Lymphatic reconstruction of the extremities

Ruediger Baumeister, David Chang, and Peter C Neligan

SYNOPSIS

- In developed countries most cases of lymphedema are caused by a local obstruction of the lymphatic system after iatrogenic intervention.
- With the help of advanced microsurgery lymphatic vessels can be sutured and lymphatic bypasses can overcome blocked lymphatic and lymphovascular areas.
- Microsurgical lymphatic reconstruction is one step in the treatment algorithm. Initially, conventional treatment including physical therapy, exercises designed to mobilize tissue fluid, and compression should be instituted for 6 months. Thereafter the option of a direct reconstruction should be taken into consideration early. Resectional interventions are the very endpoint of the algorithm.
- Microsurgical lymphatic grafts have been shown to be effective by independent investigators in nuclear medicine – long-term significant improvement of lymphatic flow – and in radiology – long-term patent lymphatic grafts (more than 10 years) are found.
- After reconstruction secondary changes such as an increase in adipose and fibrous tissue may be treated using lipolymphosuction. Alternatively, localized resection may act as an adjunct to the bypass procedures.
- The ultimate goal of reconstruction using microsurgical grafting is to come as close as possible to the original status and to avoid additional ongoing treatment.

Introduction

The lymphatic vascular system consists of a variety of lymphatic channels that appear as blind endings within the tissue, lymphatic precollectors, and finally lymphatic collectors which amount to a diameter of about 0.3 mm within the human thigh and are a similar size elsewhere in the body.

Lymphedema is a debilitating condition characterized by progressive indolent swelling in the soft tissues, usually involving the limbs but not infrequently also affecting the trunk, the genitalia and, less frequently, the head and neck. The swelling is initially caused by some failure of the lymphatic system to drain lymph fluid from the affected part, causing the area to become waterlogged. Subsequently, as the condition progresses, this is accompanied by increased adipose and fibrous tissue in the area, often accompanied by trophic skin changes, ulceration, and the propensity to develop soft-tissue infections. The lay term "elephantiasis" aptly describes the appearance of a chronically lymphedematous extremity.

Vascular surgery routinely deals with obstructions of the vascular system. These obstructions are dealt with using bypass techniques. With advances in microsurgical technique and instrumentation, the application of bypass techniques to the lymphatic system is now also possible. Furthermore, just as parts of the vascular system can be used as grafts, e.g., vein grafts, segments of these lymphatic channels can also be used as grafts.

Basic science/disease process

Lymphedema is characterized by an imbalance between the lymphatic load and the lymphatic transport capacity. The lymphatic load represents the amount of lymphoid fluid that has to be transported via the lymphatic system within a given time frame within a specific part of the body, e.g., an extremity. The lymphatic transport capacity on the other hand is the amount of lymphatic fluid that can be maximally transported by the lymphatic system. It is dependent on the number and functional status of the lymphatic vessels and the lymph nodes. When the lymphatic load outstrips the transport capacity lymphedema results. This imbalance can have a number of causes, as already described, and may be
congenital or acquired. As lymphedema progresses some changes occur in the tissues such that there is an increased amount of adipose tissue as well as fibrous tissue. Furthermore, the skin becomes thickened, firm, and unyielding and ultimately takes on an appearance similar to what one would imagine as elephant skin, hence the term “elephantiasis.”

**Classification and etiology of lymphedema**

Lymphedema is classified as primary or secondary. Two types of primary lymphedema are recognized:

1. **Type I (Nonne–Milroy):** the familial congenital type is based on a vascular endothelial growth factor-receptor-3 mutation

2. **Type II (Meige):** can be seen as lymphedema praecox, arising during adolescence, and as lymphedema tarda, with an onset after the age of 35.

Reconstructive methods can only be applied in those cases where a localized atresia or obstruction of the lymphatic system is present.

Secondary lymphedema is due to acquired damage to the lymphatic system.

