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Surgical management of lymphedema. A review

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Review

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ABSTRACT:
Lymphedema is a chronic disease in which impaired lymphatic drainage causes the accumulation of fluid in the soft tissues, resulting in a swollen limb. This ultimately leads to severe fibrosis, recurrent infections, non-healing wounds, and a poorly functional limb that negatively affects patients' quality of life. Primary lymphedema is due to abnormal development of the lymphatic system, it can be present from birth, secondary lymphedema is caused by damage to the lymphatic system due to infection, surgery to treat malignant tumors, trauma and obesity. In the past, the only treatment was compression, which is still the first line of treatment today. In recent decades, surgical treatments for lymphedema have advanced, along with advances in microsurgery. Lymphovenous anastomosis (LVA) and lymph node transplantation are physiologic therapies that can reduce lymphedema by addressing the cause. Ablative techniques such as liposuction and subcutaneous excision help resolve the accumulation of proteinaceous and fibrotic adipose tissue seen in advanced lymphedema. The objective of this review is to examine the results and limitations of current surgical techniques used in the treatment of lymphedema.

Keywords: Lymphedema, lymphovenous anastomosis

Introduction

Lymphedema is a condition characterized by the accumulation of protein-rich fluid in the interstitial space and the consequent edema of the tissues. The accumulation of this fluid causes inflammation that induces lipogenesis and fat deposition with connective tissue, eventually patients develop irreversible induration and fibrosis of the affected area (1). The early stages may have physical findings and symptoms of painless pitting edema, discomfort, and heaviness of the extremity, especially after continuous use (2). Primary lymphedema occurs due to structural and functional abnormalities of the lymphatic channels, it can become symptomatic at birth, in adolescence or in adulthood. Secondary lymphedema develops after interruption of normal lymphatic channels, leading to obstruction of the lymphatic system. The most common cause of secondary lymphedema worldwide is filariasis secondary to Wuscheria bancrofti infection. However, in developed countries, secondary lymphedema is mainly caused by iatrogenic injury during treatment for various malignancies, including breast, gynecological, and skin cancer (3). The first symptoms of primary lymphedema generally occur between the ages of 10 and 25 years, with a prevalence of approximately 1/100,000 (4,5). Studies have reported an incidence of upper extremity lymphedema after axillary lymph node dissection ranging from 7% to 45% depending on risk factors and adjunctive use of adjuvant radiation therapy (6). The affected limb becomes large, swollen, heavy, and painful, preventing them from enjoying their lifestyle, exercising, performing activities of daily living, and working, leading to severe disability. Patients can't wear normal clothes and shoes, plus it's a constant reminder that they had cancer. As the disease progresses, patients develop recurrent infections and nonhealing wounds from even minor trauma requiring intensive wound care, antibiotics, repeated hospitalization, surgical debridement, and even amputation. This becomes an economic burden for patients, their families and the health system (7). For many years, the first-line treatment of lymphedema has been conservative treatment with complete decongestive therapy (CDT): a combination of compression garments, skin hygiene, compression of the extremities, manual lymphatic drainage, and exercise (8,9) . Lymphatic decongestive therapy is labor intensive and requires access to a specialized therapist (10). CDT requires lifelong patient compliance as it is not curative and requires continuous compression to maintain treatment results (11,12,13).

Surgical treatment of lymphedema is suggested when conservative treatment fails, particularly at the onset of inflammation. The field of lymphedema surgery is a constantly evolving field.

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International Lymphedema Society. Lymphedema staging system.	
	Characteristic
Stage 0	Impaired lymphatic transport, subtle alterations in tissue and fluid composition. Patients may report symptoms, but edema is not present.
Stage I	Early accumulation of protein-rich interstitial fluid. Edema is present but improves with elevation. Patients may have pitting edema.
Stage II	Edema is present and does not improve with elevation. Initially, there will be pitting edema. Later in stage II, there will be no pitting as soft tissue fibrosis develops.
Stage III	Absence of fovea, trophic changes in the skin, increased fat deposits and fibrosis (lymphostatic elephantiasis) develop.

Table 1. Lymphedema staging system. International Lymphedema Society (17).

