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ORIGINAL ARTICLE – RECONSTRUCTIVE ONCOLOGY

An Effective System of Surgical Treatment of Lymphedema

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ABSTRACT

Background. Effective surgical treatments for lymphedema now can address the fluid and solid phases of the disease process. Microsurgical procedures, including lymphaticovenous anastomosis (LVA) and vascularized lymph node transfer (VLNT), target the fluid component that predominates at earlier stages of the disease. Suction-assisted protein lipectomy (SAPL) addresses the solid component that typically presents later as chronic, nonpitting lymphedema of an extremity. We assess the outcomes of patients who underwent selective application of these three surgical procedures as part of an effective system to treat lymphedema.

Methods. This is a retrospective chart review of patients with lymphedema who underwent complete decongestive therapy followed by surgical treatment with SAPL, LVA, or VLNT. The primary outcomes measured were postoperative volume reduction (SAPL), daily requirement for compression garments and lymphedema therapy (VLNT and LVA), and the incidence of severe cellulitis.

Results. Twenty-six patients were included in the study, of which 10 underwent SAPL and 16 underwent LVA or VLNT. The average reduction of excess volume by SAPL was 3,212 mL in legs and 943 mL in arms, or a volume reduction of 87 and 111 %, respectively, when compared with the unaffected, opposite sides. Microsurgical procedures (VLNT and LVA) significantly reduced the need for both compression garment use ($p = 0.003$) and lymphedema therapy ($p < 0.0001$). The overall rate of cellulitis decreased from 58 % before surgery to 15 % after surgery ($p < 0.0001$).

Conclusions. When applied appropriately to properly selected patients, surgical procedures used in the treatment of lymphedema are effective and safe.

Lymphedema in the developed world commonly occurs after lymph node dissection and/or radiotherapy to nodal basins for breast cancer, melanoma, or gynecologic malignancies. Less commonly, lymphedema occurs as a result of congenital causes.[1–4]

Surgical procedures to treat lymphedema have existed for many years. Vascularized lymph node transfer (VLNT) is a microsurgical procedure that involves the relocation of a lymphatic-containing soft tissue flap along with its arteriovenous supply from a donor site such as the lateral groin, chest wall, or neck to the affected limb, groin, or axilla.[5–8] Lymphaticovenous anastomosis (LVA) is also a microsurgical procedure in which lymphatic vessels, usually between 0.1 and 0.6 mm in diameter, are sewn to small adjacent venules to bypass an area of poor lymphatic flow or obstruction and drain excess lymph directly into the venous system.[9–12] Suction-assisted protein lipectomy (SAPL) allows the removal of the solid components of lymphedema swelling seen in chronic lymphedema.[13,14] We used these three procedures, together with customized conservative lymphedema therapy, in an integrated treatment system to address most effectively patients with various presentations of lymphedema.

The purpose of this study was to assess the outcomes of patients who underwent selective application of three surgical procedures (VLNT, LVA, and SAPL) in the treatment of lymphedema.

METHODS

All procedures were performed by a single surgeon (J.W.G.), and all patients were evaluated and treated by a certified lymphedema therapist. The primary outcomes

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measured were the volume reduction achieved by SAPL at 4 and 12 months after surgery, the change in compression garment use and lymphedema therapy required for VLNT and LVA, and the change in the incidence of cellulitis in all cases. Limb circumference was measured at 4-cm intervals along the limb, and volumes were calculated in cubic centimeters by using the truncated cones method.[15,16] Volume excess was determined using the contralateral unaffected limb as a baseline. In addition, the safety of each procedure was evaluated by recording all postoperative complications occurring within 30 days. Patient perspectives regarding improvement were also documented.

Data were collected in an Excel database (Microsoft Excel, Microsoft Corporation, Redmond, WA) and translated into a native SAS format using DBMS/Copy (Dataflux Corporation, Cary, NC) for analyses with SAS version 9.3 (SAS Institute, Cary, NC). For comparing the preoperative cellulitis with postoperative cellulitis rates, a paired *t* test was used for analysis. The mean differences in cellulitis rates with the associated 95 % confidence interval are reported. For the changes in garment use and need for therapy, paired *t*-tests were again used to measure the pre-post difference. A priori, it was determined that a $p < 0.05$ was statistically significant. Institutional review board approval was obtained.

