

REVIEW



SUBCLAVIAN ARTERY ANATOMICAL VARIATIONS AND ITS BRANCHING PATTERNS: LITERATURE REVIEW

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ABSTRACT

The human body exhibits a variety of morphological patterns. These variances are rather common and frequently have no discernible effect on the health of the patient. Precise awareness of typical anatomical differences leads to better clinical practice outcomes. Anatomical variations are usually discovered during imaging prior to operation and surgery, as well as routine dissection. Furthermore, scientific methods for identifying anatomical variances include observational studies employing cadaveric dissection, medical imaging, and evidence-based anatomy. This literature aimed to give an overview of the various subclavian artery variations that have been found in various studies and to compile them all into a single study so that anatomists could easily access all variations and gain insight into their origin, course, branching patterns, and clinical significance. This study concluded and according to other studies, the most common variations are aberrant right subclavian artery (ARSA), bicarotid trunk, high origin of the subclavian artery, and variant branching patterns. The courses and associated anomalies of subclavian artery in these variations is recorded. This is scientifically important for surgeons to be aware of this variation to avoid injury to the artery and to plan the surgical approach accordingly. If they wish to perform procedures in the neck and chest region, surgeons, radiologists, and other medical professionals must understand these anatomical variations.

Keywords: branching patterns, course, origin, variations, subclavian artery.

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INTRODUCTION

The morphology and attachments of ligaments, blood vessel branching, nerve patterns and muscle structure are only a few examples of the forms of variations (Gataa & Faris, 2016; Georgiev et al., 2017; Rothenberg et al., 2017; Kirkov, Iliev, & Hinovalova, 2016). Anatomical variances are important in clinical diagnostic and therapeutic processes; they may call for extra care or special accommodation (Sañudo et al., 2003). The subclavian artery and its branches are one of the numerous types of arteries that make up the human body. Subclavian artery branches are a component of the vertebrobasilar circulation (Pavazhakkurinj, 2020). Just below the clavicles are the subclavian arteries, which supply blood to both upper extremities on either side as well as the head and neck. The brachiocephalic trunk is where the right subclavian artery originates, whereas the aortic

arch is where the left subclavian artery begins. The subclavian arteries travel laterally, between the muscles of the anterior and middle scalene. The lateral edge of the first rib, where the subclavian artery changes into the axillary artery, marks the artery's distal limit. Additional branches of the subclavian arteries include the internal thoracic artery, vertebral artery, costocervical trunk, thyrocervical trunk, and the dorsal scapular artery (Rahimi & Geiger, 2019). However, variations in the subclavian artery's origin, course, and branching patterns are among the quite common anatomical variations. This literature aimed to provide an overview of the various subclavian artery variations discovered in various studies and compile them all into a single study so that anatomists could easily access all variations and gain insight into their origin, course, branching patterns, and clinical significance.

METHODS

Data sources, inclusion, exclusion criteria, and study selection were conducted according to the following:

Data Sources

The authors conducted a search on Google Scholar and PubMed between 1970 and 2023 to find English-language, subclavian artery-based studies (n=39) that looked at the origin, course, and branching patterns of the subclavian artery. Bibliographies were examined to find additional noteworthy articles.

Inclusion criteria:

The study focused on the subclavian artery that examined the artery's origin, course, and branches without regard to gender, age, race or country.

Exclusion criteria

All studies and articles involving animals were excluded.

Study Selection

Of (81) studies reviewed, (39) met inclusion criteria and covered one of the following (the origin, course, and branching patterns of the subclavian artery).

REVIEW

Three vessels emerge from the aortic arch normally. The first branch, the brachiocephalic trunk, splits into the right common carotid and the right subclavian arteries. After the brachiocephalic trunk, the left common carotid and subclavian arteries come next. About 70% of people have aortic arch arteries that follow the 'typical' configuration (Shahoud, Miao, & Bolla, 2022; Kelley, et al., 2018).

Seven bilateral cervical intersegmental arteries emerge from the dorsal aortae. The subclavian arteries are partially formed by the seventh intersegmental arteries (Rosen & Bordoni, 2020). There are several anatomical patterns

and configurations of the subclavian artery in the human body. Among these variances are:

1. **Aberrant Right Subclavian Artery:** The right subclavian artery may have an abnormal origin from the descending aorta when the left subclavian artery is located farther away from it. The "aberrant right subclavian artery" is one of the most common congenital vascular abnormalities. It might be related to a condition called dysphagia lusoria, in which the esophagus becomes compressed due to an abnormal artery, making swallowing difficult. Figure (1).

