Unusual Multiple and Bilateral Combinations of Arterial and Neural Variations in the Axillae of Single Cadaver

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ABSTRACT

Nerve During the dissection of the axillae and upper limbs of an 80-year-old male donor, multiple vascular and neural variations were encountered. On the right side, the thoracoacromial artery and the lateral thoracic artery were absent. On the left side the subscapular artery was absent, and the posterior cord of the brachial plexus gave branch to two upper subscapular nerves and then divided into radial nerve and a common stem that branched into thoracodorsal nerve, lower subscapular nerve, nerves to teres major and minor muscles and the axillary nerve. Additionally, in the left arm there was a variant communication between the musculocutaneous nerve and the median nerve. Although the existence of these variations is well documented in the literature as individual entities or few combinations, the occurrence of such multiple variations in a single cadaver in a limited area of the body involving vessel and nerves is not common. A multitude of variations in a small area of the body such as this can be a source of diagnostic and imaging interpretation errors. Unpredictable iatrogenic injuries can also occur during various procedures in the area such as during preparation of muscle flap, mastectomy with axillary lymph node dissection, reconstructive and aesthetic plastic surgery of the breast and other clinical procedures including shoulder arthroplasty.

Keywords: Thoracoacromial artery; Subscapular artery; Lateral thoracic artery; Subscapular nerves; Axillary nerve; Musculocutaneous nerve; Median nerve

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INTRODUCTION

Different patterns of variations of axillary Artery (AA) branches are frequently reported. These variations mostly occur in the 2nd and 3rd parts of the AA [1] but on the contrary, Aastha et al. [2] reported variations in the 1st and 3rd parts of AA but none in the 2nd part. Right unilateral co-existence of AA branch variations with variations of nerves were also documented, where a subscapular trunk (SST) arose from the 3rd part of AA and trifurcated into posterior circumflex humeral (PCHA), subscapular (SSA), and accessory lateral thoracic arteries (LTA). The SSA further trifurcated into circumflex scapular (CSA), lower subscapular and thoracodorsal arteries (TDA). This arterial variation was found together with an unusual communication between the musculocutaneous (MCN) and median (MN) nerves in the arm [3].

It is common textbook knowledge that the thoracoacromial artery (TAA) that arises from the 2nd part of the AA divides into four branches: clavicular, acromial, deltoid, and pectoral branches. However, according to the study done on 54 cadavers, the number of branches from the TAA can vary between 2 and 4 [4], the commonest being 3 branches. Other reports did also indicate that the TAA can have variable division patterns providing the SSA, pectoral branch, LTA and a common trunk that divides into a second pectoral branch and a deltoid branch [5]. A CT-angiographic analysis done on other 55 patients found that the TAA is a branch from the 2nd part of the AA in all cases and illustrated its variable branching patterns which were classified into 4 types: Type 1-TAA arises from the second part of AA and first gives branch to LTA (in 63.3% of the case) and then the deltoid branch, Type 2 - TAA arises from the 2nd part of AA and gives branch to the LTA, pectoral, and deltoid branches sequentially, Type 3- TAA arises from the 2nd part of AA and gives branch to pectoral first and then deltoid branch, Type 4 - any other variation [6]. The TAA, is therefore, the commonest origin of the LTA and can also be absent bilaterally [7] or unilaterally [8] with all its branches arising directly from the axillary artery [8,9].

In the common textbook descriptions, the LTA and SSA are branches of the second and third parts of the AA respectively [9,10]. However, the LTA can have variable origins and may arise from the TAA or suprascapular artery. The commonest of its variations being a common trunk of origin with the thoracodorsal artery (TDA) found in 9.5% of the cases [9,10]. On their study done on 420 formalin-fixed cadavers, Loukas et al. [11] classified the variations of LTA into six types based on its origin. Type I (most common - 67.62%) from TAA, Type II (17.02%) from the AA, Type III (5%) from the TDA, Type IV (3.93) from the SSA, Type V (3.09%) presence of multiple LTAs, and Type VI (3.33%) a complete absence of lateral thoracic artery. The SSA, the largest branch of the AA that arises from its third part commonly branches into TDA and circumflex scapular arteries (CSA) but variations of its origin, branching pattern and even its absence are also frequently reported [12-17].

