Liposuction Treatment of Lymphedema

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Abstract

In the Western world, lymphedema most commonly occurs following treatment of cancer. Limb reductions have been reported utilizing various conservative therapies including manual lymph and pressure therapy, as well as by microsurgical reconstruction involving lymphovenous shunts and transplantation of lymph vessels or nodes. Failure of these conservative and surgical treatments to provide complete reduction in patients with long-standing pronounced lymphedema is due to the persistence of excess newly formed subcutaneous adipose tissue in response to slow or absent lymph flow, which is not removed in patients with chronic non-pitting lymphedema. Traditional surgical regimes utilizing bridging procedures, total excision with skin grafting, or reduction plasty seldom achieved acceptable cosmetic and functional results. Liposuction removes the hypertrophied adipose tissue and is a prerequisite to achieve complete reduction, and this reduction is maintained long-term through constant (24 h) use of compression garments postoperatively. This article describes the techniques and evidence basis for the use of liposuction for treatment of lymphedema.

Keywords
- lymphedema
- liposuction
- adipose tissue
- fat

Breast cancer is the most common disease in women, and up to 38% develop lymphedema of the arm following mastectomy, standard axillary node dissection, and postoperative irradiation. Limb reductions have been reported utilizing various conservative therapies, such as manual lymph and pressure therapy. Some patients with long-standing pronounced lymphedema do not respond to these conservative treatments because slow or absent lymph flow causes the formation of excess subcutaneous adipose tissue.[1,2]

Previous surgical regimes utilizing bridging procedures, total excision with skin grafting, or reduction plasty seldom achieved acceptable cosmetic and functional results. Microsurgical reconstruction involving lymphovenous bypass and transplantation of lymph vessels or nodes has also been investigated.[3–7] Although attractive in concept, the common failure of microsurgery to provide complete reduction is due to the persistence of newly formed subcutaneous adipose tissue, which is not removed in patients with chronic non-pitting lymphedema.

Liposuction removes the hypertrophied adipose tissue and is a prerequisite to achieve complete reduction. The new equilibrium is maintained through constant (24 h) use of compression garments postoperatively.[8,9] Long-term follow up does not show any recurrence of the edema.[10–12]

There is some controversy regarding liposuction for late-stage lymphedemas. While it is clear that conservative therapies, such as complex decongestive therapy (CDT) and controlled compression therapy (CCT), should be tried in the first instance, options for the treatment of late-stage lymphedema that is not responding to treatment are not so clear. Moreover, various microsurgical procedures are often performed without the knowledge of adipose tissue deposition,

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which cannot be removed with these techniques. Liposuction, in contrast to microsurgical procedures, enables complete removal of the deposited adipose tissue leading to complete reduction in late stage lymphedemas.

Chronic Lymphedema Leads to Adipose Tissue Deposition

There are various possible explanations for adipose tissue hypertrophy in lymphedema. There is a physiological imbalance of blood flow and lymphatic drainage, resulting in the impaired clearance of lipids and their uptake by macrophages.[13,14] There is increasing support, however, for the view that the fat cell is an endocrine organ and a cytokine-activated cell,[15,16] and chronic inflammation plays a role here.[17,18]

For more information about relationship between slow lymph flow and adiposity, as well as that between structural changes in the lymphatic system and adiposity, see Harvey et al[1] and Schneider et al.[2]

Other indications for adipose tissue hypertrophy include:

- The findings of increased adipose tissue in intestinal segments in patients with inflammatory bowel disease (Crohn's disease), known as "fat wrapping," have clearly shown that inflammation plays an important role.[17,19,20]
- Consecutive analyses of the content of the aspirate removed under bloodless conditions using a tourniquet showed a high content of adipose tissue (mean 90%).[21]
- In Graves' ophthalmopathy with exophthalmos, adipocyte-related immediate early genes are overexpressed, and cysteine-rich, angiogenic inducer 61 may play a role in both orbital inflammation and adipogenesis.[22]
- Tonometry can distinguish if a lymphedematous arm is harder or softer than the normal one. Patients with a harder arm compared with the healthy one have excess adipose tissue.[23]
- Investigation with volume rendering computed tomography (VR-CT) in eight patients also showed a significant preoperative increase in adipose tissue of 81% in the swollen arm, followed by a normalization at 3 months paralleling the complete reduction of the excess volume.[24,25]
- Analyses with dual-energy X-ray absorptiometry (DXA) in 18 women with postmastectomy arm lymphedema showed a significant increase in adipose tissue in the non-pitting swollen arm before surgery. Postoperative analyses showed normalization at 3 months. This effect was seen also at 12 months. These results paralleled the complete reduction of the excess volume ("edema volume").[26]
- A functional inactivation of a single allele of the homeobox gene Prox1 led to adult-onset obesity due to abnormal lymph leakage from mispatterned and ruptured lymphatic vessels.[1]
- Parathyroid hormone-like hormone can inhibit adipogenesis and is downregulated both in active and chronic ophthalmopathy, indicating the possibility of an increased risk of adipogenesis.[27]
- Adipogenesis in response to lymphatic fluid stasis is associated with a marked mononuclear cell inflammatory response.[28]
- Lymphatic fluid stasis potently up-regulates the expression of fat differentiation markers both spatially and temporally.[29]
- Investigation with magnetic resonance imaging showed that excess fat is not only deposited subcutaneously, but also within the muscle, which has not been shown before.[30]

Clinicians often believe that the swelling in a lymphedematous extremity is purely due to the accumulation of lymph fluid, which can be removed by use of noninvasive conservative regimens, such as CDT and CCT. These therapies work well when the excess swelling consists of accumulated lymph, but do not work when the excess volume is dominated by adipose tissue.[8] The same may apply to microsurgical procedures using lymphovenous shunts, lymph vessel transplantation, and lymph node transfer,[3–7] which do not remove adipose tissue.

Results of Liposuction

Today, chronic non-pitting arm lymphedema of large volume can be effectively removed by use of liposuction. Complete reduction is mostly achieved between 1 and 3 months. Long-term results have not shown any recurrence of the arm swelling (►**Fig. 1a** and **b**).[8–10,31,32] Promising results also can be achieved for leg lymphedema (►**Fig. 2a** and **b**), for which complete reduction is usually reached at around 6 months.[12,33–35] These results have been confirmed by other institutions.

Damstra et al performed a prospective study of 37 women who underwent liposuction of the upper extremity followed by limb compression with short-stretch bandages, followed by flat-knit compression garments.[36] The mean preoperative excess arm volume was 1,399 mL. The total aspirate volume was 2,124 mL with 93% (range 59–100%) aspirate adipose tissue content. After 12 months, the mean reduction in excess volume was 118%. These results were confirmed by Schaverien et al in a prospective analysis of the results of 12 patients who underwent liposuction followed by compression therapy for chronic unilateral upper limb lymphedema with up to 5 years of follow-up.[37] The mean excess arm volume at admission was 1,391 mL, and the ratio of the lymphedematous to the

Fig. 1 (**a**) A 74-year-old woman with non-pitting arm lymphedema lasting for 15 years following breast cancer treatment. Preoperative excess volume was 3,090 mL. (**b**) Postoperative result.

Fig. 2 (a) Primary lymphedema: preoperative excess volume 6,630mL. (b) Postoperative result with complete reduction after 2 years.

unaffected arm was 1.48. The mean total aspirate volume was 1,713 mL, of which 87% was fat. At 1 year, the mean percentage volume reduction compared with the normal arm was 101%, meaning that the volume of both of patients' arms was virtually equivalent, and this reduction was stable with up to 5 years of follow-up. In another study, Boyages et al evaluated outcomes in 21 patients who underwent liposuction (15 arms and 6 legs).[38] Mean presurgical limb volume difference was 45.1% (arm 44.2%; leg 47.3%). This difference reduced to 3.8% (arm 3.6%; leg 4.3%) by 6 months postoperatively, with a mean percentage volume reduction of 89.6% (arm 90.2%; leg 88.2%), and all patients had improved symptoms and function.

