Original communication

CLINICALLY IMPORTANT FORMATIONS ON THE INTERIOR SURFACE OF THE BRACHIOCEPHALIC TRUNK

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RESUMEN

Las características de la división arterial representan un factor de riesgo para la oclusión arterial y causa frecuente de dificultad para la cateterización. Su forma de presentación depende de la unión del 3º y 4º arcos aórticos. Con el objetivo de evidenciar las características del tronco braquiocefálico (TBC) se estudiaron 40 fetos de entre 12 y 23 semanas de gestación. Se disecaron los grandes vasos y el TBC fue seccionado en su origen y resecado conjuntamente con la porción proximal de las arterias carótida común derecha (CCD) y subclavia derecha (SD). Se midió la longitud, el ancho y los ángulos interno y geométrico entre las arterias CCD y SD. Abrimos las arterias para observar la luz vascular. Se documentó fotográficamente. La longitud promedio fue de 4,25 mm y el ancho promedio de 1,53 mm. No se evidenció relación directa entre las medidas de los TBC y la edad fetal. La mediana del ángulo interno fue de 62º. Sólo el 50% de los TBC pudieron ser abiertos, permitiendo observar la presencia de tabiques parciales entre ambos vasos en el 20% de los casos y de espolones a nivel de la bifurcación en otro 10%. No hallamos descripciones sobre estos relieves en la literatura. El ángulo interno entre ambas arterias fue significativamente mayor en los casos que presentaron relieves. En conclusión, la presencia de relieves en la superficie interna del TBC tiene origen embriológico y representaría un factor importante de riesgo para patología obstructiva vascular y causa de dificultad para la cateterización.

***Palabras clave**: tronco braquiocefálico, grandes vasos, embriología arterial, oclusión arterial.*

ABSTRACT

Arterial division features constitute risk factors for arterial occlusion and frequently cause difficulties in catheterization. In this case the relevant feature is the junction of the 3rd and 4th aortic arches. With the aim of displaying the features of the brachiocephalic trunk (BCT), we studied 40 fetuses of between 12 and 23 weeks of gestation. Great vessels were dissected and the BCT was cut and resected at its origin within the proximal portion of the right common carotid (RCC) and right subclavian (RS) arteries. The arteries were opened to observe their internal surface. Findings were documented photographically. In each case, the internal and geometric angles were measured. Their average length was 4.25 mm, and average width was 1.53 mm. There was no evidence of a direct relationship between the measurements of the BCT and fetal age. The median value of the internal angle was 62º. Only 50% of the BCT could be opened, allowing the observation of a partial septum in 20% of the cases, or ridges at the arterial bifurcation in another 10%. No descriptions of these formations were found in the literature. The average internal angle between both arteries (RCC and RS) was significantly greater in those cases having intraluminal formations. In conclusion, formations on the inner surface of the BCT are of embryological origin and represent a major risk factor for vascular obstructive disease and a cause of difficulty in catheterization.

Keywords: Brachiocephalic trunk, great vessels, arterial embryology, arterial occlusion.

