Original Article

Aortic root dilatation among children with unoperated Fallot tetralogy. A clinical and echocardiographic study.

Khaleel I. Alsuwayfee* FIBMS

Abstract:

Bacground: Tetralogy of Fallot (TOF) is a commn congenıtal heart disease and it may be associated with aortic root dilation (ARD) before or even years after the surgical repair. To the best knowledge this is the first study in Iraq dealing with this issue.

Objectives : To dtermine the frequency of aortic root dilatation among sample of children with Fallot teralogy in Mosul-İraq and to asses its associated risk factors.

Patients and methods : A total of 110 children ,54 with TOF compared to 56 normal chıldren by echocardiography for determining the frequency of aortic root dilatation among both groups. Among TOF children different factors like age and sex, size of the ventricular sptal defect (VSD) ,degree of overrıdıng of aorta over the interventricular septum, severity of the right ventricular outflow tract (RVOT) obstruction , positive family history of TOF affecting other family member , the presence of previous paliative surgery like Blalock-Taussig shunt and the use of Beta receptors blocking drugs were evaluated for its possible association with the problem.

Results: Fifty four children with TOF (male :female=0.45) , mean age 67.55 ± 51.8 months and mean body surface area (BSA) 0.71± 0.47 m2 were compared to fifty six normal chıldren (male :female=0.46) , mean age 47.64 ± 39.59 months and mean BSA 0.60 ± 0.24 m2. The frequency of ARD among children with unoperated TOF was high (69 %) in the studied sample and goes with what was already known (15%-87%). Male sex , increasing patient age and severe (RVOT) obstruction with pulmonary hypoplasia were positivelly correlated with the increased risk of the development of ARD while the other factors did not show significant association.

Conclusion: Aortic root dilatation should be considered seriously in children with TOF and when ever possible surgical correction should be performed after infancy.

Key words: Fallot tetralogy, aortic root dilatation, echocardiography.

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İntroductıon:

The aortic root connects the heart to the systemic circulation and plays a major role in the function of the heart and cardiovascular system. It also maintains optimal coronary perfusion and plays a role in the maintenance of a laminar flow in the vascular system (1). The aortic root is an ensemble consisting of distinct entities: the aortic valve leaflets, the leaflet attachments, the sinuses of Valsalva, the interleaflet trigones, the sinotubular junction and the annulus .The aortic valve leaflets form the hemodynamic junction and physical boundary between the left ventricle and the aorta. All the structures distal to the hemodynamic junction are subject to arterial pressures, whereas all the proximal parts are subjected to ventricular hemodynamics. The annulus is the area of the smallest diameter in the blood path between the left ventricle and the aorta. The three bulges of the aortic wall are named the sinuses of Valsalva, after the Italian anatomist Antonio Valsalva. Two of the three
sinuses host the origin of the coronary arteries and the sinuses are termed accordingly the left, right and non-coronary sinus. They are limited proximally by the attachments of the valve leaflets and distally by the sinotubular junction. The distal part of the sinuses toward the ascending aorta together with the commissures form a tubular structure called the “sinotubular junction” which separates the aortic root from the ascending aorta (2)(Fıfgure I). Aortic dilation in known genetic syndrome (Marfan, Turner, Loeys–Dietz, and Ehler–Danlos syndromes) and congenital aortic diseases [bicuspid aortic valve (BAV), and coarctation of aorta (COA)] is well recognized(3). Aortic root dilatation is a well-known feature of TOF and is greatest in patients with TOF and pulmonary atresia. A medial abnormality coupled with increased aortic flow attributable to the right-to-left shunt are thought to be the pathogenetic mechanisms. Aortic regurgitation in TOF imposes volume overload on both ventricles, but more importantly on the right ventricle which also confronts systemic afterload . Aortic root dilatation may lead to aortic regurgitation, which may necessitate surgery. Risk factors for aortic dilatation and regurgitation in TOF relate to specific hemodynamic abnormalities such as pulmonary atresia, right aortic arch and a history of an aorto-pulmonary shunt, and patient demographics such as male sex and the association of chromosome 22q11 deletion (4). Definitive repair of TOF

