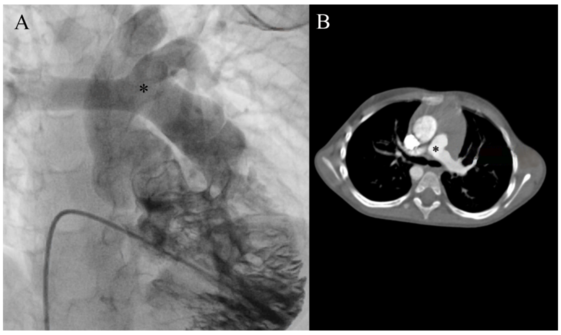

Figure 1 A: Invasive angiocardiography- right ventriculogram showing normal sized confluent pulmonary artery branches (*) in a patient with Tetralogy of Fallot; B: Computed tomography-Multi-planar reformation image showing normal sized confluent pulmonary artery branches (*) in a patient.

Twenty four patients (40%) were above 5 years. Seven patients of this group (29.17%) had PA anomalies (hypoplasia and/or stenosis) on surgery (**Table-1**). Amongst these, echocardiogram could not properly delineate the PA anatomy in 5 patients and even angiocardiography did not properly define PA anomaly in one patient. PA anatomy was correctly defined in two patients who had CT. Overall, pulmonary anomaly was seen in 26.67% of patients. In 18.33%, it was defined on echocardiogram. Three patients had got multi-detector CT performed and pulmonary anomalies were clearly defined in all three cases. For PA anatomy assessment in TOF patients below 5 years of age, echocardiography showed 89.3% sensitivity and 100% specificity. While for the entire sample, it had lesser sensitivity (especially in older children) (sensitivity- 66.67%, specificity- 98.33%). For pulmonary anatomy, sensitivity of non-invasive means collectively was improved to 96% and specificity to 100% with use of multi-detector CT.

Major APCs were there in nine patients (15%) on angiocardiography. Prevalence of collaterals was lower in below 5 years age group as compared to that in above 5 years age group (8.33% vs. 25%,

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p=0.07) (**Table-1**). Three patients (5%) had their APCs detected on echocardiography (concordant echocardiography and angiocardiography findings). Six patients (10%) had their collaterals missed on echocardiography. Only two patients amongst those were below 5 years, and those patients had their APCs detected on CT. **Figure 2** shows large APCs on invasive aortic angiogram (A) and CT- volume rendered image (B) in a TOF patient. Two patients (3.33%) required post-operative coiling of collaterals. Amongst those, one was below 5 years and APCs were previously found to be insignificant even on angiocardiography. Four patients below 5 years (11.11% of that age group) did not get angiocardiography done and none of them required re-intervention for collaterals post-operatively. In this study, for detection of major APCs, echocardiography had sensitivity of 100% in infancy, which declined to 33% in patients above 5 years.

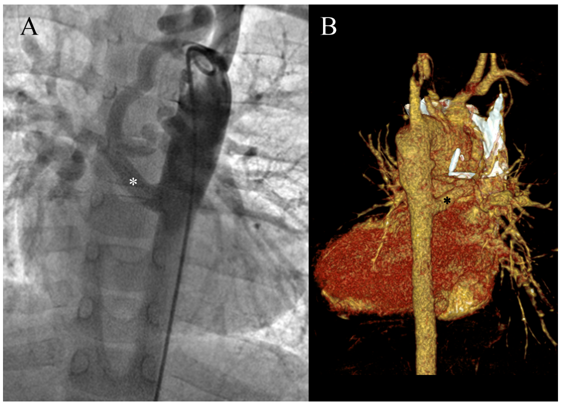

Figure 2 A: Invasive angiocardiography- aortic angiogram showing large aorto-pulmonary collateral (*) in a patient with Tetralogy of Fallot; B: Computed Tomography- volume rendered three-dimensional image showing a large aorto-pulmonary collateral (*) in the same patient.