Early techniques in the treatment of lymphedema include ablative procedures such as the Homans or Charles procedures, which involve excision of the subcutaneous tissue beneath the affected skin and covering the defect with full-thickness or partial-thickness skin flaps or grafts (14,15 ,16). Advances in microsurgical techniques have allowed the advent of more physiological and effective methods, such as vascularized lymph node transplantation (VLNT) or lymphovenous shunt (LVA). The objective of this review is to provide an analysis of current techniques in the management of lymphedema, their results and limitations.

Methods

A PubMed-MEDLINE literature review was conducted to assess current strategies in the surgical management of lymphedema. The query was made using a combination of the terms 'surgery', 'lymphedema', 'liposuction', 'lymphovenous anastomosis' and 'lymph node transplantation'. Additional queries based on relevant references from the searched articles were made.

Clinical evaluation

The initial evaluation of the patient should include a complete history and physical examination. Other etiologies of extremity edema such as congestive heart failure, renal failure, deep vein thrombosis, and venous insufficiency must be excluded. Venous Doppler should be considered to rule out venous insufficiency. The physical examination should include a thorough evaluation of the quality of the skin and soft tissues of the affected extremity. Particular attention should be paid to the presence of orange peel, which indicates soft tissue fibrosis, and Stemmer's sign (the inability to grasp the skin over the second toe), as these signs favor the diagnosis of lymphedema. on other etiologies of edema of the extremities. Serial limb circumference should be measured and compared to the contralateral side, as this may be useful in monitoring response to treatment (17). The International Lymphedema Society has described a staging system for the clinical evaluation of lymphedema (**Table 1**).

Imaging

Imaging of the lymphatic system is a vital tool in the evaluation of lymphedema. Indocyanine green lymphography is a minimally invasive imaging technique that allows dynamic visualization of lymphatic channels without radiation exposure, it has been used for decades in various specialties for evaluation of liver function, sentinel lymph node detection , cardiac output and flap viability (18). It is performed by subdermal injection of indocyanine green in the interdigital spaces of the lymphedematous extremity, the near infrared light emitted by the dye is detected with an infrared camera system, the location, route and flow of the superficial lymphatic channels of up to 2 cm deep from the skin surface can be detected immediately after injection (19). Described by Ogata et al. in 2007 in the evaluation of lymphedema, since then it has become an irreplaceable tool for real-time evaluation of lymphatic channels during lymphatic surgery (20). Lymphoscintigraphy is considered the gold standard for lymphedema evaluation and is frequently used to confirm a clinical suspicion of lymphedema. A technetium-99 (Tc-99) radiotracer is injected subdermally into the first or second web space of the affected limb, and uptake is assessed using a high-resolution gamma camera (21). Lymphoscintigraphy provides the ability to measure contrast uptake, visualize the number and size of lymphatic vessels and nodes, and assess dermal reflux patterns (22).

Radionuclide lymphography is essential for the plastic surgeon for surgical planning as well as

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intraoperative visualization of lymphatic channels that are invisible to the naked eye.

Surgical management

Surgical techniques for the management of lymphedema can be broadly divided into microsurgical physiological procedures that attempt to restore normal lymphatic physiology by increasing lymphatic fluid removal, and ablative procedures, which remove excess subcutaneous tissue to improve patient comfort. and facilitate conservative therapies.

