The Anatomy of the Posterior Wall of the Abdominal Aorta

ITS SIGNIFICANCE WITH REGARD TO HYPOPLASIA OF THE DISTAL AORTA

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SUMMARY

The anatomy of the posterior wall of the abdominal aorta has been studied in 100 cadavers, and has been correlated with the aortic diameter at four levels. In a group of 52 randomly selected White cases, 8 had a common single origin for the lowest pair of lumbar arteries, and in these cases, the mean diameter of the aorta decreased significantly ($P<0.025$) between the level of the inferior mesenteric artery origin and the bifurcation, in comparison with the remaining 44 cases. The mean decrements in cross-sectional area were 14% and 4%, respectively. It is suggested that hypoplasia of the distal aorta is due to a congenital defect occurring about the 25th day of intra-uterine life, when the two dorsal aortae fuse excessively while joining to form the abdominal aorta.

The anatomy of the region was found to vary considerably, and the description of the 'normal' given in current anatomical textbooks was true in only 43% of cases.


But on the internal surface of the great artery, from the superior branches quite to the emulgents, were beginnings of future ossification.

'This artery, though in a body of tall stature, was scarcely thicker than a finger of moderate size; and the other sanguiferous vessels, also, were narrow in the same proportion.'

John Baptist Morgagni (1733)

In the preface to the 5th edition of the textbook Anatomy — Regional and Applied, the author refers to anatomy as 'a fascinating subject, much of which is still not fully understood'. One has only to compare several of the major textbooks of anatomy to realize that controversy still exists over morphological details of certain regions of the body, and this is particularly true of the posterior aortic wall and its branches. The undergraduate dissection programme frequently stops at the anterior aortic wall, leaving the great vessels in situ and undisturbed.

In this article, we present an account of certain aspects of the anatomy of the posterior wall of the aorta of 100 cadavers, and suggest a possible mechanism to explain an anomaly which has been reported in the literature with increasing frequency over the past 70 years.

MATERIALS AND METHODS

The aortae measured in this study were obtained from two sources: 49 were studied in situ in cadavers in the Anatomy Department, and 51 were removed during routine postmortem examinations. The selection of cases was entirely random, with the exception of a few specimens in which the anatomy was grossly distorted by atheromatous disease and its sequelae, and these were excluded.

The initial purpose of the study was to see if there was any correlation between the diameter of the aorta and the anatomy of its posterior wall. The circumference of the aorta was measured directly with a vernier caliper at 4 levels after the vessel had been incised along its anterior aspect and opened flat, and the diameter obtained by dividing by $\pi$. These levels were at the diaphragm, immediately below the renal arteries, midway between the renal arteries and the bifurcation (approximately at the inferior mesenteric origin), and immediately above the bifurcation. The posterior wall was then dissected to show the morphology of the lumbar and middle sacral arteries. Finally, the distance between the orifices of the paired vessels was measured.

The study was limited to the abdominal aorta, the first centimetre of the common iliac vessels, and the origins of the posterior lumbar arteries. The further course and branches of the vessels were not followed.

In measuring the circumference of the opened-out aorta, care was taken to standardize the procedure in view of the compressability of the tissue, particularly in measuring the unfixed specimens. In practice, the mean was taken of several readings at each level. The diameter of the aorta was calculated from the measured circumference.

In cases where more than 4 pairs of lumbar arteries were present, the level of the first pair was carefully noted in relation to the lumbar spine to ensure that the subcostal arteries had not been inadvertently counted. In all cases the presence of median sacral artery was demonstrated, to avoid counting it as a fifth single lumbar vessel.
RESULTS

Of the 100 cases, 40 were females and 60 were males. The ages ranged from 15 to 96 years.

In analysing the results of the study, the most notable point was the marked variation in the anatomy. Out of 100 cases, only 43 had a 'normal' anatomical arrangement of 4 pairs of lumbar arteries. Of the remaining 57 cases, 13 had 5 pairs of lumbar arteries, and the remaining 44 cases had one or more pairs of lumbar vessels which arose as a common trunk varying in length from 1 mm to 20 mm before bifurcating into left and right branches (Fig. 1).

