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Female Cadaveric Study of Neurovascular Pedicle in *Latissimus Dorsi* Muscle Flap

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SUMMARY

Background. The goal of this investigation was to analyse the branching pattern of the arterial supply and innervation of *Latissimus Dorsi* (LD). The aim was also to determine the distance of origin of its neurovascular pedicle from the inferior scapular angle.

Methods. The present study included 9 adult female embalmed cadavers, which were available in the department of anatomy. Neurovascular pedicle of the *latissimus dorsi* was studied over the right and left sides (n=18). The long thoracic artery origin was also observed. The distance of the neurovascular pedicle from the scapular inferior angle was measured by using a digital Vernier calliper.

Results. It was observed that, in 44.4% cases, type 1a pattern of the thoracodorsal artery was observed. Type A pattern of thoracodorsal nerve was observed in 55.5% cases. It was observed that the thoracodorsal nerve was laterally related to the artery to LD in 94.5% cases. The distance of origin of neurovascular pedicle of LD from the inferior scapular angle was 60.8 ± 6.2 mm over the right side and the same measurement was 59.8 ± 6.4 mm over the left side. The comparison of this data didn't show statistical significance (Paired t Test, p=0.49).

Conclusions. It was observed that the arterial branching pattern of the LD muscle was extremely variable. The findings will assist the plastic surgery during the breast reconstruction procedure.

KEY WORDS

Breast reconstruction; latissimus dorsi; pedicled flap; surgical flap; breast tumors; cosmetic surgery.

BACKGROUND

Latissimus Dorsi (LD) is a back muscle, which is sometimes known as "climbers muscle". The LD is used in flap surgeries by the plastic surgeons particularly during the breast reconstruction. The LD flap is preferred in mammary gland reconstruction because of its lesser perioperative and long term postoperative morbidity (1). LD is innervated by thoraco dorsal nerve and its arterial supply is by the thoraco dorsal artery. In the posterior wall of axilla, the subscapular artery is inferiorly related to the LD and gives a branch, the circumflex scapular artery. After this branch, the thoracodorsal artery is the continuation of subscapular artery. The long thoracic artery supplies the serratus anterior muscle, which is a branch of thoracodorsal artery (2). Thoracodorsal artery provides two branches inside the LD, descending and transverse branches (3). LD also gets nourishment by the lumbar and posterior intercostal arteries. Thoracodorsal artery has a wider diameter and with least anatomical variations, becomes a highly reliable source (3, 4).

A pedicle of size, 50-100 millimetres can be safely harvested from the subscapular system. Since the arteries branches inside the *latissimus dorsi* muscle, the muscle can be cut longitudinally and bilobed flap can be harvested. These pedicled flaps could be used to cover the posterior defects (2). LD is also used for the reconstruction of face, scalp and cranium defects, pedicle transplant rotator cuff repairs, tendon graft surgeries and reconstruction flap for the extremities (2). LD flap is used to cover the extremely larger and deeper wounds. Because of the larger size of the LD, there are no postharvest motor deficits (2). The anatomical reports about the variations in the arterial supply branching pattern and innervation are scarce in the scientific literature. This was the stimulus to perform the present study in the female cadaveric specimens of south Indian origin. The goal

of the present investigation was to analyse the branching pattern of the arterial tree and innervation of LD muscle. The morphology of various branching patterns was noted and analysed. The aim was also to determine the distance of origin of its neurovascular pedicle from the inferior scapular angle.

MATERIALS AND METHODS

The present study included 9 adult female embalmed cadavers, which were available in the department of anatomy. The neurovascular pedicle of LD was studied over the right and left sides (n=18). The sample size was calculated after consultation with the statistician. This study has been approved by the ethics committee of our institution. Male cadavers were not included because this study was aimed to help the breast construction procedures. This was a posterior exposure just like the surgical approach and the muscular flap was elevated from the origin of LD. This is not routinely done in regular anatomical dissections, where we perform it from the anterior approach.

