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Measurements of the descending aorta in infants and children: comparison with other aortic dimensions*

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INTRODUCTION

With the development of new methods for surgical correction of congenital cardiovascular malformations, reference data on the internal diameters of the ostia of the heart and of the great vessels of normal newborn, infants and children are essential. The introduction of the M-mode and two dimensional echocardiography serves, in a certain way, this purpose. Measurements have been made on those parts of the heart and great vessels which can be visualized with these methods. However, it is not easy to visualize and measure the descending aorta distal to the ductus arteriosus (Allen, Lange, Sahn & Goldberg, 1978; Wladimiroff, McGhie & Vosters, 1981). Measurements on the descending aorta are therefore few, especially in the newborn. This paper presents post mortem reference data on the descending aorta and other segments of the first part of the aorta in normal infants and children, up to the age of 10 years, who died from non-vascular diseases.

MATERIAL AND METHODS

The material obtained at autopsy consisted of 126 hearts and great vessels of infants and children, who died from non-vascular diseases. The age range was from 21 weeks of gestation up to 10 years after birth.

Internal diameters of the aortic ostium, ascending aorta (1 to 2 cm beyond the valve), aortic isthmus (between left subclavian artery and ductus arteriosus), descending aorta (1 cm distal to the insertion of the ductus arteriosus) and ductus arteriosus were measured with the aid of calibrated probes, differing 1 mm in diameter. Diameter values up to the nearest 0·5 mm were ascertained by interpolation. This method and its reliability have been described previously (van Meurs & Klein, 1974; van Meurs, Klein & Krediet, 1977).

Linear regression analysis was used to investigate the relations between various types of data. The statistical analysis of the results was carried out using Student's *t*-test. A difference was considered as significant if the two-tailed probability was $< 0{\cdot}05$ (Sachs, 1973).

OBSERVATIONS

In four graphs the following relations are depicted: internal diameter of aortic ostium versus body length (Fig. 1); internal diameter of ascending aorta versus body length (Fig. 2); internal diameter of aortic isthmus versus body length (Fig. 3) and

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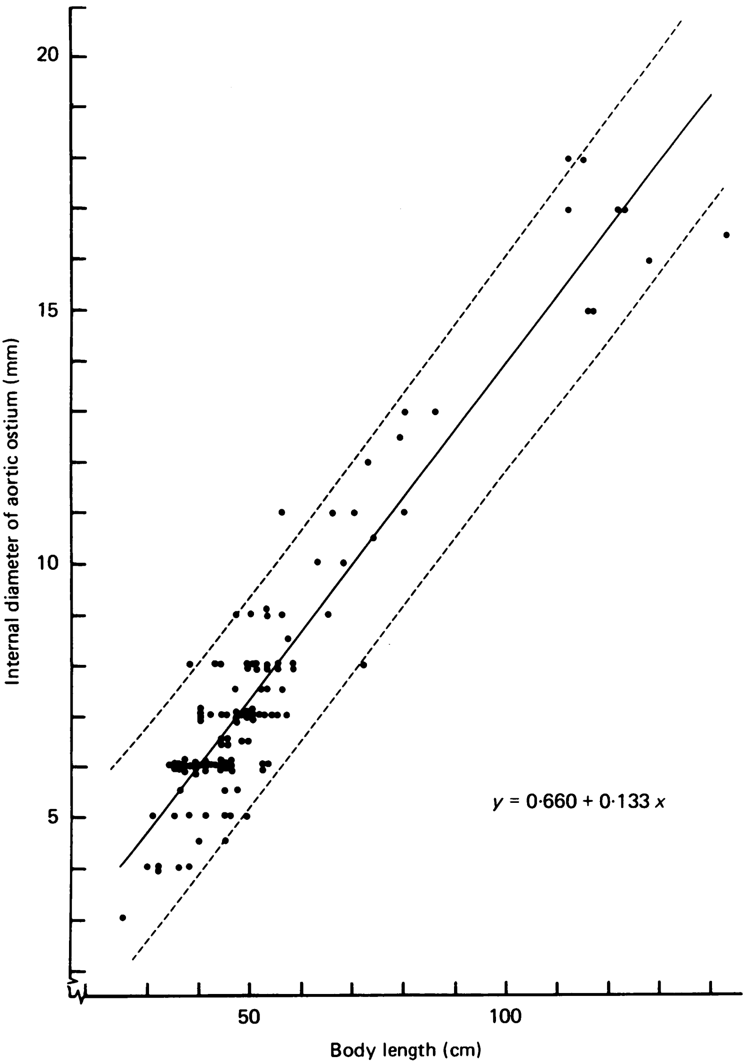

