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Reconstructive

Lymphatic System Transfer for Lymphedema Treatment: Transferring the Lymph Nodes with Their Lymphatic Vessels

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Background: Vascularized lymph node transfer is the most common physiological procedure indicated for severe lymphedema. We describe a new physiological treatment strategy for lymphedema, lymphatic system transfer (LYST), which comprises transfer of the vascularized afferent lymphatic vessels along with their draining lymph nodes.

Methods: All patients undergoing LYST for treatment of lymphedema from 2017 to 2018 were identified. Patient demographics, intraoperative factors, and postoperative outcomes were reviewed.

Results: Three patients underwent LYST. Average patient age and body mass index were 65.3 years and 23.6 kg/m^2, respectively. Indications for LYST were upper extremity lymphedema following mastectomy, radiation, and lymphadenectomy (2) and unilateral lower extremity lymphedema following total hysterectomy and bilateral pelvic lymphadenectomy (1). In all patients, lymphatic vessels could not be visualized by preoperative lymphoscintigraphy. All LYST flaps were procured from the groin region. A superficial circumflex iliac artery perforator flap, including the afferent lymphatic vessels and their draining lymph nodes, was elevated. A large portion of the skin paddle was deepithelialized, and the LYST flap was inset into a subcutaneous tunnel made in the lymphedematous limb. All LYST flaps survived completely. No donor site complications were observed. The average rate of estimated volume decrease in the patients at eighth month follow-up was 21.9%. Average follow-up was 11 months.

Conclusions: Because the afferent lymphatic vessels are transferred with the lymph nodes, a presumably lesser degree of lymphangiogenesis is required for a LYST flap to commence its physiological function. Its real-time physiological lymphatic drainage is demonstrated in a video. *(Plast Reconstr Surg Glob Open 2020;8:e2721; doi: 10.1097/GOX.0000000000002721; Published online 23 April 2020.)*

INTRODUCTION

Lymphedema is a chronic condition inflicting a significant burden, both physically and psychologically, on up to 250 million people worldwide.[1,2] Vascularized lymph node transfer (VLNT) is the most common physiological procedure indicated for severe lymphedema, where the lymphatic vessels needed for lymphaticovenous anastomosis cannot be detected on preoperative examinations.[3–7] Although the efficacy of VLNT is reported in several studies, there are still controversies over the most effective donor site.[8–18] In addition, theoretically, the effect of VLNT is postponed until the afferent lymphatic vessels develop via lymphangiogenesis. We introduce here a new physiological treatment strategy for lymphedema, lymphatic system transfer (LYST), which comprises transfer of the vascularized afferent lymphatic vessels along with their draining lymph nodes, which are also vascularized.

METHODS

All patients undergoing LYST for treatment of lymphedema from 2017 to 2018 were identified. Patient

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demographics, intraoperative factors, and postoperative outcomes were reviewed. Circumference of the affected limb was measured preoperatively and every month at anatomical sites as shown in Table 1. For consistent measurement, compression garments were taken off 3 hours before taking measurements. The average rate of decrease was defined as follows: ((Preoperative value) − (Postoperative value))/(Preoperative value). Estimated limb volume was obtained by the frustum formula mentioned by Casley-Smith, which is as follows: $V = (h)\ (C^2 + Cc + c^2)/12\ (\pi)$, where "C" is the girth measurement of distal section, "c" is the girth measurement of the proximal section, and "h" is the distance between distal and proximal section.[19]

Surgical Technique

All LYST flaps were harvested from the groin region. Reverse mapping is performed using technetium as described in previous reports.[20] Indocyanine green (ICG) is locally injected in the flank, and the afferent lymphatic vessels and the lymph nodes (1 or 2) at the end of the afferent lymphatic vessels are marked using an infrared camera system (Fig. 1 and **see Video 1** [online], which demonstrates ICG injection in the flank and visualization of the afferent lymphatic vessels and the lymph nodes thereafter using an infrared camera system).

