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Morphology of the terminal part of the abdominal aorta and subaortic angle in different periods of human life

Morfologia końcowego odcinka aorty brzusznej i kąta podaortowego w różnych okresach życia człowieka

INTRODUCTION

Typically the bifurcation of the abdominal aorta in adults is located on the level of the lower part of fourth lumbar vertebra or the intervertebral disc between L4-L5, slightly left to the median line. This point states the beginning of both common iliac arteries which go apart and form the subaortic angle [1].

Knowledge of arterial anatomical variations of the terminal part of abdominal aorta and iliac vessels is important for interventional radiologists, gynecologists as well as general, vascular and oncological surgeons. Although various modern radiological diagnostic methods such as angiography, angio-computer tomography (angio-CT) and angio-magnetic resonance (angio-MR) have developed dynamically [19], direct analysis of the vessel morphology is still a standard in anatomic studies [2-9,13,14,16]. On the other hand, the X-ray diagnosis is rarely used in prenatal period. It is secondary due to small diameters of the examined structures, but also because of teratogenic properties of the ionization radiation.

The aim of the study was to evaluate the morphology of the terminal part of the abdominal aorta, in particular the subaortic angle in different periods of human life.

MATERIALS AND METHODS

The study was performed according to the Polish law, on human bodies after a routine medical or coroner autopsy at the Pathomorphology Department and Forensic Medicine Department of the Medical University in Lublin, as well as Forensic Medicine Department of the Warsaw Medical

University in years 1987-1999. Unfixed human bodies of both sexes in age from 7 months of prenatal period to 82 years of life were examined. Any macroscopical abdominal or pelvis abnormalities and congenital cardiovascular malformations observed during autopsy excluded the body from further analysis. The analyzed population (110 males, 110 females) was divided into 19 groups according to their age (Table 1).

Each time the abdominal part of the aorta, as well as iliac arteries and their main branches were exposed. The external, transversal diameter of the terminal part of the abdominal aorta 1 cm above the bifurcation and in place of common iliac arteries ramification were measured using caliper (Stanley, USA; accuracy of 0.1 mm). The subaortic angle – between the medial margins of the common iliac arteries – was also examined with the protractor with an accuracy of 1° (Fig. 1). All measurements were conducted perpendicularly to the length of vessels.

The obtained data was statistically analyzed by U Mann-Whitney test. The 0.05 level ($p<0.05$) of probability was used as the criterion of significance.

RESULTS

In males the dimension of the terminal part of aorta – 1 cm over the common iliac arteries – increased from 3.63 mm in 7 months of prenatal period to 21.56 mm in the 50-59 age groups (Table 1). Female values were lower and set as 3 and 21 mm, respectively (Table 1).

The dimension on the level of the bifurcation increased from 4.80 to 29.16 mm in males, and 4.35 to 27.03 mm in females (Table 1).

The subaortic angle was insignificantly wider in females. Its ranged from 58.5° in the age group 1-4 years to 93° in old ones (Table 1). In males, in corresponding periods of life the angle reached 54.7 and 74.1°.

In the group comprising over 50 subjects an unusual double subaortic angle was observed in some cases (Fig. 2). The common iliac arteries departed on a small angle and then they went sideward unilaterally or bilaterally. In the male group aged 50-59, 60-69 and older such cases were found in 50, 60 and 50%, respectively. The frequency of the double angle was lower among female – 10, 20 and 50%, correspondingly. Morphologically three different principal types of the double level of the subaortic angle were found (Fig. 2): I – symmetrical double angle, II – asymmetrical right-orientated double angle, III – asymmetrical left-orientated double angle. The last type (III) was the most commonly observed (Fig. 1), while the first two (I and II) were seen sporadically.

Table 1. Transversal diameter (mm) above (1-2) and on the level of aortic bifurcation (3-4) of the terminal part of the abdominal aorta and subaortic angle (°) in male and female individual. Data presented as Mean (Min.-Max.)