Lymphedema Protocol

The diagnosis of lymphedema was confirmed by a certified lymphedema therapist and also a plastic surgeon trained and experienced in lymphedema treatment. All patients were required to have completed a course of rigorous lymphedema therapy which included manual lymphatic drainage, bandaging, and compression garment use as indicated before consideration for surgery. Lymphoscintigraphy was performed to confirm a diagnosis of lymphedema. If indicated, appropriate vascular surgery consultations to rule out additional vascular etiologies for limb swelling were obtained. All patients were offered conservative, nonsurgical therapy as an alternative.

Patients with lymphedema symptoms due primarily to a fluid component were treated with either VLNT or LVA. VLNT was preferred for upper extremity lymphedema and was performed by transferring lymph nodes and small amounts of surrounding soft tissue from the lateral groin independently or together with a deep inferior epigastric perforator (DIEP) flap to the affected axilla. When performed together with a DIEP flap, the DIEP and VLNT were harvested as a unit, with the VLNT extending from the distal side of zone 1 or the proximal portion of the ipsilateral zone 2. The flaps included an artery and vein that were anastomosed to the internal mammary vessels for DIEP/VLNT flaps or lateral thoracic vessels in the recipient axilla for VLNT alone. LVA was preferred for lower extremity lymphedema and was performed by connecting peripheral lymphatics to adjacent venules by using techniques similar to those described by Koshima et al.[17]

TABLE 1 Average incidence of cellulitis before and after lymphedema surgery

Procedure type	Average incidence of cellulitis/infection		
	Before surgery (%)	After surgery (%)	*p* Value
SAPL	70	10	0.0004
VLNT and LVA	54	19	0.009
All patients	58	15	<0.0001

Patients with volume excess primarily due to a nonpitting, solid lymphedema component were treated with SAPL, which was performed according to the protocol described by Brorson.[18] These procedures are described in more detail in our accompanying article.[19]

RESULTS

Twenty-six adult female patients were identified as having undergone a surgical procedure to treat lymphedema. VLNT was performed in 8 patients, LVA in 8 patients, and SAPL in 10 patients. In an average of 25 months of postoperative follow-up, the overall incidence of severe cellulitis decreased from 58 to 15 % ($p < 0.0001$; Table 1). No patient's symptoms worsened after surgical intervention.

VLNT and LVA: Treatment of Fluid Lymphedema Component

Eight patients with a mean age of 57 years (range 43–70 years) and an average body mass index (BMI) of 28.2 (range 23.8–33.7) underwent VLNT to treat upper extremity lymphedema. Patients reported having lymphedema symptoms for an average of 3.8 years (range 0.5–22 years) before surgery, and all except one had less than 3 years of symptoms. All eight patients had a history of breast cancer treated with axillary lymph node dissection and radiation therapy to the chest wall. In an average of 32 months (range 18–50 months) of follow-up, patients who underwent VLNT had decreased their daily requirement of compression garments ($p = 0.009$) and lymphedema therapy ($p = 0.009$) while still maintaining control of lymphedema symptoms (Fig. 1, 2). Postoperatively, one patient required bedside drainage of a seroma at the axillary recipient site. Two patients had delayed healing of the irradiated mastectomy flaps after combined DIEP and VLNT. No patient had evidence of fat necrosis or lack of postoperative healing in their DIEP or VLNT flaps.

