Vascularized Lymph Node Transfer Based on the Hilar Perforators Improves the Outcome in Upper Limb Lymphedema

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Background: Maintenance of the blood supply to the lymph nodes is necessary for survival and function. We report the outcome of vascularized lymph node transfer with hilar perforators compared with the conventional technique.

Patients: A total of 21 patients affected by early stage II upper limb lymphedema were included in this study. Of them, 11 patients received a free groin flap containing lymph nodes and 10 patients received vascularized inguinal lymph nodes with hilar perforators. Mean follow-up was 46 and 40 months, respectively. Complications, secondary procedures, circumference of the limb, and subjective symptomatology were registered. The differences were evaluated statistically.

Results: The limb circumferences decreased significantly in the new group. The number of secondary procedures was significantly higher in the standard group. There were 2 cases of partial flap loss and donor site lymphorrhea in the standard group. In both the groups, visual analog scale scores improved after the operation.

Conclusions: Transfer of vascularized inguinal lymph nodes based on the hilar perforators improves the outcomes in the treatment of early lymphedema of the upper extremity.

Key Words: vascularized lymph node, free lymph node transfer, perforator flap, lymphedema, breast cancer

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Upper limb lymphedema affects approximately 30% of women undergoing lymphadenectomy or lymphatic radiation for breast cancer.[1] Although a majority of the patients are responsive to conservative measures, in 10% the treatment fails requiring further management before fibrosis, lipogenesis, and hyperkeratosis make the process irreversible.

Normally after injury, the lymph flow is restored fairly quickly because of the robust regenerative capacity of the lymphatic vessels.[2] However, when the regenerative potentials have been damaged by scarring and irradiation, transfer of lymph nodes could represent the most physiological method to restore the afferent lymphatic pathways and to deliver the lymph load to deep venous system. Maintenance of the blood supply to the transferred lymph node is necessary for survival and preservation of function,[3–5] as afferent and efferent continuity is reestablished spontaneously following division if the nodal vascular supply is retained.[6]

The superficial location of lymph nodes, their association with known vessels, and inconspicuous scar following flap harvest have made the inguinal region a favorite donor site for the harvest of vascularized lymph nodes.[7–9] However, this technique has not gained popularity, probably because the numerous variations of the regional vascular anatomy[10] have been associated with risk of flap failure. Furthermore, if the selected vascular pedicle does not directly perfuse the lymph nodes their function could be jeopardized.

The experience gained from perforator flap surgery, and improved knowledge of vascularization of skin and lymph nodes allowed us to modify the conventional approach to the harvest of inguinal nodes, to improve the outcome and increase the consistency of the results. In 2004, we started to raise a lymph node cutaneous flap from the groin, after direct visualization of the cutaneous and hilar perforators and selection of the dominant pedicle to both components of the flap to ensure the most physiologic blood supply to the lymph nodes. In this study, we discuss the modified technique and compare the results to the outcomes achieved with the conventional approach.

PATIENTS AND METHODS

Vascularized lymph node transfer has been approved by the internal review board of our hospital for patients affected by early stage II lymphedema of the limbs according to the criteria of the International Society of Lymphology.[11] Diagnosis and staging of lymphedema are made on the basis of history, clinical examination, and lymphoscintigraphy with Technetium 99m. All patients presenting with early stage II lymphedema of the upper extremity after mastectomy and axillary dissection are offered vascularized lymph node transfer when the volume of the limb continues to increase after a minimum of 6 consecutive months conservative therapy consisting of limb elevation, compression garments, and decongestive treatment.

Operative Procedure

Standard Approach

The inguinal ligament is marked between the pubic tubercle and the anterior superior iliac spine. The axis of the flap is drawn 2 cm distal and parallel to inguinal ligament. The first incision is made laterally, down to the deep fascia. Thereafter, the dissection progresses medially over the muscle fascia. At the level of sartorius, the deep branch of the superficial circumflex iliac artery usually pierces the muscle fascia; therefore, the dissection is carried out deep to the fascia. Harvest of the flap proceeds medially until the femoral artery is reached. Lymph nodes present in the medial subcutaneous fat tissue are harvested en bloc with the flap (Figs. 1–3).