Age	M/F	1-2 diameter		3-4 diameter		subaortic angle	
		male	female	male	female	male	female
6-7 gm	4/2	3.63 (3.0-4.0)	3.20 (3.0-3.4)	4.80 (4.1-5.4)	4.350 (4.0-4.7)	55.0 (51-62)	59.5 (51-62)
7-8 gm	3/6	4.67 (3.5-5.8)	4.05 (3.2-4.7)	7.07 (5.3-8.1)	5.47 (3.9-6.5)	60.0 (49-67)	63.5 (49-67)
8-9 gm.	3/2	5.27 (4.9-5.5)	4.80 (4.4-5.2)	6.83 (6.3-7.2)	6.85 (6.4-7.3)	67.0 (64-69)	72.0 (64-69)
0-1 m	10/10	4.94 (4.3-6.1)	5.11 (4.1-6.2)	6.61 (5.7-8.0)	6.45 (5.2-7.7)	59.5 (48-73)	65.8 (48-73)
1-3 m	2/4	5.60 (5.5-5.7)	4.98 (4.5-5.4)	6.45 (5.9-7.0)	7.18 (6.5-7.5)	55.0 (50-60)	65.8(59-74)
4-6 m.	5/3	6.62 (6.1-7.3)	5.70 (5.0-6.2)	9.02 (8.5-9.8)	8.17 (7.1-8.8)	59.6 (52-65)	67.9 (50-60)
7-11 m	3/3	7.57 (6.9-8.2)	7.33 (7.1-7.6)	9.77 (8.2-11.8)	10.20 (9.8-10.5)	58.7 (55-66)	71.3 (52-65)
1-3 y	4/6	7.23 (6.7-8.0)	7.08 (6.5-8.0)	9.60 (8.8-10.6)	9.73 (8.7-11.4)	55.8 (41-70)	64.2 (55-66)
4-6 y	3/2	9.17 (8.8-9.6)	9.05 (8.7-9.4)	12.47 (12.0-13.1)	12.70 (12.3-13.1)	59.7 (56-63)	58.5 (41-70)
7-9 y	3/2	10.30 (9.5-10.5)	10.30 (9.9-10.7)	13.70 (13.2-14.0)	14.80 (14.1-15.5)	54.7 (42-71)	59.5 (56-63)
10-12 y	2/3	10.85 (10.3-11.4)	11.07 (10.5-11.7)	14.80 (13.9-15.7)	14.33 (13.2-15.7)	62.5 (58-67)	69.3 (42-71)
13-16 y	3/1	13.03 (12.4-13.7)	12.9	17.67 (17.0-18.6)	17.4	60.0 (50-69)	74
17-19 y	5/6	14.44 (13.3-15.3)	14.07 (13.3-14.7)	19.28 (18.0-20.9)	18.13(17.0-19.3)	64.2 (48-75)	71.7 (59-82)
20-29 y	10/10	15.60 (12.9-17.3)	13.89 (12.7-15.3)	20.34 (17.7-22.6)	18.49 (16.6-20.4)	57.4 (48-70)	66.1 (55-83)
30-39 y	10/10	18.73 (17.2-20.7)	16.26 (14.1-18.2)	24.64 (22.6-27.5)	21.98 (18.8-24.3)	61.5 (45-73)	71.1 (60-79)
40-49 y	10/10	17.19 (15.4-18.8)	15.05 (13.2-16.6)	22.30 (19.9-24.5)	20.06 (17.8-22.3)	65.7 (51-72)	70.4 (54-81)
50-59 y	10/10	21.56 (19.1-23.6)	17.26 (16.0-18.9)	28.64 (25.6-31.4)	23.48 (21.5-25.9)	74.1 (59-87)	73.2 (58-91)
60-69 y	10/10	19.94 (18.4-22.5)	17.81 (15.6-20.5)	26.12 (24.1-29.5)	24.99 (22.6-28.9)	73.3 (56-88)	77.9 (57-89)
≥70 y	10/10	19.48 (17.5-24.1)	19.48 (17.4-21.1)	29.16 (24.8-32.6)	27.03 (24.1-29.7)	70.8 (61-79)	79.1 (63-93)

M/F – number of male/female; Min. – minimal value, Max – maximal value, gm – gestational month,
m – month of age during postnatal period, y –year of age during postnatal period