The incision was put at T3 level both horizontally and vertically. After reflecting the superficial and deep fascia, the LD muscle was defined. The part of LD below the scapular inferior angle was released. The attachments of LD at the spine in the back was also released. The dissection was continued below the LD toward the axillary region. The arteries to LD and serratus anterior became obvious as we approached towards the axilla. Once the flap was raised from proximal to distal, the neurovascular pedicle was dissected near the posterior wall of axilla. The distance of the pedicle near the lateral border of scapula from the scapular inferior angle was noted as this may give an idea to the operating surgeon where exactly he or she can locate the pedicle. This measurement was performed by using a digital Vernier calliper. The upper extremity of the cadavers was abducted to 90º position with respect to the thorax, both during the dissection procedure and while performing the measurement.

The branching pattern of the nerve to LD muscle (thoracodorsal nerve) and arterial tree of LD were analysed. The origin of artery to serratus anterior (long thoracic artery) was also studied. The observations were analysed and tabulated. The branching pattern of the artery to LD, was classified based on its branching pattern into types 1a, 1b, 2a, 2b, 2c, 3a, 3b and 3c, which are as below (**figure 1**):

Type 1a: artery to LD (4 in the picture) was branching from SCA and later divided into two branches (4a and 4b in the pictures).

Type 1b: artery to LD (4 in the picture) was branching from SCA and later divided into three branches (4a, 4b and 4c in the pictures).

Type 2a: artery to LD (4 in the picture) was branching from SCA and later divided into two branches (4a and 4b in the pictures). These two branches again branched into two more branches each (4a and 4b again branched into 4a1, 4a2, 4b1 and 4b2 branches).

Type 2b: artery to LD (4 in the picture) was branching from SCA and later divided into two branches (4a and 4b in the pictures). The first branch 4a, again branched into 4a1 and 4a2 branches. The second branch 4b, there was no further branching.

Type 2c: artery to LD (4 in the picture) was branching from SCA and later divided into two branches (4a and 4b in the pictures). The second branch 4b, again branched into 4b1 and 4b2 branches. The first branch 4a, there was no further branching.

Type 3a: there was no single trunk (4), instead there were two arteries to LD directly arising from the SCA (4a and 4b).

Type 3b: there was no single trunk (4), instead there were three arteries to LD directly arising from the SCA (4a, 4b and 4c).

Type 3c: there was no single trunk (4), instead there were two arteries to LD directly arising from the SCA (4a and 4b). These two branches again branched into two more branches each (4a and 4b again branched into 4a1, 4a2, 4b1 and 4b2 branches).

The branching pattern of the thoracodorsal nerve was classified based on its level of branching a type A, type B and type C, which are as below (**figure 1**):

Type A: thoracodorsal nerve dividing at the level of origin of circumflex scapular artery.

Type B: thoracodorsal nerve dividing above the level of origin of circumflex scapular artery.

Type C: thoracodorsal nerve dividing below the level of origin of circumflex scapular artery.

The dimension measured was analyzed statistically by using "EZR software, version 1.38, 2019". The statistical analysis of right and left side dimensions were done by using the paired t Test. The comparison was considered as significant statistically only if the p value is smaller than 0.05.

We state that the present anatomical investigation was performed as per the international ethical standards, which are required by the international scientific indexed journal as per the opinion of Padulo *et al.* (5).

RESULTS

In all the cadavers, artery to LD was branching from the subscapular artery. But the branching was extremely variable after its origin from the subscapular artery. The various morphological branching patterns of the vascular pedicles are represented along with their frequency in **figures 2-8**.

