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The diameter of coronary arteries in infants and children without heart disease

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Abstract. Two-dimensional echocardiographic examinations of the proximal left and right coronary artery were performed in 100 children without heart disease. Fifty-nine boys and 41 girls were studied whose ages ranged from 1 day to 17 years old. The diameter of the proximal right and left coronary artery was 1 mm in newborns and 4.5 mm in teenagers. No significant difference was observed between male and female subjects. A linear correlation between the coronary artery dimensions and the patient's age, weight, length, and body surface area could be demonstrated. The closest linear correlation corresponded to the patient's length with a correlation coefficient of $r = 0.91$ and $r = 0.89$ for the right and the left proximal coronary artery respectively. A quick orientation concerning normality of coronary artery diameters is possible with our graph of body length and corresponding coronary artery size. Knowing normal echocardiographic values for proximal coronary artery diameters, even subtle changes of these vessels can be diagnosed and the number of invasive diagnostic procedures, e.g. in Kawaski disease, can be reduced.

Key words: Coronary vessels – Echocardiography – Paediatrics

Introduction

The most serious complications of Kawasaki disease are inflammatory manifestations of the myocardium and of the coronary arteries [3, 5]. According to a nationwide Japanese study [12], the incidence of dilations, aneurysms, and stenoses or occlusions of the coronary arteries is about 17%. A special score, created by Asai and Kusakawa, helps in predicting these cardiac risks [4].

Angiocardiography is still the most frequently performed diagnostic method to rule out coronary alterations in patients with Kawasaki disease and with a high risk score. Two-dimensional echocardiography (2d-E) is highly sensitive and specific in detecting saccular aneurysms compared to angiography [2], but it is less reliable in differentiating between tubular aneurysms, dilations, and stenoses [10]. This is partly due to the scanty number of echocardiographically measured coronary artery dimensions in infants and children without heart disease. Therefore, we performed a prospective study to establish reliable standards for coronary artery calibres during infancy and childhood.

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Abbreviation: 2d-E = two-dimensional echocardiography

Subjects and methods

A total of 100 children, 59 boys and 41 girls, underwent examination by 2d-E for suspected heart disease, which could be excluded in all cases. Their ages ranged from 1 day to 17 years old.

We used a real-time mechanical sector scanner (Ultramark 8, Advanced Technology Laboratories) with a 5 MHz and a 7.5 MHz transducer. Their theoretic axial resolution, according to the data supplied by the manufacturer, is 0.66 mm and 0.4 mm, respectively. A standard precordial short axis view of the aorta was recorded. From this position the left main coronary artery could be identified in all cases.

By moving the transducer superiorly and clockwise, visualization was possible up to the bifurcation in the left anterior descending branch and in the circumflex branch (Fig. 1).

For identification of the proximal right coronary artery, once again a precordial short axis view of the great vessels was used. By moving the transducer slightly superiorly and counterclockwise until the tricuspid leaflets disappeared, the origin of the right coronary artery could be visualized in 65% of our patients, mostly in infants (Fig. 2).

In order to standardize the method, the maximal end-diastolic inner diameter of the coronary arteries was measured directly at their ostium. For this purpose an integrated computerized measurement device was used. After freezing the optimal frame, the diameter was determined by cursors and the distance was automatically displayed with an accuracy of 0.1 mm. We did not round up these values, but dealing with them implies considering the axial resolution of the transducers.

Peripheral parts of the coronary arteries were excluded from this study because there is only little variability in coronary artery size from the ostium up to 1 cm distally [1] and because visualization of the more distal parts of the coronary arteries is often difficult. Fortunately, involvement of the distal coronary arteries without that of their proximal parts is very rare in Kawasaki disease [3, 6].

Correlation analysis, based on a 95% confidence limit, was used to test linear correlation between age, weight, and length of each child and the corresponding size of the coronary