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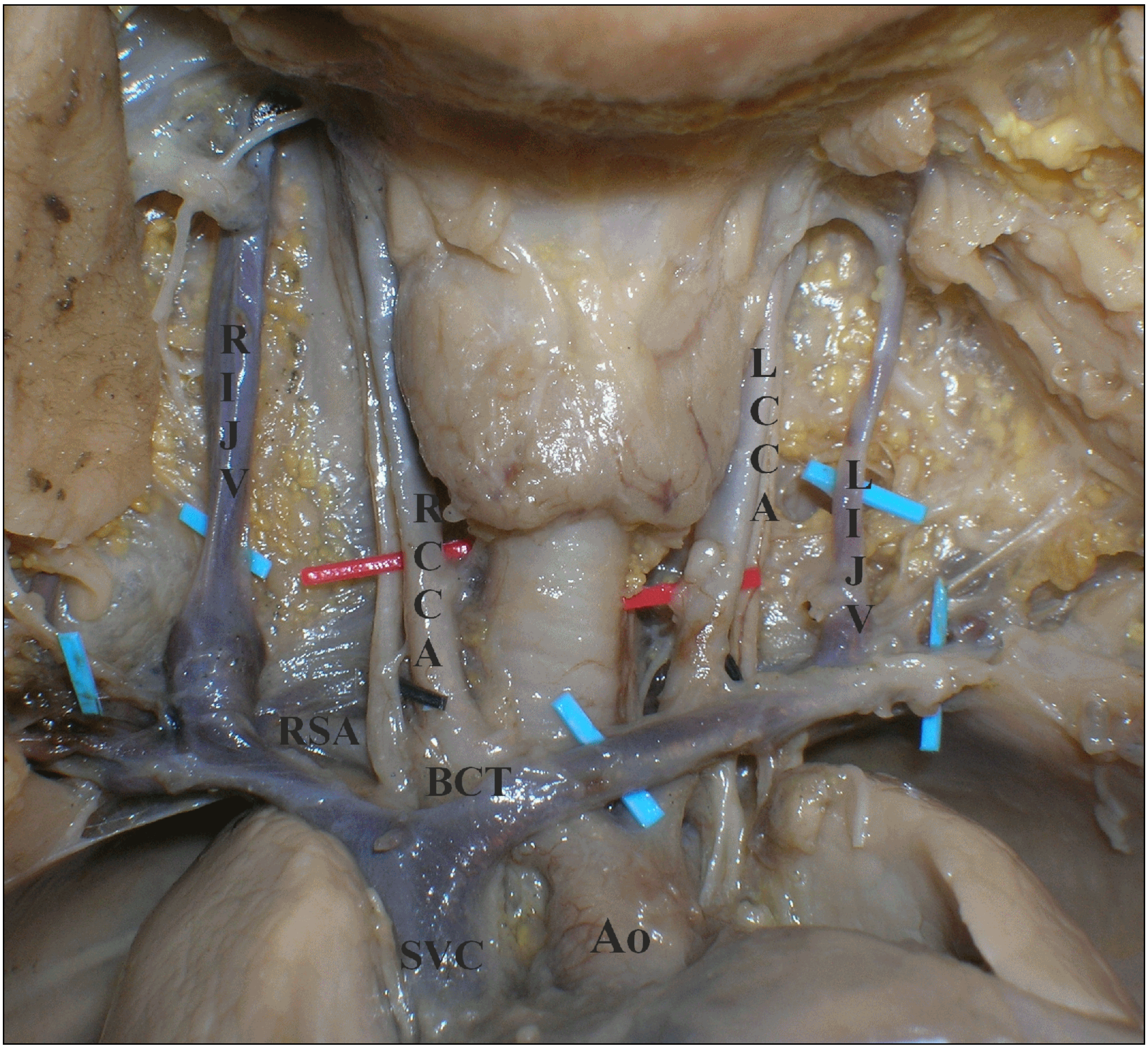


Figure 1.- View of the dissected vessels and other anatomical structures of the upper thorax and neck. Ao: Aorta, RCCA: right common carotid artery, LCCA: left common carotid artery, RSA: right subclavian artery, SVC: superior vena cava, RIJV: right internal jugular vein, LIJV: left internal jugular vein,. Black marker: vagus nerves.

INTRODUCTION

By the end of the fifth week of embryologic development, the third aortic arch originates both the common and internal carotid arteries on each side, while the fourth right aortic arch originates the proximal portion of the right subclavian artery and the brachiocephalic trunk (Sadler, 2005; Savastano et al, 1992; Smith Agreda et al, 1992; Williams and Warwick, 1992), which arises from the horizontal part of the aortic arch leaning to the right to settle in front of the trachea and right recurrent laryngeal nerve, and behind the brachiocephalic veins. The brachiocephalic trunk (BCT) usually divides, at the level of the right sternocostoclavicular joint, into the right common carotid and right subclavian arteries (Latarjet and Ruiz Liard, 1997; Racic et al, 2005; Testut and Latarjet, 1973; Williams and Warwick, 1992).

All the anomalies that can be observed in the formation, distribution and branching of the aortic arch and its branches depend on variations of the fusion mode of the aortic arches. These junctions bear characteristics of arterial division, which represent an important morphologic risk factor for arterial occlusion and difficulties in catheterization. The junction mode between the 3rd and 4th aortic arches may determine the existence of embryological remnants or formations such as a septum or ridges on the internal surface of the

BCT, adding pathological elements of risk and/or technical difficulty (García, 2006, Klabunde, 2011; Montero Granados and Monge Jiménez, 2010).
In the literature we did not find any descriptions of these intraluminal structures. The study of these formations and their relationship with other morphological elements was our objective.