Lymphovenous Anastomosis

LVA was first described in the 1960s (23). Nielubowicz and Olszewski performed the procedure on 4 patients with secondary lower extremity lymphedema and showed a persistent reduction in limb circumference during a follow-up of 1 to 9 months (24). LVA is a physiologic microsurgical procedure in which lymphatic channels are anastomosed to nearby subdermal veins, bypassing proximal lymphatic obstruction by diverting lymphatic fluid into the venous system (25). Patients with International Lymphedema Society stage I or II lymphedema who have complied with conservative measures but have shown minimal improvement are considered good candidates for LVA (26). The recent use of lymphography before and intraoperatively to visualize patent lymphatic vessels has allowed restoration of lymphatic flow by minimally invasive procedures, making LVA an attractive option in lymphedema (27,28). Lymphography is performed prior to surgery to identify properly functioning lymphatic channels and guide the location of incisions. From this point on, the procedure is performed under the microscope, a careful incision is made in the skin, and the lymphatic channels within the subcutaneous tissue are identified. Once a satisfactory lymphatic vessel has been dissected and transected proximally, an appropriately sized nearby venule is selected. The vessel can be immersed in heparinized saline or stented with a 6-0 prolene suture to prevent backwall formation and ensure full thickness is taken. End-to-end, end-to-side, or side-to-end anastomoses can be performed depending on the size, pressure, and availability of the subdermal venules (29). Lymphatic vessels are typically 0.5 to 0.8 mm in size, making the skill of the surgeon, careful handling of the tissues, and microsurgical or supermicrosurgical technique critical to success (30). After surgery, compression bandage is used, patients are recommended to walk, after two weeks, the compression bandage is changed to a compression garment. Lymphatic massage is restarted four weeks postoperatively.

Since its introduction, several studies have examined the results of LVA (31,32,33). Chang et al. (2013) found symptomatic improvement in 96% of patients with upper extremity lymphedema and significant limb volume reduction (61%) postoperatively at 3, 6, and 12 months after LVA in patients with early-stage lymphedema. (34). In a meta-analysis Jørgensen et al. (2018) found that prophylactic LVA at the time of lymphadenectomy reduced the risk of lymphedema by 77% compared to no prophylactic procedure ($P<0.0001$) (35). Chen et al. (2018) demonstrated the efficacy of LVA also in primary lymphedema, in patients with congenital forms of lymphedema who received LVA experienced approximately 4 times per year fewer episodes of cellulitis and reported increases in quality of life, appearance, symptoms, function and status. mood (36). Disadvantages of LVA include technical difficulty and the paucity of long-term results in the literature.

Vascularized Lymph Node Transfer

VLNT is a relatively new technique in the treatment of lymphedema. It was first described by Clodius et al. (1982), who transferred a pedicled inguinal flap with vascularized inguinal lymph nodes to the left lower extremity with partial success in reducing lymphedema (37). With advances in microsurgical techniques, VLNT has become a treatment option, particularly in cases of moderate to advanced lymphedema, where other treatment methods may not have been effective. The technique involves the transfer of a vascularized lymph node and surrounding tissue to a region where a lymph node has been removed or where lymph flow is impaired. A microsurgical anastomosis is created between the blood supply of the recipient site and the flap, maintaining the vascularization of the lymph node. Common donor sites for lymph nodes include omental, inguinal, mesenteric, lateral thoracic, axillary, gastroepiploic, and submental nodes (38,39). The exact mechanism by which VLNT improves lymphedema is still debated, but two main theories have been described. The first is that VLNT acts like a sponge that absorbs local lymphatic fluid and redirects it to the vascular system (40). The second theory is that the transferred lymph nodes produce vascular endothelial growth factor-C (VEGF-C) that induces local lymphangiogenesis through the formation of spontaneous efferent and afferent connections between the transferred nodes and the recipient site (41). VLNT from groin and supraclavicular donor sites is discussed below.

The VLNT of the groin is based on the superficial circumflex iliac system or a small medial branch of the femoral artery. The dissection should

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remain superficial to the deep fascia of the thigh, superior to the groin crease, and lateral to the femoral artery to avoid harvesting lymph nodes that are critical for lymphatic drainage of the lower extremities (42). The groin lymph node flap can be transferred alone or in continuity with abdominal flaps in autologous breast reconstruction, making it an ideal donor for secondary upper extremity lymphedema in the setting of breast cancer (43). For supraclavicular lymph node transplantation, the right side is preferred to avoid the left-sided thoracic duct. The nodal conglomerate is bounded medially by the sternocleidomastoid muscle, the clavicle inferiorly, and the external jugular vein laterally. The supraclavicular nodes can be transferred with a skin cover, which may be useful in patients with radiation skin changes who also require release of contractures at the time of VLNT. The advantages of supraclavicular VLNT include flap reliability, discreet scarring, and a low risk of donor site morbidity and secondary lymphedema (44). Reverse lymphatic mapping prior to surgery has been proposed as a technique to prevent donor site lymphedema after VLNT (45). VLNT has been shown to improve overall quality of life, functional status, reduce skin infection rates, and significantly reduce upper and lower extremity volume (46).