Variations of origin and branching patterns of the ANs are also well studied. Most existing resources agree on the constant origin of the axillary nerve from the posterior cord of the brachial plexus as independent nerve, however, there are some resources that described its origin posterior cord through a common stem with other nerves [18] or directly from the superior trunk of the brachial plexus [19]. As independent nerve from the posterior cord, it traverses the quadrangular space (lateral axillary hiatus) with the posterior circumflex humeral vessels, where it divides into anterior and posterior branches that innervate the deltoid and teres minor muscles respectively. In the quadrangular space the axillary nerve and the posterior circumflex humeral vessels accompanying it are prone to entrapment that can lead to quadrangular space or lateral axillary hiatus syndrome [20]. If a common trunk of origin from the posterior cord of the brachial plexus exists, it breaks up into axillary, thoracodorsal and subscapular nerves in variable combinations [21-23].

It is well known that the upper and lower subscapular nerves originate from the posterior cord of the brachial plexus (C5-C6) and in the traditional sense, they are single branches of the posterior cord of the brachial plexus. The upper subscapular nerve innervates the upper fibers of subscapularis muscle

while the lower subscapular nerve innervates the lower fibers of subscapularis and teres major muscles. However, there is a wide range of variations in the origin and number of these nerves such as three upper subscapular nerves from the posterior cord of the brachial plexus [24,25] and two upper subscapular nerves, one from the suprascapular nerve and the other from the posterior division of the upper trunk of the brachial plexus, are also documented [26].

The MN arises by two roots (medial and lateral) from the medial and lateral cords of the brachial plexus, but formation of the MN by three to five roots has been reported by many authors and its communication with the MCN is also frequently reported [27,28]. The MCN arises from the lateral cord of the brachial plexus, pierces through the coracobrachialis muscle and innervates muscles in the anterior compartment of the arm including the coracobrachialis itself. The MCN can form communications with the MN at variable levels in the arm and can occasionally be absent [28]. Maeda et al. [29] in their study described a variable number of MCN-MN communications and proposed a classification into five types (A-E) with 4 and 3 subtypes for type A and B, respectively.

In this case report, the author presents a unique encounter of multiple bilateral vascular and neural variations in the axillae of a single cadaver that need attention during anatomical dissection as well as clinically relevant to prevent unintended iatrogenic injury during various radiological, anesthesiologic and surgical procedures.

MATERIALS AND METHODS

During the routine dissection of an 80-year-old male cadaver who died of cardio-pulmonary arrest secondary to pneumonia and metastatic multiple myeloma, several structural variations in both axillae and the left arm were detected. The variant structures were carefully dissected, thoroughly cleaned, and followed farther from their origins to their termination on the various portions of the axillae and the left arm. Then the arteries and nerves were painted red and yellow respectively using Microsoft draw tools and photographs were taken for illustrations.

RESULTS

The dissection of both axillae revealed the following six unusual combinations of vascular and neural variations.

I. In the 2nd part of the right AA, the right TAA and the right LTA were absent. Three arterial branches representing the branches of TAA originated from the superior aspect of the second part of the axillary artery (Figure 1A and 1B). The first branch arose as a common acromioclavicular trunk that further divided into acromial and clavicular branches, while the other two branches formed deltoid and pectoral branches (Figure 1A).

II. A subscapular trunk (SST) from the 3rd part of axillary artery descended unusually between the axillary and radial nerves and tetrafurcated into branches that supplied the subscapularis and teres major muscles, the CSA, and a common stem for TDA and LTA. The lateral thoracic artery then crossed the axilla from lateral to medial and entered the lateral thoracic wall (Figure 1A and 1B).

III. In the left axilla, the SSA from the third part of AA was missing but a large common trunk arose

from the second part of axillary artery, crossed ventral to the medial cord of the brachial plexus, and descended on the lateral thoracic wall where it trifurcated into a branch to the subscapularis muscle, LTA and SSA. The SSA then bifurcated into TDA and CSA (Figure 2A and 2B).

IV. In the same left axilla, two upper subscapular nerves arose from the posterior cord of the brachial plexus and entered the most superior fibers of subscapularis muscle (Figure 3).

V. The posterior cord of the brachial plexus split into radial nerve and a common stem that gave branch to thoracodorsal nerve, lower subscapular nerve, a stem that divided into branches to teres minor and teres major muscles, and the axillary nerve that entered the quadrangular space (Figure 3).