Perforator-Based Approach

The position of the inguinal ligament is marked as discussed earlier in the text. A slightly oblique incision is made through the skin, just lateral to the femoral artery starting below the inguinal
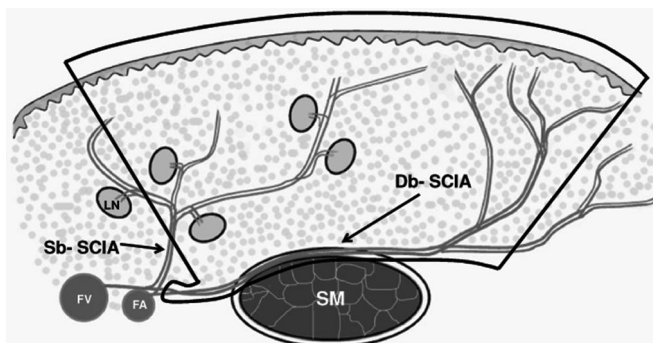
FIGURE 1. Schematic representation of the standard groin flap containing lymph nodes. The flap is harvested from lateral to medial, based on the deep branch of the superficial circumflex iliac artery (Db-SCIA). The lymph nodes are randomly included in the flap and if the superficial branch of the superficial circumflex iliac artery (Sb-SCIA) is not preserved, their physiologic vascularization is jeopardized. FA indicates femoral artery; FV, femoral vein; LN, lymph node; SM, sartorius muscle. Illustration by Antonio Rampazzo.
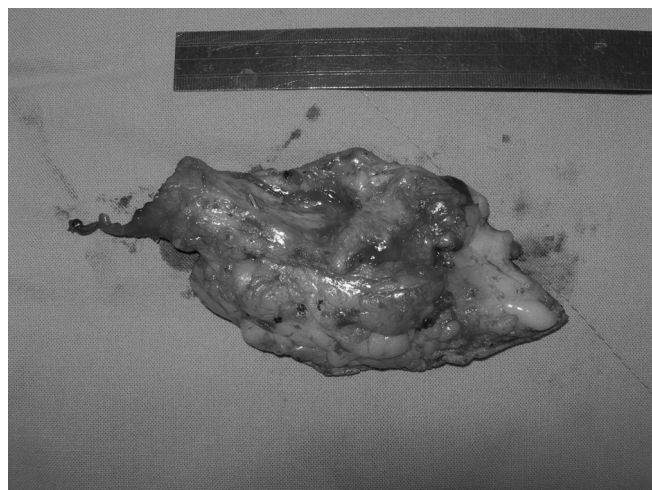

FIGURE 3. Conventional groin flap containing lymph nodes (deep surface). Sartorius fascia is covering the deep aspect of the flap.

Postoperative Protocol

After surgery, a light medication is applied and the limb is kept mildly elevated. The patients are encouraged to actively move the fingers, although movement of the wrist is restricted by an ulnar-sided wrist splint. For flaps inset at the forearm, a splint is not required. Five days postoperatively, and once wound healing is evident, the patient is encouraged to start a passive and active rehabilitation program coordinated by a trained physiotherapist. Discharge is usually possible 7 days after surgery.

Data Collection and Analysis

Circumferential measurements of the affected and normal upper limbs were taken by trained nurses, 10 cm above and below the olecranon, at the wrist, and at the midpalm level before surgery and postoperatively at regular intervals.

All of the complications were recorded. Secondary procedures required to improve the result and the number of episodes of cellulitis affecting the upper extremity were registered.

Variations of the subjective symptomatology (elasticity of the skin, heaviness of the limb, pain) were assessed with visual analog scale before and at the last follow-up.

