

Case Control Study

Effectiveness of six-step complex decongestive therapy for treating upper limb lymphedema after breast cancer surgery

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Abstract

BACKGROUND

Complex decongestive therapy (CDT) is currently recommended as the standard treatment for lymphedema. CDT is a four-step detumescence therapy that can effectively treat upper limb lymphedema after breast cancer surgery, and is considered non-invasive, painless and without side effects.

AIM

To determine the effectiveness of a six-step CDT involving a foam granule bandage for the treatment of upper extremity lymphedema pressure after breast cancer surgical intervention.

METHODS

The study included 100 patients with upper extremity lymphedema after breast cancer surgery. The surgical methods were mastectomy plus axillary lymph node dissection and breast preservation plus sentinel lymph node biopsy. The study population was further divided into the experimental group and control group with 50 cases in each group. The control group was given conventional CDT (four-step method), which included skin care, freehand lymphatic drainage, foam granule pressurized bandage, and functional exercise. In the experimental group, a six-step CDT method was applied that involved a foam particle bandage combined with air wave pressure therapy in addition to the four steps of conventional CDT. Patients in both groups were given one course of treatment daily (20 times), and the changes in body moisture and subjective symptoms were measured before and after treatment, preoperatively and 20 times after treatment.

RESULTS

No statistically significant differences in 50-Hz bioelectrical impedance and extracellular moisture ratio were observed between the two groups before treatment, suggesting comparability of the baseline data. After treatment, the 50-

Hz bioelectrical impedance of the experimental group was significantly higher than that in the control group, and the extracellular moisture ratio was significantly lower than that in the control group. A comparison of the differences between the two groups before and after treatment indicated that the treatment effect in the experimental group was better than that in the control group. After 20 treatments, according to subjective evaluations, the tightness and swelling of the limbs in the experimental group were significantly reduced as compared with those in the control group.

CONCLUSION

The six-step CDT method can effectively reduce lymphedema, promote lymphatic circulation, and alleviate the subjective symptoms of patients, and thereby improve the quality of life and treatment compliance among patients.

Key Words: Comprehensive deswelling; Foam granule bandage; Breast cancer; Upper limb lymphedema; Air pressure wave therapy

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Core Tip: The purpose of this study was to determine the effectiveness of six-step complex decongestive therapy for the treatment of upper limb lymphedema after breast cancer surgery. The results showed that this method could effectively reduce edema of the upper extremity, reduce local tissue congestion, and promote lymph circulation.

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INTRODUCTION

Breast cancer is the most common malignant tumor amongst women, accounting for 23% of all cancer cases and 14% of all cancer-related deaths in women[1]. Moreover, the incidence of breast cancer is increasing in most countries[2]. Surgical intervention is considered an important component in the management of breast cancer patients. According to the literature, upper limb lymphedema is one of the most common and most serious complications after breast cancer surgery. The incidence of unilateral arm lymphedema post-breast cancer treatment ranged from 8.4% to 21.4%[3]. Another study reported that the incidence of secondary lymphedema caused by nonspecific cancer in a UK lymphedema specialist clinic ($n = 11555$) was 2.05-3.99:1000[4]. Risk factors for lymphedema include obesity at the time of cancer diagnosis, chemotherapy, adjuvant radiotherapy, surgical methods, physical therapy and the number of axillary lymph nodes removed[3,5].

Currently, the frequency of lymphedema after contemporary surgery of the axilla is much lower, but lymphedema remains a major problem. Damage to the lymphatic system after surgery accompanied by protein leakage and abnormal accumulation thereof in the tissue space of the ipsilateral upper arm can lead to lymphatic flow obstruction, swelling, pain, fatigue, secondary infection, and extremity dysfunction in the affected upper limb[6]. Patients with lymphedema may be afflicted with the disease for their entire life and are likely to suffer from an abnormal appearance of the limb, susceptibility to fatigue, repeated limb infections and limb dysfunction, which seriously affects their quality of life after surgical intervention[7]. Active and effective treatment for upper limb lymphedema is very important for improving the health and quality of life of patients after breast cancer treatment. Complex decongestive therapy (CDT) is currently recommended as the standard treatment for lymphedema. CDT is a four-step detumescence therapy that can effectively treat upper limb lymphedema after breast cancer surgery, and is considered non-invasive, painless and without side effects[8-10]. CDT typically involves manual lymphatic drainage, elastic bandage compression, limb function exercises, and personalized skin care[7-11]. However, for the purposes of reducing scar formation and preventing axillary reticulum syndrome, this study added two steps to create a six-step CDT approach that included the use of a foam type granule bandage, which was applied for the treatment of upper extremity lymphedema pressure.