**Dept. Ofpediatrics,Ninawa medical collegeNinawa universityy.*
Email.Khalilalhadidy@yahoo.com

is increasingly being undertaken at earlier ages and repair in infancy has become standard in many institutions. Early repair obviates the need for palliative shunts with their attendant complications, such as pulmonary artery distortion and ARD. Early pressure unloading of the right ventricle would prevent right ventricular fibrosis and perhaps late-onset arrhythmias. Early volume unloading of aortic outflow with definitive repair may avoid progressive ARD. When compairing infancy repair group to post infancy repair group , preexisting ARD normalizes by 7 years of age in patients with TOF who have been repaired in infancy, whereas it persists into adulthood in the group repaired postinfancy(5).

Aims of the study:

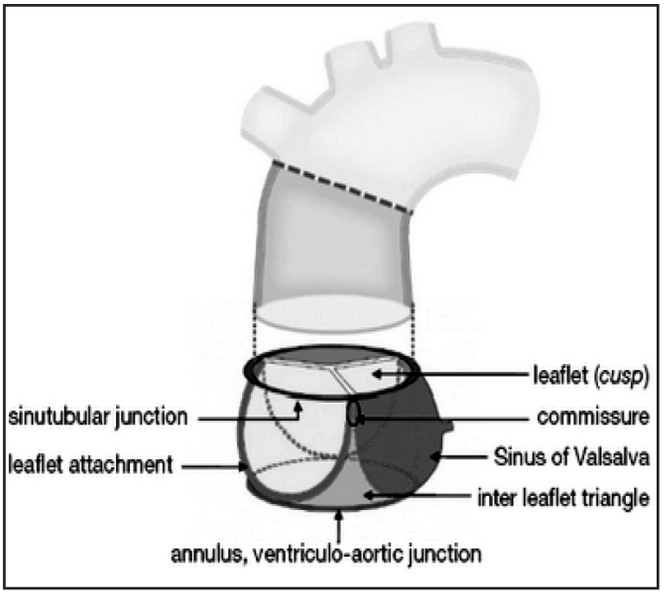
To study the frequency of ARD among sample of chıldren wıth TOF as well as to study the impact of ARD on the structural heart function of the children with unrepaired TOF.

Patients and methods:

This is a case control study performed in Al-Salam general teaching hospital in Mosul province in Iraq during the period from 01/01/2014 untill 01/06/2014 on a sample of children who were less than 14 years old and reffered to the pediatric cardiology and echocardiography unit for evaluation. After proper clinical evaluation demographic data obtained followed by echocardiographic examination in the recumbent position or left lateral position using Vived 3 GE ultarasound machine with 3MHZ and 7 MHZ multifrequency transducer. Body surface areas were calculated using Mosteller formulla. Aortic root parameters including aortic anulus , sinus of Valsalva , vestibulotubular junction and early ascending aorta were evaluated ın the long axis parasternal view using two dimension eho mode and M mode and in the same way the size of the ventricular septal defects were assesed (Figure II) . Left ventrıcular systolic and and diastolic dimensions as well as ejection fraction are assesed in same view using the M mode while colour and continuousand or pulse folw Doppler mode was used to asses valve regurgitations and flow velocities for aorta and right ventricular outflow tract with the latter being assesed in the short axis left parasternal view. Aortic root parameters of each child were assesed in relation to their height and body weight by Z-score using data from Boston Children's Hospital(18). İf z score of any parameter was more than 2 it was considerd as abnormally high value compared to the normal. Among patients with TOF different factors were evaluated for its associasion with the development of ARD including patient age and sex, size of the ventricular sptal defect (VSD) ,degree of overrıdıng of aorta over the interventricular septum severity of the right ventricular outflow tract (RVOT) obstruction , positive family history of TOF affecting other family member, the presence of previous paliative surgery like Blalock-Taussig shunt and the use of Beta receptors blocking drugs. Statistical Package for the Social Sciences (SPSS) v.18 was used for the statistical analysis regarding the calculation of means, confedence intervals and p values.

