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Review

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Intra-abdominal donors for vascularized lymph node transfer: an update and review

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Abstract

Lymphedema continues to be a very challenging clinical problem. While compression and physical therapy remain the foundation of treatment, recent advances in microsurgery and super-microsurgery have allowed for the development of promising surgical options. One of these options is vascularized lymph node transfer (VLNT), which has gained significant popularity over recent years. However, there is no consensus on the ideal donor lymph node basin for VLNT. In addition, the most commonly reported donor sites, including the groin, supraclavicular, submental, and lateral thoracic nodes, carry the risk of iatrogenic lymphedema and/or visible scarring. In order to avoid these risks, the use of intra-abdominal donor sites for VLNT has been pursued. This article reviews the reported techniques and outcomes for each of the intra-abdominal donor sites for VLNT.

Keywords: Lymphedema, lymph node transfer, omentum, jejunum

INTRODUCTION

Lymphedema is a very challenging clinical problem for physicians and can be chronically debilitating for patients. Lymphedema is the progressive enlargement of an area of the body, most commonly a limb, resulting from lymphatic dysfunction. It is categorized by excess fluid accumulation and swelling in its early stages but can progress to adipose deposition and eventually fibrotic changes.

The standard treatment for lymphedema involves a combination of compression and physical therapy. These modalities have been repeatedly shown to decrease limb volume when performed correctly. However, they require strict, long-term compliance and, unfortunately, do not provide complete relief[1]. Given these issues with non-invasive options, surgical therapies for lymphedema have been developed and show promise when standard options are inadequate.

Surgical treatments fall into two categories, debulking procedures and physiologic procedures aimed at restoring lymphatic function. Advances in microsurgery and super-microsurgery have allowed for significant progress in the physiologic category[2-4]. Vascularized lymph node transfer (VLNT) uses the microsurgical technique to transfer functioning lymph nodes to the affected limb with the goal of restoring lymphatic drainage. There are two main theories to explain how vascularized lymph node transfers improve lymphatic function. First, some suggest that the lymph node flap serves as a "wick" or a bridge that re-connects the distal to the proximal functional lymphatics, thus restoring drainage. The second theory is that the lymph nodes collect interstitial fluid and "pump" it into the systemic circulation via the lymphovenous connection within the node[5].

Since the development of VLNT, surgeons have sought the ideal donor lymph node basin. The most utilized donor sites in the literature are the groin, axilla, and supraclavicular nodes. However, a major concern with the harvest of the groin or axillary nodes is developing a secondary, iatrogenic site of lymphedema[6,7]. While reverse lymphatic mapping helps to mitigate this risk[8], many surgeons are still hesitant to use these sites or do not readily have access to reverse mapping. On the other hand, supraclavicular and submental lymph node harvests are criticized for the highly visible scar locations.

In our institution, we prefer the use of intraabdominal lymph nodes for VLNT. The most significant advantage of these donor sites is that they carry no risk of iatrogenic lymphedema. Furthermore, they can be combined safely with each other and be performed simultaneously with other procedures such as autologous breast reconstruction[9,10]. Additionally, the scars from a mini-laparotomy, low transverse incision, or laparoscopic port sites are well hidden. This will discuss the reported techniques, outcomes, and complications for omental, jejunal, and appendiceal lymph node donor sites.

OMENTAL LYMPH NODE TRANSFER

The high concentration of lymphatic tissue in the omentum makes it a desirable donor for VLNT. One of the first descriptions of a physiologic operation for lymphedema was the use of a pedicled omental flap, originally published in 1966[11]. The omentum was raised on the right gastroepiploic vessels and then tunneled extra-peritoneally to the affected limb. However, this technique never gained widespread popularity, likely due to the hernia created in the tunneling process. The advances and increased availability of microsurgery have led to renewed interest in the omental transfer for lymphedema treatment in the form of a free tissue transfer. Although they are mostly small single-center case series, numerous studies have shown positive results and improved lymphedema symptoms following vascularized omental lymph node transfers[9,12-15]. Studies with quantitative limb measurement outcomes are summarized in Table 1.