MATERIALS AND METHODS

Study design

This study was approved by the Hospital Ethics Committee (GYX2020-002). The study reporting adheres to the law of China and the 2008 version of the Declaration of Helsinki. Written informed consent forms were signed by all participants or their legally authorized guardians regarding the diagnosis, pathology, and publication of the patients' personal information in article form. A total of 100 patients with upper extremity lymphedema after breast cancer surgical intervention who were admitted to the lymphedema clinic of our hospital from March 2019 to December 2019 were selected by a convenience sampling method. Patients who met the inclusion and exclusion criteria and signed the informed consent form were directly included as research subjects. All the patients were then equally divided into the experimental group and the control group with 50 patients in each group. The inclusion criteria were: (1) Diagnosis of subcutaneous soft tissue lymphedema of the upper extremity by lymphography and/or color ultrasound; (2) no prior CDT; (3) age ≥ 18 years; (4) education level above primary school level with certain reading and writing abilities; and (5) agreement to participate in the study and provision of informed written consent. Patients were excluded according to the following criteria: (1) Past or current history of a psychiatric disorder; (2) already identified recurrence, distant metastasis or metastatic cancer; (3) serious systemic diseases related to the heart, lung, liver and kidney; (4) past history of severe complications such as severe systemic infection, anemia and cachexia; (5) past history of thrombus and tumor emboli; (6) local infections such as ulcers and bleeding tendencies; or (7) inability to continue the treatment due to physical reasons during the treatment process. The demographic and clinical data of the patients are presented in [Table 1](#).

Treatment

The patients were assessed and treated at the ambulatory clinic of Sun Yat-sen University Cancer Center by a senior nurse with an internationally recognized lymphedema therapy certification, who is also called a lymphedema therapist. According to the Vodder method, the patient was completely relaxed. The therapist used the large and small thenar muscles of the palm or the closed index finger, middle finger and ring finger to touch the nearby superficial lymph nodes with moderate strength to stimulate superficial lymph nodes, to dredge the lymphatic channels and accelerate lymphatic circulation. All patients completed one course (20 treatments over 28 days) of the six-step treatment. Skin care was provided by the lymphedema therapist for approximately 10 min. Upon completion of manual lymphatic drainage, the patients were treated with air pressure wave therapy for 15 min and then with bandages. This was followed by functional exercises supervised by a lymphedema therapist. The entire treatment process took approximately 1.5 h per day.

Conventional decongestion therapy in the control group

The control group was given conventional CDT (international standard four-step method). The steps were as follows:

Skin care: The objectives of the skin care component were to clean the skin and address any skin-related complications. Firstly, the patients were instructed to wash and dry their skin using pH-neutral soap. Any wrinkled skin was kept clean and dry. A further goal was to protect the skin from cuts, abrasions, and bites (especially sensitive skin). Finally, complications such as skin keratosis, fungal infection, lymphatic leakage, ulcers and lymphangitis were treated.

Manual lymphatic drainage: The therapist touched the affected side of the limbs from the distal end to the proximal end of the heart along the superficial lymphatic vessels, with circular propulsion, rotary propulsion, and spoon-shaped propulsion. The drainage procedure was started at the beginning of the chest wound after surgery, *i.e.*, wound scar after mastectomy and breast conserving operation, and then moved to the upper side of the chest (drainage to the contralateral axillary or ipsilateral supraclavicular lymph nodes), the lower side of the chest wound (drainage to the ipsilateral inguinal lymph nodes), the medial lymph nodes of the upper arm (drainage to the supraclavicular lymph nodes), the medial lymph nodes of the upper arm (drainage to the ipsilateral inguinal lymph nodes through the dorsal armpit or dorsal side of the body), the lymph nodes on the back of the hand, the palm and forearm (drainage to the cubital fossa lymph nodes) and, finally, the lateral upper arm. The touching technique needed to be gentle to avoid local skin reddening[12-14]; a pressure of 25-30 mmHg was applied.

Pressure dressing of foam granule bandage: The retaining bandage was wound around the finger joint and hand. Cotton bandages were run from the hand to shoulder. The foam pellet bandage started at the hand and was wrapped under the shoulder with a 50% overlap. The short stretch bandage started at the back of the hand and was then wrapped under the shoulder with 50% overlap. The pressure gradient was gradually decreased from the distal to the proximal end. During the dressing, the socket was kept in the functional position. The high elastic bandage was applied from the back of the hand. The pressure was drawn into a square pattern according to each pattern set on the surface of the bandage and wound under the shoulder with 50% overlap. The elastic bandage layer should be tightly wrapped to