Fig. 1. Relation between internal diameters of aortic ostium and body length; interrupted lines indicate '95 % limits'.

internal diameter of descending aorta, 1 cm distal to the insertion of the ductus arteriosus, versus body length (Fig. 4). The 95 % limits of the data are included.

The different groups of measurements showed a linear correlation with body length: the approximately fivefold increase in body length, from 30 to 140 cm, was accompanied by parallel increases in the internal diameters of the aortic ostium and of the ascending aorta from about 4·5 to 19·5 mm, and by parallel increases in internal diameters of the aortic isthmus and of the descending aorta from about 3·5 to 14·5 mm.

The regression lines of the internal diameters of the aortic ostium and of the ascending aorta did not differ significantly from each other ($b = 0{\cdot}133$ versus $b = 0{\cdot}138$). Similarly, the regression lines of the internal diameters of the aortic isthmus and of the descending aorta did not differ significantly from each other

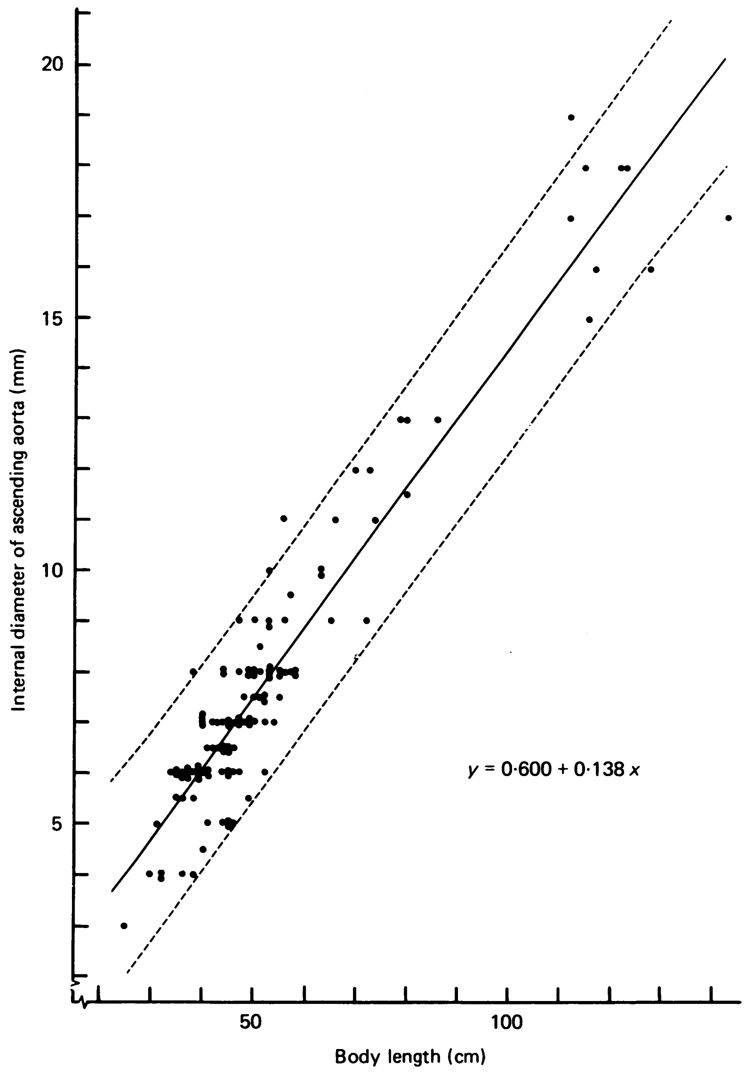

Fig. 2. Relation between internal diameters of ascending aorta and body length; interrupted lines indicate '95% limits'.