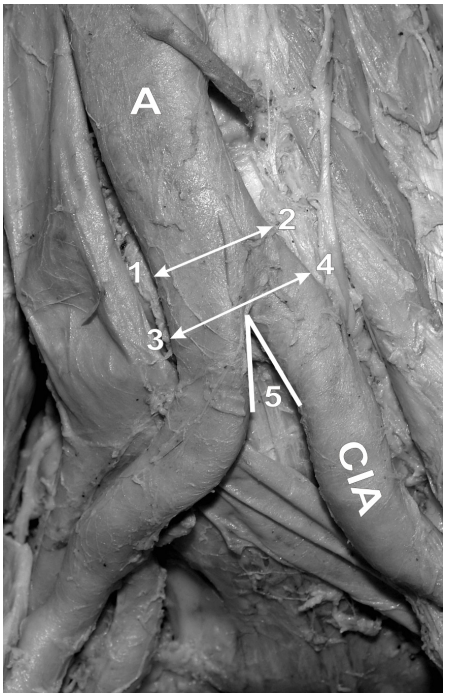

Figure 1. The terminal part of abdominal aorta (A) with examined measurements:
1-2 – external diameter 1 cm above the bifurcation, 3-4 – external diameter on the level of the bifurcation;
5 – subaortic angle, CIA – common iliac artery (left)

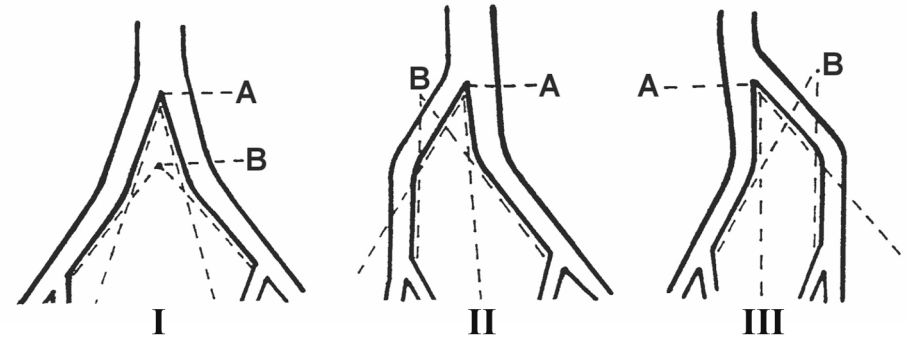

Figure 2. Three principal types of the double level of the subaortic angle: I – symmetrical double angle,
II – asymmetrical right-orientated double angle, III – asymmetrical left-orientated double angle.
A – apex of a small angle; B – apex of a big angle

DISCUSSION

The obtained data proved a logical correlation between vascular diameters and age, in both prenatal and postnatal periods [15]. The reported differences may be secondary to different hemodynamic, especially since the aortic bifurcation is responsible for dividing blood flow for the left and right part of the pelvis and both lower limbs. The structure is also important to decrease the blood pressure and for this reason was explained as so-called geometric risk factor of various cardiovascular diseases [18].

Previous analyses of the subaortic angle showed numbers of anatomical differences in both localization and degree of bifurcation [23]. According to the classical description the angle ranges from 65° in males to 75° in females and an average value is about 70° [1]. Testut [21] claimed that the average value is only 60°, while Luzsy [11] stated wider interval (40- 80°). Similar value (23-83°, average 57.48°) was found in adults by de Mendez [12]. Shah et al. [17] observed that males have the subaortic angle from 14 to 70°. Similar to our data in females, the angle was wider and reached 34 to 81°. Based on the radiological examination, Williams [22] and Szmigielski [20] found the angle in about 37 and 39°. Generally most of the research studies state the subaortic angle is wider in females, as a result of the different anatomy of their pelvis [1]. Unlike previous descriptions, the current data showed a slightly different topography of the common iliac arteries than explained in classical anatomical textbook [21]. According to the literature they run forward, downward and sideward forming the subaortic angle [1, 21]. However, based on our data, different ramifications occur in older specimens. At first the vessels departed at a small angle, and then passed widely unilaterally or bilaterally. The unusual course is probably due to the atherosclerotic lesions that could change the morphology of the arterial wall and secondarily influenced their topography. Such hypothesis is proved by a higher incidence of atherosclerosis in group over 40-50 year old [10].