Five patients (8.33%) had history of prior aorto-pulmonary shunt (**Table 1**). Echocardiographies versus surgical findings were discordant in only one patient. However, hemodynamic assessment of shunt required catheterization.

Abnormal coronary artery anterior to right ventricular outflow tract was found in six patients (10%) (**Table 1**). Amongst these, concordant findings were noted in five patients between echocardiography and angiocardiography. Only one 13 years patient had got it diagnosed on angiocardiography, which was missed on echocardiography.

Additional VSDs in five patients were diagnosed accurately on echocardiography (sensitivity- 83.33%, specificity- 100% for additional VSD) and angiocardiography did not improve the sensitivity further.

Three patients had PDA and these were detected on echocardiography. Two patients had undergone invasive angiocardiography for haemodynamic assessment while one patient had CT for pulmonary branch definition and the PDA was confirmed.

Sensitivity of echocardiography (71.43%) and multi-detector CT with echocardiography (90%) were better than that of invasive angiocardiography (64%) in below 5 years age group; while, sensitivity of echocardiography was comparatively lower (29.41%) in above 5 years age group. Sensitivity of CT with echocardiography (84.62%) is better than that of invasive angiocardiography (70%) for all patients of the entire sample. Non-invasive (multi-detector CT with echocardiography) and invasive modalities showed same specificity- 100% in all age groups. Diagnostic accuracy of echocardiography was 72.22% in below 5 years age group; but it was comparatively lower (45.83%) in above 5 years age group. Accuracy of CT with echocardiography was higher (85.71%) than that of invasive angiocardiography (82.69%) (**Table 2**).

Table 1: Patients' Baseline Characteristics

Baseline Characteristics		**Below 5 years n (%)**	**Above 5 years n (%)**	**p value**
No. of patients		36 (60)	24 (40)	-
Sex	Male	22 (61.11)	16 (66.67)	0.66
	Female	14 (38.89)	8 (33.33)	
PA anatomy	Fair sized confluent	27 (75.0)	17 (70.83)	0.72
	Hypoplastic	3 (8.33)	2 (8.33)	1.0
	Branch PA stenosis	2 (5.56)	5 (20.83)	0.07
	Non-confluent	4 (11.11)	0 (0)	0.09
Significant APCs		3 (8.33)	6 (25)	0.07
Prior Aorto-pulmonary shunt		4 (11.11)	1 (4.17)	0.34
Coronary anomalies		3 (8.33)	3 (12.5)	0.6
Additional VSD		4 (11.11)	1 (4.17)	0.34

APC: Aorto-pulmonary collateral; PA: Pulmonary Artery; TOF: Tetralogy of Fallot; VSD: Ventricular Septal Defect

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Concordance between echocardiographic findings and invasive angiocardiography was 'moderate' (kappa=0.499) for entire sample. However, this concordance was 'good' in below 5 years (kappa=0.633) as compared to just 'fair' concordance in above 5 years age group (kappa=0.273) due to echocardiography being less sensitive for older children. Overall, the inter-rater reliability of echocardiographic findings with intraoperative findings was 'fair' (kappa=0.238) for all patients. In the contrary to 'moderate' concordance between these two in below 5 years (kappa=0.439), the concordance between echocardiography and intraoperative findings obtained with above 5 years age group was comparatively 'poor' (kappa=0.093). When the CT was added to echocardiography, the strength of agreement improved in all age groups. Concordance between non-invasive modalities and intraoperative findings was 'moderate' (kappa= 0.440) for entire sample; 'perfect' for below 5 years age group (kappa=1.000) and 'moderate' for above 5 years age group (kappa=0.400). Concordance between invasive angiocardiography and intraoperative findings was 'good' for all age groups (kappa=0.664). Strength of agreement between invasive angiocardiography and CT was 'moderate' (kappa=0.4) (**Table 3** and **Figure 3**).

