Echocardiographic study of aortic root diameter in healthy children

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ABSTRACT

Objectives: Echocardiography is commonly used to measure the internal diameter of aortic root, which provides the evaluation of aortic root dilatation. Aortic root dilatation provide information concerning prognosis of aortic regurgitation and predisposition to aortic root dissection or rupture. The purpose of the study was to create normal values for aortic root diameters by using echocardiography in healthy children.

Methods: We obtained the aortic root diameters in 229 normal children, aged one day to 15 years by using M-mode echocardiography. We performed the echocardiograms from the Department of Pediatric Echocardiography Laboratory, Medical Faculty, Dicle University, Turkey. We divided the children into 6 groups according to their body surface area (BSA): 0.20-0.25 m^2, 0.25-0.50 m^2, 0.50-0.75 m^2, 0.75-1.0 m^2, 1.0-1.25 m^2, and 1.25-1.50 m^2. We corrected the aortic root diameters for BSA.

Results: The aortic root diameters in children were 7.6 mm to 24 mm with a mean value of 14.8 mm. The corrected aortic root diameter for BSA ranged from 10.7 to 40.6 mm/m^2 with a mean value of 19.9 mm/m^2. Aortic root diameters increased with age, weight and BSA. In contrast, aortic root diameter/BSA values were higher in younger children.

Conclusion: The presented aortic root diameters according to the BSA will serve as reference data for echocardiographic evaluation of patients with various cardiac diseases.

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The aortic root grows with the normal children, and it correlates well with height and body surface area, independent of gender.[1-3] The knowledge of normal aortic root diameter is important for evaluating children with aortic root dilatation and the management of children with aortic disease.[4] Aortic root dilatation is a major pathophysiological mechanism for aortic regurgitation and predisposes the aortic root to dissection or rupture which accounts for 1-2% of deaths in industrialized countries.[5] When the aortic root diameter increases, aortic valve cusps are unable to expand in area, and the cusp overlap is reduced, eventually leading to aortic regurgitation.[6] Aortic root dimensions can be accurately measured by M-mode echocardiography which is commonly used as a method of monitoring aortic root dimensions in children with connective tissue disease. Measurements are usually standardized to body surface area (BSA) to account for growth.[2,4,7] Knowledge of normal great vessel dimensions is often needed in the planning of cardiac surgery in children. Attempts to define 'normal' have so far given varied and somewhat controversial results. The purpose of this study was to determine normal values for aortic root diameters by using M-mode echocardiography in healthy children.

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Methods. We examined 229 (152 males and 77 females) healthy newborns, infants and children without cardiac disease or a history of cardiac involvement in infectious, neuromuscular or metabolic disorders with echocardiography. Most were outpatients referred for evaluation of a heart murmur which was found to be innocent on clinical, electrocardiographic and radiological grounds. The others, especially newborn infants, were inpatients in whom cardiac examination was performed to exclude congenital malformations. Chest x-rays were only performed in children in whom there was suspicion of a thoracic structural abnormality or a history of chronic obstructive lung disease. Only patients with no evidence of an abnormality were included. Their age ranged from one day to 15 years. The baseline characteristics of the study population expressed as mean±SD are shown in **Table 1**. Transthoracic echocardiographic examination was performed with the patient lying supine or in the left lateral semirecumbent position. No sedation was used during echocardiography. Examinations were carried out by a single pediatric cardiologist using a commercially available machine (Hewlett-Packard Sonos 1000, with 2.5 and 3.5 MHz transducers). Standard parasternal, apical, subcostal and suprasternal views were used. Echocardiographic measurements of the aortic root diameter were made by M-mode echocardiography at the level of the sinuses of Valsalva, according to the recommendations of the American Society of Echocardiography (ASE) and guided by cross-sectional echocardiography.[8] The aortic root diameters were measured using the parasternal short axis view. The children were divided into 6 groups according to their BSA: 0.20-0.25 m^2, 0.25-0.50 m^2, 0.50-0.75 m^2, 0.75-1.0 m^2, 1.0-1.25 m^2, and 1.25-1.50 m^2. Aortic root diameters were corrected for BSA and means, SD and min-max values were estimated (**Table 2**).

