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Color Doppler Ultrasound Assessment of Anterolateral Thigh Flap Perforators in Locally Advanced Head and Neck Cancer

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To overcome anatomic variations and make the anterolateral thigh flap (ALT) harvesting simpler and safer, we used color Doppler ultrasound to locate the cutaneous perforators preoperatively and evaluated the reliability for perforator vessels. Twenty-six patients with advanced head and neck cancer who underwent curative surgery between 2012 and 2013 were recorded. The characteristics of cutaneous perforators of the ALT were evaluated preoperatively by color Doppler ultrasound. Fifty-seven perforators detected by preoperative color Doppler ultrasound were found intraoperative. The 4 false-positive perforators were found to be a branch of suprafascial plexus in the subcutaneous fat. The average number of perforators per flap was 2.4 (range, 1–4). The color Doppler ultrasound, therefore, has an 88.3% true-positive rate. The false-positive rate was 6.7%, and the false-negative rate was 5.0%. The diameters detected by preoperative color

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Doppler ultrasound and by surgeons during the operations were significant differences. Preoperative color Doppler ultrasound assessment for perforators of the ALT can decrease the operative risk for locally advanced head and neck cancer.

Key words: Color Doppler ultrasound – Anterolateral thigh flap – Perforator – Reconstruction – Advanced head and neck cancer

Locally advanced head and neck cancer continues to be a major therapeutic challenge in clinical management. Surgery remains the first-line treatment for these tumors. And, surgery for advanced head and neck cancer comprises often-complex reconstruction techniques with extensive use of free flaps.[1,2] The anterolateral thigh (ALT) flap first reported by Song *et al*[3] in 1984 has multiple advantages including thin, pliable skin; adequate pedicle length; potential for harvest of large flaps along with fascia and muscle; and acceptable donor site morbidity, making it one of the most commonly used flaps for the reconstruction of various soft tissue defects in the head and neck.[4,5] However, elevation of the ALT flap requires meticulous dissection of the musculocutaneous perforators through the underlying muscle. Another disadvantage of the flap is variability in the position and size of the perforator vessels.[6,7] To overcome these anatomic variations and make flap harvesting simpler and safer, we used color Doppler ultrasound to locate the cutaneous perforators preoperatively. These data were compared with the intraoperative data, and their reliability was evaluated.

Materials and Methods

Between June 2012 and July 2013, 26 patients with advanced head and neck cancer who underwent curative surgery were evaluated. The number and locations of cutaneous perforators were evaluated preoperatively by color Doppler ultrasound. The patients included 23 men and 3 women; their ages ranged from 28 years to 72 years, with an average of 51.0 $\pm$ 10.9 years. In total, 12 patients had tongue cancer, 6 patients had buccal cancer, 2 patients had head skin cancer, 3 patients had oropharyngeal cancer, and 3 patients had parotid cancer. TNM staging was performed according to the criteria for head neck cancer developed by the Union for International Cancer Control (UICC, 2002). The soft tissue defect size ranged from 5.5 $\times$ 3.5 cm to 18 $\times$ 20 cm. The size of the flap ranged from 6 $\times$ 4 cm to 23 $\times$ 20 cm. A color Doppler system (Philips IU22, Royal Philips, Amsterdam, The Netherlands) with a broad-spectrum 12.5-MHz linear transducer was used to assess the number and locations of cutaneous perforators. In the supine position, the thigh length of the patient was estimated from the anterior superior iliac spine to the center of the lateral part of the patella. This line corresponds to the lateral intermuscular septum between the vastus lateralis muscle and the rectus femoris muscle. The cutaneous perforators were identified by sliding the transducer very slowly along the line. During surgery, we made a skin incision in the middle of the anterior thigh. The parameters of the perforator, including size, the pattern of course, and the origin, were recorded under direct observation. In the 26 patients, the preoperative results were compared with the intraoperative findings. The positive predictive value for the location of the perforators identified by preoperative color Doppler ultrasound were evaluated. The data were analyzed by Student *t* test. All statistical analyses were performed using SPSS (Version 16.0, SPSS Inc, Chicago, Illinois). A P value <0.05 was considered significant. The study was approved by the institutional review board of Central South University, Hunan, China, and in our study, we always complied with the tenets of the Declaration of Helsinki.