One major advantage of the omental flap is the familiarity of the dissection for most reconstructive surgeons. The reliable length and caliber of the gastroepiploic pedicle, the large size of the omentum, and the high density of lymph nodes allow for a variety of technical options when using the omental lymph node basin as a VLNT donor[21]. One potentially beneficial feature of the omentum is that it often has large and easily visible lymphatic channels. Upon transfer, these channels can be used for primary anastomoses of afferent lymphatics to augment the lymphatic function of the VLNT. Several modifications of the omental

Table 1. Summary of available intra-abdominal donor sites for VLNT

Lymph node donor site	Donor characteristics	Clinical studies*	Outcomes reported	Mean follow-up (months)
Omentum/Gastroepiploic	- Versatile - Familiar harvest - Most commonly used intra-abdominal site - Multi-level transfer possible - Access via mini-laparotomy, laparoscopic, or robotic - May be unavailable after previous surgery/if adhesions present - Perfusion should be verified (with ICG)	Nguyen *et al.*[13] (2017): 42 patients, laparoscopic harvest	Mean volume reduction = 22% Subjective improvement in 83% Rate of cellulitis: 74% of patients pre-op to 5% post-op	14
		Ciudad *et al.*[16] (2017): 10 patients, laparoscopic right gastroepiploic VLNT	Mean CRR = 39.5% Improved LYMQOL scores	14.7
		Ciudad *et al.*[16] (2017): 7 patients, double level gastroepiploic VLNT	Mean CRR = 43.7%	9.7
		Maruccia *et al.*[17] (2019): 16 patients, double level gastroepiploic VLNT	Mean CRR = 58.3% below knee, 43.4% above knee at 12 months Improved LYMQOL score	26.2
		Ciudad *et al.*[18] (2019): 16 patients, double gastroepiploic VLNT + excisional procedure	Mean CRR= 74.5% for upper, 68% for lower Improved LYMQOL scores	14.2
		Manrique *et al.*[15] (2020): 13 patients with distally inset omental VLNT; 13 w/ mid-limb inset	Mean volume reduction = Upper extremity: mid 23.3%, distal 22% Lower extremity: mid 23.3%, distal 13.3%	6
		Ciudad *et al.*[9] (2020): 6 patients gastroepiploic VLNT + DIEP breast reconstruction	Mean CRR = 30%	12.8
Jejunal mesenteric	- Consistent presence of nodes - Multi-level transfer possible - Access via mini-laparotomy - Small volume, ideal for distal extremities - Remains reliable after previous abdominal surgery - Must be aware of bowel perfusion	Coriddi *et al.*[19] (2017): 14 patients, 15 VLNT	Mean reduction in extremity lymphedema index = 5.4% at 1 month; 12/14 (87.5%) patients with symptomatic relief	9.1
Appendiceal	- Expendable donor - Laparoscopic or open harvest - Presence of lymph node rare (8%) - Small caliber vessels	Ciudad *et al.*[20] (2018): appendiceal VLNT case report	CRR = 17.4% above knee, 15.1% below knee, 12% above ankle, 9% foot No postoperative cellulitis	6

*Clinical studies reporting quantitative limb measurement outcomes were included in this table. All share the benefits of hidden scar, no risk of iatrogenic lymphedema, and the ability to combine procedures. CRR: Circumference reduction rate; VLNT: vascularized lymph node transfer.

VLNT are available and can be tailored to the recipient limb needs. The entirety of the omentum can be harvested and transferred. The volume and large surface area of the omental free tissue transfer can be very beneficial in certain locations, such as the axilla after lymphadenectomy or if there is an associated wound needing soft tissue coverage[22].

However, in many cases, using only a select portion of the omentum may be more appropriate than transferring the entirety of it. For example, if the planned recipient site is the more distal extremity, use of the entire omentum may bring excessive bulk. Additionally, previous abdominal operations, intra-abdominal adhesions, and scarring may limit omental harvest. Even patients without a history of abdominal surgery often have irregular perfusion of the omentum, and intra-operative perfusion assessment with indocyanine green or similar technique is valuable to appropriately tailor the flap and decide on outflow veins[23].

Another technique, sometimes described as "gastroepiploic lymph node transfer", is to harvest only the perivascular tissue and lymph nodes surrounding and including the right or left gastroepiploic vessels while sparing the remainder of the omentum. It is important to note that in the literature, when referring to VLNT, the terms "gastroepiploic" and "omental" are used somewhat interchangeably. Both terms are used to describe the same lymph node basin. Gastroepiploic VLNT has been described laparoscopically in several studies with reasonable operative duration and safety[13,16,24]. Robotic harvest has been reported as well[25]. Again, perfusion of the gastroepiploic nodes should be assessed, especially when the majority of the omentum is not included.