Lamprou et al compared outcomes for liposuction in 47 patients with primary and 41 with secondary lower extremity lymphedema at 2 years. In the primary group, a median preoperative excess volume of 3,686 mL (range 2,851–5,121) was reduced by 79% to 761 mL. In comparison, the secondary group fared better with a median preoperative excess of 3,320 mL (range 2,533–4,783) being reduced to –38 mL (101% reduction).[35] Supporting these findings, Stewart and Munnoch reported outcomes of liposuction in 69 patients (72 legs) with lower extremity lymphedema. Mean preoperative volume of edema was 4,372 mL (range 229–15,166), and mean volume of aspirate was 4,550 mL (range 575–12,150). Mean limb volume reduction was 88% at 1 year ($n = 60$), 94% at 2 years ($n = 41$), and 90% at 5 years ($n = 15$).[34]

To determine the longer term outcomes of the technique, Brorson published 21-year prospective data in 146 women with arm lymphedema.[11] Preoperative mean excess volume was 1,568 mL (range: 545–4,235), aspirate mean volume was 1,807 mL (range 650–3,850), and postoperative mean reduction was 103% (range 50–194) at 3 months and more than 100% during 21 years' follow-up. The preoperative mean volume ratio between the affected and unaffected arms was 1.5, declining to 1.0 at 3 months, and <1.0 after 1 year. This demonstrates the long-term effectiveness and stability of the technique.

The complication rate reported in these studies is very low and limited to minor complications.[8–10,12,31–35] Liposuction typically leads to paresthesia of the skin, which disappears within 3 to 6 months.

Liposuction for Lymphedema

Surgical Technique

Made-to-measure compression garments (two sleeves with a strap, two gauntlets, and two standard interim gloves) are measured and ordered 2 weeks before surgery, using the healthy arm and hand as a template. One set (one sleeve and one standard interim glove) is sterilized to be put on during surgery.

We now use power-assisted liposuction, which facilitates the liposuction, especially in the leg, which is more demanding to treat. Initially the "dry technique" was used.[39] Later, to minimize blood loss, a tourniquet was utilized in combination with tumescence, which involves infiltration of 1 to 2 L of saline containing low-dose adrenaline and lignocaine.[40,41]

Through ~15 to 20, 3-mm-long incisions, liposuction is performed using 15- and 25-cm-long cannulas with diameters of 3 and 4 mm, respectively, (►**Fig. 3**). When the arm distal to the tourniquet has been treated, a sterilized made-to-measure compression sleeve is applied (Jobst Elvarex BSN medical, compression class 2) to the arm to stem bleeding and reduce postoperative edema. A sterilized Easy-Slide (Credenhill) facilitates putting on the garment and is later always used for this procedure. A sterilized, standard interim glove (Cicatrex interim, Thuasne), in which the tips of the fingers have been cut to facilitate gripping, is put on the hand. The tourniquet is removed, and the most proximal part of the upper arm is treated using the tumescent technique.[40,41] Finally, the

Fig. 3 Liposuction of arm lymphedema. The procedure takes ~2 hours. From preoperative to postoperative state (*left to right*). Note the tourniquet, which has been removed at the right, and the concomitant reactive hyperemia.

proximal part of the compression sleeve is pulled up to compress the proximal part of the upper arm. The incisions are left open to drain through the sleeve. The arm is lightly wrapped with a large absorbent compress covering the whole arm (60 × 60 cm, Cover-Dri, www.attends.co.uk). The arm is kept at heart level on a large pillow. The compress is changed when needed. Operating time is, on average, 2 hours.

The following day, a made-to measure gauntlet (a glove without fingers and thumb) (Jobst Elvarex BSN medical, compression class 2) is put over the interim glove.

Postoperative Care

Garments are removed 2 days postoperatively so that the patient can take a shower. Then, the other set of garments is put on, and the used set is washed and dried. The patient repeats this after another 2 days before discharge.

The patient alternates between the two sets of garments (two sleeves, two gauntlets, and two interim gloves) during the 2 weeks postoperatively, changing them daily or every other day so that a clean set is always put on after showering and lubricating the arm. After the 2-week control, the garments are changed every day after being washed. Washing "activates" the garments by increasing the compression due to shrinkage.