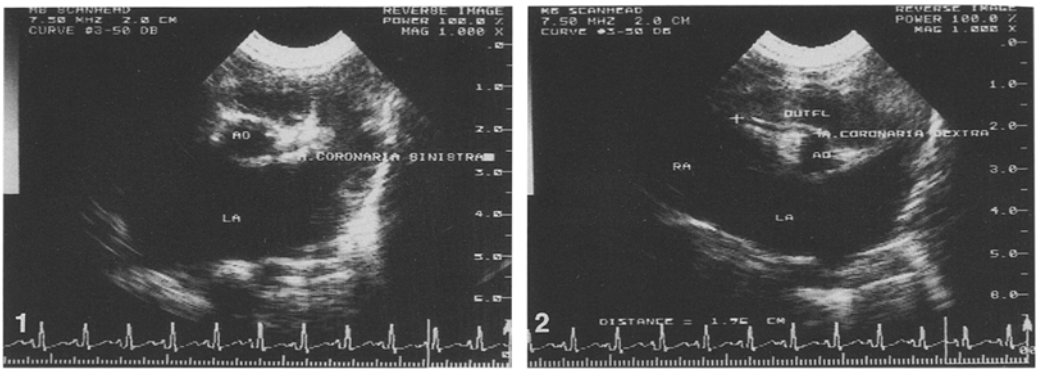

Fig. 1. Two-dimensional echocardiography (2d-E) of a 2-month-old boy. Parasternal short axis view. Left proximal coronary artery. Bifurcation into anterior descending and circumflex branch. *AO*, aorta; *LA*, left atrium

Fig. 2. 2D-E of a 2-month-old boy. Parasternal short axis view. Right proximal coronary artery. Homogenous calibre up to 2 cm = the distance between the two marks (+). *AO*, aorta; *LA*, left atrium; *RA*, right atrium; *OUTFL*, right ventricular outflow tract

arteries. Significant linear correlations were documented in a graphic form which showed the measuring points surrounded by a 95% tolerance ellipse. This type of documentation takes into account that the proportional increase of the measured variables ceases after adolescence. Statistical comparisons were made using the Student's *t*-test.

Results

The diameter of the proximal coronary arteries (right and left) in 100 patients ranged from 1 mm in newborns to 4.5 mm in teenagers. There was no significant difference between 59 male and 41 female subjects.

Figure 3 shows a linear correlation between the patients' age and coronary artery dimensions. The correlation coefficient was $r = 0.89$ for the right and $r = 0.86$ for the left main coronary artery. There was the same close relation for body surface area and coronary artery calibre ($r = 0.89$ for the right, $r = 0.86$ for the left) and a slightly worse correlation for body weight ($r = 0.86$ for the right, $r = 0.83$ for the left coronary artery) (Fig. 4).

The closest linear correlation was found for the body length (Fig. 5). The coefficient of correlation was $r = 0.91$ and $r = 0.89$ for the right and the left proximal coronary artery respectively.

Discussion

2d-E is useful and reliable to examine proximal coronary arteries in infancy and in childhood, as already emphasized in other studies [1, 9].

Due to an adequate number of subjects, we are now able to present echocardiographical normal values for proximal coronary artery dimensions in infants and children without heart disease.