On the other hand, the transversal diameter of terminal part of the abdominal aorta – just above the place of bifurcation – ranges widely as well [15]. However, the result depends on the applied measurement methods. Sash et al. [17] showed that the examined diameter was bigger in males (16-31 mm) than in females (13-24 mm). Such data was also confirmed in the preset study but with much bigger group (212 instead of 26 individuals). Results presented by Sash et al. [17] are important since the study as the first one indicated that an asymmetrical left lateral orientation of the abdominal aorta, is an important risk factor for the aneurysm location. Such position resulted in a longer right common iliac artery and smaller left common iliac bifurcation angle with a larger left radius of curvature at the aortic-common iliac bifurcation. These differences were explained as a result of local hemodynamic changes that increase the risk of abnormalities of the left iliac artery. Abnormal anatomical variations were visible mostly in males that are characterized with a relatively narrow pelvis.

It is worth to mention that similar insignificant differences between males and females were obtained for the proximal and distal transversal diameters of the common, external and internal iliac artery in the currently disused group of human bodies [9]. Furthermore, a positive correlation with arterial diameters and individual age was revealed.

In conclusion, the measured transversal diameters of the terminal part of the abdominal aorta are related to age and unlike subaortic angle, are insignificantly wider in males than in females. The morphology of the subaortic angle may relate to atherosclerotic lesion that change the course of the iliac arteries in older age, in particular over 50.

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ABSTRACT

The aim of the study was to evaluate morphology of the terminal part of the abdominal aorta in different periods of human life. Two hundred and twelve human bodies, aged from the 7 gestational months to 82 years, were examined. Transversal diameters of the abdominal aorta and subaortal angle were measured. In males the dimension of the terminal part of aorta – just over the origin of common iliac arteries – increased from 3.63 mm in 7th month of prenatal period to 21.56 mm in the 50-59 age group. The female values were lower and set as 3.0 and 21 mm, respectively. The dimension on the level of the bifurcation increased from 4.80 to 29.16 mm in males, and 4.35 to 27.03 mm in females. However, the subaortic angle was higher in females. It ranged from 58.5° in the age group 1-4 years to 93° in the old ones. In males, in corresponding periods of life, the angle reached 54.7 and 74.1°. In the group over 50, the common iliac arteries departed at a small angle and then they went sideward unilaterally or bilaterally. In the groups aged 50-59, 60-69 and older, such cases were found in 50, 60 and 50% - in males, and 10, 20 and 50% in females, respectively.

Keywords: subaortic angle, abdominal aorta, bifurcation aorta

STRESZCZENIE

Celem pracy była ocena morfologii końcowego odcinka aorty brzusznej i kąta podaortowego w różnych okresach życia człowieka. Wymiary ocenianych struktur były mierzone na 212 ciałach ludzkich w wieku od siódmego miesiąca życia płodowego do 82 lat. U mężczyzn szerokość końcowego odcinka aorty tuż powyżej rozwidlenia na tętnice biodrowe wspólne, wykazywała zależność od wieku i zwiększyła się z 3,63 w siódmym miesiącu życia płodowego do 21,56 mm u osobników w wieku 50-59 lat. Wymiar ten były mniejszy u kobiet i wynosił odpowiednio 3,0 i 29,56 mm. Wymiar poprzeczny aorty na wysokości podziału na tętnice biodrowe wspólne zwiększył się w analogicznym okresie u mężczyzn z 4,8 do 29,16 mm oraz 4,35 do 27.03 mm u kobiet. Kąt podaortowy był większy u kobiet, a jego wartość wynosiła średnio 58,5° w grupie wiekowej do 4 roku życia a 93° w grupach wiekowych powyżej 50 roku życia. W analogicznych okresach rozwojowych wartości kąta u mężczyzn wynosiły 54,7 i 74,1°. W grupie wiekowej powyżej 50 roku życia, tętnice biodrowe wspólne odchodziły początkowo pod mniejszym kątem, a następnie przebiegały bardziej rozbieżnie obustronnie symetrycznie lub niesymetrycznie.

Słowa kluczowe: kąt podaortowy, aorta brzuszna, rozdwojenie aorty