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The measurement of the dimension of the human aortic ring using echocardiography: anatomical correlations and statistical investigation of 219 living subjects

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Key words: Aortic ring dimensions, echocardiographic measurements.

SUMMARY

Using echocardiography, the dimensions of the aortic ring were measured in 219 healthy adults (103 men and 116 women; age range: 22 to 56 years). The mean diameter was determined to be 25 ± 1.9 mm (26 ± 2 in the men and 24 ± 1.8 mm in the women). It was directly proportional to both body surface area ($p < 0.01$) and height ($p < 0.01$). The mean aortic ring diameter and the body surface area (BSA) could be related mathematically by the relationship: aortic ring diameter = 15 mm × BSA (m^2); similarly, the relationship between the mean diameter of the aortic ring to height (h) could be expressed as: aortic ring diameter = 15 mm × h (m). Statistically significant correlations were not observed between the aortic ring dimensions and age, although the dimensions tended to increase with age. The mean values in men were found to be higher than those in women by a statistically significant margin.

These results were compared with clinical and anatomical findings and with the classical anatomy textbook. This comparison revealed that our values were distinctly higher than those published in the textbooks.However, when compared with more recent clinical, surgical, and anatomical data, our results agreed fairly well. The discordance with classical measurements may have been due to differences in methodology or, more likely, to differences of weight and height in the populations studied.

INTRODUCTION

This study originated from the observation that the aortic ring dimensions reported by several investigators in various anatomy textbooks differ substantially

from those reported in more recent cardiology textbooks (Braunwald, 1984) and from our own echocardiographic data. A very interesting study by Leguerrier, *et al.* (1982) has shown that the aortic ring dimensions of patients requiring surgical treatment for aortic stenosis (which leads to a reduction of the dimensions of the ring) were in fact higher than the normal values reported in the classical literature. The data from their anatomical studies confirmed (with no substantial differences between fresch and preserved heart specimens) that the aortic ring dimensions were in fact higher than those reported in the classical literature, and of course they were higher than those reported in patients requiring surgical correction of aortic stenosis. Furthermore, their data were higher in men than in women by a statistically significant margin ($p < 0.01$) and were directly proportional to height and body surface area ($p < 0.01$).

Using 2-dimensional echocardiography, the aim of our study is to determine precisely the dimensions of the aortic ring in a random population of healthy adults. With the aim of establishing possible correlations with sex, body surface area, height, and age, these findings were then compared with the data published in the anatomical and non-anatomical literature. In comparison with cadaveric measurements, the advantages of our method are the abscence of probable morphological distortions secondary to tissue changes and preservation. In comparison with surgical studies, the advantages are the possibility of obtaining the measurements under stressless conditions; moreover, the relevant dimensions may be measured several times using more sensitive instruments than those employed under conditions of tensione and urgency, as frequently occur during open-heart surgery. Moreover, reliable values of circumference may be obtained only with echocardiography: because of the nature of the organ, the circumference can be measured only with difficulty, both in the cadaveric state and during open-heart surgery.

MATERIALS AND METHODS

Two hundred nineteen healthy adults with no cardiac disorders (103 men and 116 women; age range: 22 to 56 years) were studied. Using high-resolution M-mode and 2-dimensional echocardiography, the diameter and circumference of the aortic ring were measured in the parasternal projection parallel to the long and short axis of the left ventricle and in the apical four-chamber projection.

An Acuson mod. 128 echocardiographic apparatus with a 3 MHz transducer was used.

The subjects were chosen randomly from patients with no cardiac or extracardiac pathology. the measurements of the aortic ring were performed 4 times in each projection.

