ORIGINAL RESEARCH

Assessment of Left Ventricular function and Aortic blood flow in children with Tetralogy of Fallot (TOF) attending two health institutions in Enugu Metropolis

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Abstract

Background

Children with Tetralogy of Fallot (TOF) usually present with right heart abnormalities, however much is not known if these children presents with left ventricular dysfunction.

Objectives

This article is aimed to ascertain the left ventricular function of children with TOF compared with those without any congenital heart disease. It also elicits the correlation if any, between left ventricular mass and descending aorta blood flow.

Methods

This is a comparative study involving 91 children with TOF with age and gender matched control . Echocardiographic evaluation of left ventricular function and their parameters in children with TOF were compared with controls. The data was analyzed with the IBM SPSS statistics for windows, version 20 (IBM Corp, Chicago).

Results

The mean LVIDd of subjects without TOF, 25.7±10.1 was higher than that of those with TOF, 21.2±7.1 and the difference in mean was found to be statistically significant, (Student t=3.455, p=0.001). The mean EF of respondents with TOF, 61.9±19.3 was lower than that of subjects without TOF, 67.2±9.3 and the difference in mean was found to be statistically significant, (Student t=2.333, p=0.021). The mean FS of respondents with TOF, 43.1±16.6 was significantly lower than that of respondents without FS 46.7±8.2 (Student t=3.519, p=0.001). The mean velocity of respondents without TOF, 1.3±0.3 was significantly higher than that of respondents with TOF, 1.2±0.2. (Student t=4.199, p<0.001).

For respondents who had TOF, there was a weak negative correlation between LV mass and velocity, increases with LV mass correlates with decreases in velocity but this was not found to be statistically significant, (n=63, r=-0.214, p=0.093).

Conclusion

Though it is generally known that children with TOF present with right ventricular dysfunction, however this study has shown that they also present with various degrees of left ventricular systolic abnormalities. Though left ventricular systolic function in children with TOF is lower than that in normal children, all values still fall within normal refrence ranges.

Keywords: Left ventricular function ; TOF ; children; echocardiography.

Introduction

Tetralogy of Fallot (TOF) is the commonest cyanotic heart disease and the third commonest congenital heart defect after bicuspid aortic valve and ventricular septal defect[1,2]. It accounted for about 10% of all congenital cardiac defects[3]. Tetralogy of Fallot results from an anterior-cephalad deviation of the conal septum-; a common embryological malformation seen in children with TOF[1,2]. This deviation results in mal-aligned large ventricular septal defect (VSD), aortic overriding which results from the tortuous and mal-aligned ventricular septal defect. There is also right ventricular outflow tract obstruction and right ventricular hypertrophy. Mortality in untreated children with TOF is very high by 5 years of age. Intra-cardiac repair in children with uncomplicated TOF result in good long-term survival with a very considerable quality of life[4].

Early diagnosis and timely repair has improved prognosis and outcome[3-4]. Pulmonary regurgitation, arrhythmias, right ventricular dysfunction and residual VSD have been noted as common complications after repair[3-4].

Pulmonary regurgitation among children who had intra-cardiac repair of TOF might lead to right ventricular (RV) dilatation, arrhythmia , re-entry phenomenon and sudden death (SCD)[4-7].

Though Left ventricular dysfunction, left ventricular mass alteration following hypoxaemia are uncommon complications of children with TOF, a sub-population of children with TOF presents with mild to modertae impairment of LV ejection fraction. Echocardiographic assessments of the left ventricular function is rare in children with TOF. Several studies abound in the study of the right ventricular function both for the repaired and un-repaired lesions. A study has shown that children with repaired and un-repaired TOF usually present with left ventricular (LV) dysfunction following a severe left ventricular remodelling[8].

Some studies have also documented left ventricular dysfunction and arrhythmia, as ominous signs in children with un-repaired TOF. Sudden death has been reported even in repaired cases[9].

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Table 1: Socio-demographic characteristics of respondents

Variable	TOF (n=91)	No TOF (n=91)	
Age of respondents in years			
Mean±SD	4.0±4.3	4.0±4.3	0.0 1.0
Gender			
Male	62 (68.1)	62 (68.1)	FT 1.0
Female	29 (31.9)	29 (31.9)	

FT Fishers exact test

Table 2: Left ventricular function of children with TOF and control

Variable	TOF (n=91)	No TOF (n=91)	Mann Whitney U	p value
Weight	11	88		
Mean±SD	15.3±11.6	13.5±14.6	0.382	0.703
Surface area	91	89		
Mean±SD	0.6±0.3	0.6±0.4	1.511	0.133
LV mass	91	89		
Mean±SD	59.6±84.5	79.5±91.8	1.562	0.120
LVIDd	91	91		
Mean±SD	21.2±7.1	25.7±10.1	3.455*	0.001
LVPWd	91	91		
Mean±SD	5.1±1.9	5.1±1.8	0.281*	0.779
IVSs	91	91		
Mean±SD	7.1±2.4	7.2±3.1	0.342*	0.733
LVIDs	91	91		
Mean±SD	13.5±5.8	16.4±6.8	3.103*	0.002
LVPWs	91	91		
Mean±SD	6.9±2.2	7.3±6.5	0.586	0.559
EF	91	91		
Mean±SD	61.9±19.3	67.2±9.3	2.333*	0.021
FS	91	90		
Mean±SD	43.1±16.6	46.7±8.2	3.519*	0.001
Velocity	63	76		
Mean±SD	1.2±0.2	1.3±0.3	4.199*	<0.001