Globally, lymphedema caused by filariasis is the most common. Secondary lymphedema may also arise from infection, trauma, and malignancies influencing lymphatic flow. In western countries there is a predominance of lymphedema after surgical interventions, often combined with irradiation. Cases such as these, in which there is a localized blockade of the lymphatic draining system, are excellent candidates for reconstructive procedures.

**Diagnosis/patient presentation**

The clinical picture is characterized by increased tissue thickness and decreased tissue pliability.

The so-called Stemmer sign becomes positive. This means that on the dorsal side of the toe or of a finger the tissue cannot be lifted between the thumb and the index finger of the investigator in a normal way. The tissue becomes enlarged and thickened. The swelling in the lower extremity also affects the dorsum of the foot. This is important in order to differentiate between lymphedema and lipohypertrophy where the enlargement of the tissue ends at the level of the ankles. For further evaluation, a variety of technical procedures have been described.

Direct-contrast lymphography, using oily contrast medium and invasive administration via transected lymphatic vessels, was introduced by Kinmonth and greatly advanced our knowledge of the lymphatic system. However, due to the invasiveness of the application (and injury to the lymphatic vessels and lymph nodes), it was found to cause worsening of lymphedema.

Indirect-contrast lymphography, using water-soluble contrast medium that is injected subepidermally, is unable to visualize lymphatic vessels to an extent comparable with direct lymphography and gained only limited use. In primary lymphedema this technique might be used to evaluate whether there are any lymphatic vessels present in the periphery and if so, if they might be able to transport lymph towards a proximally performed anastomosis.

First attempts to visualize lymphatic vessels with magnetic resonance imaging (MRI) using contrast medium administered subdermally are promising. This will prove useful for exact planning prior to reconstructive procedures as well as examining the patency of lymphatic grafts without damaging them. For the detection of vascular lymphatic malformations, MRI is extremely valuable both with and without the use of contrast medium.

For routine procedures, the key diagnostic tool, aside from the clinical evaluation, is lymphoscintigraphy. It can be repeated and used for diagnostic as well as for follow-up purposes. It gives quite a good impression of the function and visualizes routes of lymphatic flow. Introducing the lymphatic transport index (TI), which summarizes the findings derived from the lymphoscintigraphic studies, allows for a semiquantitative evaluation of the lymphatic flow without the need for standardized physical movement on the part of the patient. It ranges from TI = 0 for an optimal lymphatic outflow to TI = 45 for no visible flow. Normal values are below 10. This transport index also provides a good basis for follow-up studies and can show lymphatic flow along the route of lymphatic grafts.

Different approaches are described to improve exact quantification of lymphatic flow. When measuring regions of interest, it is critical to standardize the application of the radiopharmaceutical and the physical movements performed by the patient during the procedure. The visualization of cutaneous lymphatic vessels using duplex sonography is controversial and is of limited value for surgeons. Another diagnostic tool that can be used is the subepidermal injection of Patent Blue dye. Normally, lymphatic transport is visualized in the superficial lymphatic collecting system. In pathologic situations, the so-called dermal back-flow leads to pooling of the contrast within the skin that results in a “cloud”-like appearance. Since allergic reactions have been reported, staining of lymphatic vessels with Patent Blue dye is generally performed during surgery under general anesthesia.

The use of indocyanine green, a fluorescent dye that is activated by a laser light source and imaged using near-infrared technology, is also proving to be a useful tool, particularly in the preoperative mapping of superficial lymphatics.

**Patient selection**

**Nonsurgical therapy**

The basic strategies for nonsurgical therapy consist of a combination of elevation of the extremities, exercises designed to optimize lymphatic flow, manual lymphatic drainage, and compression therapy. If a reconstructive procedure is being contemplated, conservative treatment should be performed first for a minimum of about 6 months because during this time period spontaneous regression of edema is possible. Compression therapy using pneumatic devices has also become popular. However there may be some concern, at least in theory, that the resulting elevation in pressure can damage the remaining lymphatic vessels. Diuretics do not have a place
in the regular treatment protocol since removal of fluid may lead to enhanced fibrosis.