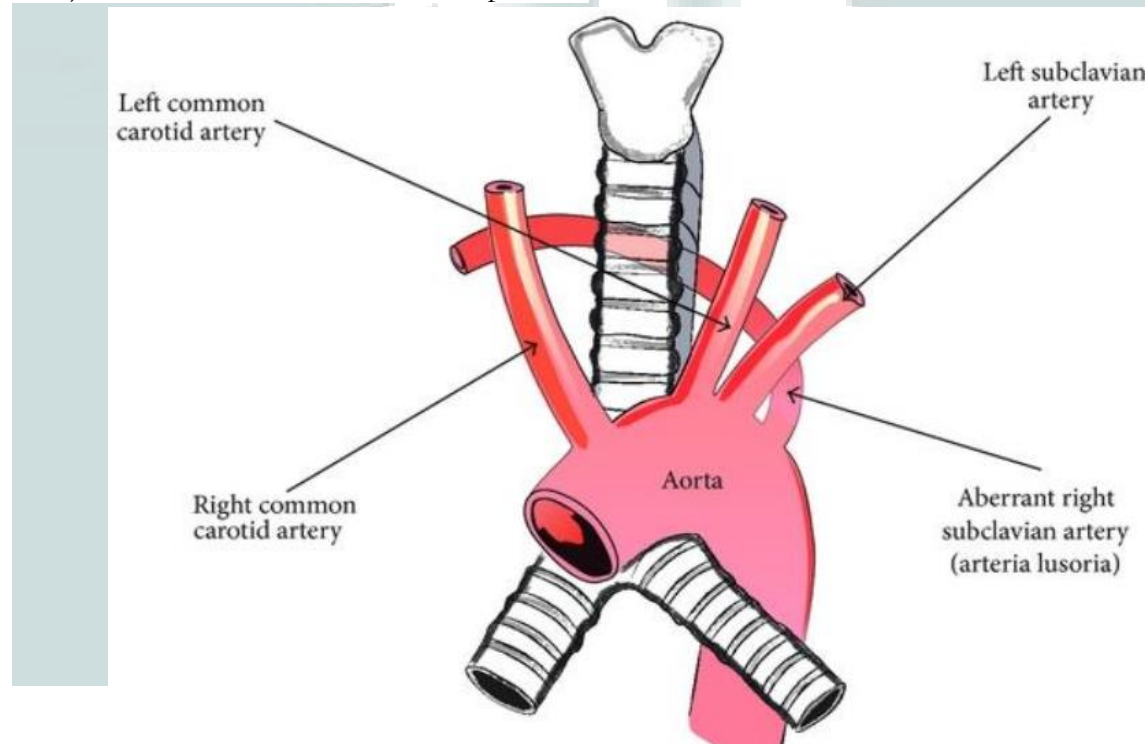


Figure 1: Diagrams showing the locations of aberrant right subclavian arteries (Polguy et al., 2014).

Hunauld originally identified the aberrant right subclavian artery in 1735, with the associated clinical symptom of "dysphagia lusoria" or

"difficulty in swallowing due to a quirk of nature," as recorded by David Bayford in 1787 (Felson B, et al.,1950).

Approximately 1% of people have aberrant right subclavian arteries. This formation results from loss of the normal proximal part of the right subclavian, which is caused by unusual regression of the R fourth aortic arch (Polguy et al., 2014).

The aberrant right subclavian artery, also known as "arteria lusoria," is one of the most prevalent anomalies, with a female predominance and an incidence ranging from 0.16% to 4.4% in the general population (Myers PO, et al., 2010). In this abnormality, the aberrant right subclavian artery develops independently from the descending aorta rather than from the brachiocephalic trunk, and it travels through the esophagus in 80–84% of cases, the trachea and esophagus in 12.7–15%, and the pretrachea in 4.2–5% of cases (12) (Myers PO, et al., 2010). According to Polguy, Michal, et al., 2014), the prevalence of arteria lusoria in was higher in female individuals than in male subjects (55.3% versus 44.7%).