*Student t

Left ventricular dysfunction has been noted as an independent predictor of cardiovascular adverse events in a recently published systematic review and meta-analysis. Early detection of left ventricular dysfunction is a very important tool that may help to avert death in both repaired and un-repaired cases[10-11].

Apart form left ventricular dysfunction, left ventricular mass, a harbinger of left ventricular hypertrophy can also be used as a prognostic marker in children with TOF. Echocardiography remains the simplest and cost effective diagnostic tool in the management of children with TOF. Other measures such as magnetic resonance imaging (MRI), and angiography are expensive but can be very useful in determining branch pulmonary vessel abnormalities and determination of major aorto-pulmonary collaterals. This is a rare study and the first of its kind in this setting where left ventricular function and descending aorta blood flow were analyzed in children with TOF. This study will help the clinician in decision making and appropriate management of children with TOF in the near future. This study is aimed to determine the left ventricular function and left ventricular mass in children with TOF. It also ascertains if left ventricular mass has any impact on descending aortic blood flow.

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Table 3: Correlation between LV mass and Descending aorta blood flow

Variable	Sample size (n)	Correlation co-efficient r	p value
Correlation of LV mass and velocity	(n=63)	-0.214	0.093
Correlation of LV mass and velocity	(n=74)	-0.161	0.182

What previous studies on this topic have shown

Previous studies only focused on the right ventricular function of children with TOF since it is a well known fact that children with TOF usually have right ventricular dysfunction.

Why this study is still needed

This study is needed because a sub- population of children with TOF still presents with heart failure and thrombosis with severe hypoxaemia. Though this may stem from right ventricular cardiopathy, but much is not known if there is any contribution from left ventricular dysfunction, neither is much known if left ventricular abnormalities have any impact on aortic blood flow; a major cause of cerebral ischaemia among children with TOF. Besides, this is the very first time this work is done in Nigeria in particular and Africa as a whole, after rigorous literature search.

Methods

Study area

This study was conducted in two private hospitals in Enugu metropolis involving a total of 182 children made up of 91 children with TOF and 91 normal children as controls. Study population: This study involved 91 children with echocardiography confirmed TOF with age and gender matched 91 normal children used as controls.

Study design and sampling: This study was a comparative study conducted among children with Tetralogy of Fallot with age and gender matched control. The children with TOF were selected by convenience sampling while the controls were children who were apparently healthy and who were screened with echocardiography to rule out any form of congenital heart defect.

Study Instrument

Children with TOF and their controls had echocardiography. Those with TOF had a detailed echo where the large VSD were ascertained using both parasternal long, short axis and four chamber views. Pulmonary stenosis were elicited in a parasternal short axis view while right ventricular outflow tract obstruction was seen using modified sub-costal short axis view. Parasternal short axis view was used to rule out any coronaries crossing the right ventricular outflow tract (RVOT) while supra-sternal view was used to ascertain descending aortic blood flow. Images obtained using echocardiography were viewed when the children were positioned in a left lateral decubitus position . The M–mode was used to evaluate the left ventricular function while the left ventricular mass was also calculated according to the Devereux – modified ASE cube formula[12].

Data analysis

Data entry and analysis were done using IBM Statistical Product for Service Solution (SPSS) statistical software version 25. Categorical variables were summarized using frequencies and proportions while continuous variables were presented using mean and standard deviation. Chi square test was used to compare the difference in proportions between two categorical variables. Student t test was used to compare the difference in mean between two groups and when the data was skewed, Mann Whitney U test was used. The level of statistical significance was determined using a p value of <0.05

Results

Table 1 shows the socio-demographic characteristics of the respondents. The mean age of respondents who had TOF, 4.0±4.3 years was comparable to that of respondents who had no TOF. (p value=1.0). The proportion of respondents who had TOF who were males, 68.1% were comparable to that of those who did not have TOF, 68.1%, (Fishers exact test, p=1.0).