**Patient selection for reconstruction**

Surgery is generally not the primary approach in the treatment of lymphedema. However the results of medical treatment are sometimes transient and may disappear after about 6 months.

Within this period conservative treatment, as mentioned above, use of exercises, manual lymphatic drainage, and application of elastic stockings or compression garments are recommended. After this first treatment period the indication for surgery has to be evaluated and a decision made between physiologic reconstructive and diverting techniques on the one hand versus resectional or ablative procedures on the other. Secondary tissue changes such as increased adipose and fibrous tissue become more prevalent over time. For this reason, early reconstruction should be considered after the period of initial conservative treatment. For resectional surgical approaches the time is not crucial since the target is the surplus of tissue and not the improvement of lymphatic flow.

When recommending surgery it is important to consider the goals of treatment (Box 3.1) and to present the various options in that context. For example, if one is considering the use of lymphatic grafts, specific prerequisites have to be considered. The indication for this procedure is similar to the use of bypasses in other fields of vascular surgery where a localized interruption of the vascular system has to be treated. This is especially true after removal of lymph nodes and lymph vessels in the axillary, inguinal, or pelvic regions as well as in the medial aspect of the knee.

In primary lymphedema only regional lymphatic atresias may be treated by lymphatic grafting. According to the lymphographic findings of Kinmonth, unilateral lymphatic atresias can exist at the inguinal and pelvic region with normal lymphatic vessels distally. This is a situation in which lymphatic transpositional grafts may be considered. The method of graft harvest is also crucial. As already mentioned, the ventromedial bundle of the lymphatics at the thigh consists of up to 16 lymphatic vessels that are running roughly parallel in the thigh. At the knee and in the inguinal region they are confluent and therefore only the region in between these endangered areas should be used for harvesting.

The length of the graft depends on the length of the thigh and amounts to about 20–30 cm. This length is sufficient to overcome the distance from the upper arm to the neck in cases of an axillary obstruction and the distance to the opposite thigh in cases of unilateral lymphedema of the lower extremities.

For maximal safety, any possible pre-existing lymphatic deficiency in the limb from which the grafts are being harvested must be excluded. There should be no prior history of edema in this leg. Lymphoscintigraphy has to show normal lymphatic transport. During surgery the behavior of lymphatic drainage after injection of Patent Blue (dye) should be normal and any evidence of persistent staining should be regarded as an indication of abnormal flow.

With respect to the affected extremities, prior to surgery, as far as possible lymphatic scintiscans should reveal the site of the obstruction and clarify the extent of the lymphatic disorder. In primary lymphedema especially, one should get additional information about the kind of lymphatic malformation by indirect lymphography using water-soluble contrast medium or nowadays preferably by MRI lymphography using gadolinium.

For resectional methods, advanced and incapacitating lymphedema is one of the prime indications for surgery.

**Treatment/surgical technique**

The history of the development of the various surgical strategies is described in the history segment of this chapter, which is available in the online version. Various surgical procedures have been used to treat lymphedema of the extremities, with varying degrees of success. These operative strategies can be classified into two categories: ablative operations and physiological operations.

**Ablative operations**

Resection of dependent folds may contribute to the patient’s comfort and can be done either in isolation, or as an adjunct to the physiologic procedures described below. Debulking procedures in which the lymphedematous tissue is resected while retaining the overlying skin is an option but is fraught with wound-healing problems. The first reported surgical procedure for lymphedema was published in 1912 by Charles, who described a procedure for scrotal lymphedema and its application to lower-limb lymphedema. The Charles procedure is an aggressive debulking surgery in which all overlying skin and soft tissue above the deep fascia in the lymphedematous area are resected. The resulting defect is covered by a skin graft harvested from the resected specimen (Fig. 3.1 and video 1). This procedure is now rarely performed but still has a role in the treatment of extreme lymphedema.