The superficial branch of the superficial circumflex iliac artery (SCIA) is found and dissected via an incision made between the anterior superior iliac spine and the pubic tubercle, as described in our previous report.[21] After locating the branches to the lymph node, a skin paddle is designed to include the marked afferent lymphatic vessels. Before flap harvest, appropriate recipient vessels are prepared in the affected limb. After microsurgical anastomoses, a large portion of the skin paddle is deepithelialized, leaving only a small skin paddle for postoperative monitoring, and the LYST flap is inset in a subcutaneous tunnel made in the affected limb. The donor site is closed primarily over a drain.

RESULTS

Three patients underwent LYST. Average patient age and body mass index were 65.3 years and 23.6 kg/m^2, respectively. All patients were women. Indications for LYST were upper extremity lymphedema following mastectomy, radiation, and lymphadenectomy in 2 cases [one with International Society of Lymphology (ISL) stage 3 and the other with ISL stage 2B] and unilateral lower extremity lymphedema following total hysterectomy and bilateral pelvic lymphadenectomy in 1 case (with ISL stage 2B). All patients had received at least 3 years of complete decongestive therapy before the surgical intervention. In all patients, lymphatic vessels could not be visualized by preoperative lymphoscintigraphy. The details of the patients are presented in Table 1.

For the upper extremity cases, the proximal region of the upper arm was chosen for the recipient site because of expectation to reconstruct both the resected lymph nodes in the axilla and the lymphatic vessels in the upper arm. For the lower extremity case, most severe objective and subjective symptoms manifested in the lower leg. Thus, the lower leg was chosen as the recipient site. The SCIA, its vena comitans, and the superficial circumflex iliac vein were anastomosed to the axillary artery and the axillary vein in an end-to-side fashion, respectively, in upper arm lymphedema cases. In the lower extremity lymphedema case, the SCIA was anastomosed to a perforator found in the medial region of the lower leg, and the vena comitans of the SCIA and the superficial circumflex iliac vein were anastomosed to the subcutaneous vein of the lower leg and the great saphenous vein in an end-to-end fashion, respectively. The lymph node end of the LYST flap was inset to the axilla, and the afferent lymphatic vessels extended to the upper arm in upper extremity lymphedema cases. In the lower extremity lymphedema case, the LYST flap was inset to the lower extremity, with the lymph node end placed cephalad.

All LYST flaps survived completely. No complications were observed at the donor sites. Compression therapy was resumed 4 weeks after the lymphatic flap transfer.

The average rate of estimated volume decrease in the patients at eighth month follow-up was 21.9% (using truncated cone estimation with circumference measurements). Average length of follow-up from surgery to last clinic visit was 11 months. These findings are summarized in Table 1.

CASE REPORT

An 81-year-old woman has had ISL stage 3 lymphedema of the left upper extremity for 20 years after undergoing radical mastectomy (Fig. 2). Lymphatic scintigraphy demonstrated neither functional lymphatic vessels nor draining lymph nodes. A 9 × 3 cm LYST flap was designed in the left groin and was elevated based on the superficial branch of the SCIA. The video demonstrates intradermally injected ICG travelling from the afferent lymphatic vessels to the lymph node and then finally to the vein approximately 5 minutes after the injection (**see Video 2** [online], which

Table 1. Summary of the Patient Demographics and Postoperative Results

					Postoperative Improvement Rate of Circumference at 8 Months after the Surgery (%)						
Patient	Age	Lymphedema Site	ISL Stage	BMI (kg/m^2)	15 cm above the Elbow (20 cm above the Knee)	5 cm above the Elbow (10 cm above the Knee)	Elbow (Knee)	5 cm below the Elbow (10 cm below the Knee)	20 cm below the Elbow (20 cm below the Knee)	Decrease Rate of Estimated Volume (%)	Follow-up Length (mo)
1	81	Upper limb	3	24.2	15.5	18.9	13.1	23.3	15.6	40.8	13
2	58	Upper limb	2B	29.2	0.0	3.5	2.3	2.7	1.1	13.8	8
3	57	Lower limb	2B	17.5	13.9	6.7	1.2	2.0	-0.5	11.0	12

Postoperative improvement rate: ((Preoperative value) − (Postoperative value))/(Preoperative value).