Controlled Compression Therapy

A prerequisite to maintaining the effect of liposuction and, for that matter, conservative treatment, is the continuous use of a compression garment.[8,9] After initiating compression therapy, the custom-made garment is taken in at each visit using a sewing machine to compensate for reduced elasticity and reduced arm volume. This is most important during the first 3 months when the most notable changes in volume occur, but even later it is important to adapt the garment to compensate for wear and tear. This can often be managed by the patient himself or herself. At the 3-month visits, the arm is measured for new custom-made garments. This procedure is repeated at 6, 9, and 12 months. When complete reduction is achieved, sleeves without straps are ordered, i.e., stay-up garments with silicone knobs. If complete reduction has been achieved at 6 months, the 9-month control may be omitted. If this is the case, garments are prescribed for the next 6 months, which normally means double the amount that would be needed for 3 months. When the excess volume has decreased as much as possible—usually the treated arm becomes somewhat smaller than the normal arm—and a steady state is achieved, new garments can be prescribed using the latest measurements. In this way, the garments are renewed 3 or 4 times during the first year. Two sets of sleeve and glove garments are always at the patient's disposal: one is worn while the other is washed. Thus, a garment is worn permanently, and treatment is interrupted only briefly when showering and, possibly, for formal social occasions.

The life span of two garments worn alternately is usually 4 to 6 months. Complete reduction is usually achieved after 3 to 6 months, often earlier. After the first year, the patient is seen again after 6 months (1.5 years after surgery) and then at 2 years after surgery. Then the patient is seen once a year only, when new garments are prescribed for the coming year, usually four garments and four gloves (or four gauntlets). For active patients, 6 to 8 garments and the same amount of gauntlets/gloves a year are needed. Patients without preoperative swelling in the hand can usually stop using the glove/gauntlet after 6 to 12 months postoperatively.

For legs, the author's team often uses up to 2 or 3 compression garments on top of each other, depending on what is needed to prevent pitting. A typical example is Elvarex compression class 3 (or 3 Forte) with a panty, Jobst Bellavar compression class 2 (or Elvarex compression class 2), and Elvarex compression class 2 (BSN Medical), the latter being a below-the-knee garment. Thus, such a patient needs two sets of two to three garments. One set is worn while the other is washed. Depending on the age and activity of the patient, two such sets can last for 2 to 4 months. That means that they must be prescribed three to six times during the first year. After complete reduction has been achieved, no panty is needed, and stay-up garments (with silicone knobs) are ordered, and the patient is seen once a year when all new garments are prescribed for the coming year.

Volume Measurements

Volumes of both extremities are always measured at each visit using water plethysmography, and the difference in volumes is designated as the excess volume.[8,9]

When to Use Liposuction to Treat Lymphedema

A surgical approach, removing the hypertrophied adipose tissue, seems logical when conservative treatment has not achieved satisfactory reduction of the excess volume and the patient has subjective discomfort of a heavy arm or leg. Liposuction should never be performed in a patient with a pitting edema, as it is dominated by accumulated lymph, which can be removed by conservative treatment.

The first and most important goal is to transform a pitting edema into a non-pitting one by conservative regimens like CDT or CCT. "Pitting" means that a depression is formed after pressure on the edematous tissue by the fingertip, resulting in lymph being squeezed into the surroundings (►**Fig. 4a**). To

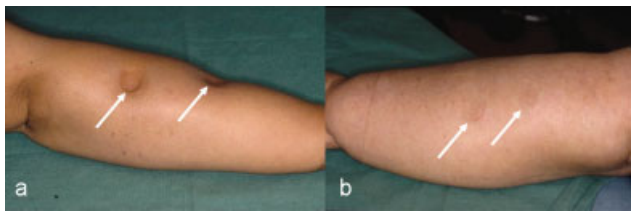

Fig. 4 (**a**) Marked lymphedema of the arm after breast cancer treatment, showing pitting several centimeters in depth (grade I edema). The arm swelling is dominated by the presence of fluid, i.e., the accumulation of lymph. (**b**) Pronounced arm lymphedema after breast cancer treatment (grade II edema). There is no pitting in spite of hard pressure by the thumb for 1 minute. A slight reddening is seen at the two spots where pressure has been exerted. The "edema" is completely dominated by adipose tissue. The term "edema" is unsuitable at this stage since the swelling is dominated by hypertrophied adipose tissue and not by lymph. At this stage, the aspirate will contain either no, or a minimal amount, of lymph.