VI. The left musculocutaneous and median nerves arose from the cords of the brachial plexus as usual, but the median nerve was mainly formed by the medial root from the medial cord with a relatively smaller root from the lateral cord. The left musculocutaneous nerve gave a small branch to coracobrachialis muscle and entered the proximal aspect of the muscle where it divided into a smaller lateral branch and a larger medial branch. Its larger medial branch joined the median nerve as a third root in the arm while the smaller lateral branch continued as the musculocutaneous nerve (Figure 4).

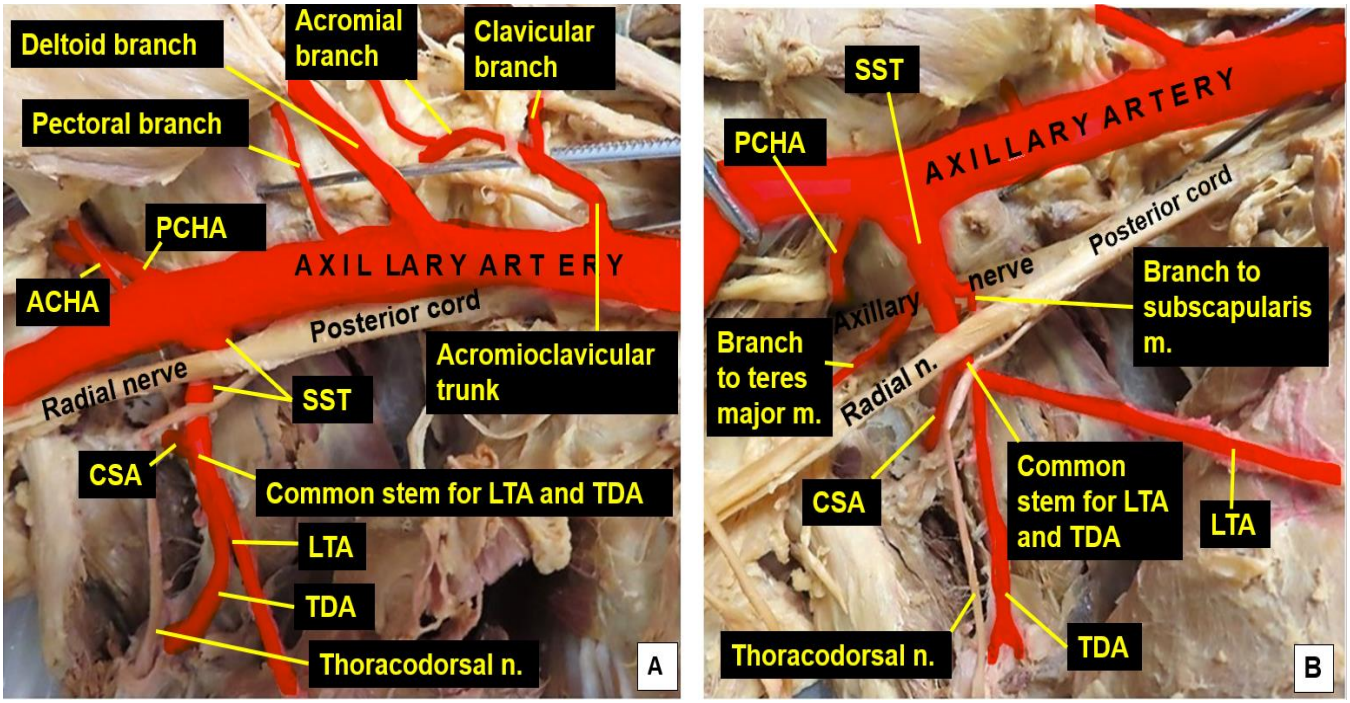

Figure 1: Right axilla: A) Demonstrates the absence of TAA and LTA in the second part of the right AA and shows the three branches representative of TAA branches arising directly from the superior aspect of the 2nd part of AA and the SST from the 3rd part of AA. B) Illustrates the SST as it descends between the axillary and radial nerves with its branches that include branches to teres major and subscapularis muscles, CSA, and the common stem for TDA and LTA. ACHA = anterior circumflex humeral artery, PCHA = posterior circumflex humeral artery, SSN = suprascapular nerve.