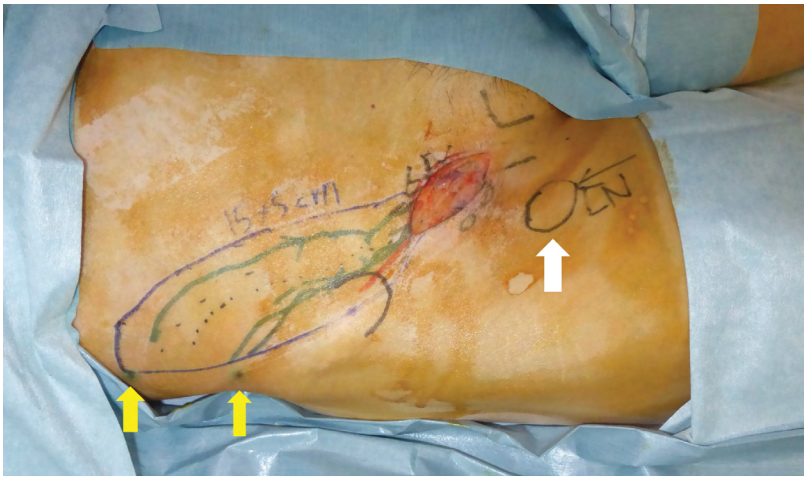

Fig. 1. The design of a lymphatic system transfer flap. Reverse mapping is performed using technetium as to mark the lymph node draining the lower extremity (white arrow). ICG is locally injected in the flank (yellow arrows), and the afferent lymphatic vessels and the lymph nodes (1 or 2) at the end of the afferent lymphatic vessels are marked using an infrared camera system.

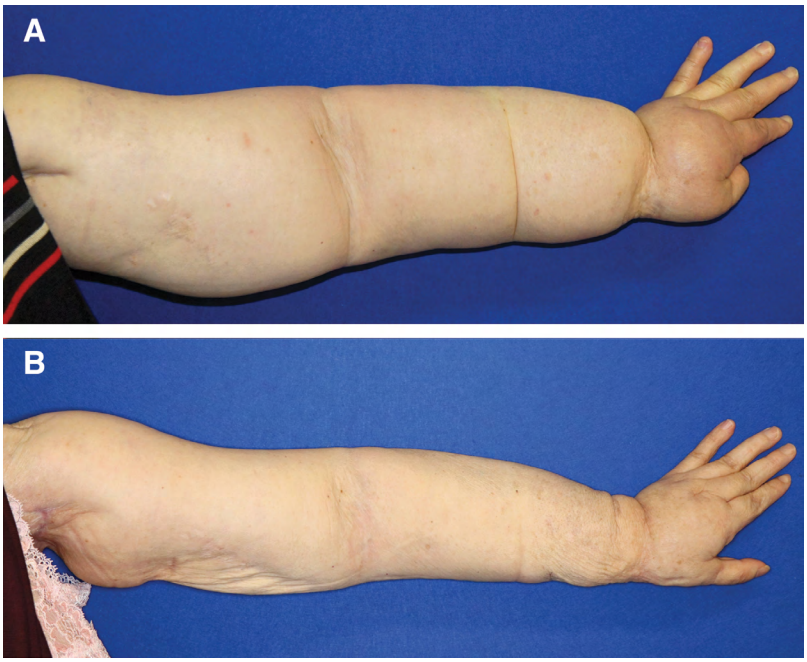

Fig. 2. Preoperative and postoperative photographs from case report. A, An 81-year-old woman has had ISL stage 3 lymphedema of the left upper extremity for 20 years after undergoing radical mastectomy. B, Postoperative photograph taken 12 months after the operation. Note the volume reduction, achieved without liposuction.

demonstrates intradermally injected ICG travelling from the afferent lymphatic vessels to the lymph node and then finally to the vein approximately 5 minutes after the injection). The SCIA was anastomosed to the axillary artery in an end-to-side fashion, and the vena comitans and a subcutaneous vein were anastomosed to the axillary vein in an end-to-side fashion. The flap survived completely, and the affected limb demonstrated a 40.8% decrease in estimated volume 12 months after the operation (Fig. 2).