Although debulking operations are the simplest surgical approach to reducing the size of lymphedematous upper limbs, such operations result in extensive scarring and cause substantial morbidity. Therefore, these operations are no longer used except in extreme cases.

Liposuction, as a debulking procedure, is still practiced and Brorson and Svensson have reported good results and recommended liposuction as the preferred surgical procedure for treating lymphedema. The rationale for this is not surprising since there is an acknowledged increase in the amount of adipose tissue in chronic lymphedema. Following debulking with liposuction, the patient must wear lifelong compression and failure to do so results in recurrence. Some argue that,
while liposuction can be effective for initially reducing the volume of hypertrophic adipose tissue, it has a risk of damaging the residual lymphatic vessels and thus exacerbating the lymphedema. \(^{29}\)

**Physiological operations**

Physiological operations are where new channels are created to improve lymphatic drainage. Various procedures have been attempted for draining lymph fluid trapped within the lymphedematous limb into other lymphatic basins or into the venous circulation. Current approaches include lymph node transplantation and lymphatic bypass operations. \(^{30-33}\)

**Lymphaticolymphatic bypass**

Baumeister and colleagues\(^{2,3}\) reported an approach to upper and lower extremity lymphedemas in which healthy lymphatic vessels from the medial thigh area are used as grafts (Fig. 3.4). Ho and colleagues\(^{83}\) reported an approach for upper-extremity lymphedema using a composite graft including the greater saphenous vein. Lymphatic vessels at each end of the graft are identified under the operating microscope and Anastomosed to recipient lymphatic vessels in the neck and upper arm in accordance with the flow direction of the donor lymphatic vessels.

Postoperative patency of the lymphatic vessels within the graft can be verified using lymphoscintigraphy. In their series, Baumeister and Siuda demonstrated newly created lymph pathways as well as faster clearance of radioisotope in the postoperative as compared with the preoperative images. \(^{79}\) In an early study the resulting volume reduction in the affected upper limb was maintained in patients for 3 years after the operation. However, the lymphatic graft operation leaves a long scar at the donor site and also has a risk of precipitating the development of lymphedema in the donor leg from which the lymphatic graft was harvested.

Campisi advocates using a vein interposition graft between the lymphatic vessel bundles above and below the site of lymphatic blockage to bypass the obstructed area (Fig. 3.3). \(^{76}\) In this procedure, multiple lymphatic vessels are inserted into the distal cut end of a vein graft and secured by sutures, and lymphatic vessels in the supraclavicular area are anastomosed to the other end of the vein graft. However, despite the good results that Campisi has reported, other groups have not been able to produce consistent results.

**Lymphatic vessel reconstruction:**

**Baumeister technique**

The lymphatic grafts are harvested from the patient’s thigh where the ventromedial bundle contains up to 16 lymphatic vessels. About 1–4 lymphatic collectors are dissected in the medial area of the thigh and great care is taken to spare the lymphatic system where it narrows at the level of the knee and groin. In both these regions the lymphatic channels become confluent so that lymphedema is likely to result if these regions are breached. Often additional peripheral branches exist, which can be dissected as well in order to create a greater number of peripheral anastomoses.

For free transfers the grafts are ligated beneath the inguinal lymph nodes using 6-0 polyglactin 910 suture material. Distally, the grafts are transected proximal to the level of the knee. The distal ends are occluded either by placing a suture or by coagulation to avoid subsequent lymphatic leakage. The grafts can then be removed.

For upper-limb lymphedema, resulting from interventions in the axilla, the grafts are interposed between ascending lymphatic vessels in the upper arm and lymphatic vessels or lymph nodes in the neck, and lympholymphatic anastomoses are performed at either end. To position the grafts between the sites of anastomosis, a tube drain is placed in the subcutaneous tissue between the incision in the upper arm and the neck. Subsequently, the grafts are pulled through the wet drain gently and without any friction. After removal of the tube the grafts remain in the subcutaneous tissue free of tension.