The preoperative and postoperative upper limb circumferences were expressed as differences with the contralateral (normal side). Differences at the last follow-up were evaluated statistically with the Wilcoxon paired rank test. Preoperative differences between the 2 groups were evaluated in the same manner. Differences in the requirement for secondary procedures between the 2 groups were evaluated with the nonparametric Fisher exact test. Results were considered statistically significant if $P < 0.05$ and highly significant if $P < 0.01$.

FIGURE 2. Conventional groin flap containing lymph nodes. The lymph nodes are included en bloc in the flap.

ligament. The subsequent dissection is carried out with the aid of the operating microscope and microsurgical instruments. The terminal perforating arterial and venous branches are identified and dissected retrograde down to the source vessels (superficial branch of the superficial circumflex iliac artery and vein, superficial inferior epigastric artery and vein, or other axial vessels with unusual course). The skin perforators usually exit between several lymph nodes, which are directly visualized and can be carefully isolated avoiding damage to their vascular hilum. At this stage, the main vascular pedicle is seen and 2 or 3 lymph nodes directly perfused by the main pedicle are selected for transfer (Fig. 4). The inferior margin of the skin flap is incised first and the course of the pedicle checked from the deep surface. The design of the flap is finalized and the superior incision is performed. When the skin flap is raised, it is possible to complete the dissection of the lymph nodes and the pedicle down to the femoral artery and vein (Figs. 5, 6). The lymph nodes are handled gently and the small afferent lymphatics to the external capsule divided with scissors and not cauterized, to help with the regeneration at the recipient site.

RESULTS

Between September 1997 and April 2008, 25 patients were treated with vascularized inguinal lymph nodes transfer (Tables 1, 2). Perforator-based approach was used in all patients from 2004. Four patients did not have complete records, and therefore were excluded from the study. The number of patients treated with the standard technique and the modified approach was 11 and 10, respectively. Mean age was 54 and 55 years, respectively. Four patients in the standard technique group and 5 patients in the perforator-based group had received radiotherapy after mastectomy

FIGURE 4. Perforator-based flap. The superficial branch of the superficial circumflex iliac artery is visualized passing between 2 rows of lymph nodes, through the medial incision.
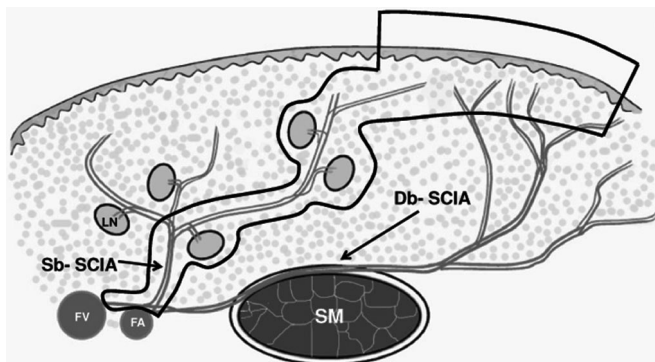
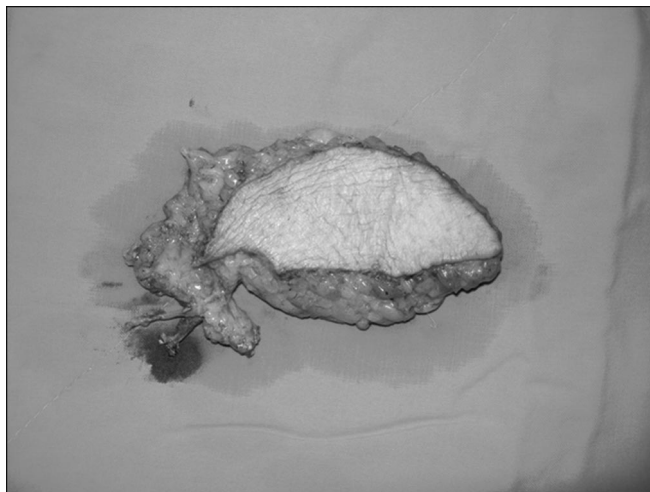**FIGURE 5.** Schematic representation of the flap based on the hilar perforators. The superficial branch of the superficial circumflex iliac artery (Sb-SCIA) is the dominant vessel responsible for the vascularization of the lymph nodes giving off the hilar perforators and the perforators to the skin. Db-SCIA indicates deep branch of the superficial circumflex iliac artery; FA, femoral artery; FV, femoral vein; LN, lymph node; SM, sartorius muscle. Illustration by Antonio Rampazzo.