Results

All cases had 61 perforators in total in the mid-lateral thigh region, along the line between the anterior superior iliac spine and the superolateral margin of the patella, detectable by color Doppler ultrasound (Table 1). There were 13 cases with 3 perforators, 7 cases with 2 perforators, 4 cases with only 1 perforator, and 1 case with 4 perforators. The average number of perforators per flap was 2.4 (range, 1–4) (Figs. 1 and 2). Fifty-seven perforators of all those detected by preoperative color Doppler ultrasound were found intraoperative (Figs. 3 and 4). The 4 false-positive perforators were found to be a branch of suprafascial plexus in the subcutaneous fat. The 3 perforators not detected by preoperative

Table 1 Patient data and the details of perforators

Patient No.	Sex	Age, y	Diagnosis (TNM staging)	Defect size, cm	Flap size, cm	No. of perforators (A/B)	Origin (B)	Diameter, mm (A/B)	Vmax, cm/s	Length, cm (B)	Complications
1	M	42	Tongue cancer (T2N0M0)	6×4	7×4.5	3/3	D, MC	0.72/0.69	8.5	6.5	No
2	M	54	Tongue cancer (T3N0M0)	8×5	9×5	3/2	D, MC	0.58/0.56	–	4.1	No
3	M	65	Tongue cancer (T4aN0M0)	9×5	10×5.5	2/2	D, MC	0.79/0.73	8.4	7.8	No
4	M	28	Tongue cancer (T2N0M0)	5.5×4	6×4	3/3	D, MC	0.82/0.80	10.5	5.2	No
5	M	41	Tongue cancer (T2N0M0)	6×4	–	0/0	–				
6	M	48	Tongue cancer (T3N1M0)	8.5×5	10×5.5	1/1	D, MC	0.66/0.66	7.2	9.5	No
7	M	37	Tongue cancer (T4aN1M0)	9.5×6	10.5×6	3/3	D, SC	0.64/0.63	7.1	6.5	No
8	F	39	Tongue cancer (T4aN2bM0)	9×5.5	10×6	2/2	D, MC	0.66/0.64	6.5	7.4	No
9	M	60	Tongue cancer (T3N1M0)	8×5	8.5×5.5	3/3	D, MC	0.92/0.90	13.2	6.8	No
10	F	72	Tongue cancer (T2N0M0)	5.5×3.5	–	2/0					
11	M	58	Tongue cancer (T2N1M0)	6×3.5	6×4	3/3	D, MC	0.78/0.76	7.8	3.7	No
12	M	45	Tongue cancer (T4aN2bM0)	10×6	11×6	2/2	D, MC	1.12/1.06	16.2	5.2	No
13	M	47	Buccal cancer (T2N0M0)	5×6	5×7	3/3	D, MC	0.46/0.42	–	4.2	No
14	M	45	Buccal cancer (T3N0M0)	6×9	5×9	1/2	T, MC	0.47/0.46	–	5.8	No
15	M	50	Buccal cancer (T4bN1M0)	6×9	5×7, 5×4	3/3	D, MC	0.83/0.80 0.56/0.55	10.1 –	3.6 6.5	No
16	M	52	Buccal cancer (T4bN2bM0)	6.5×9	5×7, 5×5	2/2	D, MC	0.56/0.54 0.47/0.45	– –	5.2 7.1	No
17	M	36	Buccal cancer (T2N0M0)	5.5×6	5×7	3/2	D, MC	1.09/1.06	19.6	10.4	No
18	M	65	Buccal cancer (T2N1M0)	5×4	5×9	1/1	D, SC	0.78/0.74	10.5	4.5	No
19	M	68	Head skin cancer (T4N0M0)	10×15	12×17	3/3	D, MC	0.79/0.76	8.7	9.7	No
20	M	54	Head skin cancer (T4N0M0)	20×18	20×23	4/4	D, MC	0.85/0.80	12.5	6.2	No
21	M	43	Oropharyngeal cancer (T4aN1M0)	12×6	13×5.5	2/2	D, MC	0.68/0.64	7.3	5.8	No
22	M	48	Oropharyngeal cancer (T4aN2bM0)	11×5	12×5	3/3	D, MC	0.87/0.84	9.8	8.5	No
23	M	60	Oropharyngeal cancer (T4aN2bM0)	10×6	12×5	3/3	D, MC	0.58/0.55	–	5.6	No
24	M	58	Parotid cancer (T4N1M0)	10×12	13×5	3/3	D, MC	0.97/0.96	12.8	8.3	No
25	F	62	Parotid cancer (T4N2bM0)	9×5	10×4.5	1/3	D, MC	0.45/0.43	–	6.4	No
26	M	49	parotid cancer (T4N0M0)	4×6	5×7	2/2	D, SC	0.78/0.76	9.1	5.9	No

