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CT Angiographic Study of Anatomical Variations of Aortic Arch Branches in Libyan Patients

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الملخص:

الهدف من هذه الدراسة هو تحديد مدى انتشار اختلافات فروع قوس الشريان الأبهر في المرضى الليبيين. وكذلك تحديد نسبة كل نوع .أجريت هذه الدراسة بأثر رجعي على مائتين وتسعة وعشرين مريضًا بالسرطان تمت إحالتهم إلى قسم الأشعة المقطعية للمسح المقطعي المعزز للصدر. أظهرت عمليات المسح أن 83٪ من المرضى لديهم نمط تفرع تقليدي لقوس الأبهر، و17٪ لديهم اختلافات في قوس الأبهر. كان تباين القوس البقري هو الاختلاف الأكثر شيوعًا حيث وصل إلى 11.4 ٪، حيث تنشأ الشرايين السباتية العضدية الرأسية والشريان السباتي المشترك الايسر كجذع مشترك من قوس الأبهر. نسبة انتشار نوع الشريان الفقري الأيسر الذي ينشأ من قوس الأبهر كانت 3.9٪. اما معدل انتشار نوع الشريان تحت الترقوي الأيمن الضال 2.6٪، والشريان تحت الترقوي الأيمن الضال مع نوع الجذع السباتي الشائع كان 1.74٪. ولم يتم العثور على علاقة بين الجنسين واختلافات فروع القوس الأبهر. نستنتج أن هناك اختلافات في تشعب الأبهر وبالتالي، لذلك يجب الانتباه أثناء العمليات الجراحية في الصدر/ وعمليات الاشعة التدخلية لضمان نتائج آمنة لهذه العمليات. كذلك، ندرك بأن الفحص بالأشعة المقطعية هو طريقة جيدة لدراسة هذه الاختلافات وأنماط التفرع المرتبطة بها.

الكلمات المفتاحية:

قوس الأبهر، تباين فروع الأبهر، القوس البقري، الشريان الفقري الأيسر، التصوير المقطعي المعزز بالصبغة..

Abstract

The aim of this study is to determine the prevalence of the aortic arch branches variations in Libyan patients. The proportion of each type will be determined. Subjects and methods: This retrospective study was carried out on 229 cancer patients referred to the CT Scan Department for enhanced chest CT scanning. The scans showed that 83% of the patients had classical aortic arch branching patterns, and 17% had aortic arch variations. Bovine arch variation was the most common variation seen, reaching 11.4%, in which brachiocephalic and left common carotid arteries arise from the aortic arch in a common trunk. The prevalence of the left vertebral artery type that originates from the aortic arch was 3.9%. The prevalence of the aberrant right subclavian artery type was 2.6%, and of the aberrant right subclavian artery with common carotid trunk type was 1.74%. No relationship was found between gender and aortic arch branches variations. We conclude that aortic arch branching variations exist and hence, attention must be paid during chest surgical operations/radiological interventions to ensure safe procedure outcomes. Also, a CT scan is a good method to study such variations and the associated branching patterns.

Keywords: aortic arch, aortic branches variation, bovine arch, left vertebral artery, contrast enhanced CT.

1. INTRODUCTION

The classical anatomical and most common configuration of the aortic arch (AA) has three great branches: a brachiocephalic trunk (BCT), which gives rise to the right subclavian (RS), the right common carotid (RCC), the left common carotid (LCC), and the left subclavian (LS) artery, from right to left. This pattern occurs in 64.9–94.3% of the cases so is described as "classical" [1]. Accordingly, considering these high percentages in variations, the branching pattern of the AA are not rare [2,3]. These variations were discovered incidentally during routine diagnostic scanning in most cases [3].

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These variations in the branching pattern of the AA range from differences in the origin of different branches to the number of branches [4].

According to the classification of Natsis et al. [5], eight different forms of aortic arch have been discovered. They were classified according to their incidence as types I to VIII, with type I being the most common, and type VIII being the least common. These types are referred to serially from I to VIII, in which type I consists of the brachiocephalic trunk (BT), left common carotid artery (LCC) and left subclavian artery (LS). Type II consists of BT with LCC and LS, while type III includes BT, LCC, left vertebral artery (LV), LS and the form of type IV is right subclavian artery (RS), carotids in common, LS, and in type V carotids in common-LS, RS, type VI carotids and subclavian in common, type VII, RS, right common carotid artery (RCC),

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LCC, LS, and in type VIII, BT, inferior thyroid artery, LCC, LS [5].