MATERIAL AND METHODS

We dissected 40 fetuses, provided by the University Maternity Hospital (with authorization from the Ethics Committee), from spontaneous abortions and according to international standards. Fetuses were preserved by immersion in 4% formaldehyde solution and their gestational age was determined by measuring the vertex-coccyx length.
The neck and thorax were opened up by medial incision from the xiphoid process to the mental protuberance, and two lateral incisions along the lower margin of the mandibular body and the costal margin. The thymus was removed, the pericardium was opened and partially resected, and the BCT, proximal common carotid and subclavian arteries were dissected. The BCT was measured in length and diameter using an accurate gauge. Statistical relation between gestational age, length and diameter was determined by the correlation coefficient. Identification marks were placed to ease identification of the anatomical structures in the pictures (Fig. 1). The BCT was sectioned and isolated, enabling it to be opened and its lumen to be observed.
The internal angle of the BCT and its branches (between the upper edge of the subclavian artery and the outer edge of the common carotid artery) and the geometric angle (the angle formed by the imaginary axial line of both vessels) were measured on the pictures. Measurements were made of the images of the isolated arterial segments to avoid variations due to the neck position. We used the 1.1 Golden Ratio 1.1 to measure angles. (Figure 2)
Statistical significance was determined by the T-test.

RESULTS

Fifteen per cent of the 40 fetuses studied were female. Gestational age was between 12 and 23 weeks (64.4 mm to 186.18 mm of vertex-coccyx length) and showed a striking difference between the genders. Both the mean and the median gestation age of female fetuses was 19 weeks (150.46 mm and 149.11 mm respectively), while the mean and the median gestation ages of male fetuses were 16 and 17 weeks (121.98 mm and 122.41 mm) respectively.

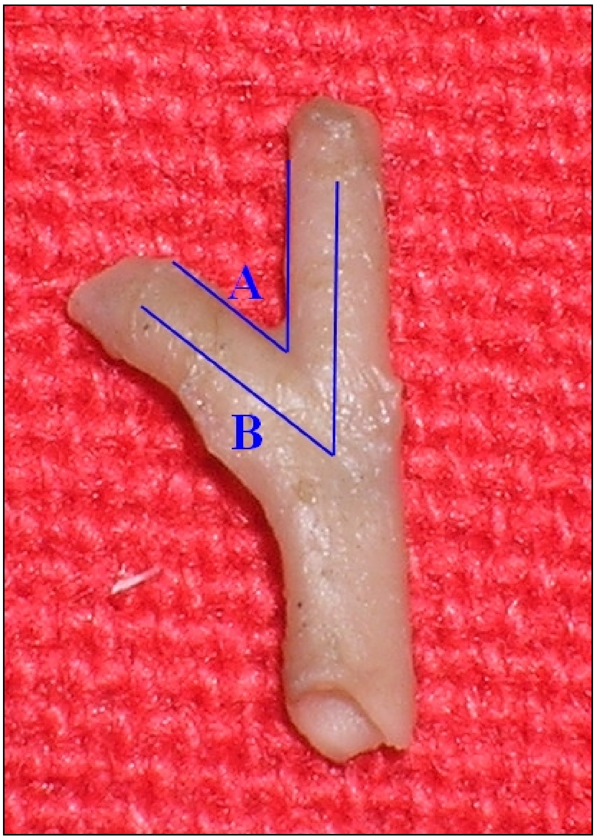


Figure 2.- Angles measured. **A**: Internal angle. **B**: Geometric angle.

During the dissection of the vessels we found a case where there was no brachiocephalic trunk, as the right common carotid artery originated from a common trunk with the left common carotid artery, but the right subclavian artery was a branch of the right pulmonary artery. Another case showed the emergence at the BCT division of a third descending branch to the pulmonary pedicle, determining an anastomosis to the right pulmonary artery. On 7 occasions (17.5%) we observed a common origin of the BCT and the left common carotid artery (a single hole in the aortic arch). The remaining cases presented in the manner usually described (Figure 3).
The length of the BCT varied between 1.9 mm and 6.72 mm (mean: 4.25 mm) while the average

diameter was 1.53 mm (0.5 mm and 5.07 mm). There was no evidence of a-direct relationship between fetal size and BCT dimensions, instead the graphic shows certain tendency to a positive correlation in the case of length. The correlation coefficients were 0.6425 for length and 0.6154 for diameter (Graphic 1).