In the upper arm, the lymphatic vessels can be found mostly epifascially – if they are not present there, they may also be located subfascially in proximity to the vessels – and can best be found through an oblique incision made medially and superior to the route of the brachial vessels. The search for these vessels is performed under the microscope using a medium magnification. In the early stages of lymphedema the lymphatic vessels have a gray, shiny appearance and the lumen can be seen clearly after transection. As the lymphatic vessels undergo fibrosis in later stages of lymphedema it becomes more difficult to discriminate between small nerves and fibrous cords. In this case the final decision regarding potential use for grafting can only be made after transection of the structure.

In the area of the neck the wall of the lymphatic vessels is thinner than in the arms and legs. Here, injections of Patent Blue dye in the hair-bearing parietal area above the ear facilitate the search for appropriate vessels. If the lymphatic vessels stain appropriately, recognition is easy. However, suturing in this area is often difficult because of the collapsing thin-walled vessels. If this is the case, it is also possible to suture the grafts to lymph nodes. A superficial incision is made in the capsule of the node and the graft connected with approximately three single interrupted sutures.

In unilateral edema of the lower extremities the grafts remain attached to the inguinal lymph nodes. In such a transposition procedure, the grafts are dissected distally after double ligation and tunneled subcutaneously superior to the pubic symphysis to the contralateral side, where end-to-end lympholymphatic anastomoses are performed (Fig. 3.5). A wet tube drain placed in the subcutaneous tunnel aids in tension-free passing of the lymphatic graft. A tension-free anastomosing technique is used to anastomose the lymphatic vessels under the operating microscope using maximum magnification. Baumeister and Frick\(^{81}\) advocate placement of the first suture on the side of the vessel opposite to the surgeon. Because of the fragility of the vessels, they are not turned over. A back-wall suture is placed and one or two further single stitches complete the anastomosis. The choice of suture material depends on the preference of the surgeon. Baumeister et al.,\(^{3}\) for example, use absorbable polyglactin and found it to be superior to nonabsorbable material in their experimental studies. Currently 10-0 absorbable sutures (Polyglactin 910), armed with a BV 75-4 needle, are the finest absorbable materials available. Other authors use 11/0 or 12/0 nylon on a
50-μm needle for lympholympathic or lymphaticovenular anastomoses.

**Microvascular lymph node transfer**

Becker and colleagues reported transplanting composite soft tissue, including inguinal lymph nodes, to the axilla and/or the elbow region in the lymphedematous limb. Lin and colleagues transferred similar flaps to the wrist (Fig. 3.6). Microvascular lymph node transfer is expected to result in new lymphatic vessels sprouting from the transplanted lymph node to drain the region. However, no objective evidence has been demonstrated that lymphatic vessels actually regenerate from transferred nodes. Nevertheless, many groups are studying this issue and objective evidence is likely to be forthcoming.

**Lymphovenous bypass**

Various lymphovenous anastomosis techniques have been described. A full description is available in the online version of this chapter. Currently, one of the most popular treatments is the lymphovenous bypass operation, which is minimally invasive. Chang reported early experience in using lymphaticovenular bypass in 20 patients with upper-extremity lymphedema related to the treatment of breast cancer (Fig. 3.7). The mean age of the patients was 54 years: 16 patients had received preoperative radiation therapy, and all patients had undergone axillary lymph node dissection. The mean duration of lymphedema was 4.8 years, and the mean volume differential of the lymphedematous arm compared with the unaffected arm was 34%. Evaluation included qualitative assessment and quantitative volumetric analysis before surgery and at 1, 3, 6, and 12 months after the procedure. Nineteen patients (95%) reported that their symptoms improved after surgery, and 13 patients had quantitative improvement. The mean reduction in volume differential was 29%, 36%, 39%, and 35% at 1, 3, 6, and 12 months, respectively (Fig. 3.8)

Table 3.1 summarizes published results for lymphovenous bypass operations. Although the results cannot be directly compared because the methods of evaluation used were not uniform, it is notable that in some patients the volume of the lymphedematous limb was reduced substantially after the operation and this reduced volume was maintained for many years.