Studying these anatomical variations is crucial especially considering head, neck and thoracic operations, in particular for vascular, cardiac, esophageal, and mediastinal surgery [6]. It has been reported that during thoracic surgery, unrecognized variations of the aortic arch branches may lead to serious complications including ischemia [4].

A contrast-enhanced CT scan is a good method to study the aortic arch and its associated branching pattern [3,6]. The development of CT has allowed researchers to study cases of large sample size such as those seen in a number of previous studies conducted in different countries such as the United Kingdom, Germany and China [3,7,8]. However, CT scans as mentioned are considered a reliable method to study the variations in the aortic arch branches, magnetic resonance imaging (MRI) also can be used to evaluate these variations. Both CT scans and MRI have high spatial and temporal resolutions, large fields of view, and multiplanar imaging reconstruction capabilities. Therefore, considering the usefulness of this technique for determining aortic arch variation, we depended on the same technique to carry out our study.

2. SUBJECTS AND METHODS

This study was carried out on 229 cancer patients referred for contrast-enhanced CT scans of the chest for staging during the study period. The patients included 179 females and 50 males, ageing between eight and eighty-nine years. The study included the patients who had their chest scans during the period from the first of July 2019 to the end of August 2019. The scans were used to study the anatomy of the aortic arch branches to determine the presence of the normal variation or the less occurring or rare variations.

All the test procedures were approved by the local ethics committee. The study is based on a retrospective evaluation of radiology records for chest CT findings of aortic arch branches variations. All cases included in this study were referred to the CT Scan Unit at the National Cancer Center, Benghazi. The chest CT scan findings were evaluated by two observers [a radiologist and an anatomist]. All subjects included in this study were known oncology cases. The CT scans were performed using a scanner by Philips; Brilliance- 6 slices. The chest CT protocol was obtained by a special parameters technique. Mainly the axial views complimentary views were performed and when needed complimentary views were taken. These views included coronal and 3D images.

Descriptive statistics were performed; including the mean of age, the standard deviation with corresponding confidence interval in the total sample and by gender, the proportions of males and females, and the proportions of subjects with aortic arch branches variations. A Chi-square test for independents was used to assess the association between gender and types of aortic arch branches variations (Normal vs variant). The data was analyzed using IBM SPSS software (version: 25.0).

3. RESULTS

The results showed that from 229 patients in this study, 17% of the cases had aortic arch branches alterations. The variations appeared more in females compared to males (table 1) which indicates the statistics used to show the gender distribution of the sample group. The mean age of the total sample was also presented (table 2), in addition to the mean age of both sexes (table 3). The scans showed that 83% of patients had classical aortic arch branching patterns (figure 1), and 17% had aortic arch variations (table 4). Bovine arch configuration (a common origin to the brachiocephalic and left common carotid artery origin) (figure 2 & 3) was the most frequent variation seen, reaching 11.4%. The second most frequent variant was the left vertebral artery type that originates from the aortic arch was 3.9% (figure 4), while the prevalence of the aberrant right subclavian artery type (figure 5) was 2.6%, and of the aberrant right subclavian artery with common carotid trunk type (figure 6) was 1.74%. The percentages do not add up to 100% as few subjects had more than one variant. The frequency of the classical configuration and other anatomical variations of the aortic arch were described and shown in (table 4). No statistically significant association between gender and the anatomy of the aortic arch (normal vs. variant), with a p-value of 0.138 (table 5), the prevalence of the aortic branches with a variant presentation with reference to the normal aortic arch branches within the sample also studied (table 6).

Table 1: Gender distribution of the patients:

	Frequency	Per cent
Male	50	21.8
Female	179	78.2
Total	229	100.0

Table 2: mean of age of total sample:

Mean ± SD*	95% confidence interval
52.45 ± 14.16	50.61 – 54.30

*standard deviation.

Table 3: mean of age of both sex:

Gender	Mean ± SD	95%confidence interval
Male	58.14 ± 19.90	53.05 – 63.23
female	50.87 ± 17.90	49.02 – 52.71

Table 4: per cent of normal and variant patients:

	Frequency	Per cent
Normal	190	83.0
Variant	39	17.0
Total	229	100.0

Table 5: The association between sex and aortic arch anatomical variation:

No, (%)	Normal	Variant
Males	38 (76%)	12 (24%)
Females	152 (84.9%)	27 (15.1%)

Chi-square p-value = 0.138 (non-significant).

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Table 6: Percent of different aortic arch variants:

	Frequency	Per cent
None	190	83.0
Bovine Arch	26	11.4
Left vertebral artery		3.9
RSC aberrant retroesophageal	6	2.6
RSC aberrant retroesophageal with common carotid trunk	4	1.74

Percentages do not add up to 100% as few subjects have more than one variant.