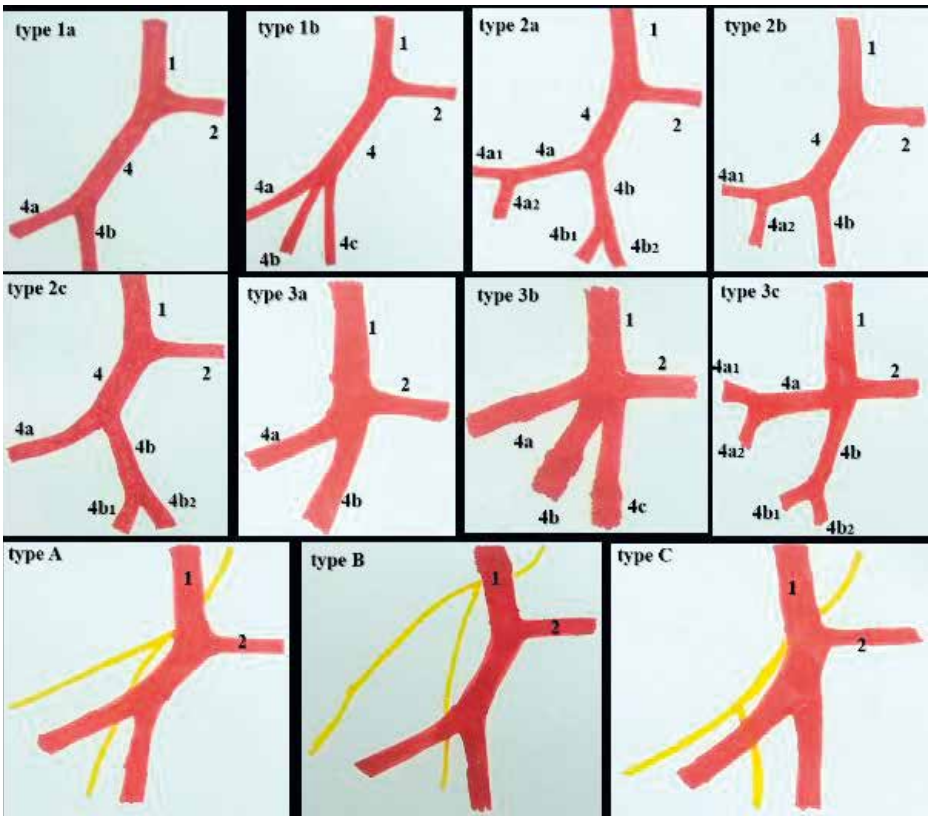

Figure 1. Schematic diagrams representing the various branching pattern of the artery to LD (type 1a, type 1b, type 2a, type 2b, type 2c, type 3a, type 3b and type 3c) and thoracodorsal nerve (type A, type B and type C), which are observed in this study.

Their frequency over the right and left sides are represented in **table I**. It was observed that, in 44.4% cases, type 1a (**figure 2**) pattern was observed, this was the most common pattern. In this pattern, artery to LD was branching from the SCA and later divided into two branches. It was also found that the branching pattern is not the same over the right and left side (77.8% cases) of the same person. The branching pattern was same bilaterally in only 22.2% cases. It was observed that in 17 cases (94.4%), the artery to serratus anterior (long thoracic artery) was branching from the circumflex scapular artery. However, in 1 case (5.6%), the long thoracic artery was branching from the artery to LD.

Table II represents the frequency of various morphological types of branching pattern of the thoracodorsal nerve. The type A variety is seen in **figure 4**, type B in **figure 8** and type C in **figure 6**, respectively. The branching pattern of thoracodorsal nerve was similar in 5 cadavers (55.5% cases) and it was different in 44.5% cases. It was observed that the thoracodorsal nerve was laterally related to the artery

Table I. Various morphological patterns of vascular pedicles of LD and their frequency over right (n=9) and left (n=9) sides.

Branching pattern	Right side	Left side
Type 1a	4 (22.2%)	4 (22.2%)
Type 1b	2 (11.2%)	1 (5.5%)
Type 2a	NUL (0%)	NUL (0%)
Type 2b	1 (5.5%)	1 (5.5%)
Type 2c	NUL (0%)	1 (5.5%)
Type 3a	1 (5.5%)	NUL (0%)
Type 3b	NUL (0%)	2 (11.2%)
Type 3c	1 (5.5%)	NUL (0%)

