

CHAPTER V

DISCUSSION AND CONCLUSION

Since the perforator base flaps were described, several myocutaneous flaps have been replaced by such flaps for resurfacing body defect of distal limbs [5]. The important reasons for selecting a free TDP flap are: 1) preserving muscle (the flap contains only the skin and superficial adipose tissue); 2) constant thickness; 3) large flap size; and 4) a long vascular pedicle [15]. The tedious dissection of perforator of varying diameters and locations, requiring prolonged surgery, is the main disadvantage of the thoracodorsal artery perforator flap, but this may be overcome by training and experience [11].

1. The Pattern of the Thoracodorsal Artery in the Latissimus Dorsi Muscle

Various authors described a constant branching of the thoracodorsal artery in a medial and a lateral branch, which ran on the deep surface of the muscle [14, 16-19]. In our study, we found all of the 60 dissections (100%) that the thoracodorsal artery divided into two branches, thus confirming the finding those reported by Bartlett et al. [14], Tobin et al. [16], Rowsell et al. [17,18], and Heitmann et al. [19].

Some authors described the bifurcation on the deep surface of the latissimus dorsi muscle approximately 4 cm distal to the tip of the scapula and 2.5 cm medial to the lateral free border of the muscle [14, 16-19]. This observation contrasted with our finding demonstrating that the bifurcation mostly was 2 cm distal to the tip of the scapula and 1.7 cm from the lateral border of the muscle. In addition, the distance of the bifurcation from the dome of the axilla has not been reported. In our study, we found the bifurcation of the thoracodorsal artery was 5.0 cm from the dome of the axilla (Table 9). This measurement will help in making out the TAP flap before dissection.

Bartlett [13] and Heitmann et al. [18] reported that the medial branch paralleled to the superior border 3.5 cm from the edge, whereas our results, we found the medial branch was 2.2 cm from the superior border of the muscle. In addition, location of the lateral and medial branches that located near the border of the muscle. The lateral branch of the thoracodorsal artery was the longest and the largest vessel.

These anatomic findings led to the clinical refinement of the split latissimus dorsi muscle.

2. The Number of the Cutaneous Perforators

The TDAP flap was not a well-known flap. Recent publications have outlined the anatomy and experience with this flap, but these accounts were limited in number contrast to other perforator flaps [20, 21].

In anatomic studies, Taylor et al. [22] found 5 to 9 cutaneous perforators, which were larger than 0.5 mm in the area of the latissimus dorsi muscle. However there were no further details given regarding the specific location and origin of the perforators. Angrigiani et al. [1] were the first who applied the principle of the perforator flaps to the latissimus dorsi muscle and were able to find at least one perforating vessel from the lateral branch of the thoracodorsal artery. Guerra et al. [20] observed similar anatomy. Heitmann et al. [19] described there was an average of 1.8 perforators of the lateral branch. Binu et al. [2] reported averages of 5.5 perforators were seen from the thoracodorsal artery supplying the skin. For our study, the number of perforators of the lateral branch of the thoracodorsal artery was a total of 76 perforators larger than 0.5 mm. There was an average 1.3 perforators (range: 1-3 perforator) (Table 10). In addition, the flap harvesting had an opportunity to find a single perforator of the lateral branch in 78.33 percent of specimens (Table 3). These results showed that there were few adequate perforators from the lateral branch. Then, the flap harvesting was a very delicate procedure requiring a high level of microsurgical skill, and had to be carried out meticulously.

Several authors reported the number for each perforator of the lateral branch was showed in table 8. In this study, we found the first perforator in all dissections (100%), while the second and third perforators were found in 21.67 and 5 percent, respectively. In accordance with other studies, the first perforator was always the largest and most consistent. The second and the third perforators were smaller and these findings were less consistent [20]. In this study, we found a similar pattern (Table 11).

3. The Location of the Cutaneous Perforators of the Lateral Branch of the Thoracodorsal Artery

The location and distribution of these perforators have not been adequately described previously. Using the Duplex ultrasound scan to locate the perforators was not accurate enough

because it was difficult to distinguish between the signal of a perforator and the main pedicle due to the relatively thin layer of the subcutaneous tissue [20, 25]. Therefore, the knowledge of the specific location of the perforator was very important in the perforator flap harvesting.

