Complex decongestive therapy combined with needle electrode stimulation facilitates postoperative rehabilitation of lymphedema

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ABSTRACT

Objective: To evaluate the clinical efficacy of complex decongestive therapy (CDT) combined with needle electrode stimulation (NES) in the management of lymphedema after lymphaticovenular anastomosis (LVA) and to compare its therapeutic outcomes with conventional CDT alone.

Methods: A retrospective analysis was conducted on 50 patients with secondary lymphedema who underwent LVA at the Department of Traumatic Orthopedics, Weifang People's Hospital, between June 2023 and June 2024. All patients met strict inclusion criteria and were randomly assigned to one of two groups: group A (CDT combined with NES; n = 25; 3 males, 22 females) and group B (CDT alone; n = 25; 3 males, 22 females). There was no significant difference in sex distribution between groups (χ^2 = 0.00; *P* > .99), indicating baseline comparability.

Results: No significant main effect of group was observed for limb swelling rate (*P* = .46; n = 50), indicating comparable overall swelling levels between groups. A significant main effect of time was found across all timepoints (preoperatively and at 2 weeks, 1 month, 3 months, 6 months, and 12 months postoperatively; *P* < .01; n = 25), suggesting a general decrease in swelling over time. Importantly, a significant group × time interaction was identified (*P* = .03; n = 25), indicating that the rate of decrease in swelling differed, with group A showing a greater and faster improvement. For quality of life assessed by the Lymphedema Life Impact Scale (LLIS), the between-group difference was not statistically significant (*P* = .09; n = 25). However, a significant time effect was observed (*P* < .01), and a significant group × time interaction (*P* = .02) indicated a more favorable trajectory in group A. No adverse events, including infection, poor wound healing, or cellulitis, were reported during the study.

Conclusions: CDT combined with NES demonstrates superior efficacy in decreasing limb swelling and improving Lymphedema Life Impact Scale scores compared with CDT alone in the postoperative management of lymphedema after LVA. This combination therapy significantly enhances postoperative recovery, suggesting its potential as a more effective approach for lymphedema rehabilitation. (J Vasc Surg Venous Lymphat Disord 2025;■:102337.)

Keywords: Lymphedema; Complex decongestive therapy; Needle electrode stimulation; Lymphaticovenular anastomosis

Lymphedema is a chronic pathological condition resulting from structural or functional abnormalities of the lymphatic system. It is characterized by impaired lymphatic drainage, leading to the accumulation of protein-rich interstitial fluid, which subsequently induces pathological changes such as edema, inflammation, fibrosis, and adipose tissue deposition. The pathophysiological mechanisms underlying lymphedema involve dysfunction of lymphatic vessel transport, abnormal lymphatic endothelial cell function, and limited regenerative capacity of lymphatic vessels.[1,2] Clinically, patients typically present with localized swelling, pain, and a sensation of heaviness in one or both limbs. In severe cases, recurrent infections, lower limb dysfunction, and significant impairment in quality of life may occur.[3]

Lymphaticovenular anastomosis (LVA) is currently one of the primary surgical treatments for lymphedema.[4] This procedure uses indocyanine green fluorescence lymphangiography and venous visualization techniques to identify critical lymphatic vessels and adjacent veins, enabling precise incision placement and selection of appropriate lymphatic vessels for anastomosis. By directly connecting lymphatic vessels to venous circulation, LVA facilitates the drainage of stagnant lymphatic fluid into the venous system, thereby alleviating lymphatic congestion.[5] However, the management of lymphedema requires long-term, and often lifelong, intervention,[6]

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underscoring the critical role of postoperative nursing care in optimizing patient outcomes after LVA.