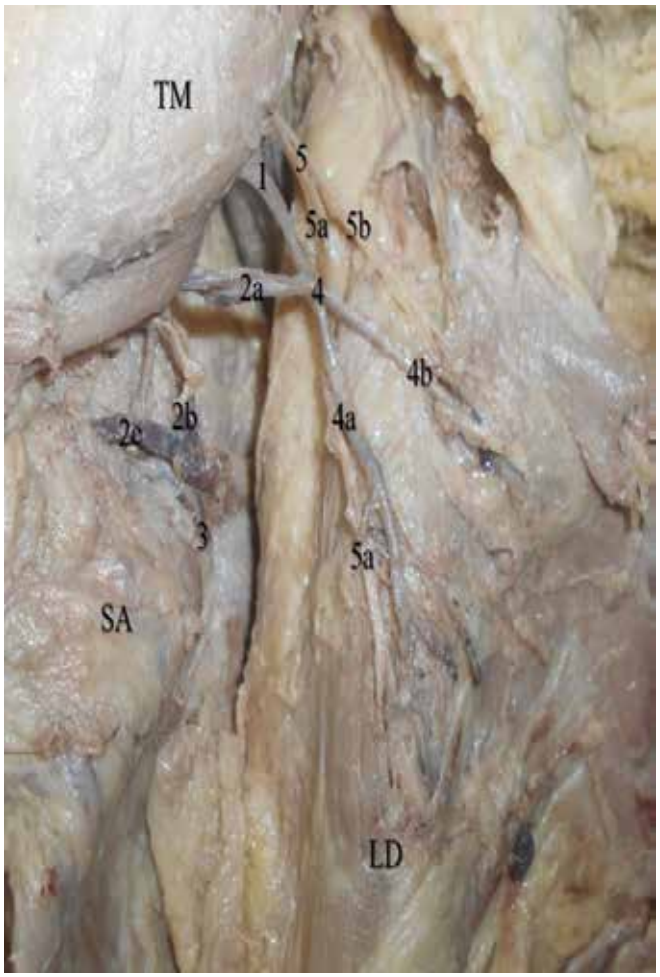

Figure 2. *Latissimus dorsi* muscle having type 1a branching pattern of the vascular pedicle (8 cases, 44.4%).

to LD (94.5% cases), except in only one side (5.5%), this was found on the medial side of the artery. The distance of the origin of neurovascular pedicle of the LD from the inferior angle of scapula was 60.8 ± 6.2 mm over the right side and the same measurement was 59.8 ± 6.4 mm over the left side. The measurements of all the cadavers over the right and left sides with respect to the distance of pedicle is given in **table III**. The comparison of this data didn't show statistical significance (paired t Test, p=0.49).

DISCUSSION

The prevalence rate of carcinoma of breast has increased in the recent years. It is fortunate that there are good treatment modalities available like surgery, chemotherapy and radiotherapy. Radical mastectomy is the best surgical proce-

Table II. Morphological patterns of the thoracodorsal nerve and their frequency (n=18).

Morphological pattern	Frequency
Type A	10 (55.5%)
Type B	5 (27.8%)
Type C	3 (16.7%)

Table III. Distance of the neurovascular pedicle from the inferior angle of scapula (n=18).

Cadaver number	Right side	Left side
1	61 mm	61 mm
2	56 mm	56 mm
3	57 mm	51 mm
4	72 mm	66 mm
5	65 mm	65 mm
6	63 mm	61 mm
7	50 mm	55 mm
8	66 mm	71 mm
9	57 mm	52 mm

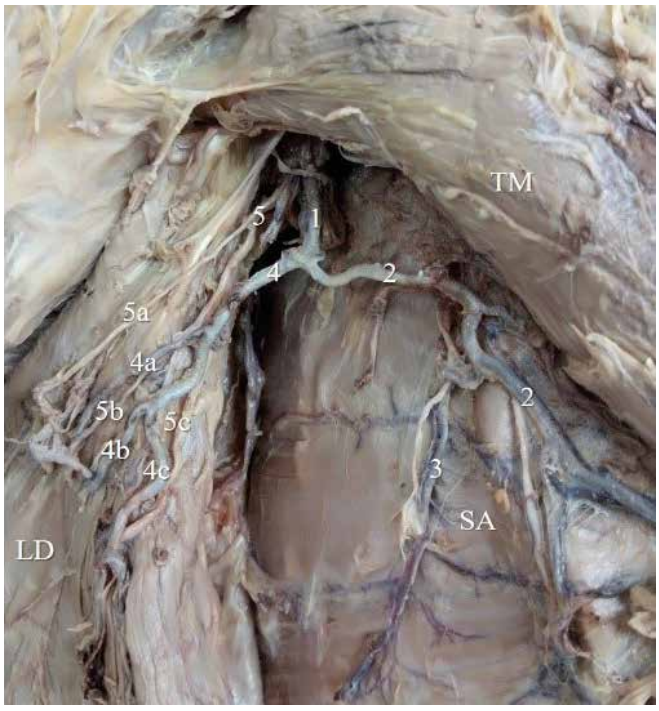

Figure 3. *Latissimus dorsi* muscle having type 1b branching pattern of the vascular pedicle (3 cases, 16.7%).