FIGURE 6. Flap based on the hilar perforators. The vascular pedicle passes between the lymph nodes before entering the skin flap.

and axillary dissection. All of the patients evidenced complete obstruction of the lymphatics at the preoperative lymphoscintigraphy. The mean follow-up was 46 months (26–120 months) and 40 months (38–50 months).

The feeding artery of the flap was the deep branch of the superficial circumflex iliac artery in all patients in the standard group. In the perforator-based group, 7 flaps were vascularized by the superficial branch of the superficial circumflex iliac artery and 3 flaps were nourished by the superficial inferior epigastric artery. In the latter patients, the design of the flap was modified intraoperatively to incorporate the superficial inferior epigastric artery as the axis of the flap. In 2 cases, the superficial branch of the superficial circumflex iliac artery did not join the deep branch and reached the femoral artery independently. In the other 5 cases, the superficial and the deep branches of the superficial circumflex iliac artery united 1 to 2 cm before reaching the femoral artery. In the perforator-based group, in all cases it was possible to select 2 to 3 lymph nodes to transfer. The recipient site was the wrist in all patients in the standard technique group, whereas in 2 cases, in the perforator-based group, the flap was inset at the forearm. Recipient vessels were always radial artery (end-to-side) or its proximal muscle branches (1 case, end-to-end) and the comitant veins of the radial artery (end-to-end).

In the standard approach group, there were 2 cases of partial necrosis of the skin paddle treated conservatively. Two patients developed seroma at the donor site. Two patients suffered from multiple episodes of cellulitis affecting the forearm during the follow-up. Eight patients requested further suction-assisted lipectomy to improve the result.

In the perforator-based group, there were no immediate complications. One patient suffered 2 episodes of cellulitis at the forearm during the follow-up (36 months). One patient required further debulking of the forearm (radical reduction of lymphedema with preservation of the perforators [RRPP][12]) and suction-assisted lipectomy of the arm. One patient required suction-assisted lipectomy of the affected arm.

We did not report any case of lower extremity lymphedema and cellulitis following transfer of the flap in either group. None of the patients complained of swelling and heaviness of the donor extremity.

In both the groups, patients reported an improvement of the subjective symptomatology following surgery as shown by the pre- and postoperative visual analog scale scores (standard group, 6.1 vs. 5.3; perforator-based group, 6.3 vs. 5.1). However, these differences were not significant.

There was no statistical difference in the limb circumference measurements between the 2 groups preoperatively. Differences between preoperative and postoperative measurements were statistically significant only in the perforator-based group at the levels below elbow, wrist, and midpalm ($P = 0.004$, 0.002, 0.007, respectively). All the other differences were not statistically significant. The difference in the requirement of secondary procedures between the 2 groups was significant ($P = 0.03$).