Statistical analyses and the calculations were performed using SPSS for Windows, version 10.0. The strength of the associations between the aortic root dimension and age, weight and BSA was assessed using Pearson correlation coefficient (r value). Differences between means of males and females were assessed with Student's t test. A *p* value of <0.05 was considered significant.

Results. The aortic root diameters in all children were 7.6 mm to 24 mm with a mean value of 14.8 mm. The corrected aortic root diameter for BSA ranged from 10.7 to 40.6 mm/m^2 with a mean value of 19.9 mm/m^2. Aortic root dimensions calculated in relation to BSA were greater in younger children. For example, mean value of aortic root diameters was 8.35 ± 0.62 in newborns and 11.9 ± 2.24 in infants, wherein diameters corrected with BSA the mean value was determined 36.54 ± 3.41 in newborns and 29.19 ± 4.60 in infants (**Figures 1 & 2**). The aortic root diameter showed good correlation with age (r=0.75, *p*=0.00), weight (r=0.73, *p*=0.00), and BSA (r=0.74, *p*=0.00). There were no significant differences in aortic root diameters (*p*=0.065) and diameters corrected with BSA between (*p*=0.62) the sexes. The results of aortic root diameters and diameters corrected with BSA are presented in **Table 2** with mean, SD and min-max values.

Table 1 - Population characteristics. Values are shown as mean (SD).

Characteristics	Cases		
	newborn	infant	2-15 age
Male/female	7/4	18/6	127/67
BSA	0.23 (0.02)	0.38 (0.08)	0.92 (0.28)
Weight (kg)	3.72 (0.50)	7.40 (2.26)	25.73 (10.97)
AR (mm)	8.52 (1.05)	12.75 (4.60)	15.70 (3.23)
AR/BSA (mm/m^2)	36.6 (4.07)	33.49 (4.74)	17.89 (4.05)

BSA - body surface area, AR - aortic root diameter

Table 2 - The results of aortic root diameters (AR) and diameters corrected with body surface area (BSA) are presented as mean, SD and min-max values.

BSA	n	AR (SD) min-max	AR/BSA (SD) min-max
0.20-0.25 m^2	11	8.35 (0.62) 7.6-9.5	36.54 (3.41) 31.4-40.6
0.25-0.50 m^2	32	11.29 (2.24) 7.6-16	29.19 (4.59) 16.2-39.3
0.50-0.75 m^2	62	13.17 (2.09) 9-18	20.53 (2.82) 15-26.1
0.75-1.0 m^2	48	15.52 (2.32) 11-22	17.82 (2.47) 11.5-22.9
1.0-1.25 m^2	41	16.98 (2.23) 12-23	15.2 (2.18) 10.7-22.3
1.25-1.50 m^2	35	19.5 (2.43) 16-24	14.51 (1.89) 10.7-18.68

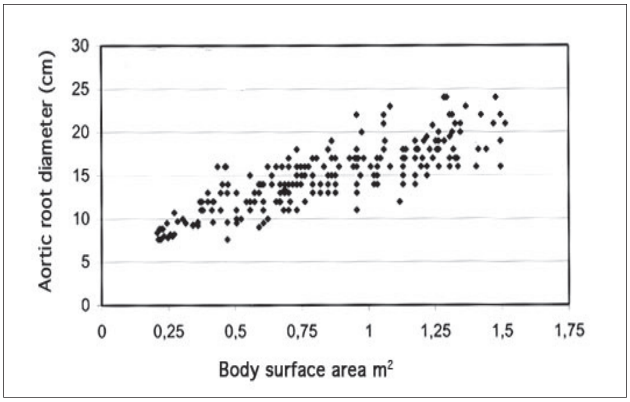

Figure 1 - Relation of body surface area to aortic root diameter in normal newborn, infants and children.