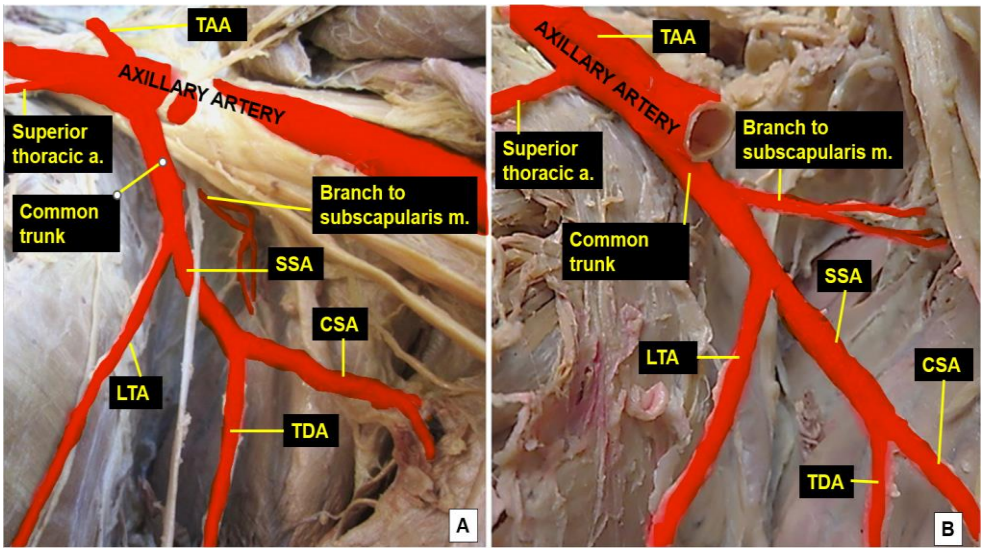

Figure 2: Left axilla: A and B show the common trunk arising from the 2nd part of the left axillary artery and its division into a branch to subscapularis muscle, LTA and SSA. A) Illustrates the relationship between the common trunk and its three branches (a branch to subscapularis muscle, LTA, and SSA with the farther division of SSA into the TDA and CSA) with the brachial plexus; B) Shows the common trunk and its three branches after the AA distal to the origin of the common trunk is cut and reflect laterally with the nerves for a better visualization of the branches.

