Original article

Variations in the Branching Pattern of Thoracoacromial Artery among the West Bengal Population

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Abstract

Introduction: The knowledge of different anatomical variations of the terminal branches of the thoraco-acromial artery is indispensable from any integumentary surgery of the anterior region of the shoulder. It is especially the case when performing surgery of reconstruction flaps of this region, whose use is increasing in recent years.

Aims & Objectives: The aim of our study is to find out the branching pattern of the thoraco-acromial artery.

Material and methods: Longitudinal study with cross sectional design of data collection was conducted on 54 embalmed cadavers bilaterally. Dissection was then used to study the location & branching pattern of the thoraco-acromial artery.

Results: Thoraco-acromial artery gave 2-4 branches. Deltoid & acromial branch arose as common acromio-deltoid trunk from thoraco-acromial artery in all cases. Other branches also showed considerable variations.

Conclusion: The anatomical variations observed on the branches of the thoraco-acromial artery is essential for any surgery of the anterior shoulder area.

Keywords: Thoraco-acromial artery; Terminal branches; Anatomical variations.

Introduction

The Thoraco-acromial artery is the main integumentary artery of the anterior deltoid region. It supplies part of the antero-cranial wall of the thorax [1,2]. This region has been used for many years as a donor site for reconstructions of the neck and head, because it is close to the cervico-facial areas in terms of color, texture and thickness [3,4]. However, the thoraco-acromial artery can be subject to anatomical variations, both regarding its birth mode and its branching [4]. The Thoraco-acromial artery arises under junction between the middle and lateral thirds of the clavicle. It is a large vessel located on the anterior side of the axillary artery; its origin is hidden by the cranial margin of the pectoralis minor muscle [5-7]. It gives off two large branches-deltoid and pectoral. It also gives off two other variable branches: a clavicular branch and an acromial branch [5-7]. The clavicular part of the pectoralis major is irrigated medially by the clavicular branch and laterally by the deltoid and acromial branches [5,7]. The latter two branches give off musculocutaneous perforators that vascularize the integuments located in the cranial portion of the pectoral wall. The deltoid branch often gives off the acromial branch directly; the latter also provides a musculoskeletal perforator towards the integuments covering the deltoid muscle and the lateral end of the clavicle [5,7]. The pectoral branch irrigates the sternocostal part of the pectoralis major muscle [5,7]. It quickly gives off three branches: a lateral branch that courses towards the lateral thoracic artery, and two medial and caudal branches directed towards the 4th intercostal space that anastomose with the anterior intercostal arteries and the perforators of the internal mammary artery [5,8].

Although several anatomical variations have been described, the pectoral branch generally courses along a line joining the acromion with the xiphoid process [4]. The deltoid branch crosses the upper part of the

delto-pectoral furrow and generally divides into two branches, one deep and the other superficial [1,2]. The deep branch runs in the furrow itself, inside a small canal formed by the duplication of the fascia. Arriving at the lower end of the intermuscular space, this deep branch perforates the superficial sheet of the fascial canal in which it is located. It thus arrives inside the subcutaneous plane and branches rapidly into the skin that covers the tendon of the pectoralis major and the distal insertion of the deltoid [1,2]. The superficial branch runs obliquely downwards and laterally and it gives series of small branches that quickly end in the skin[1,2]. The acromial branch presents numerous variations: it can be short of 2 to 3 cm, or very long and reach the posterior face of the deltoid region; it remains deep in 25% of cases and then perforates the deltoid at a greater or less distance from its anterior edge. [1,2]

The knowledge of different variations in the branching pattern of Thoraco-acromial artery is of anatomical, radiological, and surgical interest to explain unexpected clinical signs and symptoms. Moreover, they must be taken into account by the practitioner during any regional surgery in general, and particularly during flaps harvesting.

Materials and method

A cross-sectional hospital based study was carried out in Calcutta National Medical College, Kolkata during a study period of eight months. From the departmental records the residences of the donated cadavers were noted to confirm the targeted population. A total of 54 embalmed adult cadavers were dissected bilaterally by following the proper steps from Cunningham's Manual of dissection. The clavicular head of the pectoralis major was cut and the thoraco-acromial artery with branches were dissected meticulously, traced and photographed.