Table 2: Diagnostic power of different imaging modalities

Imaging Modalities	Sensitivity %			Specificity %			Precision %			Accuracy %		
	<5y	>5y	All	<5y	>5y	All	<5y	>5	All	<5y	>5y	All
Echo.	71.43	29.41	50	77.33	85.71	77.27	78.95	83.33	79.17	72.22	45.83	60
MDCTA+ Echo.	90	50	84.62	100	100	100	100	100	100	90.91	66.67	85.71
Inv. Angio.	64	78.57	70	100	100	100	100	100	100	81.82	84.21	82.69

Echo.: Echocardiography; MDCTA: Multi-detector Computed Tomography angiography; Inv. Angio.: Invasive angiocardiography

Table 3: Concordance between imaging modalities and between imaging modalities and intraoperative findings on surgery

Modalities	Pt. groups	N	Kappa	SE	95% CI	p-Value
Echo. and Inv. Angio.	All	52	0.499	0.120	0.263 to 0.734	<0.01
	Below 5 years	33	0.633	0.131	0.376 to 0.891	<0.01
	Above 5 years	19	0.273	0.209	-0.135 to 0.682	0.147
Echo. and Surgery	All	60	0.238	0.110	0.022 to 0.454	0.032
	Below 5 years	36	0.439	0.149	0.146 to 0.732	0.110
	Above 5 years	24	0.093	0.122	-0.145 to 0.331	0.433
Non-invasive modalities (MDCTA+ Echo.) and Surgery	All	14	0.440	0.304	-0.155 to 1.000	0.05
	Below 5 years	11	1.000	0.000	1.000 to 1.000	0.035
	Above 5 years	3	0.400	0.392	-0.368 to 1.000	-
Inv. Angio. and Surgery	All	52	0.664	0.096	0.476 to 0.852	<0.01
	Below 5 years	33	0.640	0.124	0.397 to 0.883	<0.01
	Above 5 years	19	0.627	0.183	0.286 to 0.986	0.004
Inv. Angio and MDCTA	All	10	0.400	0.359	-0.328 to 1.000	0.284
	Below 5 years	9	0.400	0.367	-0.361 to 1.000	0.346
	Above 5 years	1	-	-	-	-

Echo.: Echocardiography; Inv. Angio.: Invasive angiocardiography; MDCTA: Multi-detector Computed Tomography angiography; SE: Standard error; CI: Confidence interval

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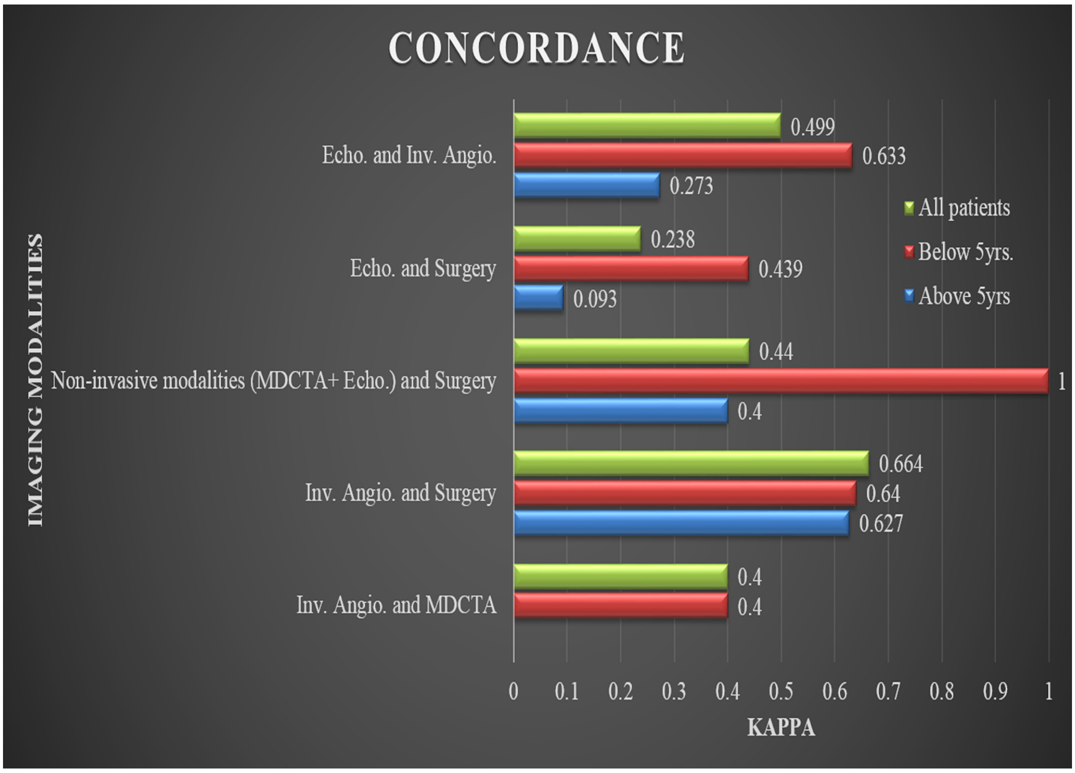