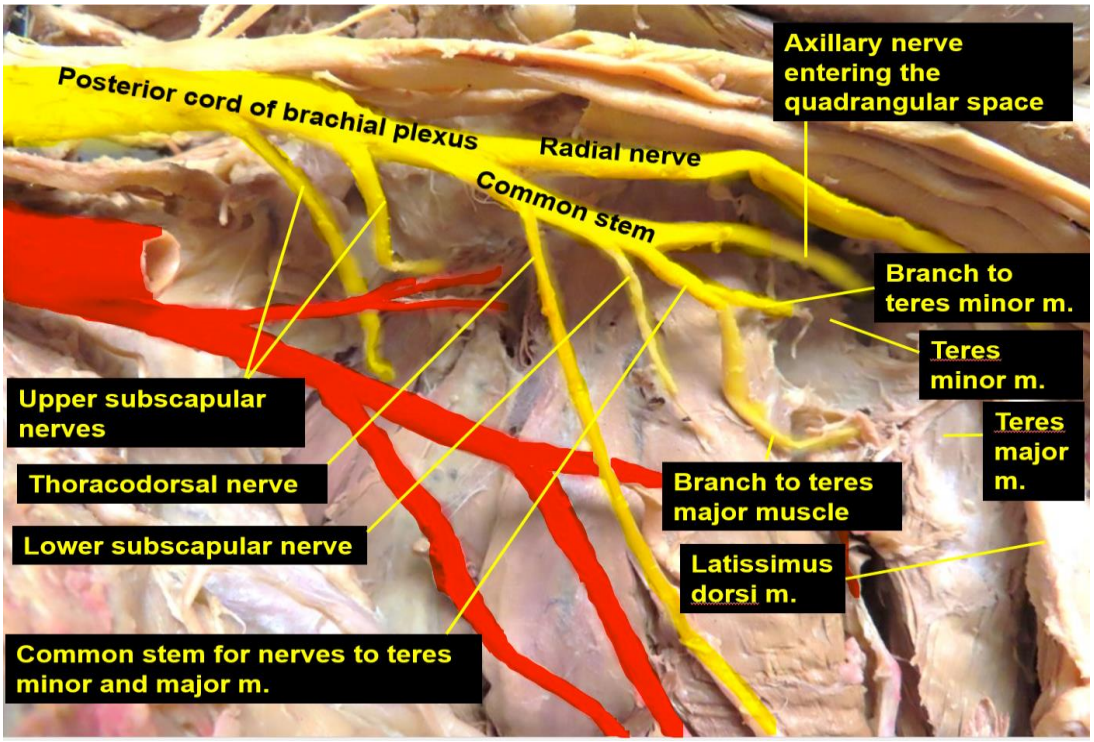

Figure 3: Demonstrates the left axilla with two upper subscapular nerves from the posterior cord of the brachial plexus and the unusual common stem that sequentially gave branch to thoracodorsal nerve, lower subscapular nerve, the stem that divided into branches to teres minor and teres major muscles, and the axillary nerve.

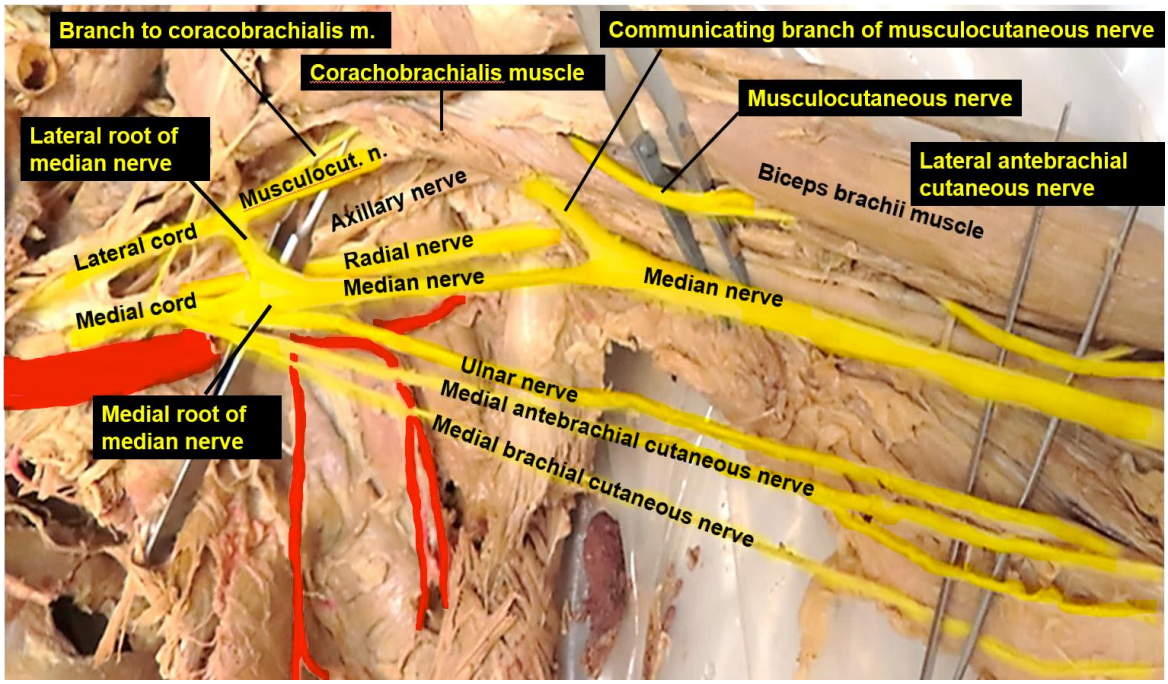

Figure 4: Shows the left axilla and arm with the smaller lateral and larger medial roots of the left MN and the course of the MCN providing a small branch to coracobrachialis and its course through the coracobrachialis muscle where a communicating branch arose within the substance of the muscle and joined the MN after crossing the inferior border of teres major muscle.