Results:

In this study 54 children wıth unoperated TOF (male :female=0.45) , mean age 67.55 ± 51.8 months , mean BSA 0.71± 0.47 m^2 and mean Z score for aortic anulus ,sinus of valsalva ,sinotubular junction and and ascending aorta were 3.9341, 2.9413 , 1.9136 and 1.2900 (95% CI for the mean 3.3495 to 4.5187, 2.4302 to 3.4523 , 1.2215 to 2.6058 and1.0223 to 1.5577) respectively ,were compared to 56 normal chıldren (male :female=0.46) , mean age 47.64 ± 39.59 months and mean BSA 0.60 ± 0.24 m^2 mean Z score for aortic anulus ,sinus of valsalva ,sinotubular junction and and ascending aorta were 0.9085 , 1.2636 , 0.9061 and 0.8012 (95% CI for the mean 0.6716 to 1.1453, , 0.9762 to 1.5510, 0.6223 to 1.2577 and 0.613 t0 1.112) respectively, for determining the frequency of aortic root dilatation among both groups (table1). There was significant difference between both groups in relation to the frequency of aortic root dilatation at the levels aortıc sinus, sinus of Valsalva and sinotubular junctıon ın decreasing frequency while it was not significant at the level of early ascending aorta (Fıgure 3). Also all patients who got aoric root dialations at the level of sinotubular junction got dilatation at the other levels and ın the same way all those with dilated aortic root at the leve of sinus of Valsalva got dilatation at the level of aortic anulus. Regarding the age only 3 (7.69 %) patient with dilated aortic root were infants , 21 (53.84 %) were 1-5 years old and 15 (38.46 %) were > 5 years old showing ıncreased risk of aortic root dilatation with advanced patients age .Regarding sex associasıon 21 of 39 TOF children (53.84 %) who got ARD were male compared to 25 % ratio among TOF chıldren without ARD which was stastically significant difference (p= .024). However there was no any posıtive or negative asoociation with the other variables like family history of TOF , the use of Beta receptors blocking drugs, size of the VSD , degree of aortic overrıding on the septum or the presence of palliative shunt , while severe RVOT obstruction in the presence of pulmonary arterial hypoplasia (as demonstrated by cardiac catheterization previously or by echocardiographic study) were posatively associated with the problem in such way all patients with pulmonary hypoplasia(n=4) got ARD. One of the consequnces of aortic root dilatation is the aortic valve regurgitation which were demonstrated with moderate severity among (9/39) of TOF children who got the dilatation and and in (3/15) among TOF childern without dilatation but the diference was statistically not significant (p=0.8). When the left ventricular function were evaluated by measuring the cariac ejection fraction and fractional shortening none of of all the patients whether with or without dilation had abnormally low cardiac function and the same thing was true for the left ventricle dimensions during systole and diastole.



Fıfgure 1. Aortic root components (2).

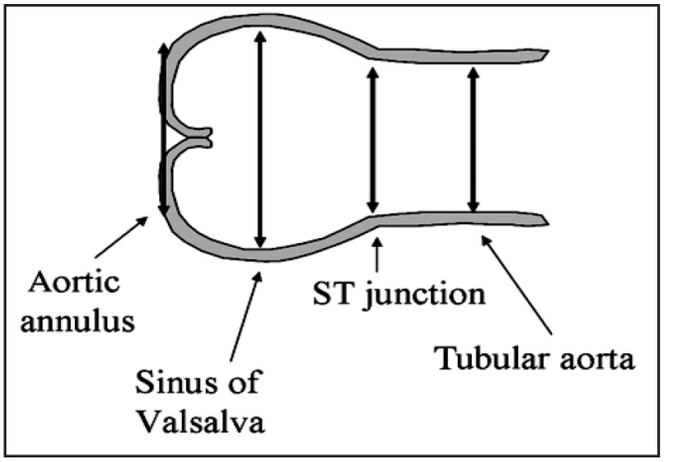


Figure 2. Levels of aortic root measurement by echocardiography .From European Journal of echocariography 2010 (19).