DISCUSSION

Lymph nodes represent physiologic lymphaticovenous anastomosis.[13] Because the colloid osmotic pressure of the lymph is lower than that of the blood, protein-free fluid is absorbed from

TABLE 1. Patients' Data: Standard Groin Flap Containing Lymph Nodes

Patient Number	Age	Upper Extremity	Radiotherapy	Feeding Artery	Recipient Site	Other Procedures	Preoperative AE, BE, W, P	Last Follow-up AE, BE, W, P	Follow-up (mo)	Complications
1	69	Right	No	Db-SCIA	Wrist	SAL forearm	7/26/2/3.5	8/15/8/3.5	26	Forearm cellulites
2	51	Left	No	Db-SCIA	Wrist	SAL forearm	7/4/0/−0.5	3/1/0/0	60	
3	48	Left	No	Db-SCIA	Wrist	SAL forearm + arm	9/7/11/5	3/0/2/0	60	
4	69	Right	No	Db-SCIA	Wrist	SAL arm	8/6/1.5/0	11/8/1/0	120	
5	46	Right	No	Db-SCIA	Wrist	SAL forearm + arm	3.5/5.5/2/2	0/4/1.5/1	26	
6	46	Left	Yes	Db-SCIA	Wrist	SAL arm	4.5/5.8/2/0	1.5/4.5/4/0	24	Forearm cellulites, inguinal seroma
7	49	Left	No	Db-SCIA	Wrist		1/4/2/2	3/1.5/2.5/3	60	Partial flap necrosis, inguinal seroma
8	79	Right	Yes	Db-SCIA	Wrist	SAL arm and forearm	8/5/1.5/0	13/7/1/0.5	36	
9	46	Left	Yes	Db-SCIA	Wrist	SAL arm	3.5/6/3.5/−0.5	1.5/2.5/4/0	30	
10	51	Right	Yes	Db-SCIA	Wrist	SAL arm	3.5/4.5/2/1	5/6/2/1	29	
11	45	Left	No	Db-SCIA	Wrist		2/4/12/15	3/4/13/14	38	Partial flap necrosis

AE indicates above elbow; BE, below elbow; W, wrist; P, midpalm; Db-SCIA, deep branch of the superficial circumflex iliac artery; SAL, suction-assisted lipectomy.

the lymph into the blood capillaries to establish the equilibrium of Starling forces across the lymph-blood barrier. If the vascular supply is not optimal, there is less opportunity for lymph absorption into the vein and the tissue itself atrophies,[2] losing the ability to spontaneously reestablish afferent and efferent continuity following division.[6,14,15] Therefore, restoration of lymphatic function following lymph node transfer requires establishment of adequate perfusion.[3,4,16]

Clinical experience with transfer of vascularized lymph nodes has been mostly limited to the inguinal region because of reduced morbidity associated with the harvest of the superficial lymph nodes and inconspicuous donor scar. Conventionally, the flaps with or without a skin component were based on the deep branch of the superficial circumflex iliac artery and dissected as a traditional groin flap is harvested.[7–9] However, the deep branch of the superficial circumflex iliac artery plays only a marginal role in the perfusion of the inguinal nodes giving off mainly branches to the muscles in the femoral triangle[17] and vascularizes the skin lateral to the anterior superior iliac spine. As already described by Acland[18] and subsequently stressed out by Cormack and Lamberty,[17] the superficial branch of the superficial circumflex iliac artery is the main supply of the lymph nodes. If the origin of the superficial branch from the main trunk is severed, the lymph nodes will lose their physiologic blood supply in most of the cases and their function will be hampered. Other 2 cutaneous arteries, the superficial inferior epigastric artery or the ascending branch of the superficial external pudendal artery can occasionally represent the dominant pedicle, running through the lymph nodes and supplying the hilar perforators, when the superficial circumflex iliac artery is absent.

Given the variability of the vascular anatomy of the groin, the success of the operation can be ensured only when the dominant artery, simultaneously responsible for perfusion of the lymph nodes and the skin, is chosen as the pedicle of the flap.

The first clinical application of vascularized inguinal lymph nodes was reported by Clodius et al.[7] Transfer of a pedicled groin flap from the contralateral side achieved stable reduction in the circumference of the lymphedematous limb. However, the second patient who received a free groin flap experienced rapid recurrence of lymphedema.