Complex decongestive therapy (CDT) is a nonsurgical, nonpharmacological multimodal therapeutic approach and is widely recognized as the gold standard for lymphedema management.[7] A key component of CDT, manual lymphatic drainage, uses gentle massage techniques to enhance lymphatic return and effectively decrease limb swelling. Needle electrode stimulation (NES) is a technique that combines traditional acupuncture needling with transcutaneous electrical nerve stimulation. Its basic principle is to deliver a controllable electric current through the inserted needle to stimulate target tissues. Electroacupuncture stimulation has been shown to reopen occluded lymphatic vessels and induce skeletal muscle contractions.[8,9] As early as 2021, Gao et al[10] showed that acupuncture and moxibustion could effectively prevent lower limb lymphedema after pelvic lymph node dissection. Moreover, a meta-analysis confirmed that acupuncture and moxibustion have a beneficial effect on breast cancer-related lymphedema (BCRL), especially in decreasing lymphedema, swelling, and pain. NES, a technique combining traditional acupuncture with electrical stimulation, has been reported to improve local blood circulation and enhance tissue perfusion.[10] NES may also involve certain risks, such as skin infections, lymphatic vessel obstruction, and burns caused by excessive current, as well as abnormal cardiac electrical activity and abnormal muscle spasms induced by the current. However, none of these issues occurred in this study. In this study, we hypothesized that NES accelerates lymphatic drainage through lymphovenous anastomoses by promoting microvascular blood flow and muscle contraction–mediated lymphatic pumping. Additionally, NES therapy has been reported to improve local blood circulation and enhance tissue perfusion. In patients undergoing LVA, the anastomosed lymphatic vessels may benefit from accelerated blood flow, potentially improving the efficiency of lymphatic fluid drainage into the venous circulation. Therefore, integrating NES therapy into CDT may further enhance lymphatic return and facilitate edema reduction.

This study aimed to evaluate the clinical efficacy of CDT combined with NES in the management of lymphedema after LVA. A comparative analysis was conducted to assess the therapeutic outcomes of this combined approach vs conventional CDT alone. Specifically, the study sought to determine whether the addition of NES to CDT can expedite a decrease in limb swelling. Clinical data from 50 patients who underwent LVA at the Department of Traumatic Orthopedics, Weifang People's Hospital, between June 2023 and June 2024 were analyzed. Patients in group A received CDT combined with NES, and those in group B received CDT alone. The findings of this study may provide valuable insights into optimizing postoperative nursing care and improving clinical outcomes in patients with lymphedema after LVA.

ARTICLE HIGHLIGHTS

- **Type of Research:** Single-center retrospective cohort study
- **Key Findings:** Among 50 patients who underwent lymphaticovenular anastomosis, those in the complex decongestive therapy (CDT) plus needle electrode stimulation group (group A) showed significantly faster limb swelling reduction than the CDT-only group (group B) ($P < .01$). No complications such as infection, poor wound healing, or cellulitis occurred in either group during the 6-month follow-up. Group A also had significantly better Lymphedema Life Impact Scale quality of life scores than group B ($P < .01$).
- **Take Home Message:** Needle electrode stimulation combined with CDT demonstrates significantly better outcomes than CDT alone in accelerating edema resolution and enhancing quality of life for patients following lymphovenous anastomosis.

METHODS

Inclusion and exclusion criteria

Patients were included in the study if they met the following criteria: (1) diagnosis of secondary lymphedema (eg, lymphedema resulting from lymphatic vessel injury owing to limb trauma, disruption of lymphatic drainage after lymph node dissection, or tumor excision); (2) age between 18 and 70 years; (3) presence of unilateral lymphedema; (4) underwent LVA surgery; (5) received postoperative nursing interventions; and (6) availability of complete follow-up data. Patients were excluded if they met any of the following criteria: (1) history of previous lymphatic surgery; (2) presence of proximal vascular abnormalities or malformations; (3) diagnosis of chylothorax or chyloperitoneum; (4) progressive deterioration of the primary disease; (5) presence of multiple-site lymphedema; or (6) loss to follow-up.

General clinical data

A retrospective analysis was conducted on the clinical records of 50 patients with lymphedema who underwent LVA at the Department of Traumatic Orthopedics, Weifang People's Hospital, between June 2023 and June 2024. Patients were assigned to group A (CDT combined with NES therapy) or group B (CDT alone). All CDT interventions were administered by the same nursing team to ensure consistency in treatment.

As shown in Table I, there were no statistically significant differences between the two groups in terms of age, sex, affected limb (left or right), lymphedema classification, or primary disease etiology ($P > .05$). For normally distributed continuous variables, a t test was performed, and categorical variables were analyzed using the χ^2 test.

Table I. Comparison of clinical characteristics between the two groups

Variables	Group A	Group B	Test statistic	*P* value
Sex			0.00	>.99
Male	3	3		
Female	22	22		
Age, years	61.76 ± 10.54	57.88 ± 11.52	1.242	.220
Interval from trauma/surgery to LVA, months	32.00 ± 17.04	35.08 ± 14.13	−0.696	.49
Stage			0.93	.818
I	5	6		
II	10	8		
III	5	6		
IV	5	5		
Affected Side			1.23	.785
Left upper limb	6	4		
Right upper limb	2	4		
Left lower limb	9	8		
Right lower limb	8	9		
Etiology			0.94	.33
Malignant tumor	17	20		
Trauma	8	5		

LVA, Lymphaticovenular anastomosis.
Values are number or mean ± standard deviation.