These findings are in line with those of K.K. Jain et al., 2012 who stated that there is a female predominance in the atypical right subclavian artery. The aberrant right subclavian artery was observed in 60-year-old Caucasian male cadaver. It had a direct route between the vertebral column and the esophagus, emerging from the arch of the aorta distal to the origin of the left subclavian artery (Saeed M, et al., 2002). It can develop alone, in combination with other vascular anomalies such as coarctation of the aorta, Kommerell diverticulum, or even as a total interruption of the aortic arch. Patients with chromosomal abnormalities, notably trisomy 21, are also more likely to develop ARSA, with a reported prevalence between 19% and 36% (Chaoui et al., 2005; Greco et al., 2016). In addition, Six cadavers

(2.2%), four females (2.8%), and two males (1.6%) had ARSA. In 83% of cases, the artery had a retroesophageal path, in 16.7% it took an interesophageotracheal course, and there was no pretracheal ARSA found. A bicarotid trunk, a Kommerell diverticulum, and a mixture of both of them in one cadaver coexisted with the ARSA. In one case (17%), the ARSA was combined with a thyroidea ima artery and a bilateral aberrant origin of the internal mammary artery, while in one case (17%), no other associated abnormalities was found. All ARSAs have a right non-recurrent laryngeal nerve present (Natsis et al., 2017). Furthermore 2.5% of people have an abnormal right subclavian artery with a retroesophageal path. 133 autopsy cases involving the right subclavian artery were examined as the final branch. It traveled between the trachea and esophagus in 15% of cases, behind the esophagus in 80% of cases, and in front of the trachea in 5% of cases (Holzapfel, 1899). Aberrant right subclavian artery was found in 32 (0.47%) consisting of 13 males and 19 females, with mean age of 60.8 ± 13.4 years. Esophageal compression was seen in 14 (47%) and tracheal compression in three (10%) of the 30 (94%) (Krupiński et al., 2019). The artery runs through the mediastinum in a retroesophageal location, with the proximal portion of the artery having a larger diameter than the distal portion. Kommerell's diverticulum, located near the proximal descending aorta, is where the artery may originate (Kommerell, 1936).

2. **Bicarotid Trunk:** In rare instances, the left common carotid artery and left subclavian artery may have the same origin, uniting to form the bicarotid trunk, a single channel. This variation may affect vascular surgery as well as

radiological operations in the chest and neck
Figure (2).

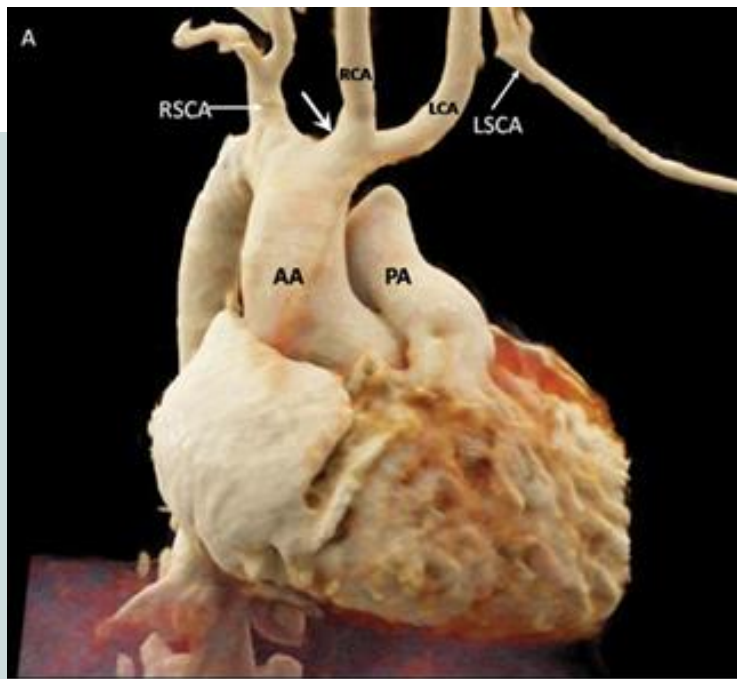


Figure 2: computed tomography angiography image (A) showing right aortic arch with bicarotid trunk (arrow) as the first branch, giving rise to the left (LCA) and the right (RCA) common carotid arteries followed by the origin of the right subclavian artery (RSCA) (Sharma et al., 2023).