DISCUSSION

Lymphaticovenous anastomosis is not indicated for advanced lymphedema, where no functional lymphatic vessels remain.[21] Though many procedures aimed at improvement of physiological status have been proposed, including VLNT and flap transfers including the lymphatic vessels, none is yet regarded as the gold standard for the physiological treatment of lymphedema.[8–18,23,24]

We combined VLNT and vascularized afferent lymphatic vessel transfer, hence the name LYST. Because the long afferent lymphatic vessels are transferred with the lymph node, a lesser degree of lymphangiogenesis (at least for the length of transferred afferent lymphatic vessels) is required for a LYST flap to commence its physiological function. The function of the transferred afferent lymphatic vessels is demonstrated in Video 2 (**see Video 2** [online], which demonstrates intradermally injected ICG travelling from the afferent lymphatic vessels to the lymph node and then finally to the vein approximately 5 minutes after the injection). It is true that VLNT with a skin paddle includes a certain degree of afferent lymphatic vessels, but not so much attention had been paid to the afferent lymphatic vessels per se. We postulate that the afferent lymphatic vessels play a vital role in the skin paddle; we selectively marked and harvested the afferent lymphatic vessels as long as possible for maximum efficacy of the transfer.

Indications of the LYST are the same as those of the VLNT: for fluid dominant lymphedema patients with no remaining functional lymphatic vessels. For fat dominant lymphedema, LYST after liposuction may be effective, but further study is needed to confirm this hypothesis.

The limitation of this method is that the possibility of donor site lymphedema still remains, although special precautions including reverse mapping can be taken. For more definite assessment of donor site lymphedema, a longer follow-up is definitely required.[25] This was a proof-of-concept study; more clinical cases with longer follow-ups are warranted to evaluate the long-term efficacy of LYST and its donor site morbidity. In addition, different donor sites that can also provide long afferent lymphatic vessels with the lymph nodes should be sought in the future.

CONCLUSION

LYST, including the lymph node and its afferent lymphatic vessels, has potential to become the optimal physiological treatment for severe lymphedema. Its real-time physiological lymphatic drainage, reported here, corroborates its efficacy.