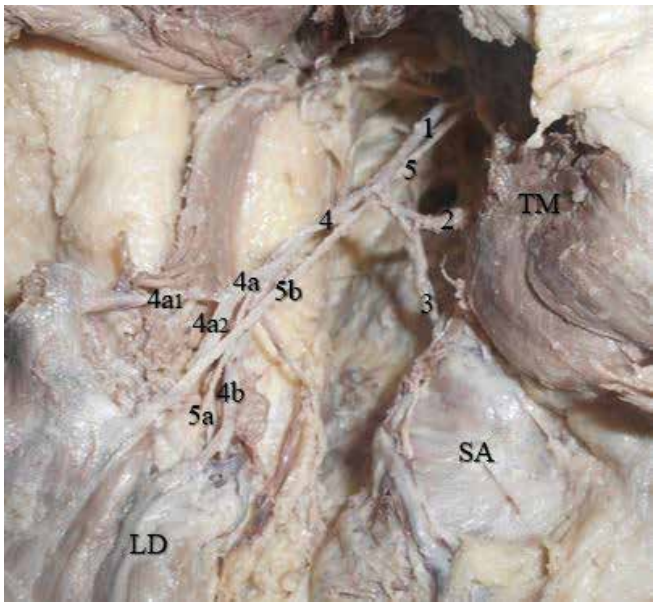

Figure 4. *Latissimus dorsi* muscle having type 2b branching pattern of the vascular pedicle (2 cases, 11.2%). The thoracodorsal nerve branching pattern in this picture is type A (n=10, 55.5% cases).

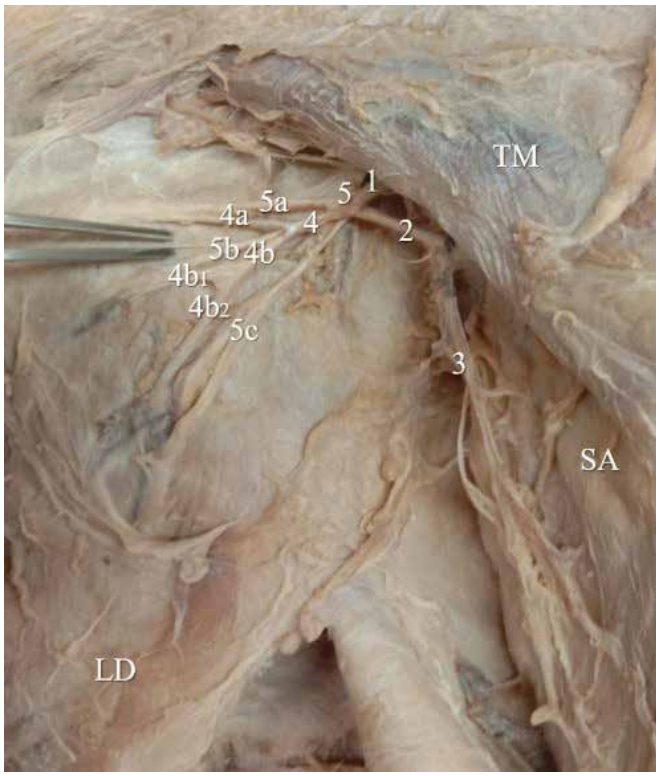

Figure 5. *Latissimus dorsi* muscle having type 2c branching pattern of the vascular pedicle (1 case, 5.5%).