A, the perforators detected color Doppler ultrasound; B, the perforators found during surgery; D, descending branch of lateral circumflex femoral artery; Diameter, the diameter of the dominant perforator; Length, the length from the dominant perforator to the main vascular; MC, musculocutaneous; Origin, the origin of the dominant perforator; SC, septocutaneous; T, transverse branch of lateral circumflex femoral artery; Vmax, the maximum velocity of the dominant perforator.

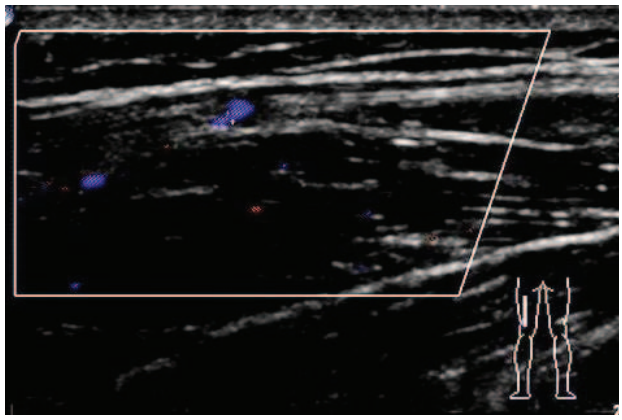

Fig. 1 The color signal of perforators from the thigh.

color Doppler ultrasound were all <0.4 mm diameter and had no pulse on visual inspection. These perforators were so small that they had insufficient blood flow for ALT nutrition; we ligated them. One case was changed to a pectoralis major myocutaneous flap, and the other was changed to an anteromedial thigh flap. The color Doppler ultrasound, therefore, has a 88.3% true-positive rate. The false-positive rate was 6.7%, and the false-negative rate was 5.0%.

The main perforator, found by surgeons during the operations, was musculocutaneous in 21 patients and septocutaneous in 3 patients. The diameters of the main perforators detected by preoperative color Doppler ultrasound ranged from 0.45 mm to 1.12 mm, with a mean diameter of 0.73 ± 0.18 mm, and the diameters of the main

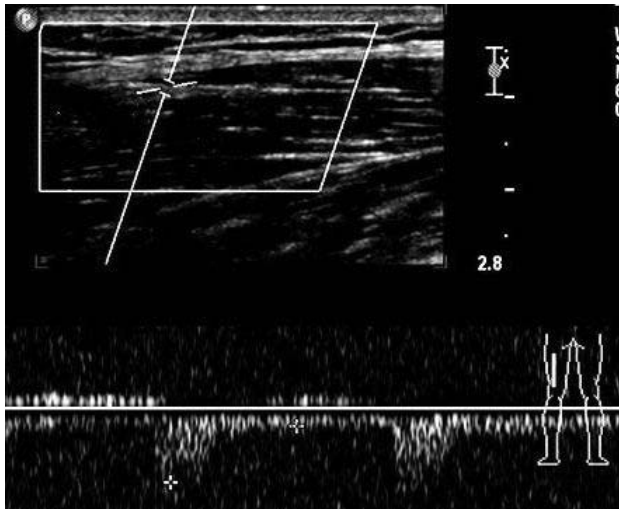

Fig. 2 The color Doppler ultrasound findings of flow velocity of the main perforator vessel for the anterolateral thigh flap.