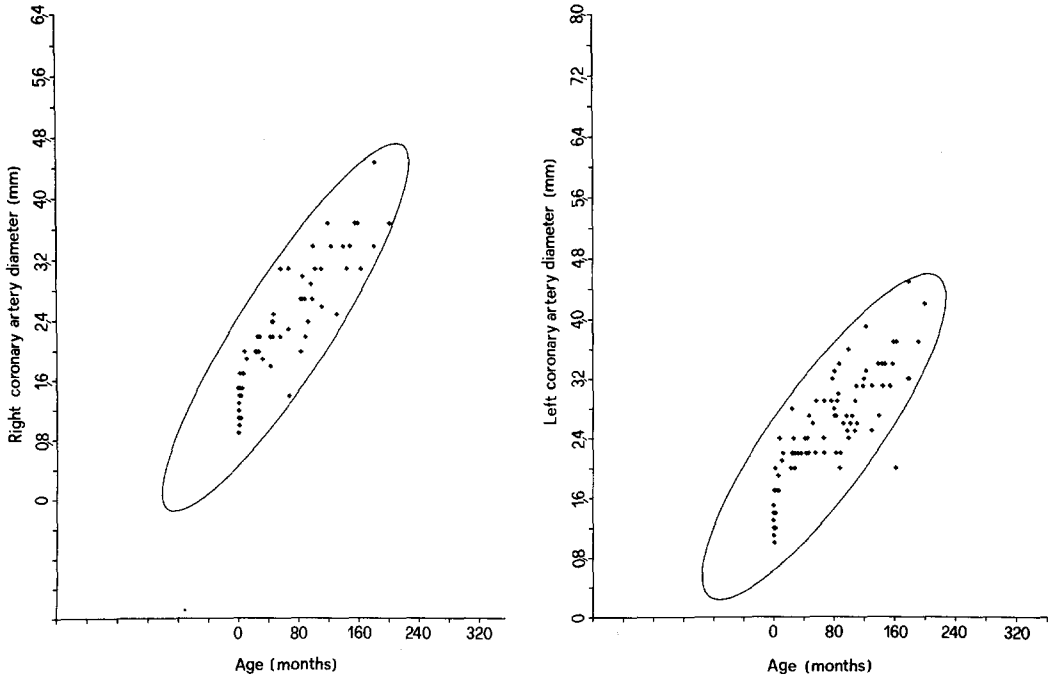

Fig. 3. Linear correlation between age and proximal coronary artery diameter (right coronary artery: $N = 62$, $r = 0.89$; left coronary artery: $N = 96$, $r = 0.86$). 95% tolerance ellipse

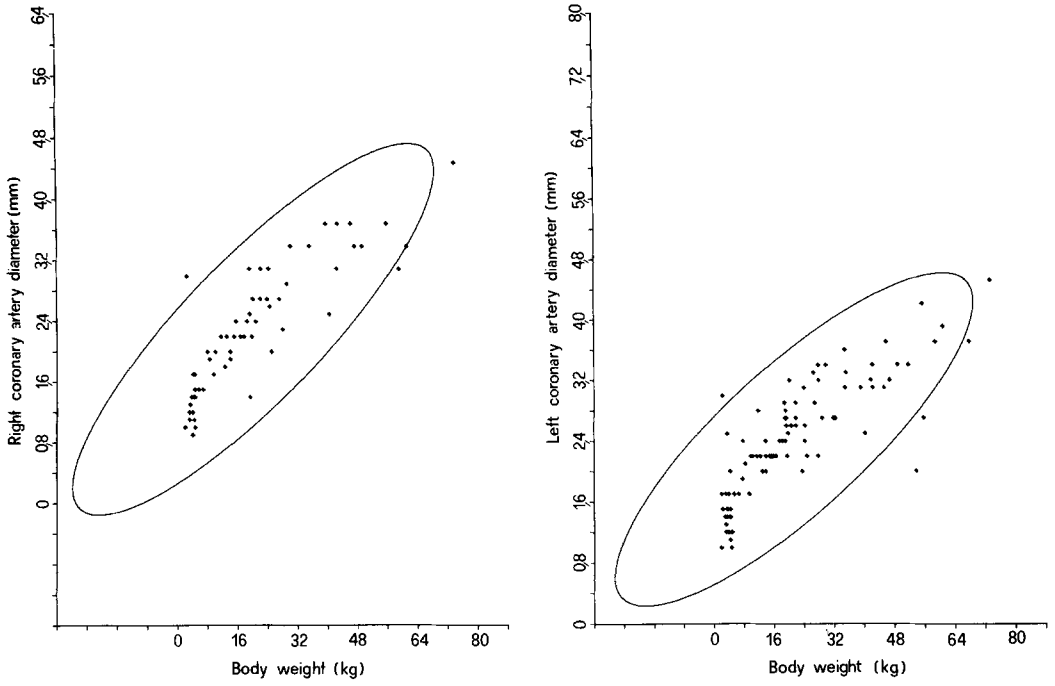

Fig. 4. Linear correlation between weight and proximal coronary diameters (right coronary artery: $N = 62$, $r = 0.86$; left coronary artery $N = 96$, $r = 0.83$). 95% tolerance ellipse