**Lymphovenous shunts**

Anecdotal evidence suggests that lymphovenous shunt operations performed using microsurgical techniques are more effective in patients with early-stage lymphedema than in
Fig. 3.7 (A) An example of lymphaticovenular bypass. Note the blue lymphozurin dye within the lymphatic vessel and the red blood within the venule. (B) Another example of lymphaticovenular bypass. A grid in the background measures 1 mm. (C) Two lymphatic vessels anastomosed to a venule. (Reproduced from Chang DW. Lymphaticovenular bypass for lymphedema management in breast cancer patients: a prospective study. *Plast Reconstr Surg.* 2010;126:752–758.)

Fig. 3.8 Quantitative volumetric analysis at 1 month, 3 months, 6 months, and 1 year after bypass. (Reproduced from Chang DW. Lymphaticovenular bypass for lymphedema management in breast cancer patients: a prospective study. *Plast Reconstr Surg.* 2010;126:752–758.)

Postoperative care

Following reconstruction by lymphatic grafting the extremities are elevated and elastic bandaging is continued. Additionally antibiotics are applied to prevent postoperative

those with late-stage lymphedema. In fact, Boccardo and colleagues and Nagase and colleagues proposed that prophylactic lymphovenous bypass operations be performed to prevent the development of lymphedema. Although this concept may be feasible to retain function in lymphatic vessels, prophylactic surgery is controversial because lymphedema does not occur predictably.

Selecting functional lymphatic vessels is crucial for the success of the lymphovenous bypass operation. One recent advance in this area has been the use of fluorescence lymphography to image the lymphatic system during lymphovenous shunt operations and to diagnose the severity of lymphedema. In this technique, an imaging system detects near-infrared light emitted by indocyanine green dye, which is injected into the affected limb (video 2). In the operating room, fluorescence lymphography allows surgeons to locate a functional lymphatic vessel for the lymphovenous shunt before making a skin incision. This technique allows for the prompt identification of the functional lymphatic vessels, and thus has the potential to improve the outcomes of lymphovenous bypass operations significantly (Fig. 3.9).
Outcomes, prognosis, and complications

Patients treated by lymphatic autografts have been followed using volume measurement, lymphoscintigraphy, indirect lymphography using water-soluble contrast medium, and MRI lymphography. The results were evaluated by volume estimation based on circumferential measurements along the limb in increments of 4 cm. Furthermore lymphatic outflow was measured semiquantitatively using the lymphatic transport index based on the findings of lymphoscintigraphic studies.\(^8^5\)

Direct visualization of the grafts in patients was difficult because in lymphangiography using water-soluble contrast medium, the lymphatic vessels generally can be visualized only over short distances. However, in several patients patent grafts could be demonstrated more than 10 years after grafting with this technique.\(^8^0\) Also with MRI lymphangiography, patent grafts have been proved more than 10 years after surgery.\(^8^6\)

Baumeister and Frick reported on a series of 127 patients suffering from arm edema. In this cohort, a significant volume reduction was achieved from a mean of 3368 cm\(^3\) preoperatively to a mean of 2567 cm\(^3\) after 8–10 days (\(P<0.001\)). At a mean follow-up period of 2.6 years the mean volume was 2625 cm\(^3\) (\(P<0.001\)). In a group of 8 patients with long-term follow-up of more than 10 years, the mean volume was reduced to 2273 cm\(^3\), in contrast to a mean preoperative volume of 3004 cm\(^3\) (\(P<0.001\)).\(^8^1\)