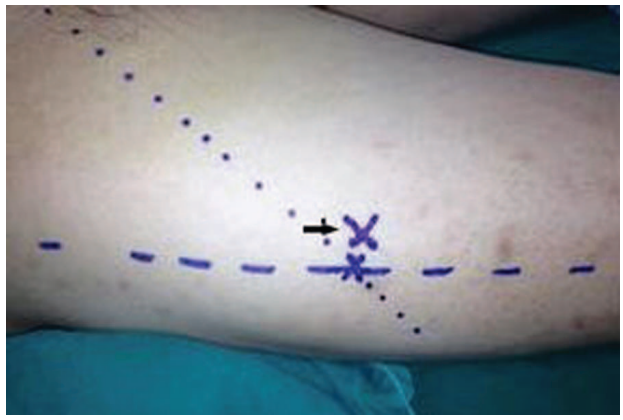

Fig. 3 Marking the main perforator vessel for the anterolateral thigh flap by color Doppler ultrasound measurement (arrow).

perforators measured intraoperatively ranged from 0.42 mm to 1.06 mm, with a mean diameter of 0.70 ± 0.16 mm. The diameters detected by preoperative color Doppler ultrasound and by surgeons during the operations were significantly different ($P < 0.01$) as determined by a paired-sample t test (average difference between means was 0.026 ± 0.015 mm). The arterial waveforms could be recorded by color Doppler ultrasound in 18 main perforators, of which the diameters were more than 0.6 mm. The peak systolic flow velocity ranged from 6.5 to 19.6 cm^{-1}. The average length from the dominant perforator to the main vessel was 6.40 ± 1.86 cm, measured by the surgeon. No postoperative complications were seen in 24 ALT flaps. Closure of the donor site by direct suturing was observed in 22 patients, whereas 2 patients required another skin graft.

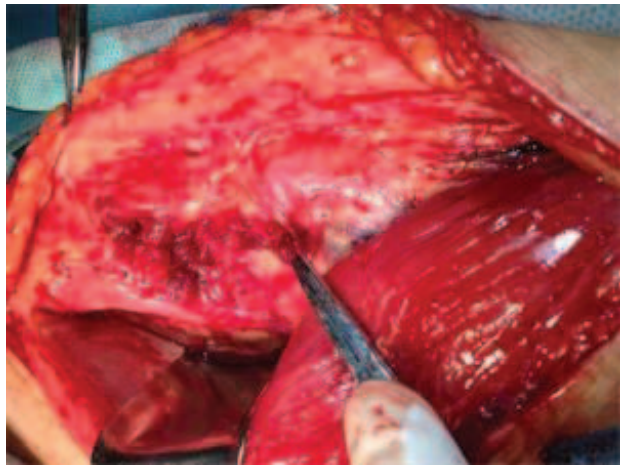

Fig. 4 The main perforator vessel just penetrated the deep fascia of the rectus femoris muscle.

Discussion

In this study, we demonstrated the usefulness of preoperative color Doppler ultrasound for locating perforators of ALT flap. The perforators of ALT flaps have an anatomic variation, which sometimes makes it challenging to use the ALT flap; the ALT flap is classified as either a musculocutaneous perforator flap or a septocutaneous perforator flap. However, the most common one is the musculocutaneous perforator flap, which often requires transmuscular pedicle dissection, so the time required is long. Furthermore, it is possible to harvest the flap without the perforators. It is sometimes difficult to estimate whether or not the flap is supplied by the descending branch of the lateral femoral circumflex artery. It is easier when the small capillary perforators are examined by color Doppler ultrasound. The time required is shorter, and the success rate of harvesting flaps is increased largely.

Some scholars reported that imaging examinations of the perforator vessels mainly depend on color Doppler ultrasound and computed tomography (CT)[8] and found that many factors could affect the outcome of color Doppler ultrasound, resulting in some false-positives and false-negatives in the measurement.[9] Tsukino *et al*[10] observed the ALT flap perforator vessels by color Doppler ultrasound and suggested that the accuracy of color Doppler ultrasound assessment for the ALT flap perforator vessels was far higher than the accuracy of the handheld Doppler. However, color Doppler ultrasound is mainly used to determine whether there are perforator vessels or not and to locate the point from which the perforator vessels go through the skin. It is not able to distinguish between a septocutaneous perforator and a myocutaneous perforator.