Figure 3: Clustered bar-diagram showing concordance between different imaging modalities and intraoperative findings. (Echo: Echocardiography; MDCTA: Multi-detector computed tomography angiography; Inv. Angio.: Invasive angiocardiography)

It shows that there was a significant difference between different age groups in numbers of patients having lack of concordance between echocardiography vs. surgical findings (p=0.03) (**Table 4**). But this difference was insignificant for non-invasive means collectively (multi-detector CT with echocardiography) (p=0.42). In addition, the numbers of patients having discordant findings between invasive angiocardiography and surgery vs. non-invasive means and surgery were not significantly different (p=0.92).

None of our patients suffered complications related to CT, while two patients suffered hypercyanotic spells with invasive angiocardiography. Post-operative morbidity and mortality were not different amongst the patients who were previously evaluated with angiocardiography versus those who were not (p=0.49).

Table 4: Discordance of findings on imaging modalities from intraoperative findings

Imaging modalities	n for discordant findings (total N)		p- Value
	Below 5 years	Above 5 years	
Echocardiography (n=60)	10 (36)	13 (24)	0.03
Non-invasive modalities (Echocardiography+ MDCTA) (n=14)	1 (11)	1 (3)	0.29
Invasive angiocardiography (n=52)	6 (33)	3 (19)	0.83

MDCTA: Multi-detector Computed Tomography angiography

DISCUSSION

The choice of preoperative imaging modalities in TOF patients depends upon the availability of non-invasive imaging tools, individual center's preference/ experience, surgical expertise in dealing with unexpected coronary anatomy, availability of conduit standby, surgical procedure itself (e.g. transatrial vs. transventricular approach). Echocardiography defines intracardiac anomalies and estimates the hemodynamics.[3,5] Our study showed that it is a reliable tool for PA assessment especially in younger TOF patients with 'moderate' concordance with intraoperative findings.

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However, it has lesser sensitivity and 'poor' concordance with intraoperative findings in older children. Most younger children have adequate acoustic windows, and an accurate diagnosis can be established even in patients with complex anatomy.[9] Transthoracic echocardiography is limited by a small field of view, variable acoustic window due to inability to penetrate air and bone and difficulty in delineating extracardiac vascular structures in their entirety, e.g. peripheral PAs, APCs and coronary artery anatomy; especially in older children.[3,9]

Sensitivity and specificity of non-invasive means has been improved with addition of multi-detector CT to echocardiography in our study. In patients with TOF with complex PA anatomy, CT is useful in demonstrating it.[3,6,7] It provides superior diagnostic accuracy in assessment of patients regarding the central and peripheral PAs, APCs as well as in demarcation of the abnormal venous anatomy.[3] It precisely identifies and allows enlargement of all branch pulmonary stenosis so as to yield subsystemic right ventricular pressures after ventricular septation. The drawbacks of CT are exposure to ionizing radiation, the risks of iodinated contrast material, requirement of general anaesthesia or sedation in paediatric patients and lower temporal resolution compared with echocardiography and cardiac MRI.[3,5,9] None of our patients suffered complications related to CT imaging. In addition, the adjustment of specific technical factors e.g. setting the lowest tube current according to weight of the patient minimizes the radiation dose in children. Doubling the pitch reduces radiation dose by half.[3,10] Implementation of radiation reduction technique like CARE dose 4D reduced the radiation exposure in our patients. Limiting the amount of contrast material to maximum of 2 ml/kg and use of non-ionic contrast agent reduces the risks associated with use of contrast exposure[4] and none of our patients suffered contrast related complications.

