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# Aortic Arch Variations among Jordanian Patients Depicted on CT-Angiogram

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**Keywords:** Aortic Arch; CT-Angiogram; Jordan; Anatomical Variation.

## Abstract

**Introduction:** Variations of branches arising from Aortic Arche (AA) are well known and documented by several authors in different races [19]. However, such variations have never been studied in Jordan. The aim of this article was to determine the prevalence of AA branching pattern variations among Jordanian patients depicted on CT-Angiogram and to compare the results with other international studies.

**Materials and Methods:** We retrospectively analyzed CT-Angiograms of 408 Jordanian patients using a Picture Archiving and Communication System (PACS) between January 2014 and April 2019 looking for presence of AA variations. AA variations were classified into eight types according to branching pattern.

**Results:** Type I (the normal) was the most frequent type of AA branches in this study 76.47% (n= 312). Type II AA (bovine arch) was found in 23.52% (n = 85). Type III AA in 1.71% (n = 7), Type V AA in 0.24% (n = 1), Type VII AA in 0.24% (n = 1), and Type VIII AA in 0.24% (n = 1). However, Types IV and VI were not identified.

**Conclusion:** Although there are some racial variations of the AA branches, the sample of Jordanian population had similar to those shown in the majority of different races. AA Type I AA is the most frequent pattern followed by type II and type III. Knowledge of these variations may be very important to the vascular, thoracic surgeons and interventional radiologist.

## Introduction

The aortic artery is a high caliber vessel which originates in the vascular ring of the aortic valve and descends until dividing into common iliac arteries in the sacral promontory, the AA which originates in the posterior portion of the second right sterno-costal joint and ends behind the second left sterno-costal joint [1]. The most common aortic arch branching pattern in humans consists of 3 great vessels originating from the arch of the aorta [2]. The first branch is the Brachiocephalic Trunk (BCT), which branches into the Right Subclavian Artery (RSA) and the Right Common Carotid Artery (RCCA). The second branch in the most common pattern is the Left Common Carotid Artery (LCCA), and the last branch is the Left Subclavian Artery (LSA) [2]. Some of these variations usually have influence on different pathological processes, surgical approaches and complications. Therefore, knowing these vascular distributions is highly relevant for diagnosing and planning open and endovascular

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surgical approaches to the aortic disease [1]. The variations of branches arising from AA are well known and documented by several authors in different races [3]. However, such variations have never been studied in Jordan which generate a degree of uncertainty in clinical, radiological and, interventionist practice [4]. The aim of this article was to determine the prevalence of AA branching pattern variations among Jordanian patients depicted on CT-Angiogram and to compare the results with other international studies.

## Materials and methods

Four hundred eight CT-Angiogram were retrospectively reviewed [5] using a PACS between January 2014 and April 2019. The inclusion criterion was Jordanian adults who underwent CTA at KAUH for the AA with different indications. Non-Jordanian patients, patient with congenital heart disease and unclear image were excluded from the study [6,5]. Aside from the origin of the population and the sex of the individual, no other sociodemographic variables were included in the study due to the lack of effect of those variables into the embryologic and anatomic configuration of the aortic arch [20]. CTA interpretation was conducted by a single vascular and endovascular surgeon with more than 10 years of experience in CTA and supra-aortic trunks surgeries and interventions. CTAs were analyzed using 3D reconstruction in order to evaluate AA branching variations. Table 1 shows the definitions of each type of AA.

## Results

Normal (type I) AA branches were present in 312 patients (76.47%). Variations of AA branches were present in 96 patients (23.52%). The incidence of each AA variation was as follows: 85 patients (20.83%) had type II variation, 7 patients (1.71%) had type III variation, 1 patient (0.24%) had type V, 1patient (0.24%) had type VII, 1 patient (0.24%) had type VIII. However, no type IV and type VI variations were identified. Type II AA variation was more common in females (70% table 2).

**Table 1:** Types and definitions of the morphological patterns of AA [1].

| Type and % | Definition |
|---|---|
| **I (71.3-83%)** | Emergence of three vascular BCT, LCCA and LSA (Regular pattern) |
| **II (15%-21.1%)** | Common vascular trunk between the BCT and LCCA, and one LSA alone (Bovine arch) |
| **III (0.16% - 8.2%)** | The origin of BCT, LCCA, LVA originating directly from the AA and LSA. |
| **IV** | Absence of BCT; the RSA has its own origin; a common trunk between the RCCA and LCCA arteries is seen, and LSA is observed. |
| **V** | There is a common trunk between RCCA and LCCA; LSA and aberrant ARSA are observed. |
| **VI** | There is a common trunk between LCCA and RCCA, and between RSA and LSA. |
| **VII** | Absence of BCT. RSA, LSA, RCCA and LCCA have an independent origin. |
| **VIII** | BCT, MTA, LCCA and LSA are observed. |

BCT: Brachiocephalic Trunk; LCCA: Left Common Carotid Artery; LSA: Left Subclavian Artery; LVA: Left Vertebral Artery; RSA: RSA: Right Subclavian Artery; ARSA: Aberrant Right Subclavian Artery; MTA: Median Thyroid Artery; AA: Aortic Arch.