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REFERENCES

1. Moffatt CJ. Lymphoedema: an underestimated health problem. *QJM*. 2003;96:731–738.
2. Rockson SG. Estimating the population burden of lymphedema. *Ann N Y Acad Sci*. 2008;1131:147–154.
3. Tourani SS, Taylor GI, Ashton MW. Vascularized lymph node transfer: a review of the current evidence. *Plast Reconstr Surg*. 2016 ;137:985–993.
4. Scaglioni MF, Arvanitakis M, Chen YC, et al. Comprehensive review of vascularized lymph node transfers for lymphedema: outcomes and complications. *Microsurgery*. 2018;38:222–229.
5. Aljaaly HA, Fries CA, Cheng MH. Dorsal wrist placement for vascularized submental lymph node transfer significantly improves breast cancer-related lymphedema. *Plast Reconstr Surg Glob Open*. 2019;7:e2149.
6. Ho OA, Chu SY, Huang YL, et al. Effectiveness of vascularized lymph node transfer for extremity lymphedema using volumetric and circumferential differences. *Plast Reconstr Surg Glob Open*. 2019;7:e2003.
7. Cheng MH, Loh CYY, Lin CY. Outcomes of vascularized lymph node transfer and lymphovenous anastomosis for treatment of primary lymphedema. *Plast Reconstr Surg Glob Open*. 2018;6:e2056.
8. Lin CH, Ali R, Chen SC, et al. Vascularized groin lymph node transfer using the wrist as a recipient site for management of postmastectomy upper extremity lymphedema. *Plast Reconstr Surg*. 2009;123:1265–1275.
9. Cheng MH, Huang JJ, Huang JJ, et al. A novel approach to the treatment of lower extremity lymphedema by transferring a vascularized submental lymph node flap to the ankle. *Gynecol Oncol*. 2012;126:93–98.
10. Althubaiti GA, Crosby MA, Chang DW. Vascularized supraclavicular lymph node transfer for lower extremity lymphedema treatment. *Plast Reconstr Surg*. 2013;131:133e–135e.
11. Sapountzis S, Singhal D, Rashid A, et al. Lymph node flap based on the right transverse cervical artery as a donor site for lymph node transfer. *Ann Plast Surg*. 2014;73:398–401.
12. Ciudad P, Kiranantawat K, Sapountzis S, et al. Right gastroepiploic lymph node flap. *Microsurgery*. 2015;35:496–497.
13. Coriddi M, Skoracki R, Eiferman D. Vascularized jejunal mesenteric lymph node transfer for treatment of extremity lymphedema. *Microsurgery*. 2017;37:177–178.
14. Coriddi M, Wee C, Meyerson J, et al. Vascularized jejunal mesenteric lymph node transfer: a novel surgical treatment for extremity lymphedema. *J Am Coll Surg*. 2017;225:650–657.
15. Chu YY, Allen RJ Jr, Wu TJ, et al. Greater omental lymph node flap for upper limb lymphedema with lymph nodes-depleted patient. *Plast Reconstr Surg Glob Open*. 2017;5:e1288.
16. Cook JA, Sasor SE, Tholpady SS, et al. Omental vascularized lymph node flap: a radiographic analysis. *J Reconstr Microsurg*. 2018;34:472–477.
17. Howell AC, Gould DJ, Mayfield C, et al. Anatomical basis of the gastroepiploic vascularized lymph node transfer: a radiographic evaluation using computed tomographic angiography. *Plast Reconstr Surg*. 2018;142:1046–1052.
18. Mazzaferro D, Song P, Massand S, et al. The omental free flap-a review of usage and physiology. *J Reconstr Microsurg*. 2018;34:151–169.
19. Casley-Smith JR. Measuring and representing peripheral oedema and its alterations. *Lymphology*. 1994;27:56–70.
20. Dayan JH, Dayan E, Smith ML. Reverse lymphatic mapping: a new technique for maximizing safety in vascularized lymph node transfer. *Plast Reconstr Surg*. 2015;135:277–285.
21. Yoshimatsu H, Yamamoto T, Hayashi A, et al. Proximal-to-distally elevated superficial circumflex iliac artery perforator flap enabling hybrid reconstruction. *Plast Reconstr Surg*. 2016;138:910–922.
22. Chang DW, Suami H, Skoracki R. A prospective analysis of 100 consecutive lymphovenous bypass cases for treatment of extremity lymphedema. *Plast Reconstr Surg*. 2013;132:1305–1314.
23. Yamamoto T, Iida T, Yoshimatsu H, et al. Lymph flow restoration after tissue replantation and transfer: importance of lymph axiality and possibility of lymph flow reconstruction without lymph node transfer or lymphatic anastomosis. *Plast Reconstr Surg*. 2018;142:796–804.
24. Chen W, McNurlen M, Ding J, et al. Vascularized lymph vessel transfer for extremity lymphedema - is transfer of lymph node still necessary? *Int Microsurg J*. 2019;3:1.
25. Ho OA, Lin CY, Pappalardo M, et al. Comparisons of submental and groin vascularized lymph node flaps transfer for breast cancer-related lymphedema. *Plast Reconstr Surg Glob Open*. 2018;6:e1923.