(b = 0·102 versus b = 0·090). However, the regression lines of the internal diameters of the aortic ostium and of the ascending aorta differed significantly from those of the aortic isthmus and the descending aorta (b = 0·133 and 0·138 versus b = 0·102 and 0·090), but in nine cases the internal diameter of the ascending aorta was equal to that of the descending aorta. The data on the aortic isthmus showed more variation than those on the other parts of the aorta measured.

Dividing the 126 hearts into two groups, those with an open ductus arteriosus (97 cases, internal diameter of the ductus from 0·5 to 6·5 mm) and those with a closed ductus (27 cases) and computing regression lines for these two groups as described above, it was found that the regression lines of the internal diameters of the aortic ostium, ascending aorta, aortic isthmus and descending aorta of the cases with an open ductus did not differ significantly from those with a closed ductus.

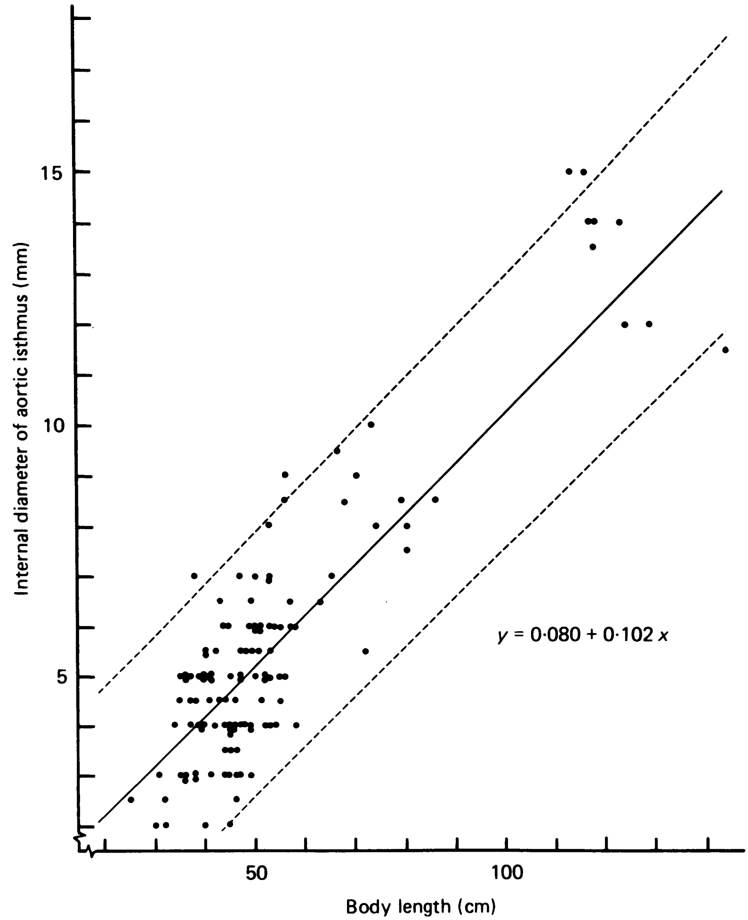

Fig. 3. Relation between internal diameters of aortic isthmus and body length; interrupted lines indicate '95% limits'.

DISCUSSION

Congenital malformations of the aortic arch are common. In the development of their surgical corrections and of non-invasive determinations on cardiac output and blood flow in the fetal descending aorta (Wladimiroff *et al.* 1981) it is necessary to know accurately the dimensions of the aortic arch including its descending part, but detailed studies on the calibres of the various parts of the aorta are few, especially for infants and children.