In another group of 81 adult patients with unilateral edema of the lower extremities, the mean preoperative volume of 13 098 cm\(^3\) was reduced to a mean of 10 578 cm\(^3\) \((P<0.001)\) at the time of hospital discharge. After a mean follow-up period of 1.7 years, the volume reduction was sustained, with a mean volume of 11 074 cm\(^3\) (\(P<0.001\)). In a subgroup of 12 patients with a further follow-up period of more than 4 years the volume was reduced to 10 692 cm\(^3\) (\(P<0.001\)).\(^8^1\)

Despite these relatively large numbers, complications were relatively few. In the original group of patients, two developed erysipelas, there was one lymphocyst at the site of graft harvest, and one patient developed swelling of the lower leg secondary to venous thrombosis.
In another study, lymphoscintigraphic examinations were undertaken in 20 patients (12 upper, 8 lower extremities) with a follow-up period of 7 years. Seventeen of the 20 patients showed improved lymphatic outflow. In 5 patients, the patent grafts could be demonstrated directly by visualizing the routes of activity.\textsuperscript{107} Patent grafts could be demonstrated after more than 10 years with indirect lymphography as well as MRI lymphography.

Semiquantitative measurements of the lymphatic outflow were investigated by lymphoscintigraphy. In the group with the best clinical results, the flux of activity within the grafts could easily be seen showing normalization of the lymphatic outflow.

**Secondary procedures following the reconstruction**

Improvement of lymphatic outflow primarily affects the fluid retention component of the edema, which results clinically in a reduction of tenderness, softening of the tissues, and overall reduction in volume. If patients want a further reduction in volume in more severe cases, additional secondary procedures may be useful. Liposuction of the limb is theoretically minimally invasive, especially if the suction is performed in a longitudinal direction to protect the lymphatic vessels.\textsuperscript{29} However direct excision of localized areas is also a good option and avoids the risk that liposuction may injure reconstructed lymphatic structures. Early experiences with these advanced stages of lymphedema show an additional significant reduction of volume after the suction. A continuous reduction of volume was possible also without further compression therapy, which means freedom of further treatment procedures can be reached.

**Summary**

Various surgical procedures have been attempted to treat lymphedema. However, whether and how to treat lymphedema surgically is still the subject of debate. Debulking operations have, for the most part, become less popular, and physiological lymphatic bypass operations have gained popularity.

However, the lymphatic bypass operation’s effectiveness varies in reports, and its efficacy is difficult to evaluate because
no standard protocol exists for measuring lymphedema. Numerous studies have provided information about lymphedema; however, most of the research data was obtained from clinical feedback, and basic research data on the etiology of lymphedema are limited. This lack of research data may be attributed to the features of the lymphatic system that make it difficult to study, such as its transparency and its fragility. However, advances are being made to address these difficulties. Several immunohistochemical markers are currently available to examine the lymphatic system histologically. A new anatomical method for visualizing lymphatic vessels on radiographs has been developed in cadaveric specimens. Several experimental animal models have also been developed for investigating lymphedema. If these animal models are used with sound, evidence-based experimental methods, various surgical procedures can be evaluated to help develop definitive treatments for lymphedema.


Clinical observations in 64 patients affected by chronic obstructive lymphedema (either arm or leg) undergoing interposition autologous lymphatic-venous-lymphatic (LVL) anastomoses are reported. This microsurgical technique is an alternative to other lymphatic shunting methods, especially when venous dysfunction coexists in the same limb and, therefore, when direct lymphatic-venous anastomosis is accordingly inadequate. Preoperative diagnostic evaluation (including lymphatic and venous isotopic scintigraphy, Doppler venous flowmeters, and pressure manometry) plays an essential role in assessing the conditions of both the lymphatic and venous systems and in establishing which microsurgical procedure, if any, is indicated. Our microsurgical technique consists of inserting suitably large and lengthy autologous venous grafts between lymphatic collectors above and below the site of obstruction to lymph flow. The data show that, using this technique, both limb function and edema improved, and in all patients followed up for over 5 years edema regression was permanent.