Catheterization yields important hemodynamic data and clearly defines anatomy in vessels that are accessible to catheterization.[3] PA size measurements for the calculation of the McGoon ratio and Nakata index are critical to surgical planning. An aortic root injection is used to evaluate the position and number of coronary arteries.[11] But it gives only indirect information regarding venous connections and PA distal to high-grade stenosis or atresia.[3] Catheter studies remain the reference standard for the hemodynamic measurements and morphologic imaging of the coronary and branch PAs when data from non-invasive imaging is inconclusive.[9,11] But, unlike inherently tomographic studies such as echocardiography, MRI, and CT scanning; angiocardiography may be limited by overlapping structures that may obscure the other structures, despite the use of multiple planes.[11] There are also risks related to high doses of ionizing radiation, iodinated contrast material, general anesthesia, procedural risks, vascular and access site complications.[3,12] In one study, the radiation exposure with invasive angiocardiography was even higher than that with CT.[13] Catheterization may lead to precipitation of hypercyanotic spells[12] as in two of our patients. Information derived from catheterization did not seem to be translated into improved post-operative morbidity and mortality in our study.

APCs in classical TOF patients are rare below 5 years. If present, they are equally defined on multi-detector CT and invasive angiocardiogram. In one study, invasive angiocardiography detected more major APCs than CT, whereas echocardiography failed to identify these major collaterals.[13] Multi-detector CT defines the relationship of the collaterals to the tracheobronchial tree and other surrounding structures; permitting the surgeon to minimize peritracheal dissection, to decrease post-operative bronchospasm.[3] Creation of neo PAs by unifocalization of the collaterals can be achieved and bypass time can be minimized if the anatomy is accurately mapped preoperatively.[3] Catheterization is required for pre-operative coiling. It is also required for pallliative RVOT stenting and balloon dilatation of pulmonary valve in some cases.

Prevalence of coronary anomalies in present study was 10%, similar to that in a study by Zakaria *et al*[4] while it was 5.4% in a study by Need *et al*.[14] In the later one, coronary echocardiography was used with sensitivity of 82%, specificity of 99% and accuracy of 98.5%.[14] In our study, there was no discordance between echocardiography and angiocardiography for coronary anomalies, especially for children below 5 years of age.

PA anatomy, coronary anomalies, additional VSD and PDA are defined on echocardiography. In children below 5 years of age, these findings are 'moderately' concordant with surgical ones. While for children above 5 years of age, multi-detector CT defines the anatomy equally as invasive angiocardiography, and the findings between CT and invasive angiocardiography as well as those between CT and surgery are 'moderately' concordant. The concordance between CT and surgical findings is 'perfect' in patients below 5 years of age. In one study, it was concluded that, in cases where cardiac MRI cannot be performed, or is not sufficiently informative, multi-detector CT correlates well with invasive angiocardiography and can provide adequate information about PA anatomy, and can replace invasive cardiac catheterization angiography with markedly reduced radiation dosage to the patient.[13] On the basis of the findings of our study, a diagnostic algorithm for preoperative imaging can be proposed for different subgroups (**Figure 4**).