Some studies have suggested that treating a lymphedematous extremity with two VLNTs (one proximal and one more distally) may be beneficial, and the omentum can easily be split into two flaps from a single donor site. The two flaps can be used for the treatment of bilateral lymphedema or two sites in a single extremity. Three recent studies have shown success with double omental VLNT to a single limb. Ciudad *et al*.[16] first reported their initial series of seven patients with upper and lower limb lymphedema who underwent double omental VLNT and demonstrated a mean circumference reduction rate (CRR) of 43.7% at 9 months without any reported complications. In 2018, Kenworthy *et al*.[14] published a series of 16 patients who had double omental VLNT. They also reported improved clinical symptoms and a decrease in postoperative cellulitis; additionally, visible uptake into the transplanted omentum was present on lymphoscintigraphy (50%, three of six patients) and ICG lymphangiogram (20%, one of five) at 1 year follow-up. Similarly, there were no donor site complications in that study. Finally, in 2019, another series of 16 patients treated with double omental VLNT for lower extremity lymphedema was published by Maruccia *et al*.[17]. Mean CRR was 43.4% above the knee and 58.3% below the knee at 12 months, and validated quality of life survey scores improved significantly.

In 2019, Ciudad *et al*.[18] published a series of patients who underwent double gastroepiploic VLNT with a simultaneous excisional procedure, radical reduction with preservation of perforators. This study achieved the greatest mean CRR among VLNT reports. Sixteen patients were included and had a mean follow-up of 14.2 months. Mean CRR was 74.5% for upper extremity procedures and 68% for the lower extremity.

Reported complications, with rates ranging from 0% to 16%, following omental VLNT include flap loss, pancreatitis, delayed return of bowel function, and hernia[13,26]. There have been no reports of bowel injury or ischemia. Both the proximal and distal ends of the gastroepiploic vein can be anastomosed on transfer to allow dual venous outflow[27] to decrease the risk of venous hypertension in the omental lymph node flap. Another option is to moderate inflow by creating an arterial flow-through flap[28].

JEJUNAL MESENTERIC LYMPH NODE TRANSFER

Use of the jejunal mesenteric lymph nodes for VLNT was recently described as an additional intra-abdominal option for VLNT. Coriddi *et al*.[19] initially published the concept of the jejunal VLNT in 2017[29]. In this initial study, including fifteen patients with an average follow-up of 9.1 months, 14 had viable

VLNTs, of which 12 (87.5%) had subjective relief, and seven of ten patients with preoperative limb measurements had objective improvements at one month. This was reported as a reduction in extremity lymphedema index, calculated by summing the squares of the circumferences of the extremity at multiple set levels then dividing by the patient's body mass index. The reduction in index ranged from 0.5% to 8.7% (mean 5.4%).

A follow-up study of 29 patients who underwent a total of 30 jejunal VLNTs with a mean follow-up of 17.6 months presented the potential complications associated with jejunal lymph node harvest[10]. Importantly, there were no reported cases of bowel ischemia. The reported complications included flap loss (3.3%), hernia (13.8%), nonoperative small bowel obstructions (10.3%), and superficial surgical site infection (3.4%). Limb measurements were not reported in this subsequent study.

In order to harvest the jejunal lymph node flap, we begin with a supraumbilical mini-laparotomy incision, typically no more than 5 cm. Once the abdomen is entered, the jejunum is identified and delivered. Directionality is confirmed with the identification of the Ligament of Treitz. A study of 5 cadavers demonstrated that the highest density of nodes is present in the proximal jejunum[29]; therefore, we elect to harvest from the proximal segment. We then transilluminate the jejunal mesentery to display the vascular arcades and lymph nodes. A peripheral packet of lymph nodes and pedicles is selected if possible and marked [Figure 1]. If no appropriate lymph nodes and associated vessels are found in the periphery of the mesentery, the nodes closer to the root are explored. Care is taken to ensure that the corresponding bowel segment remains well perfused by leaving the neighboring cascades intact. The posterior surface of the mesentery is preserved, and the mesenteric defect is closed to prevent internal hernia.

Schaverien *et al.*[30] suggested an alternative harvest technique in which the nodes are harvested primarily closer to the root of the mesentery. The lymph nodes and vessels are both typically larger closer to the mesenteric root. One concern with this technique is that the large caliber vessels will result in disproportionate inflow into a very small capillary network connecting the arterial and venous sides of the flap and the risk of minimal venous outflow. Therefore, the authors recommend augmenting the venous outflow if possible. This can be done by creating a flow-through flap, as was described with the gastroepiploic node transfer, or creating an arteriovenous loop with the distal end of the flap pedicle. No results were included in this report.