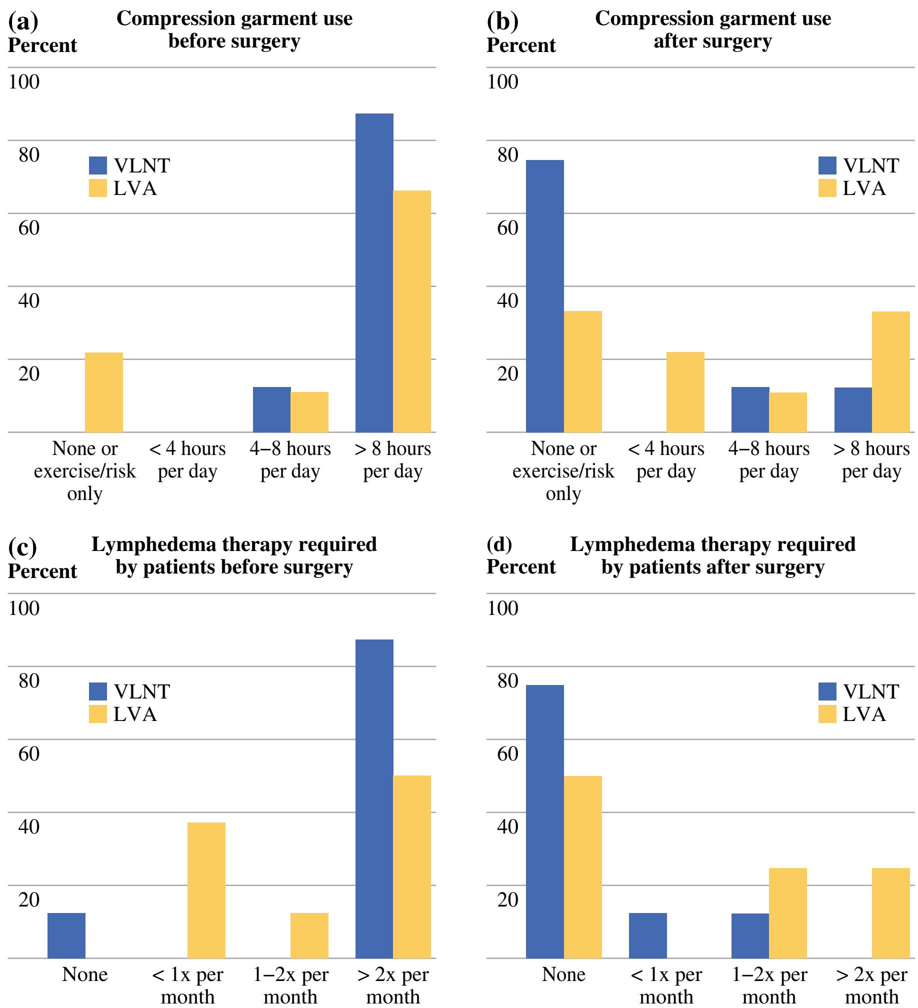

FIG. 1 Compression garment use and lymphedema therapy required before and after surgical treatment with lymphaticovenous anastomoses (LVA) or vascularized lymph node transfer (VLNT)

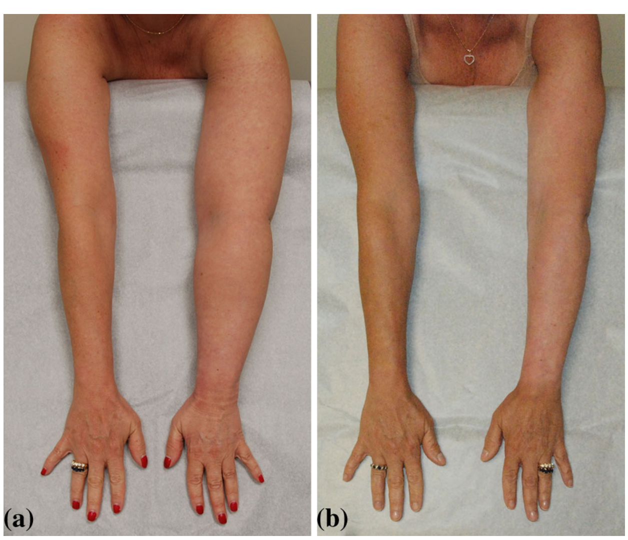

FIG. 2 Preoperative **(a)** and 11-month postoperative **(b)** views of a patient treated with SAPL. A volume excess of 1,142 mL had been calculated, and 1,200 mL of volume was removed at operation

Eight patients with a mean age of 45 years (range 16–69 years) and an average BMI of 25.0 (range 19.4–34.0) underwent LVA: seven for lower extremity and one for upper extremity lymphedema. The etiology of lymphedema was congenital in four patients and secondary to gynecologic cancer treatments in the remaining four. All cancer patients had previous pelvic lymph node dissections, and 3 of the 4 had a history of radiation therapy. Patients had lymphedema symptoms for an average of 8.3 years (range 0.5–25) before surgery. In an average of 27 months (range 12–57) of follow-up, LVA was associated with a significant reduction in lymphedema therapy ($p = 0.008$) and trended toward significance in garment reduction ($p = 0.07$). One patient had a small pulmonary embolus on the first postoperative day that caused localized chest pain but no physiologic sequelae. Another patient had a transient self-resolving partial high sciatic neurapraxia distant from the surgical site manifesting as a foot drop.