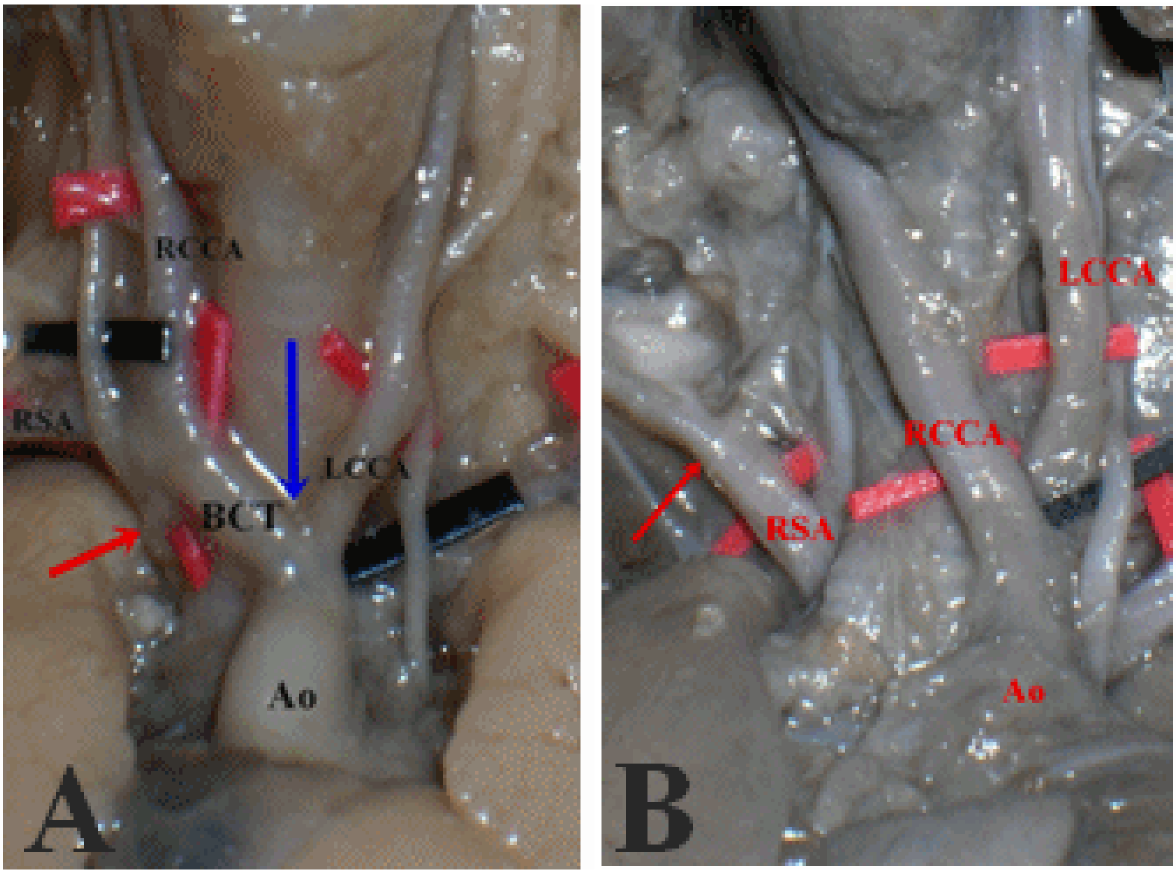