standardize the pitting test, one presses as hard as possible with the thumb on the region to be investigated for 1 minute, the amount of depression being estimated in millimeters. A swelling, which is dominated by hypertrophied adipose tissue, shows little or no pitting (►**Fig. 4b**).[32] Around 4 to 5 mm of pitting in arm lymphedema and 6 to 8 mm in leg lymphedema can be accepted. The reason for not performing liposuction for a pitting edema is that liposuction is a method to remove fat, not fluid, even if theoretically it could remove all the accumulated fluid in a pitting lymphedema without excess adipose tissue formation.

Liposuction is contraindicated in patients with untreated or uncontrolled primary cancer or recurrence or those who are medically unfit to undergo surgery safely; these patients are better served by non-surgical management. It is essential that patients are compliant with compression garments preoperatively and agree to continuous wearing of compression garments following the surgery; non-compliance will lead to rebound increases in pitting edema.

Improvement in Quality of Life

Using the 36-item short-form health survey (SF-36) to assess health-related quality of life in female patients who underwent upper extremity liposuction, Hoffner et al found that scores 12 months following the procedure were significantly improved for physical functioning, bodily pain, vitality, social functioning, and mental health compared with preoperatively,[42] supporting the findings of other studies.[43,44] In another study, using the Hospital Anxiety and Depression Score (HADS) questionnaires and a visual analogue score for overall well-being, significant reductions in anxiety and depression scores and an improvement in overall well-being were demonstrated following liposuction for lymphedema of the upper extremity.[37]

Effect on Lymphatic Function

A cadaveric study of the effect of liposuction techniques on the lymphatics of the lower extremity demonstrated that longitudinal liposuction with respect to the limb was unlikely to cause major lesions of the epifascial lymph vessels.[45] To investigate the effect of liposuction on lymph transport, an investigation was conducted using indirect lymphoscintigraphy in 20 patients with postmastectomy arm lymphedema.[31] At 3 and 12 months following liposuction, the imaging was unchanged, suggesting that the already decreased lymph transport was not further reduced after liposuction. From these studies, it can be concluded that provided the liposuction is performed axially with respect to the limb, the technique will not cause damage to the existing lymphatic vessels within the limb.

Greene et al evaluated the effects of liposuction in one patient with primary lymphedema affecting the leg, and two patients with secondary lymphedema affecting the arm.[46] Postoperative lymphoscintigraphy revealed that two of the patients had reduced dermal backflow, and one had new transit and uptake of tracer to epitrochlear nodes. Using bioimpedance spectroscopy, Boyages et al found that following liposuction for lymphedema the extracellular fluid was reduced, suggesting improved flow of the lymphatic fluid.[38] Together these studies suggest that lymphatic fluid transport may actually improve following liposuction. Another study investigating the effect of liposuction on skin blood flow in patients with lymphedema using laser Doppler imaging found that skin blood flow increased significantly to values similar to the normal arm following liposuction.[47] These improvements in lymphatic fluid flow and skin blood flow following liposuction may explain the reduced incidence of cellulitis seen in these patients. In a recent study, liposuction in 130 patients with arm lymphedema reduced the incidence of cellulitis from 534 bouts of cellulitis per1,147 observation years before to 60 bouts of cellulitis per 983 observations years after liposuction, a reduction of 87%.[48]

Conclusion

There need be no tension between those who favor conservative treatment and proponents of liposuction. Accumulated lymph should be removed using the well-documented conservative regimens until minimal or no pitting is seen. If there is still significant excess volume, it can be removed by the use of liposuction. Continuous wearing of a compression garment prevents recurrence. To date, the senior author (H.B.) has trained and approved several teams from several countries and has demonstrated that these same results are reproducible.[34–38]

- Excess volume without pitting means that adipose tissue is responsible for the swelling.
- Adipose tissue can be removed with liposuction. Conservative treatment and microsurgical reconstructions cannot do this.
- As in conservative treatment, the lifelong use (24-h a day) of compression garments is mandatory for maintaining the effect of treatment.

Conflict of Interest
None.

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