Fourteen (88 %) patients who underwent either VLNT or LVA reported subjective postoperative improvement in their symptoms.

TABLE 2 Reduction of volume excess achieved by SAPL

Variable	Calculated average initial volume excess (mL)	Average volume of aspirate at surgery (mL)	Average reduction of volume excess	
			4 months postop	12 months postop
Affected arm	878	929	111 % (90–130 %)	111 % (98–120 %)
Affected leg	3,839	3,731	87 % (58–119 %)	86 % (81–97 %)

SAPL: Treatment of Solid Lymphedema Component

SAPL was performed in 10 patients (6 arms and 4 legs) with a mean age of 58 years (range 34–68) and an average BMI of 28.5 (range 21.6–38.9). Patients had lymphedema symptoms for an average of 12.9 years (range 1–46 years). The etiology of lymphedema was cancer treatment in six patients (all with previous lymph node dissection and radiation therapy), congenital causes in two, traumatic injury after an off-road vehicle accident with extensive lower leg reconstruction in one, and a postoperative complication after harvest of a transverse gracilis flap performed elsewhere in one. Patients achieved significant volume reductions 4 months postoperatively, and these values remained stable at 12 months (Table 2). In the SAPL group, no operative complication occurred, and all patients reported subjective improvement of their symptoms.

TABLE 3 Proposed lymphedema staging system

Stage	Characteristics	Surgical treatment
0	No swelling, with changes found on imaging only (subclinical)	None[a]
1	Fluid predominant swelling (pitting edema)	LVA or VLNT
2	Solid predominant swelling (nonpitting edema)	SAPL[b]
3	Late-stage solid predominant with severe superficial skin thickening and changes, papillomatous growths, and significant disfigurement (elephantiasis)	SAPL vs. open debulking procedure

[a] Some authors advocate prophylactic LVA for subclinical lymphedema or at-risk patients [32,33]

[b] SAPL may be performed followed by LVA or VLNT after the volume reduction has stabilized

DISCUSSION

In this study, excellent outcomes were achieved after surgical intervention in patients with lymphedema. Significant decreases in daily garment use and lymphedema therapy were seen in patients having undergone VLNT and LVA procedures, and considerable volume reductions were achieved with SAPL. This is the first report of which we are aware documenting results from a comprehensive surgical treatment system using procedures to address specifically the fluid component (VLNT and LVA) and the solid component (SAPL) of lymphedema.

Perhaps the most significant finding was the dramatic reduction in episodes of severe cellulitis after surgery. Cellulitis typically progresses much more rapidly and is much more severe in patients with lymphedema. Some lymphedema patients require prophylactic antibiotics to reduce the incidence of this type of infection. This is a tremendous improvement in overall patient morbidity and health care costs, because many lymphedema patients are hospitalized repeatedly for intravenous antibiotics.[20] Patients with breast cancer and lymphedema have been shown to have more than double the infection rate and have 50 % higher medical costs than breast cancer patients without lymphedema.[21] Overall, 55 % of our patients presented with a history of at least one infection.

VLNT, LVA, and SAPL in and of themselves are neither new nor experimental and have been applied broadly to treat lymphedema for more than 20 years. All of these procedures have been shown to be effective in numerous studies that document the use of each individual technique. However, a better understanding of lymphedema leads us to believe that these procedures are most effective when applied to the appropriate phase, fluid versus solid, of lymphedema (Table 3). No single technique is optimal for all presentations. Rather, careful patient selection after a complete course of conservative lymphedema therapy has been completed will optimize outcomes. It is our observation that patients whose swelling is predominantly fluid are usually early in their lymphedema course or previously have had effective and consistent therapy. Therefore, we offer these patients VLNT or LVA to drain the fluid and prevent its reaccumulation. We believe that early surgical intervention in these patients, performed when their symptoms are less severe, can reduce the risk of their disease process progressing to the chronic, solid phase. We find that patients with long-standing lymphedema, in which the volume excess is comprised predominantly of a solid component, benefit most from SAPL. Once lymphedema swelling is in the solid phase, improvement in lymphatic drainage with VLNT or LVA alone will have little effect on the overall volume excess.[22] However, once volume reduction has stabilized after SAPL, subsequent VLNT or LVA may serve to reduce the amount of postoperative compression required.