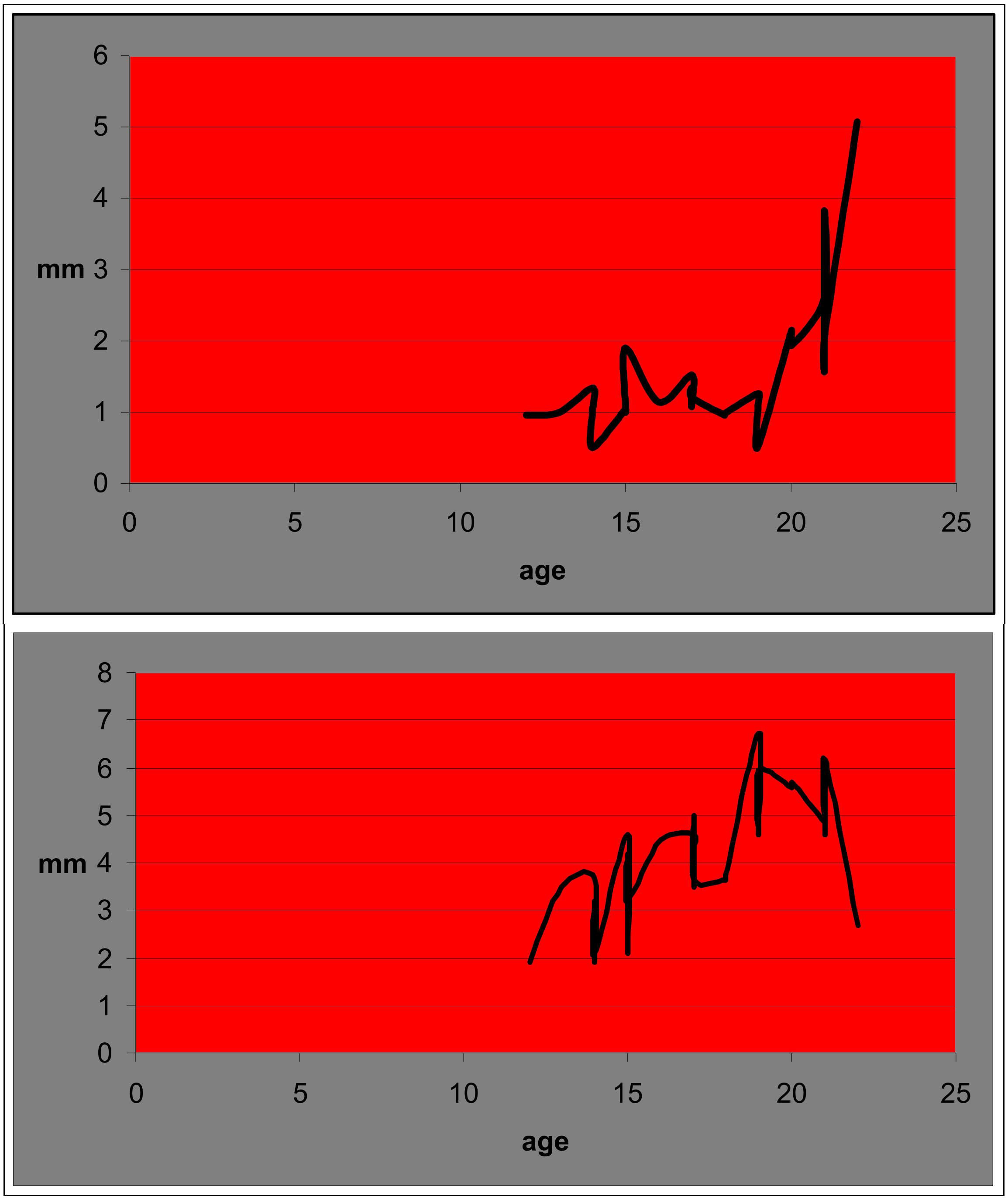