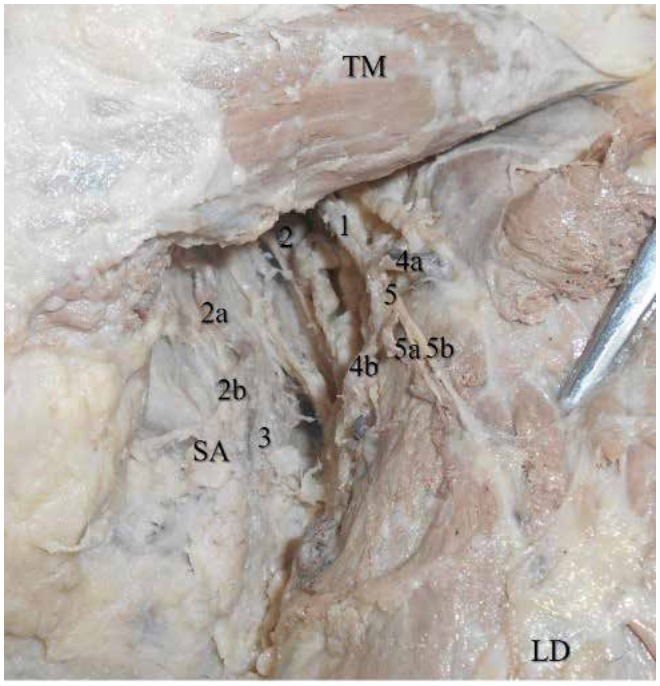

Figure 6. *Latissimus dorsi* muscle having type 3a branching pattern of the vascular pedicle (1 case, 5.5%). The thoracodorsal nerve branching pattern in this picture is type C (n=3, 16.7% cases).

Figure 7. *Latissimus dorsi* muscle having type 3b branching pattern of the vascular pedicle (2 cases, 11.2%).

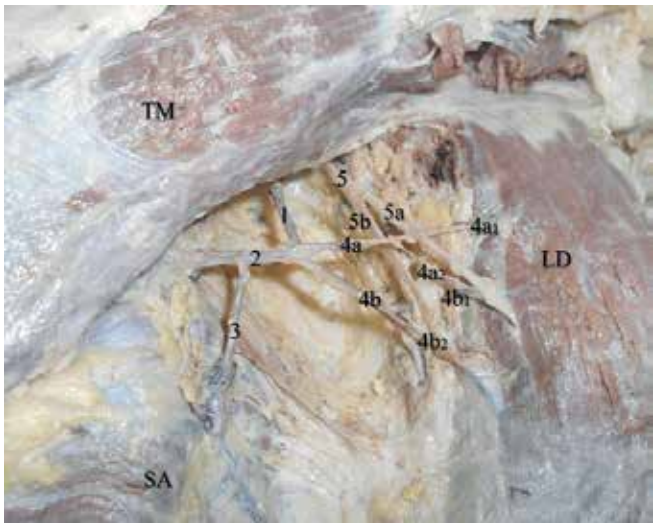

Figure 8. *Latissimus dorsi* muscle having type 3c (n=1, 5.5% cases) branching pattern of the vascular pedicle. The thoracodorsal nerve branching pattern in this case is type B (n=5, 27.8% cases).

dure, which is followed by the breast reconstruction. This is performed by the plastic surgeon for the cosmetic purpose. The graft can be harvested from the same patient during the mastectomy procedure. The LD muscle flap technique was described in 1906 by Iginio Tansini, but it became popular only in 1970s for the breast reconstruction (6). William Halsted included LD flap during the radical mastectomy (3) and Schneider *et al.* (7) reported the use of LDF in implant-based mammary gland reconstruction. LD flap maintained the shape and function of the silicone implant by forming the muscle coverage. Bostwick *et al.* (8) made a skin island over the LD to replace the skin loss during the post mastectomy breast reconstruction. Papp and McCraw (9) found a LDF which is de-epithelialized and it provided the volume replacement. The muscle flap with its nerve intact can be used for the reconstruction of the paralysed face and in Poland syndrome. With the nerve inside the flap, the muscle function is maintained (10). LD with its nerve and artery can be used as a flap to reconstruct the paralysed deltoid and triceps muscles (11). The osteo-musculo-cutaneous flaps with the LD can be used to reconstruct the mandible (12).