Ablative procedures

Ablative procedures remove excess skin and subcutaneous tissue from the affected limb to decrease limb volume and improve functional status, may be considered in patients with stage II and stage III late lymphedema who are not candidates for physiologic procedures, for excess adipose deposition and fibrosis in the affected limb. These techniques are also used after physiologic procedures to treat the fat and fibrosis component of the lymphedematous limb (47,48).

Liposuction

The use of liposuction for lymphedema was first popularized by Brorson and Svensson (1998), who examined the feasibility of combined liposuction and compression garment therapy for lymphedema (49). Liposuction is minimally invasive, low risk, and unlikely to further compromise the lymphatic drainage of the affected limb. Significant limb volume reduction is seen almost immediately in the postoperative period, but liposuction is not curative and patients must continue CDT and compression for life to maintain results (50). Suction-assisted lipectomy can also be used in conjunction with LVA or VLNT to reduce limb size in patients whose lymphatic function has been restored (51). The main limitation of liposuction therapy is that patients must wear compression garments indefinitely to maintain the reduced volume of the limb (52). Proper follow-up of liposuction therapy for lymphedema involves a multidisciplinary approach to treatment, involving plastic surgeons, physical therapists, and the committed patient (53). Patients have reported an increased quality of life after liposuction treatment, despite having to wear long-term compression garments as part of their treatment (54). Brorson H. et al suggest that the cosmetic and functional benefits of liposuction outweigh the burden caused by lifelong compression therapy (55).

Excisional Procedures

Excisional therapeutic techniques have been described since 1912, particularly for the treatment of elephantiasis (56). The Charles procedure involves radical circumferential soft tissue excision down to the level of the deep fascia followed by skin graft reconstruction, this results in complete interruption of existing distal lymphatic drainage and can lead to exacerbation of lymphedema of the distal extremity, the results of the procedure are cosmetically poor, complications including graft failure, chronic ulceration and hypertrophic scarring can be observed (57). van der Walt et al. (2009) further modernized this technique to include negative pressure wound therapy and delayed skin grafting, in an effort to improve graft capture and wound recovery, this is known as the modified Charles procedure (58). Retrospective studies have reported positive results in volume reduction, albeit with limited sample sizes and confounding results due to combination with other procedures (59,60).

Combined surgical therapy

Granzow et al. (2014) (61) and Nicoli et al. (2015) (62) reported that performing a liposuction procedure followed by VLNT enabled patients to wear compression garments less frequently, maintain reduced arm volume, and improve skin quality. Campisi et al. (2017) demonstrated that patients receiving a combination of LVA with liposuction were able to maintain limb volume despite wearing only compression garments overnight (19). City et al. (2019) in a retrospective study of 68 patients with International Lymphedema Society stage III lymphedema, reported that the combination of VLNT with excisional procedures achieved a significant reduction in limb circumference and a decreased incidence of episodes. In addition, all patients in this study were able to discontinue the use of compression garments 8 months after surgery (13).

Conclusion

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Lymphedema is a chronic and incurable disease that severely decreases function and quality of life. The surgical management of lymphedema continues to evolve as well as promising advances in the field of microsurgery. Combined surgical therapy such as ablative procedures together with LVA and VLNT have improved the functional results and quality of life of patients, which is why they are considered the best option. Lymphedema continues to be a difficult disease to manage for plastic surgeons and patients.

Conflicts of interests

The authors have no conflicts of interest to declare.