A very uncommon aortic arch anomaly, bicarotid trunk forms when the third pair of primitive aortic arch remains, with a reported frequency of less than 0.1%. (Kucukdagli et al., 2016; Meena, 2014). An unusual variation in the branching pattern of an aortic arch with three branches: the retroesophageal right subclavian artery, the left subclavian artery, and the bicarotid trunk (Sangam & Anasuya, 2010). Hanžič, Nina, et al 2019 did aortic three-dimensional reconstructions. The bicarotid trunk, which splits into the left and right common carotid arteries, was the first branch of the aortic arch. The left subclavian artery was the next branch, and an ARSA came last. Up to 2.5% of the population has both an aberrant right subclavian artery and a bicarotid trunk. From 72 Greek Caucasian formalin-embalmed cadavers (43 female and 29 male).

In addition to reviewing the Department of Anatomy's dissection records from 1986 to 2009, An ARSA and a BCT were discovered in two male cadavers (incidence: total 2.78%, men 6.9%, females 0%) (Natsis et al., 2011).

During regular anatomic dissection, an unusual, asymptomatic type of subclavian artery was discovered. The two branches of this type of the aortic arch were a common trunk for both subclavian arteries and a bicarotid trunk (Poultides et al., 2004).

15.2% of the 2,033 cases had a bicarotid trunk. Among cases with a bicarotid trunk, ventricular septal defects, valvular pulmonary stenosis, and atrial septal defects were the most common congenital cardiac defects. Trisomy 21, Williams syndrome, and CHARGE syndrome were the most prevalent genetic syndromes (Reinshagen et al., 2014).

A bicarotid truncus, was discovered to be related with an aberrant right subclavian artery in 85 of 295 instances (29%), The two carotids' origins were observed to be normal in 60% of cases and to be abnormally near to one another in 10% of cases (Klinkhamer, 1966).

3. High Origin of the Subclavian Artery:

According to the normal anatomical arrangement, the right subclavian artery directly from the brachiocephalic trunk while

the left subclavian artery originates from the aortic arch. However, where the subclavian artery has a higher origin, changes can happen. For instance, it might come directly from a neighboring vascular or the aortic arch next to the brachiocephalic trunk. Sometimes, the compression of adjacent structures by this elevated origin might cause symptoms like dysphagia (difficulty swallowing) or chest-compressing sensations. Figure (3).