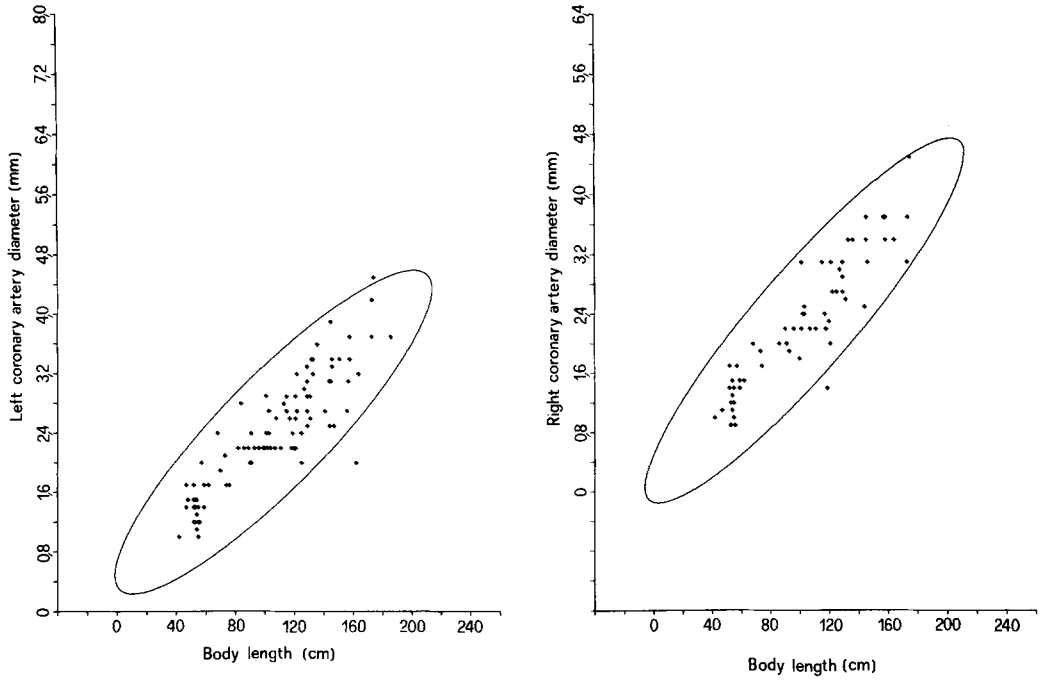

Fig. 5. Linear correlation between length and proximal coronary artery diameter (right coronary artery: $N = 62$, $r = 0.91$; left coronary artery: $N = 96$, $r = 0.89$). 95% tolerance ellipse

Their diameter ranges from 1 mm in newborns to 4.5 mm in teenagers without significant differences between male and female subjects. Our results are confirmed by Arjunan's echocardiographic study in 42 healthy children, where a diameter of 2 mm was found in infants and children and of 5 mm in young adults [1].

Our study of 100 children shows that there is a significant linear correlation between age, weight, length, and coronary artery calibres in normal children. The measured values of a normal population of children fit into the corresponding elliptical graph with a probability of 95%.

For practical use the patient's length presents as an ideal dimension to deal with, since it is easy to obtain and has the best linear correlation with the proximal coronary artery size.

The results of our investigation are also confirmed by angiocardiographically measured coronary diameters [1,7]. In patients with Kawasaki syndrome without coronary artery involvement they are comparable but consistently smaller than values obtained by 2d-E [1]. Coronary artery spasm, caused by the contrast medium, and the method of angiocardiographic measurements that exclude the coronary artery wall may account for this phenomenon [1].

Between angiocardiographically measured coronary arteries [7] and body surface area there is a linear correlation ($r = 0.74$ for the right and $r = 0.80$ for the left main coronary artery), whereas our measurements suggest an even closer relationship.

In contrast to angiocardiography, which may cause complications in patients with coronary artery lesions in the active period of Kawasaki disease, 2d-E is a safe, non-invasive diagnostic method at every stage of the illness. We have found that it takes from 5 to 10 min, depending on experience, to obtain an optimal echocardiographic view of the coronaries and in order to assess their diameter. The interobserver error for these measurements, as noted by Arjunan et al. [1], is relatively small considering that coronary vessels are tiny and constantly moving.

Besides Kawasaki disease, transposition of the great arteries is a field of application for echocardiographic examination of the coronary arteries. Knowing their diameters in normal infants and children their echocardiographic assessment before and after switch operation may be facilitated.

In conclusion, by knowing normal echocardiographic values for proximal coronary artery diameters, even subtle changes of these vessels can be diagnosed and the number of invasive diagnostic procedures in Kawasaki disease could be further reduced. Primary coronary or aortic root angiography should only be necessary in those patients with a high risk score in whom echocardiographic visualization of both proximal coronary arteries is not possible. To be sure, echocardiography can only be relied on for diagnosis of lesions in the proximal portions of the coronary arteries and not for their recognition in the distal parts. A quick orientation concerning the normality of proximal coronary artery diameters is possible with our graph of body length and corresponding coronary artery size.

Recent reports have emphasized that stenoses account for the greatest number of late complications in Kawasaki disease [8, 11]. An early diagnosis of this affection using close serial 2d-E follow-up studies could prevent the risk of sudden death.

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