Our patients treated with VLNT had significant reductions in cellulitis and the need for compression garments and therapy. The exact mechanism for the effectiveness of VLNT is unclear but is thought to be related to the release of axillary scarring, the reconnection of transplanted and donor site lymphatics, and also a direct pumping/fluid removal of the excess lymph by the transferred lymph nodes.[23] In this series, patients treated for the fluid phase of lymphedema with VLNT had a greater reduction than with LVA in the number of hours of daily garment use and lymphedema therapy required. One explanation for the superior results of VLNT may be that most of the LVA patients were treated for lower extremity lymphedema, whereas VLNT patients all had upper extremity lymphedema. Legs inherently have a higher propensity for swelling than arms secondary to the increased hydrostatic pressure present, and other authors have reported similar findings after LVA.[24] The lower effectiveness of LVA may also be secondary to the fact that half of the patients who underwent the procedure had congenital lymphedema, whose swelling is more likely due to intrinsic defects of the lymphatic channels and may be less amenable to surgical treatment.

Although VLNT proved more effective than LVA, this must be balanced with the unlikely risk of lymphedema occurring at the donor site where lymph nodes are harvested for a VLNT.[25, 26] In contrast, the connections between lymphatics and nearby veins in LVA procedures typically are superficial and require only a fraction of the lymphatics in the affected limb. In this series, we opted for VLNT over LVA in patients with upper extremity lymphedema because we believed that the risk of donor site lymphedema may be lower when harvesting from the groin compared with the axilla or chest wall. No patient developed lymphedema at the donor site, perhaps because we took only the most lateral lymphatic tissue from the groin, leaving the lymphatics that primarily drain the leg intact. We now also perform sentinel lymph node mapping of the donor site with technetium tracer to specifically identify and preserve the primary lymphatics and prevent donor site lymphedema.

VLNT and LVA procedures typically do not yield the same dramatic volume reductions seen with SAPL. The main goal of VLNT and LVA is improved maintenance of lymphedema with less use of garments and therapy rather than the mechanical removal of solid volume achieved with SAPL. All of our patients were under strict requirement to undergo effective conservative therapy before any surgery was offered, thus minimizing the preoperative excess fluid component. The remaining excess volume was due to the residual fat and solids still present that could not be removed with conservative treatment. Therefore, when we performed VLNT or LVA, actual volume reductions were not as high as when SAPL was performed to remove the residual excess solids. These results are consistent with previously reported results for LVA and VLNT, which reported more modest quantitative volume reductions of up to 35 %.[22,27,28] These volume reductions are much lower than the 87–111 % reductions we achieved with SAPL in chronic lymphedema patients, consistent with previously reported results for this procedure.[29]

The safety of SAPL has been established and found not to further damage the already impaired lymphatic flow.[30] Although the procedure effectively removes excess volume and decreases infection risk, the technique does not address the pathophysiology causing the lymphedema. Thus, the main drawback of the procedure has been that patients must maintain continuous postoperative compression to prevent reaccumulation of excess fluid in the affected limb.[31] Integration of a lymphedema therapist with experience with patients undergoing SAPL is critical for a successful result.[18]

We now offer patients VLNT or LVA after SAPL once their volume reduction has stabilized to reduce the amount of postoperative compression required. Two of the patients in this series went on to have VLNT after SAPL. They were able to maintain their improved volumes with compression only in the evening and at night, instead of the continuous compression typically required after SAPL.[32]

CONCLUSION

Using a system of conservative therapy combined with the surgical options of SAPL, VLNT, and LVA in properly selected patients, we were able to achieve significant improvements in both early and chronic lymphedema. Regardless of the procedure performed, almost all patients experienced significant subjective improvements in their symptoms. Patients often reported that the best results from their procedure were improvements in heaviness, fullness, mobility, and function after surgery. Although these results are encouraging, we wish to emphasize that no surgery yet offers the "magic bullet" of a complete cure for the condition. Lymphedema precautions such as compression garment use with strenuous physical activity and airline travel, as well as vigilance with cuts and scratches, should be continued in all patients regardless of the results achieved with surgery.

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CONFLICT OF INTEREST None.

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