The mean LVIDd of respondents without TOF, 25.7±10.1 was higher than that of those with TOF, 21.2±7.1 and the difference in mean was found to be statistically significant, (Student t=3.455, p=0.001). The mean EF of respondents with TOF, 61.9±19.3 was lower than that of patients without TOF, 67.2±9.3 and the difference in mean was found to be statistically significant, (Student t=2.333, p=0.021). The mean FS of respondents with TOF, 43.1±16.6 was significantly lower than that of respondents without FS 46.7±8.2 (Student t=3.519, p=0.001). (Student t=3.519, p=0.001). Conversely, the mean velocity of respondents without TOF, 1.3±0.3 was significantly higher than that of respondents with TOF, 1.2±0.2. (Student t=4.199, p<0.001). Table 2

For respondents who had TOF, there was a weak negative correlation between LV mass and velocity, increases with LV mass correlates with decreases in velocity but this was not found to be statistically significant, (n=63, r=-0.214, p=0.093). For respondents with no TOF, there was a very weak negative correlation between LV mass and velocity, increases in LV mass correlates with decreases in velocity, but this was not found to be statistically significant, (n=74, r=-0.161, p=0.182). Table 3

Discussion

This study explains the fact that left ventricular function in children with TOF is low when compared with normal children with any form of congenital heart disease. It also showed the interraction between left ventricular mass and aortic blood flow among children with TOF. We noted a negative correlation between descending aorta blood flow with left ventricular mass (LVM) in this study. It is noted that children with both repaired and unrepaired TOF, an abnormal aortic flow which is often associated with abnormal ejection flow patterns and low LVM was ascertained[13]. They also noted that though increased systolic velocity was not associated with right ventricular dilation, yet systolic blood flow in the left ventricle remains isolated and does not depend on impaired LV contractile mechanics and inter-ventricular interactions[13].

The markedly decreased left ventricular mass seen in children with TOF when compared to normal children was also supported by a study that noted reduced left ventricular mass and left ventricular volume among 31 children with

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TOF using cineangiocardiograms[14]. This study also showed impaired parameters of almost all indices of left ventricular function in children with TOF when compared to age and gender matched normal children. These parameters include the left ventricular internal diameter in diastole and systole, left ventricular posterior wall diameter, inter-ventricular septal wall diameter in systole and diastole. These reduced parameters of left ventricular systolic function in children with TOF could explain the changes that occur in the left heart size. It is noted that combination of impaired indices of LV function of children with TOF with resultant reduced pulmonary blood flow both had direct impact on reduce aortic blood flow[15]. The infarct and thrombosis experienced by these children may be explained by this phenomenon, but further study to seek if there is any impact/association between impaired left ventricular mass and impaired aortic blood flow on frequency of infarcts in children with TOF is needed to buttress this point. It has been documented that decreased LV mass and reduced pulmonary and aortic blood flow seen in children with TOF is a serious prognostic marker for mortality[15]. The decreased left ventricular ejection fraction seen in children with TOF may be explained by an increasing impedance and increased peripheral resistance of the great vessels[15]. Left ventricular ejection fraction begins in late systole during iso-volumetric contraction, which causes a decreased left ventricular volume and left ventricular mass causing a low wave systolic stress and systolic tension and decreased after load. Left ventricular function are very high predictor of pulmonary and aortic blood flow[15]. The decreased left ventricular function and left ventricular ejection fraction seen in this study has also been buttressed by Andrade[16] et al who noted decreased left ventricular ejection fraction and left ventricular mass in children with TOF . They stated the fact that children with TOF also present with left heart anomaly as against the well know right ventricular dysfunction seen among them[16]. A study has also shown cardiomyopathic changes that stemmed from impaired systolic and diastolic function in children with TOF. This probably arose from decreased left ventricular mass/volume ratio[16]. Van der Hulst[17] et al also noted depressed left ventricular function among children with TOF in their reportage when compared to normal children. They attributed this alteration to decrease global circumferential and radial strain in the left ventricle due to constant hypoxia and a shift to oxy-haemoglobin curve to the right with attendant erythropoesis[18-20].

Conclusion

Though it is generally known that children with TOF present with right ventricular dysfunction, however this study has shown that they also present with various degrees of left ventricular systolic abnormalities. Though left ventricular systolic function in children with TOF is lower than that in normal children, all values still fall within normal refrence ranges.

Recommendation

Assessment of children with TOF should include evaluation of the left ventricular function, especially the left heart catheterization. This will help to screen those who are at risk of sudden death from left ventricular dysfunction.

Declaration

Ethical Approval and Consent to participate

The approval of the Health Research Ethics Committee of the University of Nigeria Teaching Hospital, Enugu was obtained. Patients and parents or caregivers were duly informed in detail about the purpose of the study. An oral informed consent was obtained from parents or caregivers of all study participants while an assent was obtained in participants aged 7 years and older. The oral informed consent was approved by the the Health Research Ethics Committee of the University of Nigeria Teaching Hospital, Enugu. In addition, all methods were performed in accordance with the relevant guidelines and regulations or declaration of Helsinki. An informed consent was obtained from all subjects and their legal guardian(s).

Consent for publication

Not applicable

Availability of data and materials: Data are however available from the authors upon reasonable request and with permission of the corresponding Author

Competing Interest

The authors declare that they have no competing interests.

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Authors' contributions

CJM conceived and designed this study while CJM, OEN, CAT, OJT helped in critical revision of the article. CJM and OEN also did the Data analysis/interpretation. All authors have read and approved the manuscript.

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