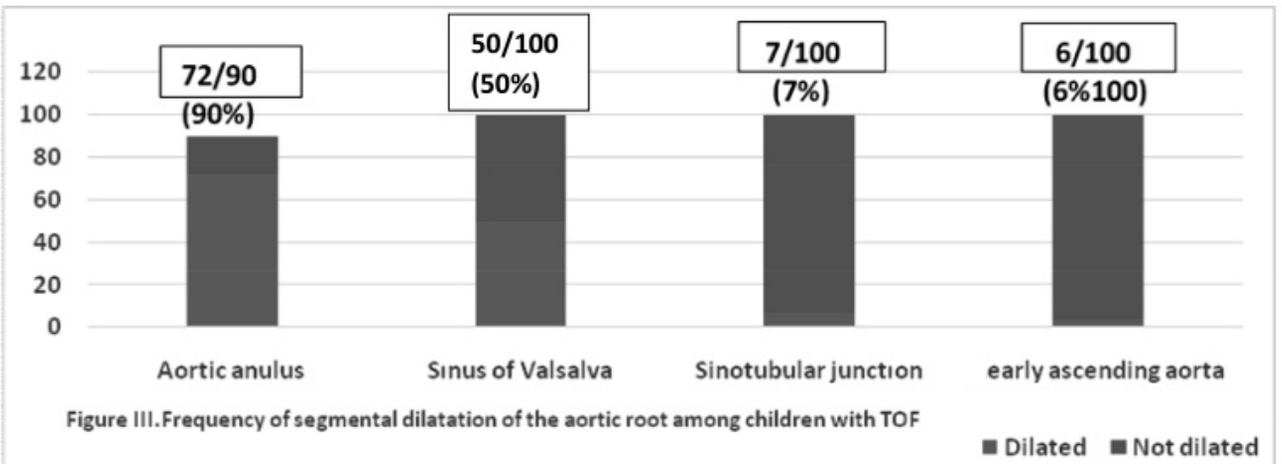


Figure III. Frequency of segmental dilatation of the aortic root among children with TOF

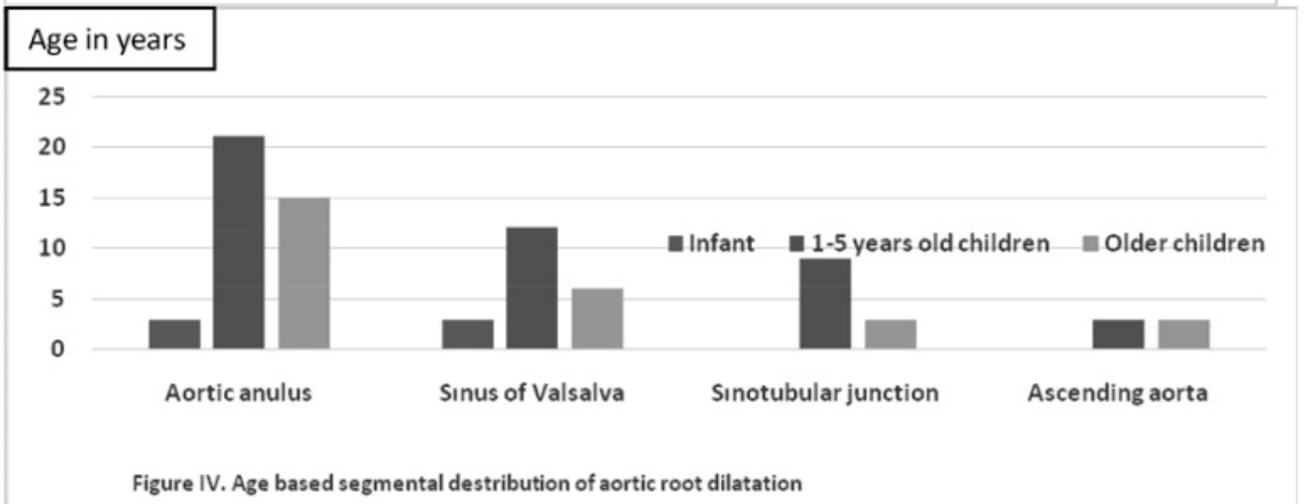


Figure IV. Age based segmental destribution of aortic root dilatation

Table 1.Frequency of aortic root dilatation

Category	Patient		Control		P-value
	Dilated (Z score >2)	Non dilated (Z score <2)	Dilated (Z score >2)	Non dilated (Z score <2)	
Aortic anulus	39	15	0	56	< 0.00001.
Sınus of Valsalva	27	27	2	56	< 0.00001
Sınotubular junction	4	50	0	56	.038008
Ascending aorta	2	52	0	56	0.146102