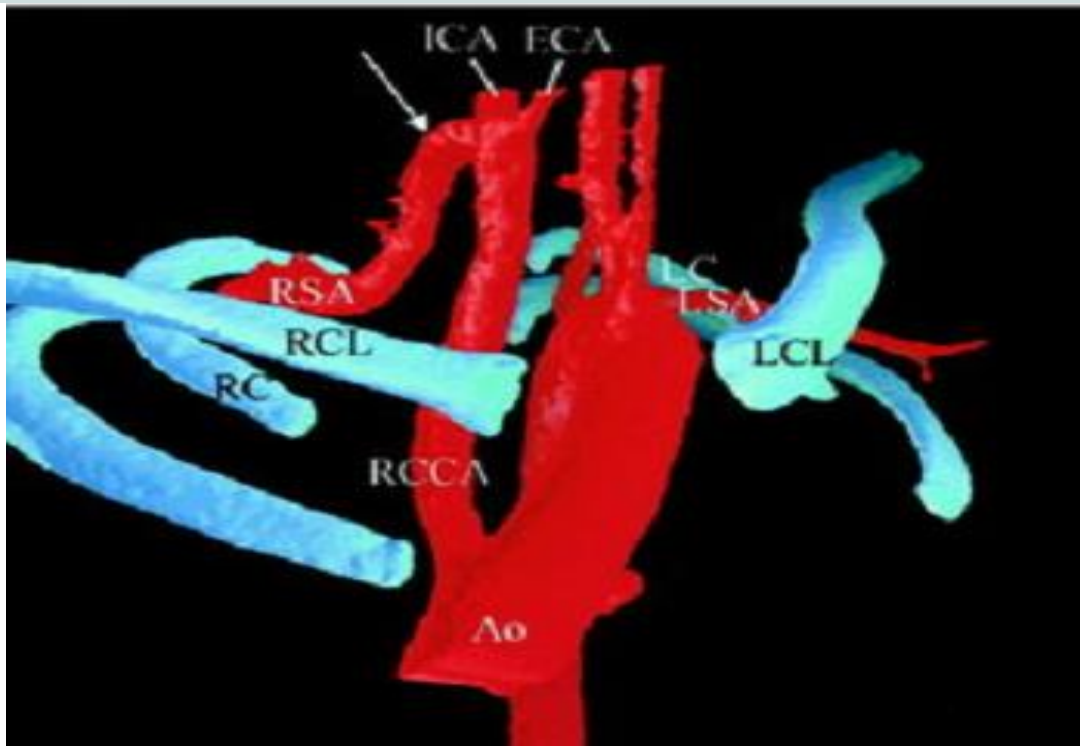


Figure 3: Diagram demonstrates the cervical origin of the right subclavian artery (arrow) (Greil et al., 2004).

Rauch et al., 2002 described the frequency of the anomalies of subclavian arteries in 136 patients with conotruncal malformations. They found cervical origin of the right subclavian artery in 11 of the 37 patients who had anomalies of origin of the subclavian arteries. The associated cardiovascular anomalies in these cases included interruption of aortic arch in 6 patients, pulmonary atresia with ventricular septal defect in 4 patients, and tetralogy of Fallot in one patient. In the cervical origin of the right subclavian artery it

arises excessively high from the common carotid artery near the junction of the external and internal carotid arteries.

The right subclavian artery is elevated abnormally in 14 of 21 newborn hearts (66%) with an aortic arch disruption between the left common carotid and left subclavian arteries. It originated from the right common carotid artery high in the neck in 4 hearts (19%) as a trifurcation with the internal and external carotid arteries. In these cases, following its descent down the neck to the right arm, the

subclavian artery beginning is surrounded by the right recurrent laryngeal nerve (Kutsche & Van Mierop, 1984)).

4. **Variant Branching Patterns:** The branches of the subclavian artery may also vary.

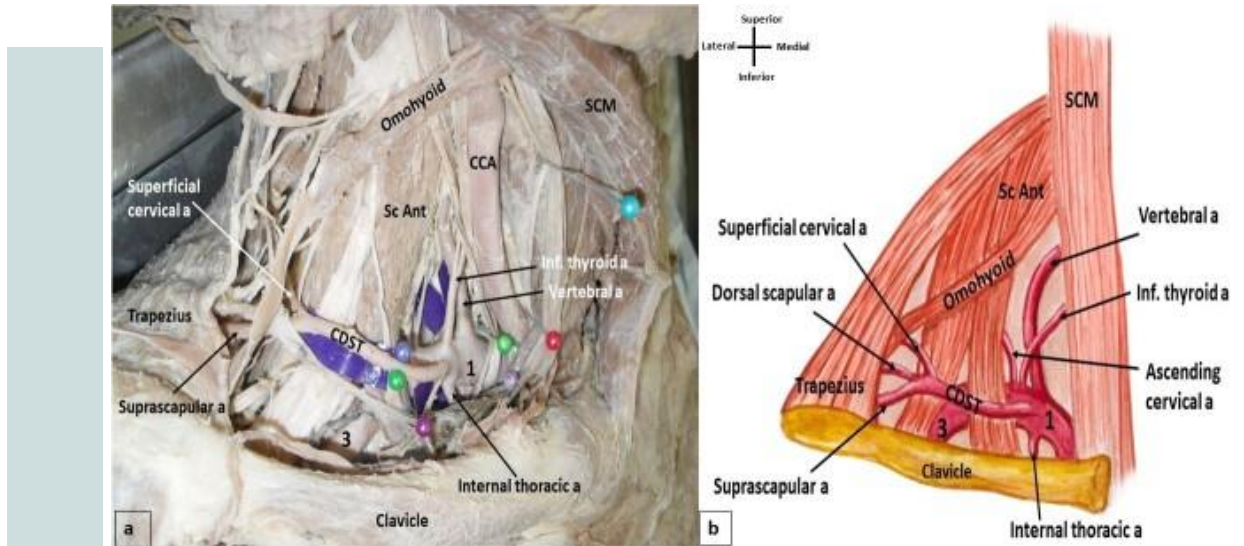


Figure 4: (a) Dissection of the right cervical region showing the variant branching pattern of the subclavian artery; (b) Schematic diagram showing the variant branching pattern. CDST stands for cervicodorsoscapular trunk; SCM for sternocleidomastoid muscle; CCA for common carotid artery; Sc Ant for scalenus anterior; and 1-first and 3-third portions of the subclavian artery (Kumar et al., 2023).