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References

1. Tiwari A, Cheng KS, Button M, et al. Differential diagnosis, investigation, and current treatment of lower limb lymphedema. Arch Surg 2003;138:152-61.
2. Warren AG, Brorson H, Borud LJ, Slavin SA. Lymphedema. Annals of Plastic Surgery. 2007;59(4):464-472.
3. Rockson SG, Rivera KK. Estimating the Population Burden of Lymphedema. Annals of the New York Academy of Sciences. 2008;1131(1):147-154.
4. Catherine L. McGuinness KGB. Chapter 49 – Lymphedema. In: Hallett JLM, Earnshaw JJ, Reekers JA, et al. editors. Comprehensive Vascular and Endovascular Surgery 2ed. Mosby, 2009:862-75.
5. Smeltzer DM, Stickler GB, Schirger A. Primary lymphedema in children and adolescents: a follow-up study and review. Pediatrics 1985;76:206-18.
6. Cormier JN, Askew RL, Mungovan KS, et al. Lymphedema beyond breast cancer: a systematic review and meta-analysis of cancer-related secondary lymphedema. Cancer 2010;116:5138-49.
7. Ezzo J, Manheimer E, McNeely ML, et al. Manual lymphatic drainage for lymphedema following breast cancer treatment. Cochrane Database Syst Rev 2015:CD003475.
8. Melam GR, Buragadda S, Alhusaini AA, et al. Effect of complete decongestive therapy and home program on health- related quality of life in post mastectomy lymphedema patients. BMC Womens Health 2016;16:23.
9. Mondry TE, Riffenburgh RH, Johnstone PA. Prospective trial of complete decongestive therapy for upper extremity lymphedema after breast cancer therapy. Cancer J 2004;10:42-8; discussion 17-9.
10. Lasinski BB, McKillip Thrift K, Squire D, et al. A systematic review of the evidence for complete decongestive therapy in the treatment of lymphedema from 2004 to 2011. PM R 2012;4:580-601.
11. Shih YC, Xu Y, Cormier JN, et al. Incidence, treatment costs, and complications of lymphedema after breast cancer among women of working age: a 2-year follow-up study. J Clin Oncol 2009;27:2007-14.
12. Head LK, Momtazi M. Economics of Lymphovenous Bypass. Plast Reconstr Surg 2019;144:751e-9e.
13. Ciudad P, Agko M, Huang TCT, et al. Comprehensive multimodal surgical treatment of end-stage lower extremity lymphedema with toe management: The combined Charles,' Homan's, and vascularized lymph node transfer (CHAHOVA) procedures. J Surg Oncol 2019;119:430-8.
14. Homans J. The treatment of elephantiasis of the legs - A preliminary report. N Engl J Med 1936;215:1099-104.
15. Dellon AL, Hoopes JE. Charles Procedure for Primary Lymphedema - Long-Term Clinical Results. Plast Reconstr Surg 1977;60:589-95.
16. Kung TA, Champaneria MC, Maki JH, Neligan PC. Current Concepts in the Surgical Management of Lymphedema. Plast Reconstr Surg. 2017;139(4):1003e-1013e.
17. The Diagnosis and Treatment of Peripheral Lymphedema: 2016 Consensus Document of the International Society of Lymphology. Lymphology. 2016;49(4):170-184.
18. Narushima M, Yamamoto T, Ogata F, Yoshimatsu H, Mihara M, Koshima I. Indocyanine Green Lymphography Findings in Limb Lymphedema. J Reconstr Microsurg. 2016;32(1):72-79.
19. Campisi CC, Ryan M, Boccardo F, et al. Fibro-Lipo-Lymph-Aspiration With a Lymph Vessel Sparing Procedure to Treat Advanced Lymphedema After Multiple Lymphatic-Venous Anastomoses: The Complete Treatment Protocol. Ann Plast Surg 2017;78:184-90.
20. Ogata F, Azuma R, Kikuchi M, Koshima I, Morimoto Y. Novel lymphography using indocyanine green dye for near-infrared fluorescence labeling. Ann Plast Surg. 2007;58(6):652-655.
21. Yoshida RY, Kariya S, Ha-Kawa S, Tanigawa N. Lymphoscintigraphy for Imaging of the Lymphatic Flow Disorders. Tech Vasc Interv Radiol. 2016;19(4):273-276.
22. Garza RM, Chang DW. Lymphovenous bypass for the treatment of lymphedema. Journal of Surgical Oncology. 2018;118(5):743-749.
23. Nielubowicz J, Olszewski W. Surgical lymphaticovenous shunts in patients with secondary lymphoedema. Br J Surg 1968;55:440-2.
24. Jacobson JH, 2nd, Suarez EL. Microvascular surgery. Dis Chest 1962;41:220-4.
25. Baltzer HL, Winocour S, Harless C, Saint-Cyr M. Lymphaticovenous Bypass: Adaptations and Lessons Learned. Plast Reconstr Surg Glob Open. 2017;5(6):e1328.
26. De Brucker B, Zeltzer A, Seidenstuecker K, Hendrickx B, Adriaenssens N, Hamdi M. Breast Cancer-Related Lymphedema: Quality of Life after Lymph Node Transfer. Plast Reconstr Surg. 2016;137(6):1673-1680
27. Yamamoto T, Narushima M, Yoshimatsu H, et al. 510 Park et al. Minimally invasive lymphatic supermicrosurgery (MILS): indocyanine green lymphography-guided simultaneous multisite lymphaticovenular anastomoses via millimeter skin incisions. Ann Plast Surg 2014;72:67-70.
28. Shih HB, Shakir A, Nguyen DH. Use of Indocyanine Green-SPY Angiography for Tracking Lymphatic Recovery After Lymphaticovenous Anastomosis. Ann Plast Surg 2016;76 Suppl 3:S232-7.

