lympholymphatic anastomosis and lymph node-venous anastomosis. Two approaches that have gained most traction in the microsurgical community have been lymphaticovenular anastomosis and vascularized lymph node transplantation, which will be the focus of this review. This brief passage is in no way meant to exclude other viable procedures, only to highlight a handful of techniques that have become of recent interest and have demonstrated promising results.

CONTRAINDICATIONS TO PHYSIOLOGIC PROCEDURES

There are many patients who will call the office for lymphedema or swelling of the limbs from one cause or another and it is worthwhile knowing in advance which patients will not be candidates for surgery, particularly physiologic procedures. The two main contraindications we encounter is significant venous disease and obesity. Because a lymph node transfer or LVA relies on lymphovenous shunting, any venous hypertension may compromise this pressure gradient and result in a failed operation. Venous insufficiency is also a very common cause of lower extremity swelling, and treating the venous disease may alleviate some of the swelling. A history of deep vein thrombosis in the affected limb, varicosities, and prior vein surgery are relative contraindications to VLNT or LVA in our practice.

Obesity is another relative contraindication for physiologic lymphatic procedures. Elevated BMI has been shown to impair lymphatic clearance and worsen lymphedema, and is reported to be a risk factor in developing postmastectomy lymphedema.[35–40] If a patient were to consider VLNT, obesity may not only compromise efficacy but may also increase the risk for donor site lymphedema and thromboembolic complications. For these reasons, we recommend weight loss to all patients until their BMI is ≤30 before offering physiologic lymphatic surgery.

THE INITIAL PATIENT VISIT

The initial visit focuses on evaluating the patient's type of lymphedema, their goals, and determining whether a physiologic, debulking, or excisional procedure is appropriate. A focused history includes the status of the venous system, history of deep vein thrombosis or pulmonary embolus, duration of lymphedema, current compression regimen (as a baseline for postoperative comparison), history of cellulitis, radiation, and cancer history. Physical exam includes inspection of the site of the previous cancer to assess for recurrence, and inspection of groin, axillary, and cervical lymph nodes to ensure these potential donor sites do not have pathology. Exam of the affected limb for fibrosis and the presence of pitting quickly provides information about whether the limb is mostly fluid-filled or is already in the advanced stages of fat hypertrophy and fibrosis. Evidence of varicosities, and hemosiderin staining suggest venous disease and may exclude the patient from LVA or VLNT.

On a typical visit, the patient is first evaluated for the possibility of being a candidate for a physiologic procedure such as VLNT or LVA. If the patient has a significant fluid component to their lymphedema evidenced by pitting edema and a good response to compression and elevation, they may be considered for a physiologic procedure. If they have more advanced lymphedema with a mostly fatty limb with no pitting, and are 100% compliant with compression, liposuction may be the best option. Of course there are gray areas with a mixed picture that may benefit from a combination of liposuction and either LVA or VLNT, although the timing of these procedures is still a matter of debate.

On the first visit, every patient should be informed of the risks of VLNT including no improvement, worsening lymphedema, or donor site lymphedema. Donor site lymphedema has been reported, but the quantitative risk of this serious morbidity is unclear because these reports were of VLNT without reverse lymphatic mapping, which has improved the safety of this technique.[41–45] In our current series of 70 lymph node transfers over the past 5 years, we have not observed donor site lymphedema using the reverse lymphatic mapping (RLM) technique, although we need another 5 years and many more cases to better quantify this risk.[19]

Finally, while VLNT has a clearly established role in secondary lymphedema following oncologic treatment, its use in primary lymphedema is less clear-cut. This is because there is a spectrum of disease within the category of primary lymphedema, with a variety of congenital abnormalities that may all lead to swelling. In our early experience, results were mixed. Becker has suggested that patients with abundant hyperplasic lymphatic vessels seen on magnetic resonance lymphangiography (MRL) could potentially benefit from VLNT, while those with lymphatic vessel hypoplasia are generally avoided, although this is anecdotal observation (Corinne Becker, pers. comm., December 2014). When starting a lymphatic surgery program, there is a greater comfort zone in focusing on cancer-related lymphedema. If a lymph node transfer is considered in primary lymphedema, both four-limb lymphoscintigraphy and IGL are performed to rule out occult impaired lymphatic function near potential donor sites to minimize the risk of causing lymphedema in a patient with an already abnormal lymphatic system.

After discussing risks and benefits, the patient often decides if the risk of surgery outweighs the risk of natural progression of disease. This rules out patients who are on the fence; the best patient is one that is highly motivated for surgery and is not second-guessing their decision. If a patient is interested in surgery, the next step is referral to a certified lymphedema therapist and performing a thorough imaging work-up. Preoperative coordination with a lymphedema therapist is important in ensuring the limb is in optimal condition to promote lymphangiogenesis and to have a seamless postoperative physiotherapy regimen.