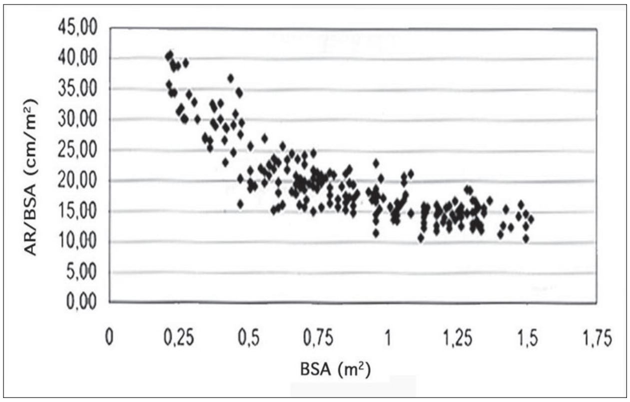

Figure 2 - Relation of body surface area (BSA) to aortic root diameter (AR) corrected with BSA (AR/BSA) in normal, infants and children.

Discussion. Echocardiographic methods are commonly used to measure the internal diameter of aortic root, which provides the evaluation of aortic root dilatation. Aortic root dilatation gives information on prognosis of aortic regurgitation and predisposition to aortic root dissection or ruptures in different diseases, and is a common finding in Marfan's syndrome, aortic stenosis, bicuspid aortic valve, patients after surgical repair of tetralogy of Fallot and so forth.[9-12] Nidorf et al[13] have studied cardiac dimensions in 196 children (aged from 6 days to 18 years) and have reported that heart and great vessels grow in unison and at a predictable rate after birth, reaching up to 50% of their adult dimensions at birth, 75% by 5 years and 90% by 12 years. As the aortic root widens with growth in childhood in the normal population, normal values of aortic root diameter is important in the diagnosis and follow-up of patients with various cardiac abnormalities.[13] Aortic dimensions have been related to both BSA and height.[13-15] Roman et al[16] have reported a linear relation with BSA and aortic dimensions in children aged from one month to 15 years.[17] A few studies, including also newborns and infants, have reported a logarithmic relationship between BSA and aortic dimensions.[13,15] Also, in the present study, age, weight and BSA correlated well with aortic root diameters. In comparison with previously published normal values determined with M-mode echocardiography, our mean values of aortic root diameters are smaller than Kampmann et al,[7] study but in the presented min-max limits. Also, our mean values of aortic root diameter over BSA's are smaller than Poutanen et al,[4] and the mean values of the aortic root diameter in our study groups are also in the 95% confidence limits used as the standard for children proposed by Roman et al.[16] Our data, however, were obtained from M-mode echocardiography, whereas Roman et al,[16] study on nomogram was based on 2-dimensional echocardiography. Information on differences in the diameter of the aortic root between the 2 modes is limited. Roman et al,[16] who studied 52 normal children with both echocardiographic approaches, observed that the aortic root diameters at the level of the sinuses of Valsalva were systematically larger when assessed by cross-sectional echocardiography than by M-mode, by a mean of 2 mm. They found aortic root dilatation in 40% of normal children when 2 dimensional measurements were compared with M-mode nomograms.[16] Cassottana et al[17] reported that M-mode echocardiography systematically overestimated the 2-dimensional echocardiography aortic diameters at the level of the anulus, as well as at the level of the sinuses of Valsalva and of the supra-aortic ridge.[17] In contrast, Rozendaal et al[3] found no systematic clinically relevant difference between the 2 methods and reported that factors such as 2 different technicians, intraobserver and interobserver variability, the use of different recorders and transducers, and different patient positioning largely account for the distribution of these differences in measurement results. Consequently, they reported that the 2 modes can be used interchangeably and 2 different nomograms for either cross-sectional or M-mode echocardiography did not appear to be necessary.[3] Poutanen et al[4] notified that the greater estimates for aortic sinus by 2-dimensional echocardiography than by M-mode may lead to false diagnoses of aortic root dilatation if adequate reference data are not used. Thus, the normality of 2-dimensional echocardiography aortic root measurements should be compared with normal values assessed by 2-dimensional echocardiography. In the last 15-20 years there have also been dramatic improvements in echocardiographic equipment, whereby it is now possible to obtain direct digital measurements, while 2 dimensional resolutions afford more accurate placement of the M-mode beam.[7]

The presented aortic root diameters according to the BSA from a large group of healthy children will serve as reference data for echocardiographic evaluation of patients with various cardiac diseases and for further studies.

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