Other investigators have measured the aorta with the aid of a ruler after slitting and flattening the vessel. However, different pressure on the ruler can give variations of 4 mm (Beneke, 1878; Rowlatt, Rimoldi & Lev, 1963; Wright, 1969). Measurements on plastic casts and cine-angiographic measurements (Sinha *et al.* 1969; Wright, 1969; Rudolph, Heymann & Spitznas, 1972; Shinebourne & Elseed, 1974) may also not be fully reliable: we have noted that gas bubbles in plastic casts and incorrect filling of the vessels with contrast can cause variations greater than those observed using our technique (van Meurs & Klein, 1974). Recent M-mode echocardiographic ultrasound studies on normal persons showed that imaging of the

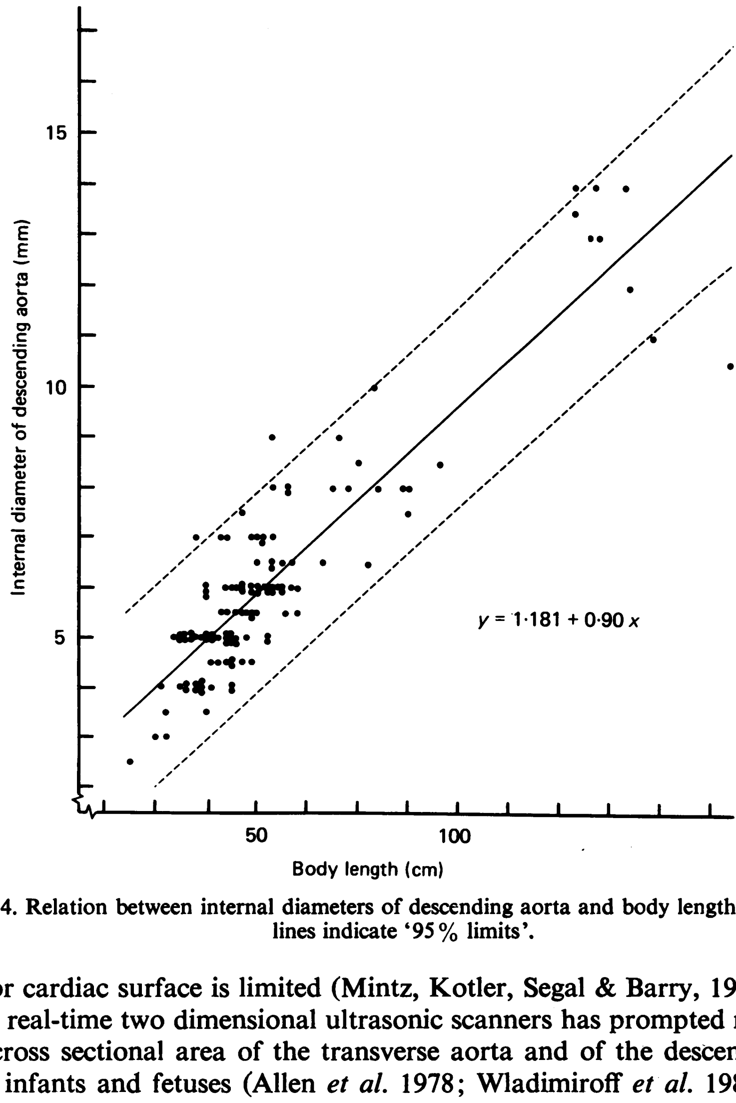

Fig. 4. Relation between internal diameters of descending aorta and body length; interrupted lines indicate '95% limits'.

posterior cardiac surface is limited (Mintz, Kotler, Segal & Barry, 1979). Improvement in real-time two dimensional ultrasonic scanners has prompted measurements of the cross sectional area of the transverse aorta and of the descending aorta in normal infants and fetuses (Allen *et al.* 1978; Wladimiroff *et al.* 1981). However, data on correlation between the dimension of the aortic arch and body length or body surface in infants and children, to be discussed later, are few. Since our post mortem data on the aortic and pulmonary ostium, derived from measurements with the aid of calibrated probes, correspond with echocardiographic data (van Meurs *et al.* 1977), we again used this method to measure the aortic arch to the descending aorta 1 cm distal to the ductus arteriosus.