This retrospective study was approved by the Ethics Committee of Weifang People's Hospital (Approval No. KYLL20250402-3). The requirement for informed consent was waived owing to the anonymized retrospective nature of the data.

Nursing interventions

All procedures were performed by the same nursing team. Surgical sutures at the incision site were removed 14 days postoperatively, followed by the initiation of a CDT regimen.

Key screening criteria for lymphatic vessels. During the operation, target lymphatic vessels are identified via indocyanine green (ICG) fluorescent lymphography (ICG, diagnostic grade, 0.1 mL intradermal injection), with centripetal fluorescent flow appearing within 10 minutes after ICG injection. Priority is given to those located at the proximal end of the edematous area and the penetration points of the deep fascia. Additionally, they should have no palpable induration (to rule out fibrosis) and no ICG extravasation.[9]

Pretreatment assessment. Before the intervention, a thorough assessment of skin integrity was conducted.

Manual Lymphatic Drainage. Patients were positioned in a supine posture. The nursing team applied static rotational stimulation techniques to lymph nodes, lymphatic vessels, and the lymphatic structures surrounding the surgical incision to facilitate lymphatic drainage. Subsequently, centripetal manual lymphatic drainage was performed to enhance lymphatic circulation, directing lymphatic fluid into adjacent functional lymphatic pathways and small veins, thereby reducing lymphatic fluid stasis. The technique emphasized gentle, superficial, rhythmic strokes to avoid skin irritation. Each session lasted approximately 60 minutes.

NES (group A only). Sterile disposable needles (0.3 mm × 40 mm) were used for NES at an intensity of 3 to 5 mA. Needle insertion sites were selected along the projected surface course of the LVA. Specifically, two or three stimulation points were located 1 cm above and below the incision, avoiding major vessels (eg, the ulnar artery in the upper limb or posterior tibial artery in the lower limb). Needles were inserted 1 to 3 cm from the center of the LVA incision, to a subcutaneous depth of 0.5 to 1.0 cm in the upper limb (reaching the superficial fascia without penetrating muscle) and 1.0 to 1.5 cm in the lower limb (passing through subcutaneous fat to the lymphatic-rich superficial fascia). The duration of electrical stimulation was 25 minutes each.

Compression bandaging. After manual lymphatic drainage (and electroacupuncture for group A), both groups underwent compression bandaging with a retention bandage applied around the toe joints and foot (for upper limb lymphedema: finger joints and palm), a cotton bandage wrapped from the foot to the proximal thigh (for the upper limb: from the palm to the proximal upper arm), and an elastic bandage applied in an overlapping manner (50% overlap) from the dorsum of the foot to the proximal thigh (for the upper limb: from the palm to the proximal upper arm). The bandage pressure was carefully controlled, ensuring a gradient that decreased from distal to proximal. Functional positions of the popliteal fossa and ankle (for the upper limb: elbow and wrist) were maintained throughout the process.

All procedures were initiated 14 days post LVA surgery (after suture removal) and repeated twice weekly for 3 months. The standardized protocol included the following. After 3 months, patients were instructed to continue the interventions at home. Group A continued CDT combined with NES, and group B received CDT alone. Home-based interventions were conducted biweekly for 12 months postoperatively.

Post-treatment care instructions. After each nursing session, patients were advised to (1) clean the skin before and after treatment and avoid vigorous scrubbing, (2) keep skin folds dry and clean, (3) protect the skin from sun exposure, trauma, compression, and insect bites, (4) wear loose, comfortable shoes and socks, and (5) perform appropriate functional exercises to promote lymphatic fluid return.

Efficacy assessment

Limb swelling rate. The swelling rate of the affected limb was calculated using the formula:

$$\textit{The swelling rate of the affected limb}(\%) = (\textit{circumference of the affected limb} - \textit{circumference of the healthy limb}) / \textit{circumference of the healthy limb} \times \%$$

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A single evaluator used a nonelastic soft measuring tape to assess 10 predefined anatomical sites on patients with lower limb lymphedema (foot, ankle, lower one-third of the calf, mid-calf, upper one-third of the calf, knee, lower one-third of the thigh, mid-thigh, upper one-third of the thigh, and proximal thigh) and upper limb lymphedema (hand, wrist, lower one-third of the forearm, mid-forearm, upper one-third of the forearm, elbow, lower one-third of the upper arm, mid-upper arm, upper one-third of the upper arm, and proximal upper arm) at each follow-up visit. The mean swelling rate was calculated for each patient.