Figure 1: (A) MIP reconstruction Maximum Intensity Projection and (B) 3D VRT Volume Rendering Technique showing the Classical pattern of aortic arch branches.

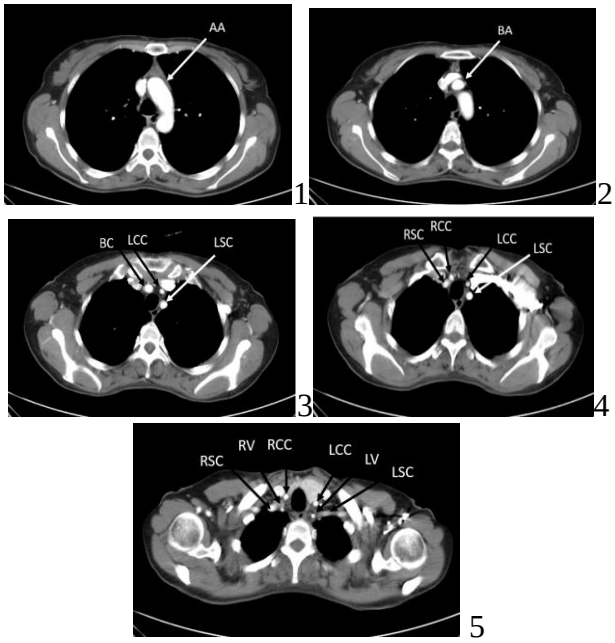


Figure 2: Contrast-enhanced axial cuts through the upper chest demonstrating a bovine arch configuration variant aortic arch branches.

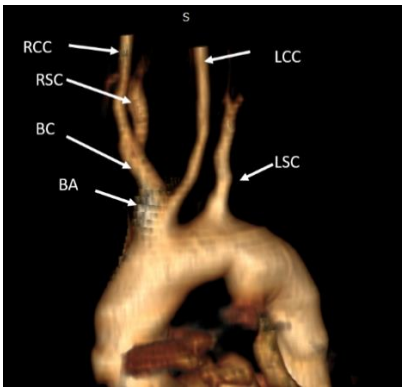


Figure 3: VRT Volume Rendering Technique showing a bovine arch configuration.

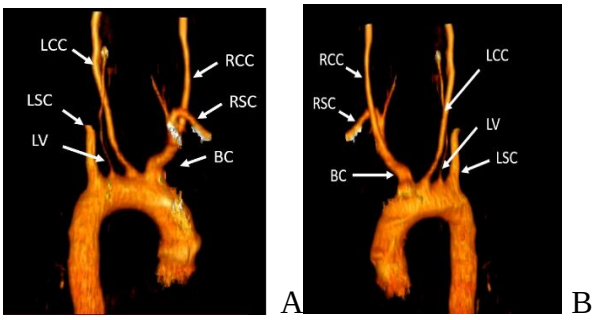


Figure 4: 3D VRT Volume Rendering Technique (A) Anterior Right AR view showing Aberrant left vertebral otherwise classical configuration pattern, (B) Anterior Left AL view of the same subject.

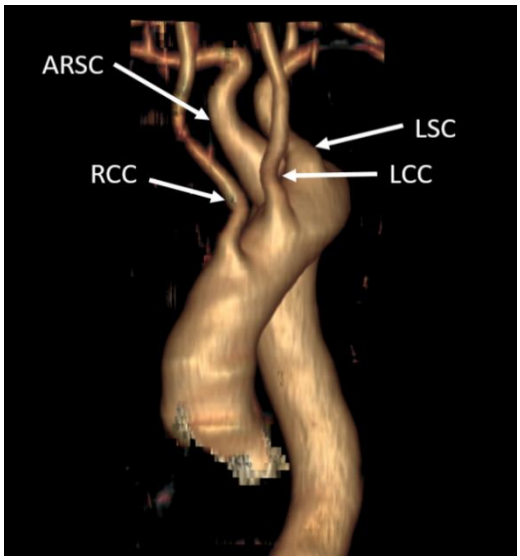
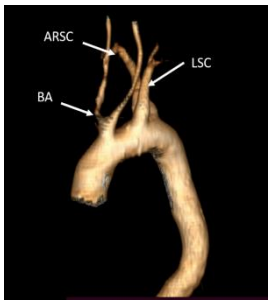
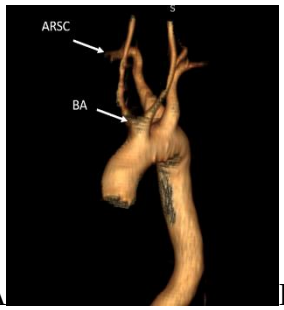


Figure 5: 3D VRT Volume Rendering Technique showing aberrant right subclavian "ARSC".

