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Clinical Insight into aortic arch and brachiocephalic trunk variations among fetuses of different gestational ages

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Abstract

This study provides quantitative data and information about the variations in branching patterns of aortic arch, normal lengths of BT and trachea, as well as their diameters, in 30 spontaneously aborted human foetuses aged 14–35 weeks. Among all the foetuses examined, the aortic arches were found to have mainly two kind of variations in its branching pattern, without gender differences. In 53% of cases, the usual pattern of the aortic arch with its three main branches was observed. A common origin of the brachiocephalic trunk and left common carotid artery occurred in 35% of individuals. However, in 12% of the cases, common origin of all the three branches arising from aortic arch was observed No significant gender differences were observed ($p \geq 0.05$). Length of brachiocephalic trunk was observed to vary from 4.39 mm to 10.79 mm. Diameter of brachiocephalic trunk was observed to be 2.58 ± 0.79 mm at its point of origin. Increase in length of the brachiocephalic trunk was marked between 16 and 16.5 weeks, and last peak was seen after 27 weeks. Both length and diameter of trachea showed significant increase at 16weeks and 27 weeks. We also observed level at which trachea was being crossed by BT. In 65% cases, BT was seen crossing trachea at level of lower one third during its course from origin to its division, while it was seen crossing trachea at its middle in rest of the cases. Such high rate of variations in branching pattern among fetuses can be attributed to their developmental. The variant branches that arise from the aortic arch are due to the changes in the extent of the fusion process and absorption of some of the aortic arch into aortic sac. These variations represent an important morphological risk factor for arterial occlusion and difficulty in catheterization

Key words: aortic arch, fetuses, length, brachiocephalic trunk, variations

INTRODUCTION

In prenatal and pediatric cardiovascular surgery knowledge of the various arrangements of the aortic arch and its branches as well data regarding its quantitative values are essential (1). Knowledge of variations in branches of aortic arch as well as length and diameter of brachiocephalic trunk can prove to be useful guide during vascular surgeries in various ischaemic cerebrovascular diseases (2). The brachiocephalic trunk develops from the ascending part of the right dorsal aorta (3). Regression of the right dorsal aortic root (between the right subclavian artery and the descending aorta) and the right ductusarteriosus leaves the normal left aortic arch. The proximal segments of the third pair form the common carotid arteries.Previous morphometric studies on the foetal aorta have been

conducted in relation to its diameter only, using echocardiographic [3 - 5] methods. The aims of the present study were to study frequency of variations in relation to branching pattern of aortic arch as well as to establish the reference range and growth curve of various dimensions of brachiocephalic trunk at various gestational ages.

MATERIAL AND METHODS

The material examined consisted of 30 spontaneously aborted human foetuses of both genders 23 males, 7 females) aged 14–35 weeks. The foetuses were fixed by the immersion technique in a 10% neutral formalin solution and then dissected under a stereoscope at a magnification of 10. Specimens that had detectable morphological malformations were excluded from the study. For the analysis fetuses were grouped into six monthly cohorts, ranging from the fourth to the ninth month of gestation. In each foetus the dissected aortic arch and its branches were placed, with a millimetre scale and digitalised to JPEG images. Next, digital pictures were taken. In the study, we aimed to observe variations in branching pattern of aortic arch, various other parameters like length and diameter of the brachiocephalic trunk (BT), at point of origin and relation of brachiocephalic trunk (BT), with trachea along its course from point of its origin to its division. The developmental growth of the brachiocephalictrunk was statistically analysed by means of regression analysis. Gender differences were analysed by means of Student's t test for two mean independent variables using the SPSSprogramme.

RESULTS

Among all the foetuses examined, the aortic arches were found to have mainly two kind of variations in its branching pattern,without gender differences. In 53% of cases, the usual pattern of the aortic arch with its three main branches (brachiocephalic trunk, left common carotid artery and left subclavian artery) was observed. A common origin of the brachiocephalic trunk and left common carotid artery occurred in 35% of individuals (Figure 1).

Figure 1Common origin of brachiocephalic trunk and Left CCA(CCA, Common carotid artery; SA, Subclavian artery)

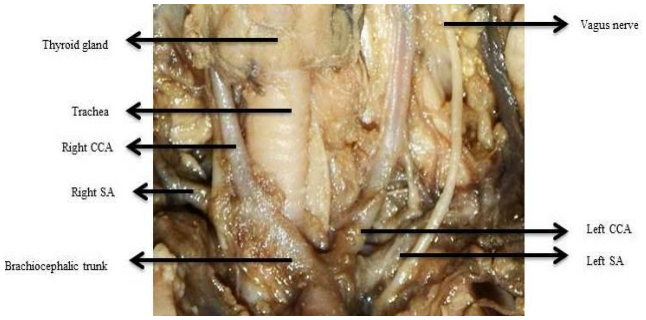

Figure 2Common origin of all three branches from aortic arch(For abbreviations, refer fig. 1)

However, in 12% of the cases, common origin of all the three branches arising from aortic archwas observed (Figure 2).

We further observed length and diameter of brachiocephalic trunk. Length of brachiocephalic trunk was observed to vary from 4.39 mm to 10.79 mm (Average length was found to be 7.99 mm). Diameter of brachiocephalic trunk was observed to be 2.58 ± 0.79 mm at its point of origin. The morphometric features of the brachiocephalic trunk indicated the differing developmental dynamic. Increase in length of the brachiocephalic trunk was markedbetween 16 and 16.5 weeks. Thereafter, its length remained same. Second peak in growth of length of BT was observed at 18 – 20 weeks and last peak was seen after 27 weeks (Figure 3).