Because we are dealing with a poorly understood disease and the role of lymphatic surgery is still evolving, our inclination is to study the patient with as many tools at our disposal as possible, in order to see patterns in disease and hopefully some day predict which of these patterns best responds to a given treatment. This work-up includes magnetic resonance angiography (MRA) of potential donor sites and recipient site; magnetic resonance lymphangiography (MRL) of the affected limb; four-limb lymphoscintigraphy and IGL; perometer for limb volume or an equivalent

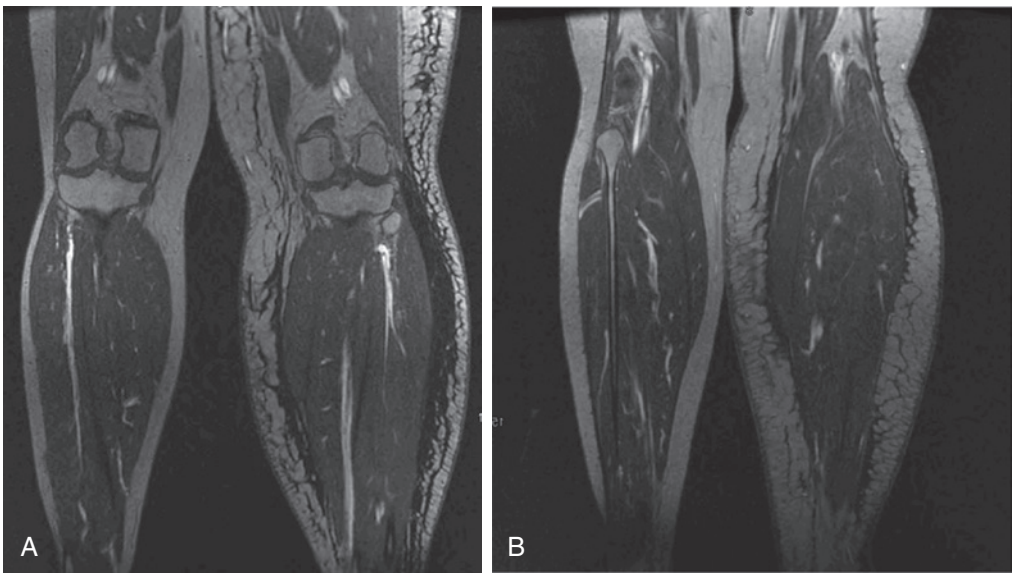

Figure 8.4 (A) MRA of the leg, coronal section. Lymphedema of the left leg in a patient with a significant fluid component (black = fluid). (B) Lymphedema of the left leg in a different patient with pronounced fat hypertrophy and a relatively smaller fluid component. These patients may respond differently to LVA or VLNT in terms of volume reduction.

method; limb impedance measurements; elastometer measurements; and standardized photographs. This list of studies is generally not feasible in many centers, but the most important ones involve some form of MR imaging, and physiologic evaluation of the lymphatic system using lymphoscintigraphy and/or IGL. Interpretation of this work-up involves its own learning curve and close collaboration with nuclear medicine and radiology.

ANATOMIC IMAGING

Radiographic imaging includes magnetic resonance angiography (MRA) of both the recipient and potential donor sites. Ablavar contrast, as opposed to gadolinium, is used and stays in the blood for a longer period of time yielding higher resolution. The thin-cut venous phase is used for review. For the *recipient site*, the fluid versus fat component as well as limb volume can be calculated (Fig. 8.4). Occult recurrence and severe stenosis of the axillary, femoral, or iliac veins following surgery and radiotherapy can also be visualized. If present, venography can better characterize the nature of vein stenosis. We have seen a number of patients with axillary node dissection and radiation with severe axillary vein stenosis requiring extensive lysis to dilate the vein and one patient who required axillary vein reconstruction. As stated earlier, venous hypertension can be a component of limb swelling and could compromise the VLNT or LVA. MRA of the recipient site is performed 1 year postoperatively to confirm viability and quantity of lymph nodes successfully transferred.

MRA of the *donor sites* allows the surgeon to select the side with the most favorable lymph nodes and vascular anatomy (Fig. 8.5). This is the side with the largest number and size of lymph nodes, positioned farthest away from the lymph nodes that drain the adjacent extremity.[17] For example, if performing an axillary lymph node transfer, the side with the most abundant lymph nodes located farthest from the axillary vein and its adjacent lymph nodes would likely be a safer and more effective choice. If both sides are equivalent, then the side contralateral to the limb with lymphedema is selected, as this is the preference of most lymphedema therapists. This theoretically allows for clearance of the lymph from the affected limb to adjacent lymph node basins, which would preferably not be harvested.

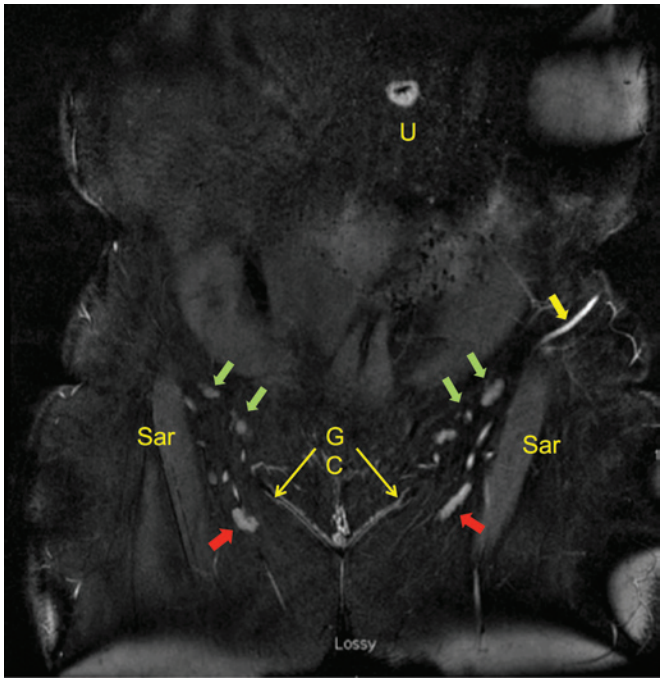

Figure 8.5 MRA of the pelvis, coronal section illustrating location of the target lymph nodes (green arrows) and the sentinel lymph nodes draining the lower limbs (red arrows). U, umbilicus; GC, groin crease; Sar, sartorius; Yellow arrow, distal superficial circumflex iliac vein.