Figure 1 shows several echocardiographic images that demonstrate the measurement of the dimensions of the aortic ring. The diameter of the aortic ring was obtained by taking the mean between the direct measurement of the diameter and

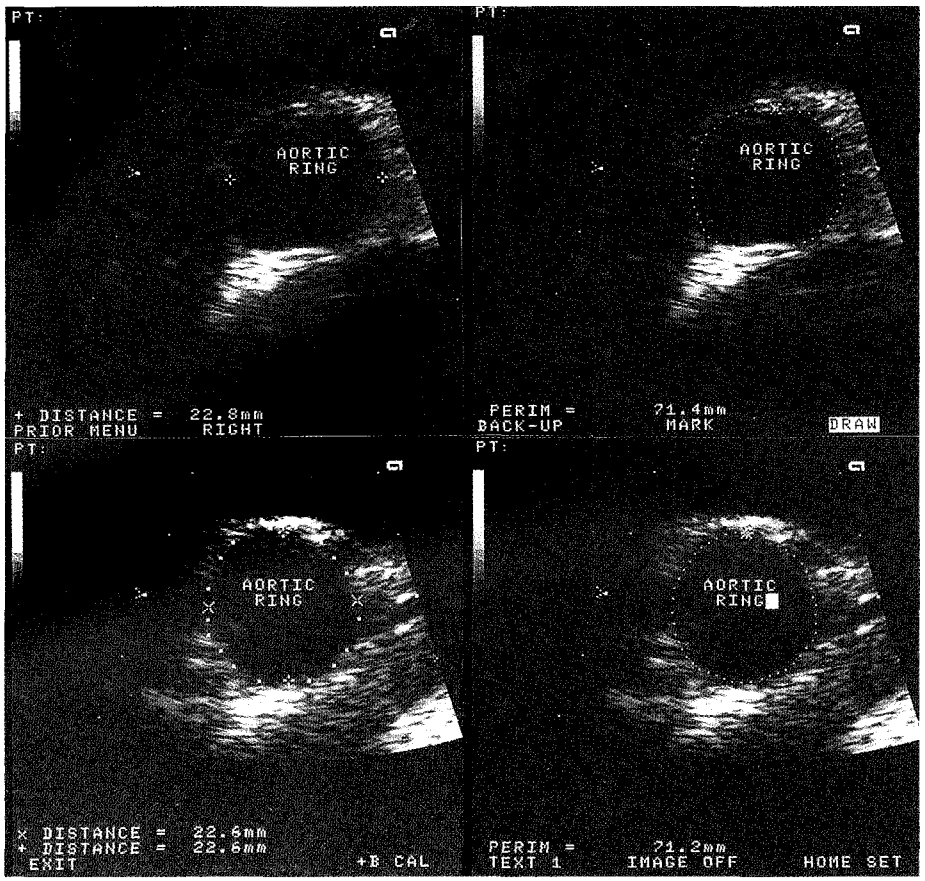

Fig. 1A — Method of visualization and measurement of the diameter and the circumference of the aortic rings examined using echocardiography.

the diameter calculated from the circumference. These values are expressed in millimeters.

RESULTS

The aortic ring diameters of the 219 subjects are given in *Figure 2*. The mean diameter was found to be 25 ± 1.9 mm, with a minimum of 21 mm and a maximum of 30 mm. In the women, the mean diameter was 24 ± 1.8 mm, while in the men it was 26 ± 2 mm ($p < 0.01$). The aortic ring dimensions were found to be directly proportional to the body surface area (*Fig. 3*); this correlation was statistically significant ($p < 0.01$). The mean diameter was found to be 15 mm per mm² of surface area. Similarly, we observed a statistically significant ($p < 0.01$) correlation