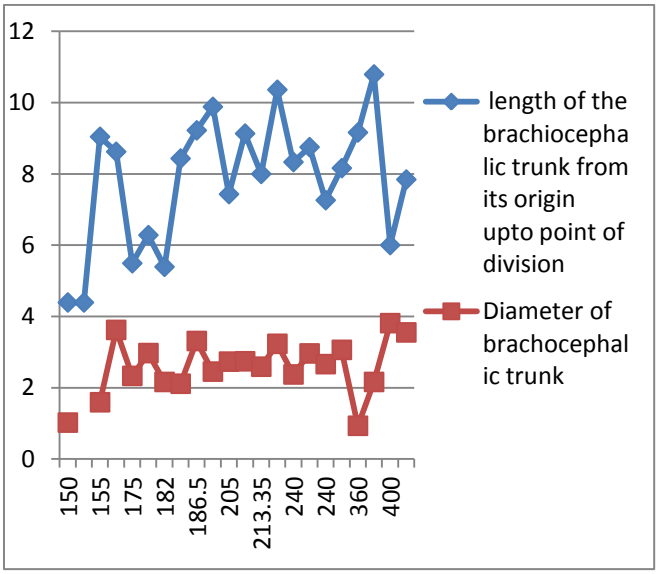

Figure 3 Length and diameter of brachiocephalic trunk among different gestational age groups of fetuses

Similarly, increase in diameter of BT was observed at 16 – 16.5 weeks and 27 weeks onwards ($p<0.001$). Thus, both the length and diameter of BT revealed an increase in values with increased foetal age according to the regression line. We also observed level at which trachea was being crossed by BT. In 65% cases, BT was seen crossing trachea at level of lower one third during its course from origin to its division, while it was seen crossing trachea at its middle in rest of the cases. We further observed length and diameter of trachea. Length of trachea was measured from mid point at lowest border of cricoid cartilage upto the carina. It was observed to be 22.23 ± 3.99 mm. Mid diameter of trachea was observed to be 4.80 ± 0.98 mm (Figure 4). Both length and diameter of trachea showed significant increase at 15 weeks and 27 weeks ($p < 0.001$).

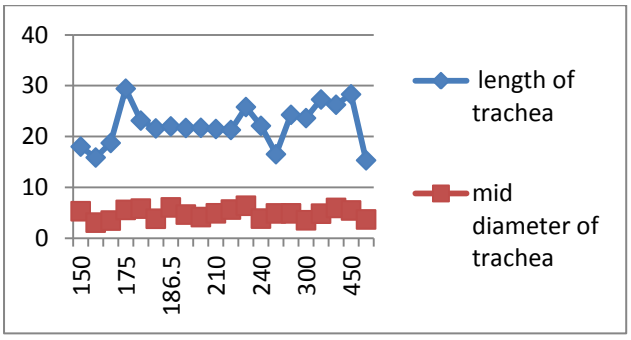

Figure 4 Length and diameter of trachea among different gestational age groups of fetuses

DISCUSSION

This study provides quantitative data and information about the variations in branching patterns of aortic arch, normal lengths of BT and trachea, as well as their diameters. Normal branching pattern of aortic arch from right to left is: brachiocephalic trunk (BT), left common carotid artery (LCCA) and left subclavian artery (LSA). The aortic arch is formed in the ventral and dorsal area as a pair and six arches between the aorta at initial period of gestation. Changes involved in the aortic arch system such as regression, retention, or reappearance result in the variations in branching pattern. The variant branches that arise from the aortic arch are due to the changes in the extent of the fusion process and absorption of some of the aortic arch into aortic sac (6). The number of branches that arise from the arch of aorta depends on such process (7, 8). The branching pattern of brachiocephalic trunk varies due to the embryological reason that the proximal part of the third aortic arch normally gets extended and absorbed into the left horn of aortic sac. If it gets absorbed into right horn of aortic sac, these variations occur. This variation was observed in 35% cases in the present study, in which both BT and LCCA were seen arising from a common point (Figure 1). In the current study, authors found 12% cases of aortic giving rise to one branch (common origin of BT, LCCA, SA). The number of primary branches may be reduced to 1–2 or increased to 4–6 (9 – 12).

If the aortic sac fails to bifurcate into right and left limbs, then the left common carotid artery will connect to aortic sac directly resulting in a common origin of the carotid arteries. The left limb of the aortic sac normally forms the part of the arch that intervenes between the origins of the brachiocephalic trunk and the left common carotid artery. Thus, these morphological variations are of greater importance in cerebral hemodynamics and in all non-invasive proceduresand are also associated with abnormalities of the heart and persistent fetal conditions.

Reference data for the lengths and diameters of the brachiocephalic trunk as well as trachea is less in foetuses and children. We observed changes in these parameters with age of fetuses. As reported by some authors the dimensions of brachiocephalic trunk were found to be independent of gender (13, 14). The length and diameter of the brachiocephalic trunk increased with the increasinggestational age. Authors in current studyobserved that prenatal growth of the length and diameter of brachiocephalic trunk was uniformly distributed, because their relationships to one another was constant. In contrast, Hirata (15) performed an anatomical study of the foetal aorta in 20 specimens aged 6–8 months and claimed that growth rates of the aortic subdivisions differed. Proportions of the aortic arch to the whole aorta increased in foetuses aged 6–7 months. In the professional literature there has been a paucity of quantitative anatomical data concerning the length of the different aortic segments addressed by this study. These variations represent an important morphological risk factor for arterial occlusion and difficulty in catheterization (16).

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CONFLICT OF INTEREST:

Authors have no conflict of interest

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