Lymphedema Life Impact Scale. The Lymphedema Life Impact Scale (LLIS) questionnaire was used to comprehensively assess the impact of lymphedema on patients' quality of life.

Postoperative complication monitoring. The occurrence of postoperative complications, such as anastomotic issues, hematoma, and infections, was systematically recorded and analyzed.

Statistical analyses

Statistical analysis was performed using SPSS 25.0 software. Continuous variables were expressed as mean ± standard deviation. A repeated measures analysis of variance was conducted to assess the longitudinal changes in lymphedema severity over time and to compare the therapeutic effects between the two groups. A significance level of P value of less than .05 was considered statistically significant.

RESULTS

Evaluation of limb swelling rate. Follow-up assessments were conducted for both groups at baseline (preoperative), 2 weeks, 1 month, 3 months, 6 months, and 12 months postoperatively. Valid follow-up data were obtained at all timepoints, and the results are summarized in Table II.

Analysis of variance was performed to evaluate changes in limb swelling over time. Mauchly's test of sphericity indicated a violation of the sphericity assumption ($W = 0.079$; $P < .01$); therefore, the Greenhouse-Geisser correction was applied. The analysis revealed a statistically no significant difference in limb swelling between the two groups ($P = .56$). Additionally, a significant interaction effect was observed between time and treatment group ($P = .03$), suggesting that the degree of lymphedema improved over time in both groups ($P < .01$), with a more pronounced reduction in swelling observed in group A compared with group B (Fig, *A*) at different postoperative timepoints. The statistical analysis indicates a significant between-group difference ($P = .036$), a significant time effect ($P < .01$), and a significant interaction effect ($P < .01$), demonstrating that limb swelling gradually decreased over time in both groups, with a more rapid reduction observed in group A.

Results of the LLIS. Both groups of patients were followed, and effectiveness follow-up data were collected before surgery, 2 weeks after surgery, 1 month after surgery, 3 months after surgery, 6 months after surgery, and 12 months after surgery. No complications, such as infection, poor wound healing, or cellulitis, were observed in either group. The follow-up results are summarized in Table III.

A repeated measures analysis of variance was performed. The sphericity assumption was violated ($W = 0.213$; $P < .01$), prompting the use of the Greenhouse-Geisser correction. The analysis revealed no significant differences in the LLIS scores between the two groups ($P = .09$). Additionally, a significant interaction effect was observed between time and treatment group ($P = .02$). These findings suggest that, over time, the impact of lymphedema on the patients' quality of life decreased in both groups ($P < .01$), with group A showing a more rapid reduction in the impact compared with group B (Fig, *B*).

DISCUSSION

Our results showed that, compared with CDT alone, the combined application of NES and CDT in post-LVA rehabilitation significantly accelerated the resolution of swelling

Table II. Comparison of limb swelling rate between the two groups

Timepoint	Group A (n = 25)	Group B (n = 25)	F	*P* value
Preoperative	40.64 ± 5.09	40.24 ± 4.68	0.084	.774
2 Weeks postoperative	37.60 ± 4.70	37.96 ± 4.62	0.075	.786
1 Month postoperative	34.92 ± 4.43	36.08 ± 4.64	0.817	.370
3 Months postoperative	31.04 ± 4.20	32.36 ± 4.42	1.168	.258
6 Months postoperative	26.92 ± 4.26	27.44 ± 4.30	0.184	.670
12 Months postoperative	21.84 ± 4.02	24.12 ± 3.56	4.507	.039
F	195.65	145.71		
P value	<.01	<.01		
Overall test				
Within-group effect (F, *P*)	(0.56, .46)			
Time effect (F, *P*)	(670.45, <.01)			
Interaction effect (F, *P*)	(3.26, .03)			

Values are mean ± standard deviation.