**Table 2:** Distribution of anatomical variations of the aortic arch and gender variations.

| Variant | Type I | Type II | Type III | Type IV | Type V | Type VI | Type VII | Type VIII |
|---|---|---|---|---|---|---|---|---|
| **%** | 76.47% | 20.83% | 1.71% | 0.00% | 0.24% | 0.00% | 0.24% | 0.24% |
| **n** | 312 | 85 | 7 | 0 | 1 | 0 | 1 | 1 |
| **Gender** | 56% Males | 70% Females | 57% Females | - | 100% Females | - | 100% Males | 100% Females |

**Table 3:** Distribution of anatomical variations of the aortic arch in the world population and in this study [1].

| Study | Type I | Type II | Type III | Type IV | Type V | Type VI | Type VII | Type VIII | Country |
|---|---|---|---|---|---|---|---|---|---|
| Natsis et al. | 83% n= 527 | 15% n= 96 | 0.16% n=5 | 0.16% n= 1 | 0.16% n= 1 | 0.16% n= 1 | 0.16% n= 1 | 0.16% n= 1 | Greece |
| Celikyay et al. | 74.4% n= 845 | 21.1% n= 240 | 2.9% n=33 | 1.6% n= 18 | | | | | Turkey |
| Herrera et al. | 71.3% n= 87 | 17.2% n= 21 | 8.2% n=10 | 3.3% n= 4 | | | | | Colombia |
| Alsaif et al. | 77% n= 27 | | | 23% n= 9 | | | | | Saudi Arabia |
| Rojas M et al. | 74.29% n= 26 | 11.43% n= 4 | 8.57% n=3 | 0% n= 0 | 3% n= 1 | 0% n= 0 | 0% n= 0 | 3% n= 1 | Colombia |
| This study | 76.47% n= 312 | 20.83% n= 85 | 1.71% n=7 | 0% n= 0 | 0.24% n= 1 | 0% n= 0 | 0.24% n= 1 | 0.24% n= 1 | Jordan |

## Discussion

The usual or normal branching pattern is seen with an incidence of 64.9-94.3% according to the literature [7]. Variation in the AA branches occurs mainly due to the abnormal fusion or disappearance of aortic arch arteries during the embryonic period [7]. The aorta develops during the third week of gestation, with six pairs of aortic arches developing between the ventral and dorsal aorta [8]. The aorta, AA, and its branches develop through a complex process in the fetus during the first few weeks of development [9]. In normal embryonic morphogenesis, the AA develops from five pairs of pharyngeal arch arteries with left-to-right symmetry. The mature configuration of the thoracic aorta and its branches is a result of a defined pattern of asymmetric regression and persistence of specific embryologic arch structures [10,11].

Modern radiological techniques, especially CTA have enabled an elegant insight into the thoracic blood vessels [12]. In this study, we used CTA to look for the AA variation because CTA with 3D reconstruction is accepted as a non-invasive diagnostic procedure to assess anatomical variations of AA prior to surgery or interventional procedures and it offers a wide outlook of vessels and the spatial relationship of adjacent organ [6].

The form of the branches were classified into Type I, Type II, Type III, Type IV, Type V, Type VI, Type VII and type VIII table_1 [1,13]. See table 1.

The present study revealed that (76.47%) of patients had type I AA, while (23.52%) of them had AA variations table 2. The second most common type was type II (Bovine Arch) followed by type III. Type V, VII and VIII were very rare. However, no type IV and type VI variations were identified. This compares favorably with other published studies table 3.

Anatomical variations in the branching pattern of AA are significant for diagnostic, surgical, and interventional procedures of the thorax and neck [14,3]. They are, however, more important for thoracic operations (especially in vascular, cardiac, esophageal and mediastinal surgeries) and various procedures of interventional radiology [8]. With the increase in recent years of thoracic aortic stenting and hybrid aortic reconstructive procedures, recognition of these variations has assumed greater importance, to ensure safer and more accurate endovascular and surgical planning [9]. In order to anticipate possible difficulties during catheterization, it is of great importance to know the prevalence of such variants in stroke patients [15]. On the other hand, radiologists and surgeons attempting vascular entry in order to reach supra-aortic branches through catheter, also needs to go through AA [13].

There is increased number of AA interventions and surgeries in Jordan. However; there is no data in the Jordanian population regarding this variation. Therefore, awareness of these variations is of crucial importance for cardiac, vascular and thoracic surgeons as well as interventional radiologist. Moreover, Prior knowledge of the arch anatomy will facilitate other interventional decisions, such as catheter shape selection, or whether to use embolic protection devices [9].

## Conclusion

Although there are some racial variations of the AA branches, the sample of Jordanian population had similar to those shown in the majority of different races. AA Type I AA is the most frequent pattern followed by type II and type III. Knowledge of these variations may be very important to the vascular, thoracic surgeons and interventional radiologist.

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