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Original Article

Anatomy Section

Morphometric Analysis of Brachiocephalic Trunk in Brazilian Cadavers of Human Foetuses

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ABSTRACT

Introduction: The Brachiocephalic Trunk (BCT) is the largest branch of the aortic arch, with an average of 4-5 centimetres length. It usually divides into two vessels, the Right Common Carotid Artery (RCCA) and the Right Subclavian Artery (RSA).

Aim: To conduct a morphometric study of BCT in cadavers of human foetuses and associate it with gender.

Materials and Methods: An observational study was conducted from year 2012 to 2020, in which 35 foetal cadavers (18 male and 17 female) were dissected and fixed in 10% formalin, all belonging to the Human Anatomy Laboratory of the Morphology Department of the Federal University of Sergipe, Aracaju, SE, Brazil. After dissection and exposure of the aortic arch and its branches, measurements were made of the BCT length (from the edge of the aortic arch to its division into the right common carotid and subclavian arteries) and outside diameter (at the origin of the aortic arch) using a 0.05 mm precision digital calliper. The t-Student test was used for independent or unpaired samples to compare the BCT morphometric values in relation to gender, taking $p<0.05$ as statistically significant. Data were analysed using the Bioestat 5.3.

Results: The length of the BCT varied from 6.19-15.34 mm, with an average of 10.22 mm, and its diameter from 1.51-5.11 mm, with an average of 3.16 mm. The comparative analysis between morphometric measurements and gender did not show any statistically significant difference ($p>0.05$).

Conclusion: The knowledge of the BCT morphometry in foetuses can assist in the safe execution of various surgical procedures in the mediastinum, as it reduces the chances of serious complications resulting from these procedures.

Keywords: Aortic arch, Biometry, Common carotid artery, Innominate artery

INTRODUCTION

The BCT is described as the first and largest branch of the aortic arch, measuring about four to five centimetres in length. After its origin, it ascends to the right of the trachea until, at the level of the right sternocostal joint it forks into two important vessels: the RCCA and the RSA [1].

The BCT, the left subclavian artery and the left common carotid artery arise from the aortic arch [2]; this type of branching was initially classified as a normal type A, standard by the anatomist Adachi B in 1928 [3-5]. The type B consists of a common trunk for the left common carotid and the brachiocephalic artery and therefore has only two aortic arch branches, and type C has a vertebral artery originating proximal to the left subclavian artery as a fourth branch of the aortic arch [3-5]. These branches usually originate from the aortic arch or from the upper part of the ascending aorta, but variations in this branching pattern may occur, either in their origin, topography, in the number or in the distances between them [1,6,7]. In addition, RCCA and LSA may have an origin in the aortic arch of a common trunk; the left BCT [1,2,8,9]. This may be missing or doubled [2], as well as the left vertebral artery can arise from the aortic arch, between the left common carotid artery and the left subclavian artery or between the brachycephalic trunk and the left subclavian artery [8,10]. These anatomical variations can alter the cerebral blood flow, leading to neurological lesions or be associated in the genesis of cardiovascular events [11], which could lead to serious complications in clinical practice, in performing interventional surgical procedures [2], in tracheostomy, thyroid and parathyroid gland surgeries [5,12-14].

For this reason, the knowledge of these anatomical variations, as well as the analysis of morphometric data of the BCT is an important parameter for the safe performance of surgical procedures, both in cases of tracheostomy and in those of catheterisation in cases of aneurysm and stent implants [13,15,16].

Thus, recognising the morphological variations, can not only optimise existing anatomical knowledge, but also serve as a basis for several diagnostic methods, as well as in intrathoracic and vascular surgical techniques, in addition to preventing iatrogenesis and complications [2,13,17-19]. Thus, the objective of the present study was to conduct a morphometric study of the BCT in cadavers of human foetuses and associate it with gender.

MATERIALS AND METHODS

An observational study was conducted on 35 foetal cadavers of both sexes (18 male and 17 female), selected for convenience during the period from year 2012 to 2020. Specimens were fixed in 10% formalina and dissected, belonging to the Human Anatomy Laboratory of the Morphology Department of the Federal University of Sergipe Aracaju, SE , Brazil. The present study's sample was selected in accordance to the Brazilian Federal Law 8.501 (November 30, 1992) and an institutional approval was obtained. The present study was approved by the Research Ethics Committee of the Federal University of Sergipe, under protocol number 0383.0.107.000-11.