Any deviation from the normal branching pattern was also noted along with gender and side. Moreover, the angles between the branches of the thoracoacromial artery were also measured separately with the help of a protractor. Finally, the obtained data was methodically charted in a Microsoft Excel worksheet and evaluated by standard statistical methods.

Results

Out of 54 cadavers (108 upper limbs), 41 (75.93% cases) were male and 13 cadavers (24.07% cases) were female. Most of the study population belonged to 70 years (16.7% cases) with a mean age and standard deviation (SD) of 61.76 years & 6.6892 years respectively (Range: 50-73 years). In all limbs origins of the thoraco-acromial artery were from the second part of the axillary artery as usual. The number of the branches of thoracoacromial artery was found to be varied from 2-4 but the commonest number was 3 (98.15% of the cases).

In cases of **trifurcation** of the thoracoacromial artery the following branches were encountered in 99.05% cadavers: a) pectoral, b) clavicular & c) common acromio-deltoid branches. **(Fig-1**) But a single case was also found on the left upper limb of a 58 years old male where the thoracoacromial artery divided into two clavicular and one common acromio-deltoid branches. The pectoral branch arose from that common trunk 8 mm distal its origin from thoraco-acromial artery. **(Fig-2)**

The angles between the three branches were also measured separately and the result was depicted according to gender and side in **Table-I & II** respectively. No significant difference in angle was obtained in any of the cases among the males & the females as well as among the right & left sided cases ('P' value <0.05 is significant).

Two branches of the thoracoacromial artery (0.9% of the cases) were found on the right upper limb of a 62-year male cadaver where the artery **bifurcated** into: a) one clavicular branch and b) one common acromio-

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deltoid trunk. The pectoral branch arose unusually from the deltoid branch of that common trunk. **(Fig-3)** In this case, the measured angle was 164 degrees towards the side of proximity of the two primary branches.

Only a single case was found on the left side of a 68-year-old male cadaver (0.9% of the cases) where the thoracoacromial artery gave **four branches** namely two pectorals (medial & lateral), one clavicular and a common acromio-deltoid trunk. **(Fig-4)** Among the two pectoral branches one was medial and the other one was lateral in position. The angle among the different branches were as follows: a) between two pectoral branches (lateral &medial) =10 degree, b) between acromio-deltoid & lateral pectoral branches =88 degree, c) between acromiodeltoid & clavicular branches =170 degree, d) between clavicular & medial pectoral branches =92 degree.

In the present study the pectoral branch showed considerable variations in respect to its origin and number. Another isolated case of **double acromial arteries** was also recorded on the right side of a 70 years old female cadaver where an additional acromial branch arose from the common acromio-deltoid trunk 1.2 cm distal to its beginning from the thoraco-acromial artery.

The average length of the common acromio-deltoid branch was 4.0287cm standard deviation of 0.7562cm (range: 2.6-5.8cm) but the commonest distance was 3.8cm (in 12%cases).

The mean length with standard deviation, range & mode of the common acromio-deltoid branch are depicted in **Table-III** according to gender and side. Interestingly, significant difference in mean length was obtained among the males & the females as well as among the right side & left sided cases ('P' value <0.05 is significant).

The branching pattern of the common acromio-deltoid branch was also observed and documented separately. Two sets of branches were recognized according to their point of origin. The first category portrayed some isolated arteries that branched out from any part of the common trunk up to its termination and the second category represented a bunch of arteries arising together from the point of termination.

Origins of pectoral & acromial branches were found on the left side of one male (2.44%) and on the right side of a female (7.69%) along the course the common trunk. Moreover, a muscular branch to pectoralis major was also found on the left side of one male cadaver (2.44%) 2.6cm distal to its origin from thoraco-acromial artery. Therefore, first category represented some inconsistent branches only.