 DOI 10.5281/zenodo.6544984

29. Chang EI, Skoracki RJ, Chang DW. Lymphovenous Anastomosis Bypass Surgery. Semin Plast Surg. 2018;32(1):22-27.
30. AlJindan FK, Lin C-Y, Cheng M-H. Comparison of Outcomes between Sideto- End and End-to-End Lymphovenous Anastomoses for Early-Grade Extremity Lymphedema. Plastic and Reconstructive Surgery. 2019;144(2):486-496.
31. Rosian K, Stanak M. Efficacy and safety assessment of lymphovenous anastomosis in patients with primary and secondary lymphoedema: A systematic review of prospective evidence. Microsurgery 2019;39:763-72.
32. Tourani SS, Taylor GI, Ashton MW. Long-Term Patency of Lymphovenous Anastomoses: A Systematic Review. Plast Reconstr Surg 2016;138:492-8.
33. Scaglioni MF, Fontein DBY, Arvanitakis M, et al. Systematic review of lymphovenous anastomosis (LVA) for the treatment of lymphedema. Microsurgery 2017;37:947-53.
34. Chang DW, Suami H, Skoracki R. A prospective analysis of 100 consecutive lymphovenous bypass cases for treatment of extremity lymphedema. Plast Reconstr Surg 2013;132:1305-14.
35. Jørgensen MG, Toyserkani NM, Sorensen JA. The effect of prophylactic lymphovenous anastomosis and shunts for preventing cancer-related lymphedema: a systematic review and meta-analysis. Microsurgery 2018;38:576-85.
36. Cheng MH, Loh CYY, Lin CY. Outcomes of Vascularized Lymph Node Transfer and Lymphovenous Anastomosis for Treatment of Primary Lymphedema. Plast Reconstr Surg Glob Open 2018;6:e2056.
37. Clodius L, Smith PJ, Bruna J, et al. The lymphatics of the groin flap. Ann Plast Surg 1982;9:447-58.
38. Suami H, Chang DW. Overview of surgical treatments for breast cancer-related lymphedema. Plast Reconstr Surg 2010;126:1853-63.
39. Schaverien MV, Badash I, Patel KM, et al. Vascularized Lymph Node Transfer for Lymphedema. Semin Plast Surg 2018;32:28-35.
40. Scaglioni MF, Arvanitakis M, Chen YC, Giovanoli P, Chia-Shen Yang J, Chang EI. Comprehensive review of vascularized lymph node transfers for lymphedema: Outcomes and complications. Microsurgery. 2018;38(2):222-229.
41. Pappalardo M, Patel K, Cheng MH. Vascularized lymph node transfer for treatment of extremity lymphedema: An overview of current controversies regarding donor sites, recipient sites and outcomes. J Surg Oncol. 2018;117(7):1420-1431. 22.
42. Cheng MH, Chen SC, Henry SL, Tan BK, Lin MC, Huang JJ. Vascularized groin lymph node flap transfer for postmastectomy upper limb lymphedema: flap anatomy, recipient sites, and outcomes. Plast Reconstr Surg. 2013;131(6):1286-1298.
43. Tourani SS, Taylor GI, Ashton MW. Vascularized Lymph Node Transfer: A Review of the Current Evidence. Plast Reconstr Surg. 2016;137(3):985-993.
44. Maldonado AA, Chen R, Chang DW. The use of supraclavicular free flap with vascularized lymph node transfer for treatment of lymphedema: A prospective study of 100 consecutive cases. J Surg Oncol. 2017;115(1):68-71.
45. Dayan JH, Dayan E, Smith ML. Reverse lymphatic mapping: a new technique for maximizing safety in vascularized lymph node transfer. Plast Reconstr Surg 2015;135:277-85.