Of note, a single case report has been published on the harvest of the ileocecal mesenteric lymph nodes, as well as a follow-up discussion suggesting the use of the terminal ileal mesentery[31,32]. However, to our knowledge, there are currently no larger series reporting these techniques. Also, this region may carry higher risks given the possibility of appendiceal ischemia or the need for ileocolic resection and anastomosis in the event of complications.

APPENDICEAL LYMPH NODES

Additional intraabdominal donor sites have been considered but, thus far, have not been found to be as reliable or useful as the techniques previously discussed here. One of these is the mesoappendix, which would be an ideal source as it is well known to be truly expendable, and laparoscopic harvest could be performed safely and quickly with the assistance of a general surgeon. Ruter *et al.*[33] examined the mesoappendix as a potential lymph node donor. In the pathologic examination of 25 mesoappendix specimens, a single lymph node was only present in two specimens (8%).

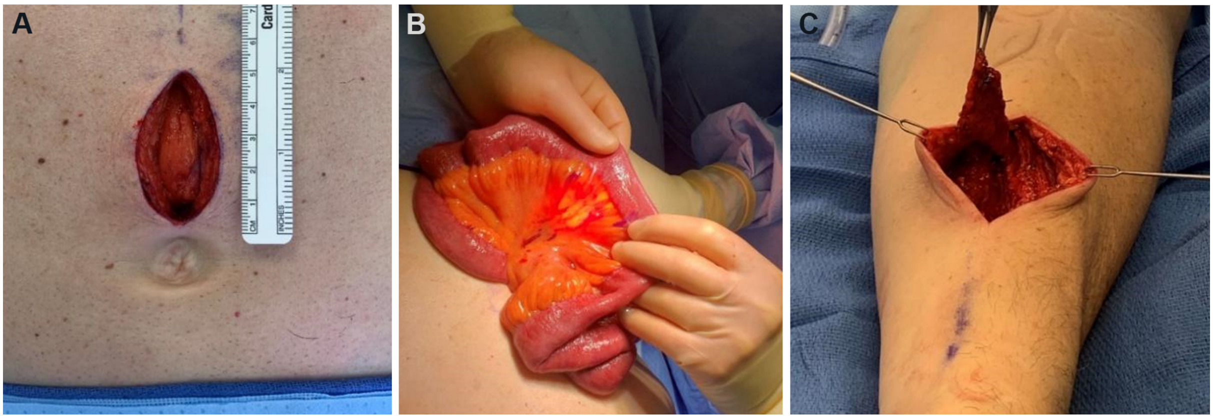

Figure 1. (A) Mini-laparotomy incision for access. (B) Transillumination of proximal jejunum for visualization of vascular cascades and lymph nodes. (C) Inset of jejunal mesenteric vascularized lymph node transfer (end to side to the radial artery; end to end venous anastomosis).

We would not recommend relying on the appendiceal lymph node basin given these findings; however, if a multilevel transfer is desired during a planned jejunal or omental VLNT, the mesoappendix could be easily examined for the presence of a node and vessel caliber and then harvested if found to be suitable for transfer. In our review of the literature, a single case report of appendiceal lymph node transfer to the lower extremity has been published. The patient, in that case, did have a reduction in limb circumference (17.4% above knee, 15.1% below knee, 12% above ankle, 9% foot) and no postoperative episodes of cellulitis at six months[20].

CONCLUSIONS

The abdomen is a rich source of lymphatic tissue and provides multiple options for VLNT donor sites. Intraperitoneal lymphatic donor sites completely avoid the dreaded complication of iatrogenic lymphedema that is a risk of groin and axillary-based flaps; additionally, intraperitoneal operations result in well-hidden scars. Multiple intraabdominal lymph node flaps can be harvested from a single incision, thus giving surgeons more options for multilevel transfers or treatment of bilateral lymphedema. Currently, the omental/gastroepiploic nodes are the most commonly transferred intraabdominal lymph nodes - likely due to the familiarity of the omental harvest. Jejunal mesenteric VLNT has also been recently described with promising results. Some surgeons may hesitate to use intraabdominal lymph nodes because of the risks of an abdominal operation, including bowel injury and hernia. However, the existing studies demonstrate that while surgeons and patients must be aware of risks, these operations can be performed with reasonably low complication rates and do result in improvement of lymphedema.

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Authors' contributions

Made substantial contributions to conception, structure, writing, and editing this review: Danforth R, Skoracki R

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