Various patterns of terminations of common acromiodeltoid branch were observed. It showed **bifurcation** on the left side of the 2 male cases (4.88%) where it was divided into two consistent branches i.e. acromial and deltoid. **(Fig-5) Trifurcation** of that artery was observed in all female cases in both the sides but among the males 97.56% and 92.68% cases were confined to the right & left sides respectively. Among those cases, the trifurcated common trunk provided two consistent branches i.e. acromial, deltoid along with an unusual muscular branch to pectoralis major muscle which was also supplied by the pectoral branch of thoracoacromial artery as usual. **(Fig-1)** Only a **single case** was found on the right side of a male cadaver (2.4%) where the common acromio-deltoid branch finally divided into four branches: a) acromial, b) deltoid, c) a muscular branch to pectoralis major and d) another muscular branch to pectoralis minor. Those muscular arteries provided an additional supply to pectoral muscles because they were also supplied by the pectoral branch of thoraco-acromial artery. **(Fig-6)**

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Table-I: Angles among the branches of the thoracoacromial artery according to gender. (n=108)

Sl.No.	Angle	Sex	Mean (degree)	Standard Deviation(degree)	Range (degree)	Mode (degree)	Test of Significance
1.	Between clavicular & pectoral branch	Male (n=82)	161.0366	23.4486	90-180	180	T=1.2219 P=0.2245 (P>0.05)
		Female (n=26)	154.4231	25.897	110-180	120	
2.	Between clavicular & common acomiodeltoid branch	Male (n=82)	106.8293	20.6307	90-170	90	T=0.0205 P=0.9837 (P>0.05)
		Female (n=26)	106.9231	19.3431	90-160	90	
3.	Between pectoral & common acomiodeltoid branch	Male (n=82)	92.6220	12.2027	30-130	90	T=2.1686 P=0.0324 (P>0.05)
		Female (n=26)	98.6538	12.8497	80-120	90	

Table-II: Angles among the branches of the thoracoacromial artery according to side. (n=108)

Sl.No.	Angle	Side	Mean (degree)	Standard Deviation(degree)	Range (degree)	Mode (degree)	Test of Significance
1.	Between clavicular & pectoral branch	Right (n=54)	161.4815	24.1385	90-180	170	T=0.8773 P=0.3823 (P>0.05)
		Left (n=54)	157.4074	24.1212	90-180	165	
2.	Between clavicular & common acomiodeltoid branch	Right (n=54)	103.8889	18.0844	90-160	90	T=1.5309 P=0.1288 (P>0.05)
		Left (n=54)	109.8148	21.9554	90-170	90	
3.	Between pectoral & common acomiodeltoid branch	Right (n=54)	95.1852	11.4085	80-130	90	T=0.9179 P=0.3607 (P>0.05)
		Left (n=54)	92.963	13.6506	30-130	90	

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Table-III: Length of the common acromiodeltoid branch according to gender and side. (n=108)

	Mean (cm)	Standard Deviation(cm)	Range (cm)	Mode (cm)	Test of Significance
Male(n=82)	3.9402	0.7519	2.6- 5.8	3.8	T= 2.1973
Female(n=26)	4.3077	0.7133	3.0-5.6	4.2	P= 0.0302 (P<0.05)
Right side(n=54)	3.8611	0.7555	2.6-5.4	4.5	T= 2.3515
Left side(n=54)	4.1963	0.7255	3.0-5.8	3.8	P=0.0205 (P<0.05)

Discussion

According to Loukas et al. [9] the thoracoacromial artery originates from the second portion of the axillary artery. However, DeGaris et al.[10] noted that in most of their dissections the thoracoacromial artery originates from the first portion of the axillary artery. In the study by Huelke[11], the thoraco-acromial artery was a branch of the second portion of the axillary artery in 2/3 of the cases, and it originated medially to the tendon of the pectoralis minor muscle in 1/3 cases. In one case the thoraco-acromial artery even originated from the brachial artery. These findings concerning the origin of the thoraco-acromial artery do not agree with the results of DeGaris et al.[10] DeGaris reports that the thoraco-acromial artery is more frequently born from the first (86%) and the second portions (12%) of the axillary artery. The study by Park et al.[12] also shows that the thoracoacromial artery arises truncularly from the axillary artery and then laterally moves 2-3 cm below the clavicle, before rapidly giving rise to several terminal branches.