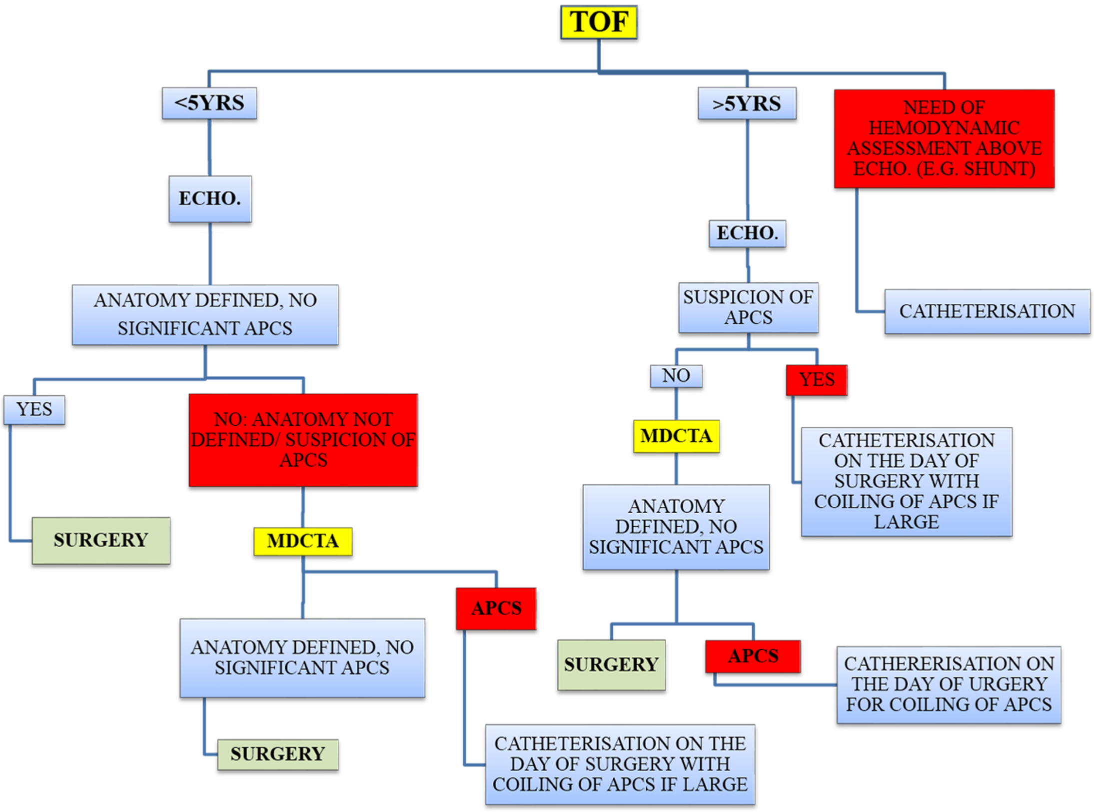

Figure 4: Preoperative diagnostic algorithm for Tetralogy of Fallot patients of different subgroups. (TOF: Tetralogy of Fallot; APCS: Aorto-pulmonary collaterals; Echo.: Echocardiography; MDCTA: Multi-detector Computed Tomography angiography)

Limitations of this study: This is a retrospective study with a small number of patients. In our study, the selection of the second line modality was physician and operator based. In addition, we have not evaluated other non-invasive modalities like cardiac MRI for preoperative work-up due to non-availability and limited resources.

CONCLUSION

In a TOF patient below 5 years of age, if there is no doubt regarding PA anatomy, APCs, coronary anomalies, additional VSD and PDA on echocardiography, the patient can directly be subjected to surgery with no further work-up. If PA anatomy is not clearly defined or there is suspicion of APCs on echocardiography; multi-detector CT is valuable tool and invasive angiocardiography is not essential for diagnosis. Cardiac catheterization is required for therapeutic interventions and hemodynamic evaluation of post-shunt surgery patients over and above echocardiography.
In TOF patients above 5 years of age, if there is no doubt regarding major APCs, multi-detector CT better defines the anatomy. If there are significant collaterals on echocardiography, the patient should be subjected to angiocardiography for their definition and coiling prior to surgery.

This study has changed the practise in our institute and this can be translated to other institutes with limited resources in developing nations. So, the use of preoperative non-invasive modalities successfully obviates the need of invasive angiocardiography and limits its use to certain sub-groups.

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