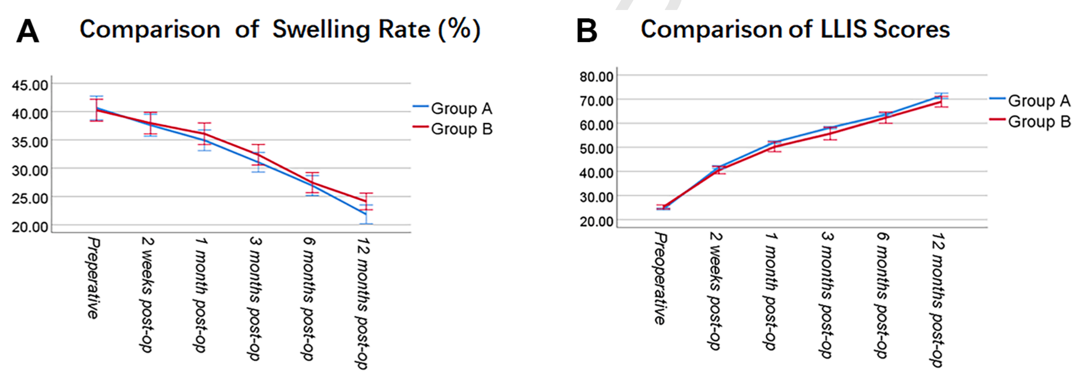

Fig 1. (A) The change trend of Limb swelling Rate (%) and **(B)** Lymphedema Life Impact Scale (LLIS) Scores between the two groups over time.

Table III. Comparison of Lymphedema Life Impact Scale (LLIS) scores between the two groups

Timepoint	Group A (n = 25)	Group B (n = 25)	F	*P* value
Preoperative	24.40 ± 0.91	25.24 ± 2.01	7.35	.06
2 Weeks postoperative	41.80 ± 1.41	40.52 ± 3.69	12.91	.11
1 Month postoperative	52.12 ± 1.36	50.20 ± 4.95	17.10	.07
3 Months postoperative	58.16 ± 1.25	55.68 ± 6.28	3.33	.06
6 Months postoperative	63.56 ± 1.29	62.92 ± 5.69	0.99	.28
12 Months postoperative	71.36 ± 2.64	68.92 ± 5.30	0.72	.05
F	706.42	658.78		
P value	<.01	<.01		
Overall test				
Between groups (F, *P*)	(2.91, .09)			
Time (F, *P*)	(2548.07, <.01)			
Interaction (F, *P*)	(3.63, .02)			

Values are mean ± standard deviation.

in the affected limb (*P* = .03) and improved the recovery trajectory of the LLIS quality of life score (*P* = .02). The faster swelling resolution in group A (CDT + NES) confirms our initial hypothesis that NES may enhance lymphatic fluid pumping through muscle contraction and optimize anastomotic function by improving local hemodynamics, thereby synergizing with CDT to accelerate the resolution of postoperative lymphedema. This finding supports the study by Gao et al, who reported that acupuncture can reduce postoperative edema. The synergistic effect observed in this study provides a new idea for the application of NES combined with CDT in rehabilitation therapy for patients after LVA.[10]

Lymphedema can be categorized into primary and secondary types based on its etiology. Primary lymphedema is typically associated with abnormalities in the development of the lymphatic vascular system. It may be linked to various genetic syndromes or occur idiopathically. Secondary lymphedema, in contrast, is acquired and results from obstruction of the lymphatic vessels or lymph nodes, often owing to surgery, trauma, infection, or other forms of damage to the lymphatic system. This obstruction impedes lymphatic drainage and leads to fluid retention and swelling.[11,12] Because the focus of this study was on evaluating the effects of different nursing methods on lymphatic fluid reflux, patients with primary lymphedema were excluded from the study. Secondary lymphedema is more commonly observed in cancer patients, particularly those whose lymph nodes have been compromised through surgical procedures or chemotherapy, thus obstructing the normal flow of lymphatic fluid.[13]

LVA is a surgical technique that redirects lymphatic fluid through the venous system, offering an alternative route for fluid drainage. This method facilitates the transfer of lymphatic fluid to upstream areas of lymphatic obstruction, thus alleviating fluid congestion and decreasing edema. The process relies on the pressure gradient between the high-pressure lymphatic vessels and the low-pressure venous system, which enables the lymphatic fluid to reenter the bloodstream.[13] Studies have demonstrated that CDT significantly improves fatigue, sleep quality, and the overall quality of life in patients with lymphedema after breast cancer surgery.[14] As a result, CDT is recommended as an integral component of the rehabilitation protocol for lymphedema after breast cancer surgery. In addition, research by Vo et al[15] has established that CDT is an effective treatment for BCRL, significantly decreasing limb volume and improving function. Patients with smaller limb volumes before treatment and those undergoing treatment for the first time show the most pronounced benefits, highlighting the importance of early intervention. The medical team led by Wang[16] reported the case of a 40-year-old female patient with stage IV lymphedema in both lower limbs, 6 years after endometrial cancer treatment. After 6 months of CDT therapy and three LVA procedures, the patient lost 49 kg, and the maximum circumference of her left and right lower limbs decreased by 35.2 cm and 37.5 cm, respectively. The patient's leg pain was alleviated, swelling was significantly reduced, and she returned to a nearly normal lifestyle.