DISCUSSION

Anatomical variation of structures in the axilla particularly of arteries and nerves are well documented and frequently reported. These variations occur as isolated variations of the individual arteries and nerves or as combinations of different variations involving both arteries and nerves. As pointed out by a study conducted on 30 cadavers (60 upper limbs), variations of the branching pattern of AA are limited to its 2nd and 3rd parts while no variation was observed in 1st part [1], whereas a case report indicated that variation of branches of AA are seen only in the 1st and 3rd parts but no variation was seen in the second part [2]. Unilateral combined variations such as the occurrence of subscapular trunk that trifurcated into subscapular artery, the posterior circumflex humeral artery and two LTAs together with a rare variant innervation of latissimus dorsi muscle by the lower subscapular nerve and communication between musculocutaneous and median nerves in the arm were also reported [3]. Though the individual variations are different, similar combinations were observed in present case report, where a number of variations of branches from the 2nd and 3rd parts of AA in the right axilla and a combined variations of branches of the AA and posterior cord of the brachial plexus in the left axilla with MCN-MN communication in the left arm were observed.

Various studies and case reports have shown that there is an extensive variation of the individual branches of the AA. A study on 24 TAAs revealed that its branches varied from 2-4. In the case where there are 4 branches the deltoid and pectoral branches

are larger and are constantly found, while the remaining two are smaller and inconstant [4]. On the other hand, other studies and reports illustrated that some of direct branches of the AA such SSA and LTA [5] can arise from the TAA. In another study the bilateral absence of TAA with all 4 branches arising directly from the second part of the axillary artery was documented in about 8.8% of studied 40 cadavers [6]. A similar but right unilateral variation is also reported [7]. According to the later, the absence of TAA is combined with other variations of the axillary artery branches including a common stem for LTA and TDA and subscapular artery that divided into three branches: upper branch to teres major muscle, middle branch (circumflex scapular artery) and a lower branch to subscapularis muscle. The current case report illustrates the absence of TAA which is replaced by three branches that arose from the superior aspect of the second part of the AA with the first branch bifurcating into acromial and clavicular branches. This finding was also accompanied by the absence of the lateral thoracic artery in the second part which took its origin from the subscapular artery in the third part of AA.

In the classic description, the LTA and SSA are branches of the second and third parts of the AA respectively [8]. Variations of these two arteries are also frequently reported. In a study done on 83 dissected cadavers it was found that the SSA arose from the LTA in 5.4% of the cases, the LTA originated from the SSA in 4.2% and the LTA gave rise to the CSA and the TDA in about 2.4%. About half of these variations were reported to be bilateral [8]. In about 7.2% of the cases these two arteries arose by a common stem from the AA [9]. A study of 420 cadavers revealed that the origin of the LTA is variable and found that its most frequent origin is from the TAA (67.62%) and while its origin from the 2nd part of the AA is the second most frequent with an incidence of 17.02%. These authors stated that there is a need for re-evaluation of the TAA taking the LTA as one of its main branches [10]. This previous finding was also agreed upon by a recent study, listed above as number 13, with a frequency of 63.3%. Even though, reports like the current case report related to these two arteries are documented, this case is unique and unusual in that the variations are alternating in the two axillae in that the LTA did not originate from the second part of AA but arose from the subscapular trunk in the third part of AA on the right side and the LTA and SSA shared a common trunk that originated from the second part of the AA on the left side.

The largest branch of the AA, the SSA, can arise with a common trunk that tertrafurcates into TDA, CSA, PCHA and LTA [11]. A right SSA serving as a common origin for the TDA, CSA, ACHA and PCHA and the profunda brachii artery was also noted in another report [12]. In these two cases the variations of SSA were on the right side and it originated from the 3rd part of AA. However, another case report by Olutayo et al. [13] illustrated a left trifurcating branch arising from the 2nd part of the AA serving as a common trunk for LTA, SSA and common circumflex humeral arteries [13]. The same author [14], in 2020, reported absence of left SAA in the left axilla coexisting with multiple variant branches of the brachial plexus, where the thoracodorsal and lateral thoracic arteries shared a common trunk and the circumflex scapular arose directly from the AA. Radiographic analysis of 200 AA systems in 100 adult patients revealed that the SSA was absent either bilaterally or unilaterally in about 25% of cases. They found bilateral absence in

5 patients and unilateral absence in 15 patients. In all the patients with absent SSA, the TDA arose directly from the AA, and the circumflex scapular artery arose either from the AA (23 patients) or from the Posterior circumflex humeral artery (1 patient) [15]. Even though the absence of TAA combined with other variations of AA branches were noted in previous studies and case reports, the individual variations observed in this case report are different in that clavicular and acromial branches arose from the second part of the AA by the acromioclavicular trunk and the arteries supplying subscapularis and teres major muscles, the CSA, the common stem for TDA and LTA arose from a common subscapular trunk.