Astik R et al., 2012 [13] reported a case of absent thoracoacromial trunk and all its branches arose directly from the second part of the axillary artery; division of thoracoacromial trunk into deltoacromial and clavipectoral trunks, which were divided into all branches of thoracoacromial trunk. According to Hallock [6] the thoracoacromial artery has four terminal branches, however the deltoid and pectoral branches are the largest, with a clavicular branch of variable origin, and an acromial branch which is most often born of the deltoid branch. This assertion of is true in our work.

Although most authors agree that the thoracoacromial artery invariably arises as a direct and isolated branch of the axillary artery, the literature reports numerous anatomical variations in both the collateral branching of the axillary artery and in that of the thoraco-acromial artery [7, 14]. These variations have been studied by Trotter et al.[15] during the dissection of axillary arteries of 384 arms. From their work it appears that the supreme thoracic and thoraco-acromial arteries arise from the axillary artery in almost all the dissected specimens. However, in 4 dissections (1%), the supreme thoracic artery originated from the thoraco-acromial artery, and on a dissected specimen the thoraco-acromial trunk was absent and its terminal branches thus arose directly from the axillary artery. Lee et al.[16] also compiled data about collateral branches of the axillary artery. They report that in 69.2% of cases the lateral thoracic artery arises from the axillary artery. It emerges from the thoracoacromial artery in only 2.6% of cases. Huelke[11] reports a similar trend (6.7%).

Apart from the work of DeGaris et al.[10] those of Pandey et al.[17] and those of Loukas et al.[18] most studies show that the origin of the lateral thoracic artery in the thoracoacromial artery is rather rare. The results of Lee et al.[19] are consistent with Korean work by Kang et al.[20] and with the Japanese works of Adachi et al.[21] though much older. All this suggests that there are probably variations of racial origin. For Paraskevas et al.[22]

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the incidence of the origin of the lateral thoracic artery on the thoracoacromial artery cited in the work of DeGaris et al.[10] is not 43% as reported by Huelke[11] & Loukas[9]. This incidence is actually 73% in Caucasians and 52% in Black Americans. Pellegrini et al.[23] report when to them a frequency of 14%. According to Paraskevas et al.[22], the literature reports in addition to the racial differences of the tendencies according to the sex with regard to the configuration of the collateral branches of the axillary artery.

The configuration of the terminal branches of the thoraco-acromial artery is also subject to anatomical variations. Our work shows that the thoraco-acromial artery has 2 to 4 terminal branches with an average of 3. Several authors consider the pectoral branch to be the largest of the terminal branches of the thoraco-acromial artery[23]. Park et al.[12] classified the mode of birth of the pectoral branch of the thoraco-acromial artery. The pectoral branch could be directly derived from the thoraco-acromial artery (type I: 79%). It could also arise from the thoraco-acromial artery via a medial pedicle (type II) or a lateral pedicle (type III). These variations may have major clinical implications, since from an anatomical point of view, the arterial distribution of the pectoralis major muscle is supplied by the pectoral branch of the thoraco-acromial artery, the lateral thoracic artery and the anterior intercostal arteries.

Geddes[5] also write about the constant nature of this pectoral branch. Indeed, in his work on the perforators of the anterior wall of the thorax, he reports that the pectoral branch of the thoraco-acromial artery is inconstant, and that it presents only tiny muscular-cutaneous perforators in the infero-lateral and middle zones of the pectoralis major muscle. This variation would have clinical repercussions, since it would make the probability of producing a pedicled perforating flap on this pectoral branch weak, as opposed to the flaps exploiting the deltoid and clavicular branches of the thoraco-acromial artery. Moreover, according to the work of Geddes [5], despite the fact that the arterial territories vary significantly, the path of the different terminal branches of the thoraco-acromial artery as well as that of their perforators is more constant, both integumentary than muscular.