LD tendon transfer is among the best treatment options for the massive posterior-superior rotator cuff tears, especially in the younger patients (13). The LD is best suited for the transfer procedures, because of its strength, vascularization, and larger surface area. These things are essential to the successful healing (14). In the arthroscopic surgeries performed with the lateral decubitus position for the rotator cuff tears, the traction is given to the LD muscle. This requires the topographical location of the thoracodorsal nerve and knowledge about its variability. It was described that the LD pedicle with supply by the long thoracic artery and nerve can be mobilized without tension up to 80 mm (14).

During the surgical mobilization of the LD muscle, all the perforating arteries from the posterior intercostal and lumbar will be divided and the only arterial supply from the thoracodorsal artery remains (15). Hence it was essential to study the branching pattern of thoracodorsal artery inside the LD. The LD is supplied by a single motor nerve, thoracodorsal nerve which divides after entering the LD (16). The nerve passes posterior to the axillary artery, joins the vascular pedicle, and enters the LD along with the artery. The artery and nerve to LD bifurcate after their entry into the LD muscle. It was reported that, based on this branching pattern, one can use one or both units of the muscle for the transfer as required by the individual case (17, 18).

In the literature, there are few clinical reports available, there are not enough anatomical studies which explain the neurovascular distribution of the LD. Anatomical reports are very much essential as they serve as the basic in the medical research. The present study has examined the detailed distribution of thoracodorsal nerve and branching of the thoracodorsal artery in female cadavers. This type of study is not reported earlier from the female cadavers of the south Indian population. The data of the present study were compared with the few available previous reports. Bartlett *et al* (17) observed the subscapular-thoracodorsal artery vascular pedicles of 11 cm mean length. The long thoracic artery branches from the thoracodorsal artery were observed previously by Bartlett *et al.* (17). In the present study, this pattern of origin of long thoracic artery was observed only in 5.6% cases. It was observed that, in 94.4% of our cases the long thoracic artery was branching from the circumflex scapular artery. Bartlett *et al.* (17) reported that the neurovascular structures in the *latissimus dorsi* were bifurcated into superior and lateral intramuscular bundles in 86% of their specimens. This pattern is labelled as type 1a in this study and it was observed in only 44.4% cases. Kwon *et al.* (10) opined that the thoracodorsal nerve always branched before the thoracodorsal artery, and the distance from the first branch of the nerve to the first branch of the artery was 20.4 ± 8.9 mm. In the present study, the thoracodorsal nerve branching before the artery was labelled as type B and observed in 27.8% cases.

It is described that the surgeon should have adequate knowledge about the arterial tree and divisions of thoracodorsal nerve of the LD muscle. This LD muscle is commonly used in the pedicle grafts in the plastic surgical practice

following the mastectomy. It was observed that the arterial branching pattern of the LD muscle was extremely variable. The finding of the present study is useful to the reconstructive surgery, since the distance of origin of neurovascular pedicle of LD from the inferior scapular angle was constant. There was no statistically significant difference between the right *versus* left sides, in all the female embalmed cadavers. So, the data of the present study can be used as anatomical guide for the surgical dissection with respect to the distance of the neurovascular pedicle from the inferior angle of scapula.

However, this study has certain limitations like the sample size, which was very small. We could be able to dissect only 18 muscles, from the 9 female cadavers. The study can be more accurate with a large sample size of female cadavers. This study also focused on evidence gathered using cadavers from Indian region, the results may be influenced by the ethnic predispositions in the Indian sample. Further studies, based on larger and ethnically diverse samples, may determine whether outcomes vary for different ethnic groups. The high variability in the pattern of the vascular tree between the two sides of the same subject has modest clinical relevance. The surgeon, in fact, operates just one out of the two sides. But the remarkable variability of the vascular and nervous pattern, on the other hand, has practical relevance to the surgeon. The upper extremities were positioned at 90º abduction and this can affect the distance of the lower angle of the scapula to the pedicle. But the patients can be positioned with 90º abduction of arm in the surgical setting as well.

CONCLUSIONS

The present study has provided information about the various branching pattern of the arterial supply and innervation of the LD muscle. This study was performed exclusively by using the female cadavers from the sample south Indian population. The data of the present study may help the operating surgeons while harvesting the neurovascular pedicle flaps during the breast reconstruction procedure.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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