The relative incidence of single trunks at the 5 levels was as follows. At the level of the first lumbar branches, 3 cases out of 100 had a common origin. At the second, 16 cases had a common origin; at the third, 16 cases, and at the fourth, 29 cases had a common origin. Some cases had a common trunk at more than one level while others at only one level.

Finally, it was of interest to note that 21 cases had a fifth pair of lumbar arteries of which 8 had a common origin, and 13 were paired (see Table I).

The aortic dimensions at the 4 levels were as follows. At the diaphragm the mean diameter of the 100 aortae was 1.66 cm ± 0.30 cm. At the infrarenal level 1.34 cm ± 0.26 cm; at the mid-point 1.33 cm ± 0.27 cm and at the bifurcation 1.30 cm ± 0.26 cm (see Table II).

The cases were then divided into 2 type groups, the first consisting of those cases having a common lumbar artery origin at the lowest level with all the upper lumbar arteries being paired, while those with any other anatomical variation were placed in the second group.

There were 16 cases in the first group—12 males and 4 females, and 84 cases in the second group—48 males and 36 females.

The mean value was obtained for the aortic diameters of each group, and although the first group tapered slightly more than the second, the difference between the two was not statistically significant.

The cases were then separated into racial groups in view of the marked racial difference in the incidence of atheroma, and this was of interest because although the Bantu and Coloured cases in whom atheroma is uncommon continued to show no significant difference between the two types, the White cases showed a marked difference. There were 52 White cases of whom 8 were of the first type and 44 of the second.

The mean diameters and standard deviations of the two groups were as follows. At the 4 levels described above, the mean diameters of the 8 cases having a single lumbar artery trunk at the lowest level only were 1.77 ± 0.22 cm, 1.53 ± 0.22 cm, 1.49 ± 0.18 cm, and 1.38 ± 0.22 cm, respectively. The mean diameters of the 44 cases in type group II were 1.75 ± 0.34 cm, 1.44 ± 0.25 cm, 1.39 ± 0.25, and 1.36 ± 0.24 cm (see Table III).

TABLE I. RELATIVE NUMERICAL INCIDENCE OF SINGLE AND PAIRED LUMBAR ARTERIAL BRANCHES OF 100 AORTAE

<table>
<thead>
<tr>
<th>Lumbar artery</th>
<th>Single</th>
<th>Paired</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>3</td>
<td>97</td>
</tr>
<tr>
<td>L2</td>
<td>16</td>
<td>84</td>
</tr>
<tr>
<td>L3</td>
<td>16</td>
<td>84</td>
</tr>
<tr>
<td>L4</td>
<td>29</td>
<td>71</td>
</tr>
<tr>
<td>L5</td>
<td>8</td>
<td>13</td>
</tr>
</tbody>
</table>

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The diameters of the 2 type groups are compared in a histogram in Fig. 2.

As can be seen, the type I aortae tapered from the mid-point to the bifurcation more than type II aortae, and this difference was statistically significant (0.025 > P > 0.0125). The diameters of the 2 groups were com-
pared by means of the variance-covariance matrix, and the results were submitted to Student's t-test.

If the cross-sectional areas are calculated, group I aortae decreased from a mean of 1,744 cm$^2$ at the mid-point to 1,496 cm$^2$ at the bifurcation, a decrease of 14%, while group II aortae decreased from 1,515 cm$^2$ to 1,453 cm$^2$ at the same levels, a decrease in cross-sectional area of only 4%. In 1 female case in group I, the aorta decreased in cross-sectional area by 42% between the inferior mesenteric artery and the bifurcation. Coincidentally it was noted that in the group I cases there was an increase of atheromatous disease, but as most of the cases in the series were over 40 years of age, the incidence of atheroma was high in both groups.

**DISCUSSION**

There have been reports in the medical literature of hypoplasia or narrowing of the distal aorta since the condition was described by Quain in 1847. In 1902 Burke reported 100 cases of generalized aortic hypoplasia, and extensively reviewed the literature at that time. He attributed the first report to Morgagni who in 1733 reported the case of a 33-year-old monk who died of dropsy, and on postmortem examination was found to have generalized aortic hypoplasia. In 1768, Meckel reported an identical case occurring in a 17-year-old female.