Becker et al[8] published a series of 24 patients with long-term outcome following microsurgical inguinal lymph node transplantation to the axilla. The flap consisted of lymph nodes and subcutaneous fat vascularized by superficial circumflex iliac artery and vein. They sustained that the upper limb perimeter returned to normal in 10 patients (42%) and decreased in 12 patients (50%). Twenty-nine percent of the patients[7] required a secondary transfer because of the incomplete result following the first operation. Lymphorrhea compared in 33% of the patients and 29% suffered 1 episode of cellulitis.

Lin et al[9] reported the transfer of vascularized groin lymph nodes using the wrist as a recipient site. A groin flap based on the superficial circumflex iliac vessels was performed in 13 patients. The hand circumferences decreased significantly in 12 patients. Two patients required further debulking procedures. The incidence of cellulitis was decreased in 11 patients.

In the recent years, the concept of perforator flaps and attainment of refined skills necessary to dissect fine perforators has gradually modified our approach to the harvest of inguinal lymph nodes. Exploration of the vascular anatomy is performed through retrograde dissection of the small perforators to the skin down to the source vessel, with direct visualization of the lymph nodes, their distribution, and localization of the hilar perforators. This approach allowed us to harvest safely the skin island and lymph nodes on the same vascular pedicle in 10 patients. We compared the results of the perforator-based approach with the standard technique. The pa-

TABLE 2. Patients' Data: Flap Based on the Hilar Perforators

Patient Number	Age	Upper Extremity	Radiotherapy	Feeding Artery	Recipient Site	Other Procedures	Preoperative AE, BE, W, P	Last Follow-up AE, BE, W, P	Follow-up (mo)	Complications
1	76	Right	No	SIEA	Wrist		2/8.5/8/4.5	4/2.5/2/1.5	38	
2	48	Left	No	Sb-SCIA	Wrist		7/11.5/3.5/1.5	4.5/8/2/2	23	
3	47	Left	No	SIEA	Wrist	Skin reduction/SAL arm	8.5/7.5/4/3	4/6/3/1	40	
4	63	Right	Yes	Sb-SCIA	Wrist		2/7/8/4.5	4/2.5/2/1	43	
5	47	Left	No	Sb-SCIA	Wrist	SAL forearm	10/8/5/3	4/6/3/1	50	Forearm cellulites
6	22	Left	No	Sb-SCIA	Wrist		4/3/1/1	2/2/0/0.5	35	
7	75	Left	Yes	SIEA	Wrist		1/2/1.5/2	1/1/1/1	44	
8	53	Right	Yes	Sb-SCIA	Forearm		4/1.5/4/1	0.5/0/1/0	45	
9	69	Right	Yes	Sb-SCIA	Forearm		1/7/3/0	0/5/1.5/0	39	
10	56	Left	Yes	Sb-SCIA	Wrist		1/0/2/1.5	1/0/1/0.5	40	

AE indicates above elbow; BE, below elbow; W, wrist; P, mid-palm; Sb-SCIA, superficial branch of the superficial circumflex iliac artery; SIEA, superficial inferior epigastric artery; SAL, suction-assisted lipectomy.

tient population in the 2 groups was homogeneous, and there were no significant differences in upper limb circumferences preoperatively. Postoperatively, the circumferences decreased significantly only in the perforator-based group. Although patients in both the groups reported improvement of the subjective symptomatology, the patients in standard approach group required significantly more debulking procedures. There were no statistical differences in the complication rate between the 2 groups but only 2 cases of partial flap necrosis and inguinal seroma occurred in the standard approach group.

In conclusion, the perforator-based approach showed to be a versatile method, which allows modification of the preoperative plan on the basis of the intraoperative findings, direct selection of the main vascular pedicle, and the number of transferred lymph nodes. All these factors contribute to improve the outcomes of vascularized lymph node transfer in the treatment of early upper limb lymphedema, as the physiological blood supply to lymph nodes is preserved. The possibility to select the dominant vascular pedicle and the number of transferred lymph nodes is helpful in increasing the predictability of the results and reducing the donor site morbidity.

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