The first effort to locate the perforators by using the posterior axillary fold and the anterior border of the latissimus dorsi muscle as landmarks was performed. Angrigiani et al. [1] first used these landmarks in their original description of the thoracodorsal artery perforator flap. The proximal perforator exited the muscle into the subcutaneous tissue approximately 8 cm below the posterior axillary fold and 2 to 3 cm posterior to the lateral border of the muscle. The second perforator of the thoracodorsal artery arose 2 to 4 cm distal to the origin of the first perforator. The first and second perforators were consistently found in all dissection. A third perforator originated 2 to 4 cm from the origin of the second perforator. In addition, as pointed out by Binu et al. [2], identification of the perforator by using the anterior border of the latissimus dorsi muscle and the lowest point of the scapula was useful. The most proximal perforator was usually seen about 3.0 cm medial to the anterior border of the muscle in line with the inferior angle of the scapula. The second perforator was seen usually 2.5 to 4.0 cm inferior to the first. Spinelli et al. [10] described the presence of a predictable row of perforator from the lateral branch of the thoracodorsal artery. Kim et al. [5] observed these similar anatomical findings. In our study, the dome of the axilla and the lateral border of the latissimus dorsi muscle were used to be landmarks. The first perforators emerged from the muscle approximately 9.8 cm distal to the dome of the axilla. The second and third perforator exited the muscle at 11.6 cm and 12.8 cm distal to the dome of the axilla, respectively (Table 7 & 11). These results contrasted by Angrigiani et al. [1] and Binu et al. [2].

In addition, our study showed the location of all of the perforators (76 perforators), which penetrated the muscle at an average distance of 10.2 cm from the dome of the axilla (range: 4.1-14.8 cm). In the majority of dissections (88.2%, 67 of 76 perforators), the perforators located in a range between 7 to 14 cm distal to the dome of the axilla, especially the first perforator had 52 of 67 perforators. In 53 of 60 flaps (88.3%) were found to have at least one perforator in this range. In the remaining 7 of 60 flaps (11.7%), no perforator was found in this range. In addition, focused on the location of the perforators ranging from 9 to 12 cm distal to the dome of the axilla, we found to have at least one perforator in 35 of 60 flaps (58.3%). In the remaining 25 of 60 flaps (41.7%), perforators were not found in this range. For designing of the flap, we suggested that the perforator flap harvesting area should range from 7 to 14 cm distal to the dome of the axilla and closely the lateral border of the muscle (Figure 1).

Binu et al. [2] reported that the perforators located 3.0 cm from the lateral border of the muscle to its origin. Angrigiani et al. [1] showed that the perforators exited the muscle approximately 2 to 3 cm from the lateral border of the muscle. Whereas our study, the perforators located 1.7 cm from the lateral border of the muscle to its origin and emerged the muscle near the lateral border of the muscle.

Some authors reported that all the cutaneous perforators were within 8 cm of the bifurcation [19, 20] whereas our study found all the cutaneous perforators were within 10 cm of the bifurcation.

We noticed that all the perforators were thin, fragile, and oblique course, then the dissection of the perforator might be difficult. Leaving several strips of muscle fiber attached to the perforator was suggested to allow safe dissection and prevent any kinking or undue tension of the perforator during flap inset [4].

4. The Relationship of the Nerve and Vessels to the Muscle

Some authors described the site of neural division divided into two branches: the lateral and the medial branch of the nerve [14, 16]. The branching pattern of the nerve paralleled to the vasculature. The relationship of the nerve and vessels to the muscle has not been previously reported. We found the lateral thoracodorsal pedicle was accompanied by the thoracodorsal nerve. In the majority of dissections (58.33%), the thoracodorsal nerve was found in a lateral and superficial location relative to the vascular structures. This result can be used for preventing nerve injury during flap harvest and the dissection.

5. The Direct Cutaneous Perforator of the Thoracodorsal Artery

The reliability of the thoracodorsal artery perforator flap may have been tainted by the inconstant presence of a direct cutaneous branch which arose from the thoracodorsal artery and traveled anterior to the muscle edge. This vessel was the basis for the thoracodorsal axillary flap described by Cabanie et al. [24] but it was not a perforator as it did not travel through the latissimus dorsi muscle. Cabanie et al. [24] found this branch in only 75% of dissections, while Rowsell et al. [16] documented its presence in 81% of cadaver dissections, yet only 47% of the time it originated from the thoracodorsal artery. Heitmann [19] and Binu et al. [2] reported this branch in 55% and 60% of the specimens. In our study, we found this branch in 93.3% of dissections (Table 13). In addition,

location of this branch has not been previously reported. We found this branch generally located at 1.5 ± 0.6 cm proximal to the bifurcation or 3.6 ± 1.5 cm from the dome of axilla.

Direct cutaneous perforator, compared with the musculocutaneous perforator; 1) there was no need for transmuscular dissection; 2) it guaranteed perfect preservation of the thoracodorsal nerve; and 3) more easily found anterior to the latissimus dorsi muscle border because of its more reliable location [23].

In clinical experience, to harvest the flap, the patient had to be positioned in the lateral decubitus position with abducted to 90 degrees at the shoulder. Whereas our study, cadavers were placed in the supine position with the shoulder abducted to 90 degrees. In our opinion, the position of the cadaver might have influenced the location of the perforators. But the difference might not significant because it was previously fixed by formalin embalming.

Conclusion

Our study has clarified all details of the anatomy of the thoracodorsal artery and the cutaneous perforators of the lateral branch within the latissimus dorsi muscle. Most perforators located about 7 to 14 cm from the dome of the axilla and closely the lateral border of the muscle which it determined center for designing of the flap and supported the clinical use of the TAP flap.