Dimensions of vessels as parameters of growth are usually related to body surface. We decided to use body length as a parameter of growth, because near-death body weight of children can change considerably within a few days, which is not the case with body length. The data revealed linear correlations between the internal diameters of the aortic ostium, ascending aorta, aortic isthmus and descending aorta and body length (Figs. 1–4). The regression line of the internal diameters of the aortic ostium did not differ significantly from those derived from 46 hearts in a previous paper (b = 0·126 versus b = 0·133; van Meurs *et al.* 1977). The regression line of the internal diameters of the aortic ostium did not differ from that of the ascending aorta and the regression line of the aortic isthmus did not differ from that of the descending aorta. The data on the aortic isthmus showed more variation than those on the other parts of the aorta. This is due to a greater variation in internal diameter at the time of birth, which has already been discussed in a previous paper (van Meurs & Krediet, 1982).

In our study we found that the internal diameter of the ascending aorta is, with few exceptions, larger than that of the descending aorta. This is at variance with the literature. Rudolph *et al.* (1972), Sinha *et al.* (1969) and Shinebourne & Elseed (1974) found cine-angiographically in neonates that the ascending aorta had a diameter similar to that of the descending aorta. In our material we found this in only nine out of the 126 cases (7 %). Rosenberg, Klima, Henderson & McNamara (1971) stated, based on work with the aid of casts, that in premature infants and in infants up to 2 years of age the internal diameter of the ascending aorta was slightly larger than that of the descending aorta with a ratio of 1·13. In our material we found such ratios to be 1·25 in the cases with an open ductus (age up to 10 weeks) and 1·40 in the cases with a closed ductus (age range from 3 days to 10 years after birth). From this we may conclude that the internal diameter of the ascending aorta increases more in size during bodily development than that of the descending aorta. The ascending aorta is the stem vessel of the aortic tree and so provides a sufficient blood flow through the aortic arch during bodily development the stem of the aortic arch must grow more in diameter than each of its branches.

After the closing of the ductus arteriosus, blood flow through the descending aorta depends only on blood flow through the ascending aorta. In spite of the alterations in blood flow after closing of the ductus we could not find differences in internal diameter of the descending aorta between the cases with open and closed ductus.

We compared our post mortem data on the ascending aorta, 1 to 2 cm beyond the valve, with the echocardiographic data *in vivo* of the ascending aorta at the level of the right pulmonary artery, obtained with the suprasternal notch position (Allen *et al.* 1978). The echocardiographic data, re-calculated using the Table by van Wieringen (1973) for converting body surface area to body length, are just at the lower 95 % limits of our data for the ascending aorta. Since the ascending aorta is smaller at the level of the right pulmonary artery than 1 cm beyond the aortic ostium, it was found again that our post mortem data correspond with the echocardiographic data *in vivo*.

The embryological origin of the descending aorta is different from that of the ascending aorta, i.e. dorsal aorta versus truncus arteriosus. Therefore, it is of interest to know whether the alterations in vessel calibre, such as those reported here for these parts of the aortic arch, are accompanied by comparable histological changes in the vascular wall. This will be of clinical importance in the assessment of the chance of normal outgrow of the aortic arch after surgical correction. The investigation of such histological changes will be the next step in defining border lines between the normal and pathological conditions.

SUMMARY

In paediatric cardiovascular surgery, knowledge of internal diameters along the first part of the aorta is essential. This paper presents reference data on the internal diameters of aortic ostium, ascending aorta, aortic isthmus and descending aorta, 1 cm distal to the ductus arteriosus. Measurements were made with the aid of calibrated probes in 126 post mortem specimens of normal hearts with great vessels. The age range was from 25 weeks of gestation up to 10 years after birth.

The data revealed linear correlations between the internal diameters of the different parts of the aortic arch and body length. At variance with the literature, we found that, with few exceptions, the internal diameter of the ascending aorta was greater than that of the descending aorta.

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