Hallock [6] also reports this constant character of the deltoid branch of the thoraco-acromial artery. In his work, the deltoid branch irrigates the clavicular insertion of the pectoralis major muscle. It often gives an acromial branch which supplies a musculocutaneous perforator towards the integuments covering the deltoid muscle and the lateral extremity of the clavicle. This pectoral branch divides rapidly to irrigate the sternocostal portion of the pectoralis major muscle.

In addition to the 4 “classic” terminal branches of the thoracoacromial artery, the literature is already inconsistently reporting the existence of additional terminal branches. These include the lateral thoracic and supreme thoracic arteries. Lee[16] & Loukas[18] reported the existence of a radial artery directly from the thoracoacromial artery. This anatomical variation can be explained by embryological factors.

Conclusion

The knowledge of the variation of the axillary artery and its branches is useful in determining pathology, appropriate treatment and proper surgical procedures. In surgical practice, the treatment of certain lesions of the regions of the head and neck sometimes requires large resections, thus requiring the realization of reconstruction flaps. The condition for achieving these flaps is a good arterial perfusion of the tissue removed. It is therefore essential to have a precise knowledge of the vascularization of the region concerned and possible anatomical variations so that a good postsurgical outcome is obtained.

This type of abnormal blood vessels is often to be kept in mind in pectoralis major myocutaneous graft, plastic surgery or during cardiac bypass surgery for grafting also. They can be easily delineated by doppler

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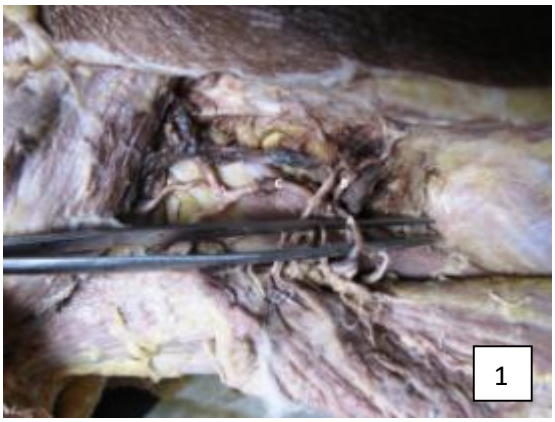
study or angiography, and by doing such kind of study, unwanted vascular injuries can be avoided during any of the surgeries involving intervention of axillary region, as in mastectomy. Even the presence of such type of variation may help in the explanation of the cause and pathogenesis of various peripheral vascular diseases in the upper limb and their treatment such as stenting of subclavian artery. They are also important in the ante grade cerebral perfusion in vascular surgery in case of axillary artery thrombosis.[24]



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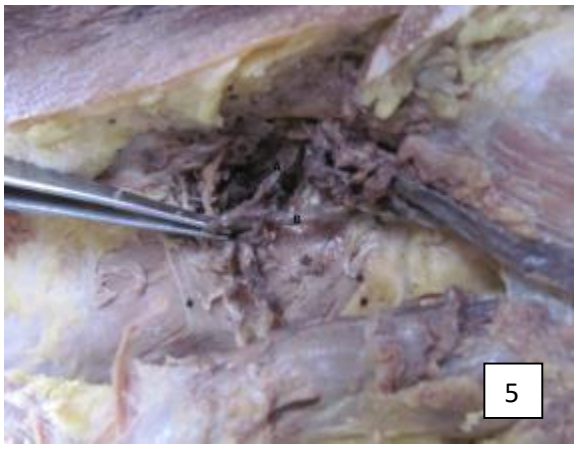

Fig-1: A-Pectoral B-Clavicular C- Common acromio-deltoid trunk

Fig-2: A & B- Clavicular C- Common acromio-deltoid trunk

Fig-3: A- Clavicular B- Common acromio-deltoid trunk

Fig-4: A- Medial pectoral, B- Lateral pectoral, C- Clavicular D- Common acromio-deltoid trunk

Fig-5: A- Acromial branch, B- Deltoid branch

Fig-6: A- Acromial branch, B- Deltoid branch, C- Branch to pectoralis minor D- Branch to pectoralis major

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