Lu et al[17] treated BCRL of the upper extremity with transcutaneous electrical acupoint stimulation combined with warm acupuncture. In terms of therapeutic effect, the sense of swelling was alleviated in both groups, and the visual analog scale score of the treatment group (electrical stimulation group) was significantly lower than that of the control group (CDT therapy alone) ($P < .01$). They believe that transcutaneous electrical acupoint stimulation improves local microcirculation, promotes lymphatic vessel reconstruction and leukocyte phagocytic function, and, at the same time, the tissue fluid overflowing from the needle holes may reduce the edema pressure of the affected limb. Meanwhile, the mechanical action of skeletal muscle contraction helps to reopen the lymphatic flaps in muscle tissue, promotes lymphatic flow, and relives lower extremity lymphedema. Additionally, acupuncture can enhance metabolism and increase blood circulation, which accelerates the resolution of stagnated lymphatic fluid. Localized acupuncture, particularly targeting microvessels crucial for lymphatic reflux, plays a vital role in restoring normal lymphatic drainage.[9] Jeong et al[18] demonstrated that acupuncture can significantly reduce the severity of postmastectomy lymphedema, with improvements observed in both subjective symptoms and objective circumference measurements, and the effect can be sustained for at least 4 weeks. Additionally, the treatment showed good safety profile with no serious adverse reactions reported. Yao et al[19] conducted a randomized controlled trial to compare the efficacy of warm acupuncture and diosmin in the treatment of breast cancer-related chronic lymphedema. The results indicated that, compared with diosmin, warm acupuncture was more effective in reducing the degree of lymphedema at specific acupoints, improving patients' quality of life, and exhibited favorable clinical safety without adverse effects on the blood and cardiovascular systems.

Chronic inflammation in lymphedema tissues often leads to fibrosis and abnormal adipose tissue deposition, contributing to morphological and functional impairments of the lymphatic vessels. Such abnormalities exacerbate lymphatic reflux obstruction and promote inflammatory cell infiltration, creating a detrimental cycle of worsening lymphedema.[20] Consequently, improving the local inflammatory microenvironment is a critical aspect of lymphedema treatment. Wang et al[21] developed an innovative piezoelectric microneedle system mediated by ultrasound. This noninvasive technology provides localized electrical signals that regulate macrophage polarization, inhibit inflammation and fibrosis, and promote lymphangiogenesis.

CONCLUSIONS

Both CDT and NES have demonstrated efficacy in alleviating lymphedema and reducing the degree of limb swelling. In the present study, the combination of CDT and NES showed superior results in reducing lymphedema after LVA compared with the use of CDT alone.

LIMITATIONS

This study aimed to evaluate the effectiveness of CDT combined with NES in treating lower limb lymphedema by analyzing the swelling rate of the affected limb and comparing it with that of the healthy limb. As a result, only patients with unilateral lower limb lymphedema were included, and those with bilateral lymphedema were excluded. However, bilateral lymphedema, particularly secondary to malignant tumors, is common in clinical practice. Based on the findings of this study, it can be inferred that, for patients with secondary bilateral lymphedema after LVA surgery, the combination of CDT and NES may offer superior outcomes compared with CDT alone. Additionally, patients with primary lymphedema were not included in this study owing to the generally poor therapeutic effects of LVA surgery for this condition. Therefore, patients with primary lymphedema were not part of the study cohort.

AUTHOR CONTRIBUTIONS

Conception and design: QW, LA, LX, XL, QT, XS
Analysis and interpretation: LA, XL, LL, NF, XS
Data collection: QW, WZ, QT, XS
Writing the article: QW, LA, WZ, XL, LL, XS
Critical revision of the article: QW, LX, QT, NF, XS
Final approval of the article: QW, LA, LX, WZ, XL, LL, QT, NF, XS
Statistical analysis: QW, LA
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Overall responsibility: NF

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AVAILABILITY OF DATA AND MATERIALS

All data generated or analysed during this study are included in this published article.

DISCLOSURES

None.

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