Figure 3.- Variations found in the brachiocephalic trunk (BCT). **A**: Sixteen weeks of gestation: fetus with a common origin of the BCT and the left common carotid artery (blue arrow), and an anastomotic branch to the pulmonary artery (red arrow).Ao: Aorta, RCCA: right common carotid artery, LCCA: left common carotid artery, RSA: right subclavian artery. Black marker: vagus nerves. **B**: Twenty three weeks of gestation: fetus without BCT. The right subclavian artery (RSA) comes out of the right pulmonary artery (red arrow). Ao: Aorta, RCCA: right common carotid artery, LCCA: left common carotid artery.

The angle between the right common carotid artery and the right subclavian artery was measured following two different options: a) the internal angle and b) the geometric angle. The median value of the internal angle was 62º (from 23º to 96º) and that of the geometric angle was 63º (from 32º to 100º). These angles were highly variable from one case to another (Fig. 4).
Due to the small vessel diameter, only on 20 occasions (50%) was it possible to open the BCT and its branches to observe the internal surface. In 4 cases (20%), a partial septum was found extending from the trunk division to its origin in the aortic arch (Figure 5). In 2 cases, (10%) there was a thickened arterial division, forming a ridge.
Considering only those cases where we could open the BCT to check the internal surface and compare the values obtained by measuring the angles, we were able to realize that those that had a septum or ridge also had a significantly higher angle (77.5º instead of 59.5º in the others, P= 0.0379).



Graphic 1.- Dispersion graphic showing the minimal relationship between fetal age and BCT legth (above) and fetal age and BCT diameter below.

DISCUSSION

Most Anatomy books describe the BCT in regard to its origin in the aortic arch, position, main relationships and branching (Latarjet and Ruiz Liard, 1997; Moore and Dalley, 2002; Smith Agreda et al, 1992; Testut and Latarjet, 1973; Williams and Warwick, 1992), and only mention average measurements. Of the consulted literature, only Testut and Latarjet (1973) refers to the great variances in length and diameter (including measurements) and variances in orientation that modify its relationships with other anatomical structures, determining clinical-surgical consequences.

Many authors include some embryological aspects of the BCT in their descriptions, some discrepancies appearing among those who state that the BCT and the subclavian artery originate from the 4th aortic arch (Savastano et al, 2002; Smith Agreda et al, 1992; Williams and Warwick, 1992) and others who associate their origin with the aortic sac (Moore, 1982; Sadler and Langman, 2005).

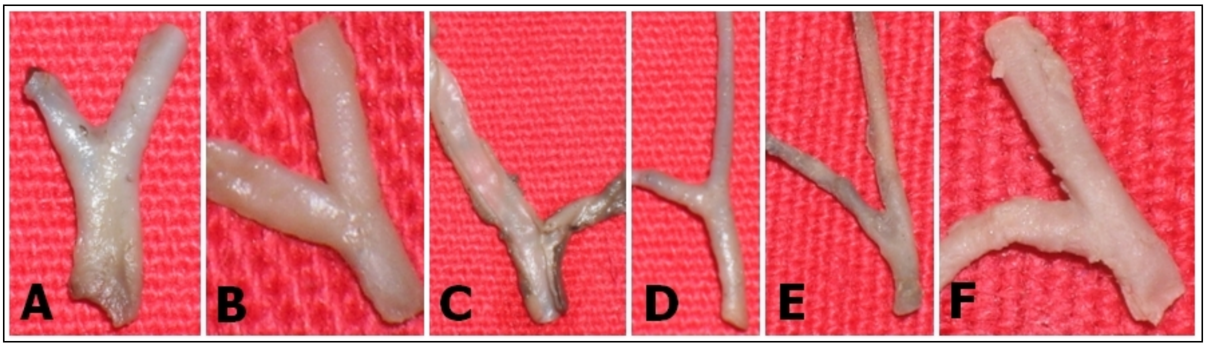


Figure 4.- Different types of brachiocephalic trunk branching and angles. **A-** Nº 11 (22 weeks of gestation), **B**- Nº 15 (15 w), **C**- Nº 22 (21 w), **D**- Nº 27 (18 w), **E**- Nº 31 (17 w), **F**- Nº 32 (13 w).