In 1838 Rokitansky suggested that the anomaly was due to a congenital lesion, and his views were supported by Virchow in 1872. There are several reports in the literature of cases of distal aortic hypoplasia occurring in children, and one author relates the disorder to eclamptic toxæmia of pregnancy. He referred to a report of 77 females who died of eclampsia, of whom 47% had narrowing of the distal aorta demonstrated at postmortem examination.

The majority of authors favour a congenital aetiology to account for this disorder and one author has suggested an association with maternal rubella during pregnancy.

The abdominal aorta is formed somewhere between the 13 and 15 somite stage in the embryo, at about the 25th day of life by the fusion of the 2 dorsal aortae. This fusion includes the initially paired vitelline vessels, which eventually form the vessels supplying the alimentary canal, leaving the lateral and most of the posterior vessels as paired structures.

Maycock suggested two embryological possibilities to account for the lesion: (a) lack of, or unequal fusion of, the 2 dorsal aortae; (b) kinking of the fused aortae, with localized increased longitudinal tension, producing a permanent constriction.

In contrast, the present study seems to suggest that the deformity is due to overfusion of the primitive dorsal aortae which has included the origins of the posterior branches of the 2 vessels which normally remain as paired structures (Fig. 3).

**DISCUSSION**

One point which must be answered is the apparent difference in racial incidence of the disorder. The different racial incidence of atheroma is well recognized and can be explained on a dietary and nutritional basis. This suggests that the deformity is limited to, or at least more marked in, the Caucasian races, and the series is currently being extended in an attempt to clarify this point.

Another point that arises concerns the sex incidence of the disorder. In discussing aorto-iliac disease it has been observed that young women appear to have a different type of disease to that which is found in males or older women, and it has been suggested that this is associated with abnormal tapering of the distal aorta. However in the present series, the deformity is more common in males—a ratio of 3:1. A possible explanation of this is that the increased incidence of hypoplasia would be masked by the incidence of atheromatous disease in males in the 30-50-year age group, while conversely the relative rarity of the atheroma in premenopausal women would highlight any vascular deformity that did exist.
CONCLUSION

A review of the medical literature suggests that hypoplasia of the abdominal aorta is a definite entity, and its occurrence in children seems to indicate that the lesion has a congenital aetiology. Many authors have suggested this, but no clear proof has so far been established.

In this series of 52 randomly selected aortae of White patients, 7 had a single lumbar trunk at the L4 or L5 level which subsequently divided into left and right lumbar arteries, and the mean aortic diameter of this group decreased markedly from the level of the inferior mesenteric artery to the bifurcation, with a decrease in cross-sectional area of 14%. Within this group 1 female case had marked tapering, with a decrease in cross-sectional area of 42%.

In view of the association of a common lumbar artery origin and abnormal tapering of the aorta, it is suggested that the cause of distal aortic hypoplasia is a congenital one, and is due to excessive fusion of the embryonic dorsal aortae about the 25th day of intra-uterine life. This study has also shown that the anatomy of the posterior distal aortic wall is subject to considerable variation, and it is perhaps incorrect to describe 4 pairs of lumbar arteries being given off by the abdominal aorta as the normal. In this series of 100 randomly selected cases, this anatomical arrangement obtained in only 43% of cases, the remaining 57% having either 5 pairs of lumbar arteries or one or more single lumbar trunks, which subsequently divided into left and right branches.

We should like to thank Professor L. H. Wells of the Department of Anatomy for his guidance and advice, and for allowing us to dissect the cadavers in his department; and Professor C. J. Uys of the Department of Pathology for allowing us to examine the aortae of cases coming to post-mortem in his department. Finally, we should like to thank Mrs J. Juritz of the Department of Mathematical Statistics for suggestions and advice on the statistical analysis of the data.

REFERENCES


Books Received: Boeke Ontvang