46. Cook KH, Park MC, Lee IJ, Lim SY, Jung YS. Vascularized Free Lymph Node Flap Transfer in Advanced Lymphedema Patient after Axillary Lymph Node Dissection. J Breast Cancer. 2016;19(1):92-95.
47. Dumanian GA, Futrell JW. The Charles procedure: misquoted and misunderstood since 1950. Plast Reconstr Surg 1996;98:1258-63.
48. Miller TA, Wyatt LE, Rudkin GH. Staged skin and subcutaneous excision for lymphedema: a favorable report of long-term results. Plast Reconstr Surg 1998;102:1486- 98; discussion 99-501.
49. Brorson H, Svensson H. Liposuction combined with controlled compression therapy reduces arm lymphedema more effectively than controlled compression therapy alone. Plast Reconstr Surg 1998;102:1058-67; discussion 1068.
50. Bolletta A, Di Taranto G, Chen SH, et al. Surgical treatment of Milroy disease. J Surg Oncol 2020;121:175-81.
51. Hoffner M, Bagheri S, Hansson E, et al. SF-36 Shows Increased Quality of Life Following Complete Reduction of Postmastectomy Lymphedema with Liposuction. Lymphat Res Biol 2017;15:87-98.
52. Schaverien MV, Munnoch DA, Brorson H. Liposuction Treatment of Lymphedema. Semin Plas Surg 2018;32:42-7.
53. Boyages J, Kastanias K, Koelmeyer LA, et al. Liposuction for Advanced Lymphedema: A Multidisciplinary Approach for Complete Reduction of Arm and Leg Swelling. Ann Surg Oncol 2015;22 Suppl 3:S1263-70.
54. Klernäs P, Johnsson A, Boyages J, Brorson H, Munnoch A, Johansson K. Quality of Life Improvements in Patients with Lymphedema After Surgical or Nonsurgical Interventions with 1-Year Follow-Up. Lymphat Res Biol. 2020 Aug;18(4):340-350.
55. Brorson H, Ohlin K, Olsson G, et al. Quality of life following liposuction and conservative treatment of arm lymphedema. Lymphology 2006;39:8-25.
56. Sistrunk WE. Contribution to Plastic Surgery: Removal of Scars by Stages; an Open Operation for Extensive Laceration of the Anal Sphincter; the Kondoleon Operation for Elephantiasis. Ann Surg 1927;85:185-93.
57. Miller TA, Wyatt LE, Rudkin GH. Staged skin and subcutaneous excision for lymphedema: a favorable report of long-term results. Plast Reconstr Surg. 1998;102(5):1486-1498; discussion 1499-1501.
58. van der Walt JC, Perks TJ, Zeeman BJ, et al. Modified Charles procedure using negative pressure dressings for primary lymphedema: a functional assessment. Ann Plast Surg 2009;62:669-75.
59. Sapountzis S, Ciudad P, Lim SY, et al. Modified Charles procedure and lymph node flap transfer for advanced lower extremity lymphedema. Microsurgery 2014;34:439-47.
60. Karonidis A, Chen HC. Preservation of toes in advanced lymphedema: an important step in the control of infection. Ann Plast Surg 2010;64:446-50.
61. Granzow JW, Soderberg JM, Dauphine C. A novel two-stage surgical approach to treat chronic lymphedema. Breast J 2014;20:420-2.
62. Nicoli F, Constantinides J, Ciudad P, et al. Free lymph node flap transfer and laser-assisted liposuction: a combined technique for the treatment of moderate upper limb lymphedema. Lasers Med Sci 2015;30:1377-85.

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