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A


B

Figure 6: (A) and (B) VRT Volume Rendering Technique showing bovine arch with aberrant right subclavian.

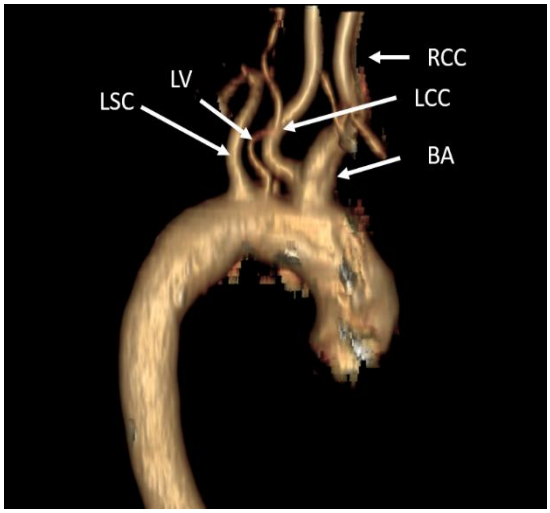


Figure 7: VRT Volume Rendering Technique showing bovine arch with aberrant left vertebral.

4. DISCUSSION

The accurate information about the AA branches and their variations will help chest, cardiovascular surgeons and interventional radiologists make decisions about the appropriate clinic treatment. The most common aortic arch variation is the bovine arch, which has a common origin to the brachiocephalic and left common carotid arteries, with a prevalence of 1- 41 per cent in different studies, in Jakanani et al study [7], the bovine arch variant occurred in 20% of participants [7], and was seen in approximately 13% of patients in Layton et, al study [9]. Our results lie in this range as the percentage of the bovine arch was (11.4%).

This study included 229 patients; 50 males (21.8%) and 179 females (78.2%), with a mean age and standard deviation for the entire group (52.45 ± 14.16), the mean age for males (58.14 ± 19.90) and for females (50.87 ± 17.90). The aortic arch (AA) classically has three large branches which are classified as (type I) and has been noticed in 190 patients (83%) of the total number of cases in this study, while the variations of the branches of the AA were found in 39 patients (17%). According to the literature, the normal three-branch pattern of the aortic arch is found with an incidence of 64.9–94.3% [1,3,4,5]. In this study, the relative incidence of 78.2% lies in this wide range.

It has been found at autopsy from individuals of Japanese descent born in Hawaii, that out of 193 individuals, 182 (94.3%) show a typical artery branching pattern trees [10] which is in line with this study. Also, in agreement with our study, Lale et al. [6] reported that in 881 of studied cases, the classical variation of the aortic arch was observed in 87.4% (770) of the total number of cases. Also, variations in branching patterns were seen in 111 (12.6%) patients. An aberrant right subclavian artery was seen in 1.9%. Whereas 4 (1.74%) of patients had an aberrant right subclavian artery with common carotid trunk [6]. In this study, (76 %) of males and (84.9 %) of females are considered classical, there is no statistical difference between genders (p-value = 0.138). Similar to the results of a large study of 1000 patients, which concluded that the incidences of the variations of aortic arch branching were similar among males and females [11]. In addition, Natsis et al. [14] reported that no significant gender or ethnic differences exist among the 5 branching types [12]. Another study on the Mexican population reveals no statistically significant difference between males and females [13]. In this study 9 patients (3.9%), had left vertebral artery originating directly from the aortic arch, which goes with Müller et al. study [3] who found that 4.2% of the patients showed a left vertebral artery [3]. An analysis of 113 aortic arches in Kenya showed that there was 67.3% of the usual pattern and the remaining 32.7% showed a great variety of patterns, the most common of which (25.7%) was two branches namely the left subclavian artery and a common stem that gave rise to the brachiocephalic trunk and left common carotid artery [14]. Recently, it has been reported that twenty studies with typical (78% prevalence) and variable (22%) branching patterns were included. Common variants were the brachiocephalico-carotid trunk (49% prevalence), the aberrant left vertebral artery (41%) and the aberrant right subclavian artery (8%) [12].

Limitations of the study:

The limitation was that the study was completed at a single centre. It would be important to conduct a multi-ethnic analysis of aortic anatomical patterns.

5. CONCLUSION

Understanding the aortic arch branching alterations gives accurate information that can help chest and cardiac surgeons during surgical interventions and decreases postoperative complications and improves post-operative prognosis. Hence, this study highlights the aortic arch branching variations which might be significant in future clinical education.

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