Discussion

Fallot tetralogy is the commonest cyanotic congenital heart disease among Iraqi children and represents about 10 % of all congenıtal heart disease ın Iraq and worldwide (6,7,8). Increased aortic blood flow due to RVOT obstruction and possible aortic wall pathology lead to ARD among patients with TOF which has been described among those patients with negative effect on the aortic valve function and left ventricular sytolic dysfunction because of the subsequent development of aortic valve regurgitation and aortic aneurysm and dissection (8,9,10,11). Although iatrogenic valve damage, recurrent/ residual ,VSD, or infective endocarditis were highlighted as causes of postrepair aortic regurgitation in earlier studies, ‘‘idiopathic’’ root dilatation seems to be the most common cause today (2). This problem is well studied among children and adult patients with TOF after surgical repair of their disease but less among unoperated ones like what was done ın this study (13,14,15). In this study the frequency of ARD was significantly higher than the control group (69 % versus 3.7 % , p< o.o5). It was impossible to find similar national publications for comparism , but other studies performed on operted adults and children showed a prevalence of 15%-87 % at defferent levels of the aortic root with increasing prevalence from 17% to 50 % during the period 1980-1990 , which is going with what we found by this study; a finding could be explained by the simllar nature of causation of the problem which are the increased antegrade flow and structural wall abnormalities of the aortic root among children with TOF (3,8,14). This study showed that age is important factor for the development of ARD and need to be seriously considered among childern with TOF . The frequency of the problem was least among infants , highest among preschool children and less among older children (Figure 4) this is different from what was found by other studies ((13,14,15) which demonstrated higher prevalence in older patients i.e the older the age the higher the prevalence in other studies and this is probably because older chilren and adolescents are evaluated by adlut cardiologists rather than by the pediatric cardiologist in Iraq and the number of older children with TOF that we included in our study was less than the reality if compared to the other studies performed elsewhere. Bhat et al(5) and François K et al (17) found that aortic dimensions normalize by the age of 7 years if TOF was repaired in infancy, while they remain higher than normal in case of later repair, a conclusion that needs to be taken in consideration during patient assesment for surgery so that early surgical repair should become a standard approach whenever it is possible. According to this study , male sex was a risk factor for the development of aortic root dilatation , a finding that is supported by other studies (3) but there is no clear explanation for this fiding , prpably genetic factors or higher level of child activity among male group that causes higher left ventricular output are the possible reasons . Other factors that are evaluated for its association with the develoment of aortic root dilatation among our patients like the size of the VSD ,degree of overrıdıng of aorta over the interventricular septum , the use of Beta receptors blocking drugs or positive family history of TOF affecting other family member all found not to be positively or negatively associated with development of the problem because the severity of the right ventricular outflow tract (RVOT) obstruction is the main factor that determines the magnitude of of the right to left shunt and the degree of increased aortic blood flow. The presence of previous palliative surgery like Blalock-Taussig shunt was also not found to be associated with the problem in contrast to Bhat AH (6) who stated that mean post shunt aortic annular size was significantly larger than preshunt annular size and this can be explained by the fact that only 2 of our studied children (very small number compaired to the referrence n=99) got palliative shunt in the form of Blalock-Taussig shunt while other types of shunts were not part of the studied sample. Left ventricle dilatation also did not have positive association with the ARD which is different from what was found by Cruz C et al (16) who related the left ventricular sıze and function as predictor for the development of the problem ,probably this can be explained by the fact this study was echocardiography only based study compaired to the others which used Computed tomography scan, megnatic resonance imaging and or cardiac catheterization for evaluation (3,16,17).

Conclusion:

Aortic root dilatation was highly prevelant among the studied children with unoperated TOF especially in male group, a

problem that necessitate a prompt and regular evaluation and when possible early surgical repair after infancy.

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