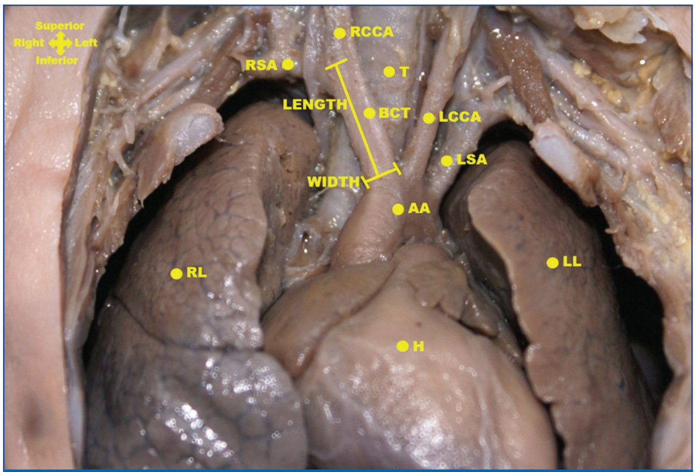
Foetal age was determined by the hallux-calcaneus measurement [20].

Inclusion criteria: All foetuses that were available in the laboratory were included.

Exclusion criteria: Foetuses with cardiovascular malformations were excluded.

Study Procedure

After resection of the anterior chest wall, the adipose tissue was carefully removed, the thymus, the brachiocephalic veins and the pericardium that covered the ascending aorta and the great vessels. The aortic arch was exposed and the BCT was carefully dissected and classified according to Adachi B [3]. Its length was measured from the edge of the aortic arch to its division into right common and right subclavian carotid arteries, and its external diameter at its origin with a 0.05 precision digital pachymeter [Table/Fig-1].



[Table/Fig-1]: Photograph of the aortic arch showing its branches and the Brachiocephalic Trunk (BCT) morphometry.
AA: Aortic arch; BCT: Brachiocephalic trunk; H: Heart; LCCA: Left common carotid artery; LL: Left lung; LSA: Left subclavian artery; RCCA: Right common carotid artery; RL: Right lung; RSA: Right subclavian artery; T: Trachea

STATISTICAL ANALYSIS

The variables were expressed as means and standard deviations. The t-Student test was used for independent or unpaired samples to compare the BCT morphometric values in relation to gender. Values of p>0.05 were considered not statistically significant. Data were analysed using the Bioestat Program 5.3.

RESULTS

The BCT morphometry was performed on 35 foetuses, being 18 males and 17 females, the majority of the aortic arches found were classified as type A (97.14%), except for one case of type B (2.86%). The age of the foetuses ranged from 18.1-37.8 weeks, with an average of 24.97 weeks. In general, the length of the BCT ranged from 6.19-15.34 mm with an average of 10.22 mm, and its outside diameter from 1.51-5.11 mm with an average of 3.16 mm.

When comparing both the lengths [Table/Fig-2] and the average diameters [Table/Fig-3] of the BCT in relation to sex, no statistically significant difference was found (p>0.05).

	BCT length (mm)					
Gender	n	Minimum	Maximum	Mean	Standard deviation	p-value
Male	18	7.02	15.11	10.16	2.47	0.44
Female	17	6.19	15.34	10.29	3.04	

[Table/Fig-2]: BCT length in relation to gender.
t-Student test; *significance (p≤0.05)

	External diameter of the BCT (mm)					
Gender	n	Minimum	Maximum	Mean	Standard deviation	p-value
Male	18	1.51	5.11	3.31	1.05	0.16
Female	17	1.77	4.78	2.99	0.84	

[Table/Fig-3]: External diameter of the BCT in relation to gender.
mm: Millimetre; t-student test; *significance (p≤0.05)

DISCUSSION

The aortic arch and supra-aortic branches are important anatomical structures for surgeons and interventionists and are responsible for the blood supply of the upper limbs, neck and head [2]. Anatomical characteristics of the aortic arch, such as inclination, angulation and distances between the supra-aortic branches, can influence the viability and difficulties of interventional and/or surgical maneuvers. Thus, knowledge of the distribution, regularity or irregularity and typology of the various anatomical characteristics is essential in the optimisation of all types of diagnostic and/or therapeutic interventions involving the aortic arch [17].