From Thirty embalmed cadavers 63% of cases show the subclavian artery's typical five branching pattern. The vertebral artery is lacking in one subclavian artery but originates from the aortic arch. Internal thoracic artery in 3% of cases arises from the cervical trunk. One subclavian artery lacks the Thyrocervical stem, yet its branches emerge from the subclavian artery. In 75% of cases, the thyrocervical trunk has three branches. The dorsal scapular artery emerges from the costocervical trunk in two subclavian arteries. Third-part suprascapular artery and axillary artery were both visible in 22% and 13% of cases, respectively. In 18% of cases, there is no transverse cervical artery from the thyrocervical trunk (Pavazhakkurinji, 2020).

The left vertebral artery originates from the aortic arch in around 5% of cases, usually between the subclavian arteries

Common branches include the thyrocervical trunk, internal thoracic artery, and vertebral artery; however, the exact origins and courses of each one of them may vary figure (4).

and the left common carotid and. It is possible for the proximal segment to be duplicated, emerging from the left subclavian artery and the aortic arch, before they combine into one artery (Lemke et al., 1999)).

Also, in a large postmortem series, between 2.4% and 5.8% of cases had the left vertebral artery emerging directly from the aortic arch between the left common carotid artery and left subclavian artery (Choi, Chung, & Kim, 2018). In ten case reports, the origin of the right vertebral artery from the right common carotid artery was confirmed, along with the right subclavian artery's distal origin from the left subclavian artery (artery lusoria). The right vertebral artery's anomalous origins were broken down into three groups: those coming directly from the aorta ($n = 9$), those coming from the carotid arteries (aside from those coming from those combined with the artery

lusoria) or from the brachiocephalic artery (n = 10) and those coming from duplicated origins (n = 13) (Kumar et al., 2023).

In addition, The aortic arch served as the origin of the left vertebral artery. There was no thyrocervical trunk on the right side. The two branches that typically emerge from the thyrocervical trunk were not from the same source. The internal thoracic artery gave rise to the suprascapular artery, which in turn gave rise to the transverse cervical artery (Singh, 2018). The transverse cervical artery and thyrocervical trunk were absent from the right side of the neck, and the first part of the subclavian artery served as the origin for all of its branches. Direct branching from the subclavian artery was the inferior thyroid artery. An isolated case of a cervicodorsoscapular trunk was reported. A similar branching pattern was also seen in the left lateral cervical area. The inferior thyroid artery was a straight branch of the subclavian artery, and there was no left transverse cervical artery or left thyrocervical trunk. The first part of the subclavian artery served as the origin for all of its branches. (Yücel et al., 1999).

Also, variations in the suprascapular artery's origin was noticed, it was found to arise abnormally from the axillary artery's first part (Singh, 2018). The dorsal scapular artery, suprascapular artery and superficial cervical artery have different origin patterns also, since they might arise from the thyrocervical trunk and subclavian artery separately or together as common trunks (Yücel et al., 1999).

Conclusion

The human subclavian artery has various patterns, with the aberrant right subclavian being most common. It may occur alone or

with other anomalies, more so in females, and can lead to dysphagia. This artery typically arises from the aortic arch after the left subclavian. It can take different paths, such as retroesophageal or between the esophagus and trachea. Another variation is the high origin of the subclavian artery, originating near the common carotid artery or the aortic arch, causing compression and symptoms like chest-compressing sensations and dysphagia. This variation is often linked to heart anomalies. The rare Bicarotid trunk variation is usually associated with heart defects and genetic disorders, along with an anomalous right subclavian artery. Various branching patterns exist within the subclavian artery. The normal pattern includes five branches. Variations involve the internal thoracic artery possibly arising from the cervical trunk. The suprascapular artery may derive from it, leading to the transverse cervical artery. Thyrocervical stem absence and direct branch emergence are possible. Right vertebral artery origins vary, while the left may stem from the aortic arch. Transverse cervical artery absence and multiple trunk branches are observed. The costocervical trunk can give rise to the dorsal scapular artery. Origin patterns differ for various arteries. Furthermore, the first part of the subclavian artery may be the origin for all its branches. Awareness of these variations is crucial for medical professionals to avoid artery injury and plan the surgical approach and to perform procedures appropriately.

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Data Availability Statement

All data supporting the findings of this study are available within the paper.

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