Table 10 Reported series of the pattern of the thoracodorsal artery

Year	Author	Neurovascular hilus	Branches
1981	Bartlett et al.(14) (50 fresh cadavers)	2.1 cm medial to lateral border of the muscle	Upper branch parallel to the superior border 3.5 cm from the edge
			Lateral branch parallel to the lateral border 2.1 cm from the edge
1981	Tobin et al. (16) (60 cadavers)	2.6±0.07 cm medial to lateral border of the muscle	Upper branch separated from lateral branch at neurovascular hilus at 45 degree angle
		8.7±0.14 cm distal to the subscapular artery origin	lateral branch parallel to the lateral border 1-4 cm from the edge
1984	RowSELL et al. (17) (58 cadavers)	-	Upper and lateral branch
1986	RowSELL et al. (18) (13 fresh cadavers)	-	Upper branch separated from lateral branch at neurovascular hilus at 45 degree angle
			94% from the subscapular artery 5% from the axillary artery 1% from the lateral thoracic artery
2003	Heitmann et al. (19) (16 fresh cadavers)	2.5 cm medial to lateral border of the muscle	Upper branch parallel to the superior border 3.5 cm from the edge
		4 cm distal to the inferior scapular border	Lateral branch parallel to the lateral border 2.0 cm from the edge
2005	Our study (30 cadavers)	1.7 cm medial to lateral border of the muscle	Upper branch parallel to the superior border 3.2 cm from the edge
		2 cm distal to the inferior scapular border, mostly	Lateral branch parallel to the lateral border 1.7 cm from the edge
		5.0 cm from dome of axilla	



Table 11 Reported series of the number of the perforators of the TDAP flap

Year	Author	Number of cadaver	Number of perforator
1987	Taylor et al. (22)	-	5-9 perforator in the area
1995	Angrigiani et al. (1)	40 fresh cadavers	2-3 perforator from the lateral branch
2003	Heitmann et al. (19)	16 fresh cadavers	1.8 perforator (range:1-4) from the lateral branch
2004	Guerra et al. (20)	20 cases	At least one perforator from the lateral branch
2005	Binu et al. (2)	15 fresh cadavers	5.5±1.8 perforator (range:3-11) from the thoracodorsal artery
2005	Our study	30 cases	1.3±0.6 perforator(range:1-3) from the lateral branch

Table 12 Anatomy studies of the thoracodorsal artery perforating vessels

Year	Auhor	1 st perforator	2 nd perforator	3 rd perforator
1995	Angrigiani et al. (1)	40/40 (100%)	40/40 (100%)	32/40 (80%)
2003	Heitmann et al.(19)	20/20 (100%)	13/20 (65%)	2/20 (10%)
2004	Guerra et al. (20)	20/20 (100%)	12/20 (60%)	10/20 (50%)
2005	Our study	60/60 (100%)	13/60 (21.7%)	3/60 (5.0%)

Table 13 Published series of the TDAP flap about the location of the perforator of the lateral branch

Year	Author	1 st perforator	2 nd perforator	3 rd perforator
1995	Angrigiani et al. (1) (50 fresh cadavers)	8 cm from posterior axillary fold	2-4 cm from the origin of the 1st perforator	2-4 cm from the origin of the 2nd perforator
		2-3 cm from lateral border of muscle		
2001	Kim et al. (5) (12 case)	Perforator near the lateral border of muscle		
2003	Heitmann et al. (19) (16 fresh cadavers)	All perforator originated within a distance of 8 cm from the bifurcation		
2004	Guerra et al. (20) (20 cadavers)	2-4 cm from the bifurcation	2-6 cm from the origin of the 1st perforator	-
		All perforator originated within a distance of 8 cm from the bifurcation		
2005	Binu et al. (2) (15 fresh cadavers)	Inferior angle of the scapula	2.5-4 cm from the origin of the 1st perforator	-
		3 cm from lateral border of muscle		
2005	Our study (30 preserved cadavers)	9.8±2.6 cm from dome of axilla	3.4±2.1 cm from the origin of the 1st perforator	3.0±1.6 cm from the origin of the 2nd perforator
		1.7±0.6 cm from lateral border of muscle		

Table 14 Reported series of the direct cutaneous perforator of the thoracodorsal

Year	Author	Direct cutaneous perforator
1980	Cabanie et al. (24)	75% of 30 cadaveric dissections
1984	Rowell et al. (17)	81% of 100 cadaveric dissections but arose from the thoracodorsal artery in only 47%
2003	Heitmann et al. (19)	55% of 20 cadaveric dissections arose from the thoracodorsal artery
2005	Binu et al. (2)	60% of 15 cadaveric dissections arose from the thoracodorsal artery
2005	Our study	93.33% of 30 cadaveric dissections arose from the thoracodorsal artery