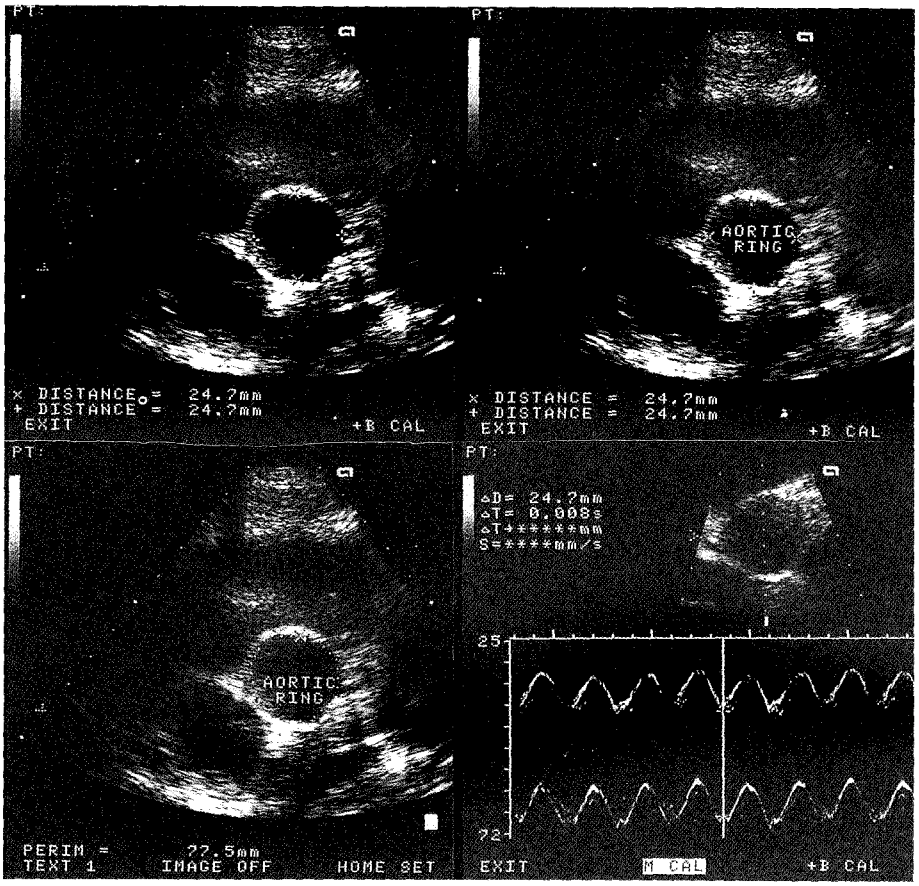

Fig. 1B — Method of visualization and measurement of the diameter and the circumference of the aortic rings examined using echocardiography.

Fig. 2 — Dimensions of the aortic ring (echocardiographic examination): mean values (mm ± sd).

males	26 ± 2	females	24 ± 1.8	total	25 ± 1.9

between the dimensions of the aortic ring and height (*Fig. 4*): the mean diameter was found to be 15 mm per meter of height. These correlations are in turn related to sex, since height and body weight are lower in females than males.

DISCUSSION AND CONCLUSIONS

Our results confirm that the dimensions of the aortic ring are truly higher than those classically described in anatomy textbooks (*Fig. 5*). In fact, among the latter,

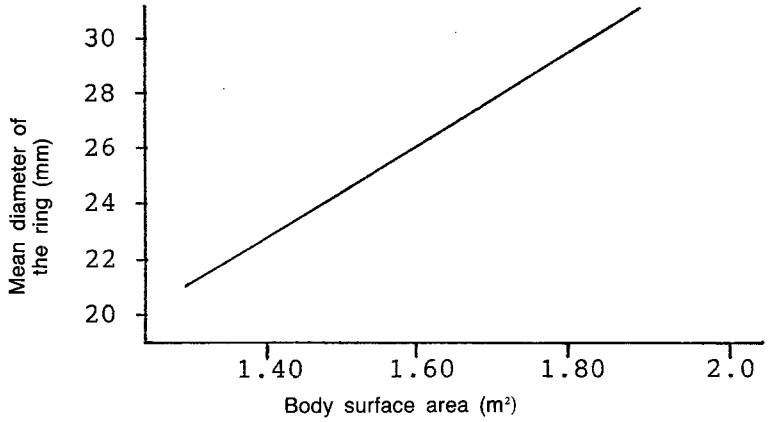

Fig. 3 — Correlation between the mean diameter of the aortic ring and the body surface area.