There are many documented cases of variation of the axillary nerve related to its origin and branching pattern. Most agree on the constant origin from the posterior cord of the brachial plexus as independent nerve or through a common stem with other nerves. A report indicated that it can be a direct branch of the superior trunk of the brachial plexus [16]. If it originates as a common trunk, it branches off into axillary, thoracodorsal and subscapular nerves [17,18].

Albeit two subscapular nerves (upper and lower) are frequently described, there is a significant variation in the origin and number of the subscapular nerves that can arise from different parts of the brachial plexus. Multiple accessory subscapular nerves could arise from the posterior cord of the brachial plexus or from the lower subscapular nerves [17]. There is also a report that described double upper subscapular nerves arising from the suprascapular nerve and the posterior division of the upper trunk [18]. However, in this current case both upper subscapular nerves arose from the posterior cord of the brachial plexus while the lower subscapular nerve originated from a common stem.

The AN shows a variability in its origin from the posterior cord of the brachial plexus. Various studies have shown that it originates from the posterior cord of the brachial plexus in 82-90% of the cases, while in 10-18% of the cases it arose by a common stem with the thoracodorsal, upper subscapular and lower subscapular nerves in a variable combination [19-23]. Moreover, it is well known that the upper and lower subscapular nerves originate from the posterior cord of the brachial plexus formed by ventral rami of C5 and C6. In the traditional sense, they are single branches of the posterior cord of the brachial plexus but a wide range of variations in the origin and number of these nerves is also well known. In addition to sharing a common stem with axillary nerve, according to the report of Deshmukh et al. [24] and Siwets et al. [25], the upper subscapular nerves can arise from the posterior cord of the brachial plexus as triplets. Double upper subscapular nerves, one originating from the suprascapular nerve and the other from the posterior division of the posterior cord of the brachial plexus are also reported [26]. According to the observation in this current case the posterior cord gave branch to two upper subscapular nerves and then divided into radial and axillary nerves. The axillary nerve independently originated from the posterior cord and gave give branch to thoracodorsal and lower subscapular nerves and to a common stem that split up to enter teres minor and teres major muscles.

There are many documented studies and reports regarding the relationship and variable communications between the musculocutaneous and median nerves [27,28]. As demonstrated by those

previous studies, musculocutaneous to median nerve communication arises either before the coracobrachialis or distal to the muscle in the arm. A communicating branch of musculocutaneous nerve to median nerve piercing the coracobrachialis muscle was reported in about 17% of the 60 study cases [28]. The finding in this present case that a large medial branch of musculocutaneous nerve arose within the substance of the coracobrachialis muscle and joined the median nerve in the arm distal to the coracobrachialis muscle forming its third root, is comparable to the Type A2d reported by Maeda et al. [29].

In addition to the co-occurrence of multiple variation in the axilla that involved arteries and nerves, specific features that make this report different from others so far are the finding of: a) alternating absence of the lateral thoracic and subscapular arteries, b) the descent of right subscapular artery between the axillary and radial nerves and c) the common stem shared by two upper subscapular, thoracodorsal, lower subscapular, common stem for the nerves to teres minor and major muscles, and axillary nerve.

CONCLUSION

Despite their rarity, multiple variations like this can be sources of uncertainty during performing invasive diagnostic, therapeutic and cosmetic procedures. Such a co-occurrence of variations of different structures in a very restricted area of the body like the axilla, would be a potential risk factor for misdiagnosis and unpredictable iatrogenic injuries. This is particularly important during bilateral mastectomy with axillary lymph node dissection, preparation of latissimus dorsi flap for breast reconstruction surgery, pectoralis major flaps in variety of head and neck surgeries and aesthetic plastic surgeries of the breast and other clinical procedure like shoulder arthroplasty. Therefore, equipping surgeons, anesthesiologist, interventional radiologist, and other related professionals with the knowledge of such complex variations would help in the diagnostic and decision-making process and in taking the appropriate precautionary measures prior to and during actual clinical procedures.

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