However, several variations have been reported in the literature regarding the number and topography of the branches that originate from the aortic arch [2,16,21,22]. The typical pattern (type A) consists of the BCT, left subclavian and left common carotid artery, a pattern found in more than 70% of cases [2,16,21,22]. The other patterns are rare and can present from two to seven branches [23-26]. Although it was not the focus of our study, the type A pattern was found in 97.14% of our cases.

The understanding of these variations is extremely important both anatomically and clinically, since they impact on haemodynamic procedures, the aetiology of brain injuries resulting from these vessels, the management of upper chest and neck trauma and also prevent or decrease the occurrence of medical malpractice during surgical procedures [23,27].

However, in addition to morphological variations, modern surgical and radiological procedures, the recognition of the BCT morphometric data and anatomical vascular variations of the branching pattern of the aortic arch are of great importance in vascular dynamics, as well as in endovascular surgery and in stent implants [17,28,29]. Thus, in the present study, the morphometric data (length and diameter) of 35 cadavers of human foetuses, with a mean age of 25 weeks, analysed by hallux-calcaneus measurements [20]. In general, the average length and diameter of the BCT were 10.22 and 3.16 mm, respectively. However, among male foetuses, the average length and diameter obtained were 10.16 mm and 3.31 mm, while in females, 10.29 mm and 2.99 mm, respectively, showing that there was no statistically significant difference. In general, these results differ from those found by Szpinda M et al., [30]. the only morphometric work performed on cadavers of human foetuses, as well as in relation to the various authors, where they performed this morphometry, either through adult cadavers or through radiological images such as angiotomography or computed tomography [Table/Fig-4] [13,16,21,23,28-32].

				BCT	
Author	Study	Year of study	Place	Length (mm)	Diameter (mm)
Racic G et al., [13]	Adult cadaver	2005	Croatia	-	8.0
Panagouli E et al., [16]	Adult cadaver	2020	Greece	38.2	-
Alsaif HA and Ramadan WS [21]	Adult cadaver	2010	Saudi arabia	15.0	17.97
Ortiz NEH et al., [23]	Adult cadaver	2012	Colombian	30.2	9.7
Kumar R et al., [28]	Computed tomography	2016	India	-	11.4
Aboulhoda BE et al., [29]	Adult cadaver	2019	Egypt	-	15.7
Szpinda M et al [30]	Fetus cadaver	2005	Poland	6.99	2.55
Honig EI et al [31]	Angiotomography	1952	New York	43.5	10.0
Babu CS and Sharma V [32]	Adult cadaver	2015	India	6.0	18.84
Present study	Fetus cadaver	2021	Brazil	10.2	3.16

[Table/Fig-4]: Morphometric analysis of the BCT in several studies (mm) [13,16, 21,23,28-32].
mm: Millimetre

Therefore, these data will serve as an anatomical basis for the insertion of catheters in the main branch of the aortic arch, which certainly helps obtain a better understanding of the morphometric aspects of the BCT, allowing endovascular surgery in foetuses, to be performed with greater safety.

Limitation(s)

The limitation of this study is the fact that there are a small number of foetuses, as well as the fact we did not group the foetuses by age. Therefore, we suggest that future studies carried out in human foetuses make a division by gestational age groups to obtain more reliable measurements and associations to their respective groups and sexes.

CONCLUSION(S)

The morphometric data offered by the present study provides a valuable base about the normal values on foetuses and call attention to the possibility of arterial stenosis or occlusion in cases of obviously reduced dimensions. The morphometric parameters of the BCT taken in foetuses, can help cardiothoracic surgeons in the planning, execution and performance of safer surgeries in the upper mediastinum, as well as in the choice of angiographic catheters, prostheses or stents for the treatment of aneurysms or in vascular or mediastinal lesions in emergency surgery, which provides a valuable basis on normal values on a population basis. The lack of this information can cause serious complications in procedures performed on the mediastinum or base of the neck, while it can also cause brain damage and serious to fatal haemorrhagic incidents.

Author contributions: Conceptualization: JAA; Data acquisition: JAA, LEOJS, JCSJ, GRCM; Data analysis or interpretation: ICSA, FMSA; Drafting of the manuscript: JAA, FPR, DRG; Critical revision of the manuscript: JAA, FPR, LEOJS, JCSJ, GRCM, ICSA, FMSA.

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