Our team applied color Doppler ultrasound to determine the course and diameter of the ALT perforators before flap elevation. We clarified that the preoperative identification of the perforators of the ALT flap with color Doppler ultrasound is highly reliable. After elevating the flaps, we found that none of them needed a change in the donor site. According to the result, the color Doppler ultrasound assessment is beneficial for evaluating the perforator vessels of the ALT flap and designing the incision for surgery, making the procedure simpler and shorter for the surgeons. However, the technology has some false-negatives and false-positives; during the operation, we can find a useful perforator vessel, at least, depending on the result of the color Doppler ultrasound assessment. The perforator vessel of one patient was located by color Doppler ultrasound assessment, but it was rooted in the bundles of musculus vastus medialis during the operation, and the perforator vessel was found to cross the incision in the fat layer near the surface of the fascia lata; the incision was stretched inside to be an arch incision for the elevation of the ALT. According to Table 1, we could see that there are 22 cases in which the perforator diameter is more than 0.5 mm, although there are 4 cases $<$0.5 mm. We could say, there is a dominant perforator and that the other perforators have a tendency to be less dominant. So the flap design could be done after detecting the dominant perforators in this study.

If the perforator vessel could be located by color Doppler ultrasound examination before the surgery, donor sites could be changed if necessary, and surgery time, risk, and cost could be shortened. Color Doppler ultrasound is useful for marking the supplying vessel on the body surface and for assessment of the elevation of the ALT flap as well as for avoiding the risk of vessel variation or absence.

Conclusion

Surgery for advanced head and neck cancer comprises often complex reconstruction techniques. Preoperative color Doppler ultrasound assessment for perforators of the ALT can decrease the operative risk for locally advanced head and neck cancer.

References

1. Fang QG, Shi S, Li MJ, Zhang X, Liu FY, Sun CF. Free flap reconstruction versus non–free flap reconstruction in treating elderly patients with advanced oral cancer. *J Oral Maxillofac Surg* 2014;**72**(7):1420–1424
2. Klug C, Berzaczy D, Voracek M, Enislidis G, Rath T, Millesi W *et al*. Experience with microvascular free flaps in preoperatively irradiated tissue of the oral cavity and oropharynx in 303 patients. *Oral Oncol* 2005;**41**(7):738–746
3. Song YG, Chen GZ, Song YL. The free thigh flap: a new free flap concept based on the septocutaneous artery. *Br J Plast Surg* 1984;**37**(2):149–159
4. Kekatpure VD, Trivedi NP, Shetkar G, Manjula BV, Mathan Mohan A, Kuriakose MA. Single perforator based anterolateral thigh flap for reconstruction of large composite defects of oral cavity. *Oral Oncol* 2011;**47**(6):517–521
5. Cordova A, D'Arpa S, Di Lorenzo S, Toia F, Campisi G, Moschella F. Prophylactic chimera anterolateral thigh/vastus

lateralis flap: preventing complications in high-risk head and neck reconstruction. *J Oral Maxillofac Surg* 2014;**72**(5):1013–1022

6. Kimata Y, Uchiyama K, Ebihara S, Nakatsuka T, Harii K. Anatomic variations and technical problems of the anterolateral thigh flap: a report of 74 cases. *Plast Reconstr Surg* 1998;**102**(5):1517–1523
7. Yu P. Characteristics of the anterolateral thigh flap in a Western population and its application in head and neck reconstruction. *Head Neck* 2004;**26**(9):759–769
8. Masia J, Kosutic D, Clavero JA, Larranaga J, Vives L, Pons G. Preoperative computed tomographic angiogram for deep inferior epigastric artery perforator lap breast reconstruction. *J Reconstr Microsurg* 2010;**26**(1):21–28
9. Cheng HT, Lin FY, Chang SC. Evaluation of diagnostic accuracy using preoperative handheld Doppler in identifying the cutaneous perforators in the anterolateral thigh lap: a systematic review. *Plast Reconstr Surg* 2012;**129**(4):769e–770e
10. Tsukino A, Kurachi K, Inamiya T, Tanigaki T. Preoperative color Doppler assessment in planning of anterolateral thigh flaps. *Plast Reconstr Surg* 2004;**113**(1):241–246