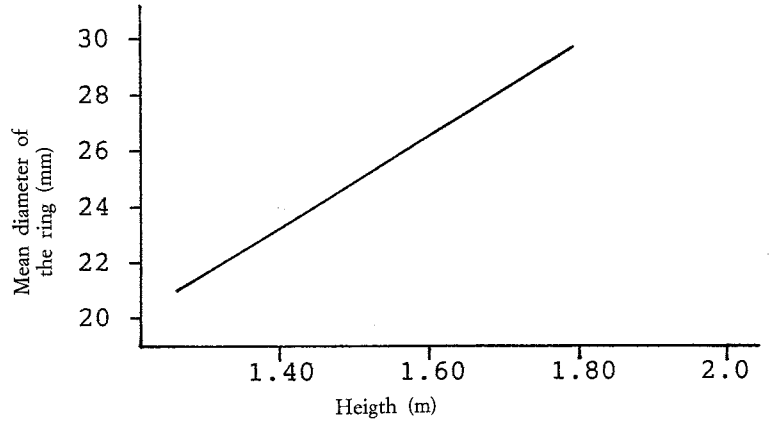

Fig. 4 — Correlation between mean diameter of the aortic ring and heigth.

Fig. 5 — Dimensions of the aortic ring (classical measurements): mean values (mm ± sd).

Poirier et Charpy	21.15	Paturet	15
Chiarugi	21.3	Rouvière	22.3
Gérard	21.5	Testut and Latarjet	21.5

the average of the mean values of aortic ring diameter is 20.45 mm, as compared to 25 mm, which we report. They correspond to circumferences of 64.23 and 78.5 mm, respectively. one may no more than suppose that this discordance is statistically significant, since single values are not provided in the classical literature (see *Fig. 5*).

On the other hand, with the exception of insignificant differences, our results agree with those of Leguerrier (1977), who has reported a mean diameter of 23.97 mm (22.4 in women and 24.6 in men) in patients who underwent aortic valve replacement and a mean diameter of 25.23 mm (23.8 in women and 26.9 in men) in an anatomical study in which there was no significant difference between measurements in fresh and preserved heart specimens. With respect to Braunwald (1984), the mean diameter that we report is lower by as much as 2 mm (25 as compared to 27 mm).

With regard to correlations between aortic ring dimensions and sex, age, body surface area, and height, uniformity may be found among the classical textbooks of anatomy and cardiovascular medicine, but our values differ significantly from those reported by the classical anatomy textbooks. This is confirmed by authoritative textbooks of cardiovascular medicine (Braunwald, 1984) and in scientific works which compare anatomical data and surgical data on living patients (Leguerrier, *et al.*, 1982). While on the one hand they confirm the reliability and specificity of our method for the determination of the dimensions of the aortic ring, this discordance is perplexing. As a matter of fact, with the exception of Paturet (1958), who reports a mean diameter of 15 mm and thus a circumference of 47 mm, the mean aortic ring diameters reported in the classical anatomical literature are concordant among themselves.

This may be explained as either erroneous data or, more likely, by differences in the method of measurement. In the latter case, however, the methodology must have been common to almost all the authors, given the similarity of their results. Alternatively, there may have been an overall difference in the weight and height of the subjects studied. This is important, insofar as there is a statistically significant correlation among the aortic ring dimensions, weight, and height. Furthermore, one must keep in mind that many of the studies classically reported by anatomy textbooks date to the early years of the 1900s, when studies were typically performed on a limited number of subjects. Between then and today, the mean values of stature and body weight have changed significantly (Pineau, 1970). Furthermore, stature varies from state to state and from region to region (Pineau, 1970). The same is true of body weight (Pineau, 1970), which depends on the constitution of the subject and is also influenced by the economic well-being of the state or region.

One may well wonder at the level of interest in the dimensions of the aortic ring, aside from the naturally justified gnosiological and cultural interest in a piece of anatomical data whose value reported by us and authoritative clinical investigators contrasts markedly with that reported in the classical anatomical literature.

From a clinical point of view, the dimensions of the aortic ring are of great importance in cases of aortic valve disorders that require surgical intervention. In fact, from a hemodynamic point of view, the performance of a mechanical valvular prosthesis is enormously influenced by the internal valvular diameter, which is obviously proportional to the dimensions of the aortic ring (Brawley, 1975). In the case of a small aortic ring, a prosthesis may be hemodynamically inadequate; in such a case, a preliminary enlargement of the aortic ring may be required (Konno, 1975; Bloch, 1978). the importance of an exact determination of this parameter is clear, even in a clinical setting. The echocardiographic method that we have described can provide this information.

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