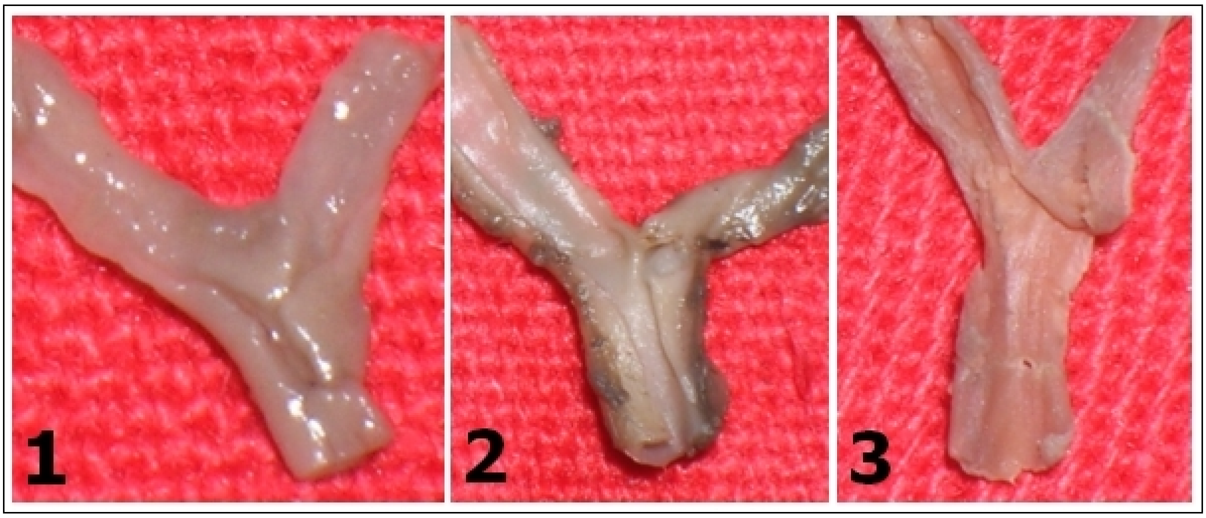


Figure 5.- Pictures of the partial septum in the brachiocephalic trunk. **1)** Age: 15 weeks; **2)** Age: 21 weeks; **3)** Age: 19 weeks.

Embryological features determine anatomical variations and anomalies that often occur in the BCT : 1) at its origin, such as a common origin with the left common carotid artery (Chahwan et al, 2006; Jakanani and Adair, 2010; Katz et al, 2006; Moskowitz and Topaz, 2003; Turgut et al, 2001), coming from any of the pulmonary arteries (Gil-Jaurena et al, 2011; Martin et al, 2006) or absence (Chaoui et al, 2005; McDowell et al, 1980; Natsis et al, 2011), 2) in length and anatomical relations (Hori et al, 2004; Maldjian et al, 2007; Ozlugedik et al, 2005; Racic et al, 2005), 3) in its branching, such as the observed origination of a coronary artery (Davies and Lie, 1977; Duran et al, 2008), a pulmonary artery (Hung et al, 2001; Tsutsumi et al, 1991), a thyroidea ima artery (Yilmaz et al, 1993) and others.

Most of the BCT-related publications are case reports, usually on anatomic anomalies with clinical consequences, or on diagnostic and surgical findings.

Savastano et al (1992) refers to the hypoplasia, atresia and agenesis of the BCT, and its implications for brain irrigation.
We have not found any publication in which the internal surface of the BCT was studied, this explaining why the formations we are describing had gone unnoticed up to now. In addition, only a few of the studies published were carried out on fetuses.
These formations (partial septum or ridge) showed no relation to vessel length and/or diameter, which are both highly variable, and whose development is not consistent with other morphologic features or criteria. In this regard, we differ with the statements expressed by Szpinda et al (2005). They were not related to superficial abnormalities of the BCT either.
The study of the angle between the right common carotid artery and the right subclavian artery should be determined by the characteristics of the junction of the 3rd and 4th aortic arches. Although we could not establish a direct relationship between the angle and the presence of intraluminal formations, we determined that the mean and median values of these angles were significantly higher in cases with a septum or ridge than in those with an even surface. Hence, the characteristics of the junction should determine the permanence of embryologic remnants in the arch fusion site during the first weeks of pregnancy.
This study demonstrates the existence of these intraluminal formations in fetuses but we do not know if they persist in adult age. The presence of these formations in children and adults should be a major risk factor for obstructive arterial disease and, without doubt, represents a difficulty for arterial catheterization (García, 2006, Klabunde, 2011; Montero Granados and Monge Jiménez, 2010). The 30% we found of these formations could be related to the 17% of atherosclerosis of the BCT reported by Sixt et al (2009) and others (Nakahara et al, 2010; Savastano et al, 1992; Stone et al, 2010).
In conclusion, the observation of the inner surface of the BCT in fetuses showed that, under normal conditions, there could be a partial septum or ridges. These formations, if persisting in adulthood, should determine a major risk factor for vascular occlusive disease and may cause technical difficulties for arterial catheterization.

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