Table 1 Demographic and clinical data of the two groups

	Control group (n = 50)	Experimental group (n = 50)	χ^2	P
Age, yr	46.32 ± 10.08	49.50 ± 11.64	1.683	0.195
< 50	38	31		
≥ 50	12	19		
Academic level			2.319	0.314
Primary school	12	7		
Middle school	27	34		
Bachelor degree or above	11	9		
Cancer staging			2.186	0.335
I	5	7		
II	9	14		
III	36	29		
Type of operation			0.177	0.674
Mastectomy plus axillary lymph node dissection	48	46		
Breast conserving plus sentinel lymph node biopsy	2	4		
Chemotherapy	46	49	0.842	0.359
Radiotherapy	32	41	3.247	0.072
Duration of postoperative edema (mo)			6.398	0.094
< 3	1	4		
3-6	7	3		
6-12	8	3		
> 12	34	40		

accommodate the finger. The pressure was maintained appropriately, as making the bandage too tight could affect the blood circulation of the affected limb and leaving it too loose would not achieve the therapeutic effect[15].

Functional exercises: After bandaging, the patients were instructed to partake in functional exercise, and each joint was moved according to the six-step health exercise[15]. During exercising, the muscles expand and contract, and the bandage resisted muscle expansion and exerted force on the intermittent pressure of deep tissue. When resting, the muscle relaxes, and the bandage's resilience acts on the tissue to produce persistent pressure, thereby promoting the flow of lymph. This protocol is consistent with the guidelines for preventing upper limb lymphedema proposed by the National Lymphedema Network in 2003[16]. The patients were advised to practice self-care to prevent lymphedema by avoiding the following things: infusion into the affected limb (to avoid increasing the circulation load of the affected limb); measuring blood pressure; wearing tight jewelry; performing any swinging, throwing, pulling, or pressing movements; lifting weights; damaging the skin; exposing the affected limb to excessive heat or cold; and wearing elastic cuffs for extended periods of time. In addition, during airplane flights, the cabin pressure is less than the atmospheric pressure on the ground. As the plane rises from sea level to an altitude of 6000-8000 feet, the pressure in the cabin decreases further. Reduced cabin pressure leads to changes in tissue pressure that may worsen lymphedema. Therefore, when flying, patients should wear elastic sleeves and perform unarmed lymphatic drainage.

Six-step therapy in the experimental group

The experimental group received six steps of CDT. The additional two steps were as follows:

Treatment of scar tissue: Firstly, the nurse opened the lymphatic pathways as mentioned earlier. Then, the therapist touched the superficial lymph nodes with their index finger, middle finger, and ring finger, applying a static rolling motion with moderate intensity. The nodes were touched in the following order: supraclavicular lymph nodes, cervical lymph nodes, anterior and posterior auricular lymph nodes, sternal lymph nodes, axillary nodes, elbow lymph nodes, thoracic lymph nodes, dorsal lymph nodes and inguinal lymph nodes[12]. Then the therapist used the finger pulp of both hands to relieve

the scar tissue, loosen the connective tissue, and reduce the scar contraction, which further led to reductions in lymphatic compression and backflow obstruction and increased the range of motion of the shoulder joint.

Foam granule bandage combined with an air wave pressure therapy instrument: A foam granule bandage combined with a POWER-Q6000 air wave pressure therapy instrument was used for treatment. The instrument is produced in Korea, and includes two parts: an electric air pressure pump and an inflatable sleeve. The sleeve generally has six cavities, and the nurse works one by one after inflating the sleeve along the long axis of the limb to the root of the limb press. The patient was placed in the supine position, and then a foam pellet bandage was wrapped around the back of the hand with 50% overlap until it reached below the shoulder. Then the whole affected limb was wrapped with the upper limb cuff of the air wave pressure therapy instrument containing 6 air sacs. The nurse then pressed the area from the distal end to the proximal end of the full circle with pneumatic pressure in an orderly manner. The pressure was increased gradually from 25 to 30 mmHg. The maximum pressure was kept at 45 mmHg, once a day, for 15 min. At the same time, according to the observation and analysis of subjective and objective symptoms, the subjective symptoms were numbness and pain of the affected limbs and fingers, and the objective symptoms were dark purple and cold fingers. If the patient felt uncomfortable with the affected limb or had dark purple fingers on the affected side, the treatment was suspended immediately[17].

Observational indices and methods

Bioelectrical impedance analysis (BIA): Bioelectrical impedance analysis (BIA) was used to measure the change in body water content before and after treatment. Electrical impedance is one of the most important physical characteristics of the human body. The body bioelectrical impedance (50 HKz) and extracellular moisture ratio of patients in both groups were compared from before the start of the session to after the 20th session. A lower bioelectrical impedance indicated a higher extracellular moisture ratio, indicating more serious edema[9]. An InBody S10 body composition monitor (BCM) was used to measure the trunk bioelectrical impedance and extracellular water ratio at 50 Hz before treatment (the first time) and after treatment (the 20th time).

Subjective symptom evaluation

The Lymphedema and Breast Cancer Questionnaire (LBCQ) 17, which includes 19 lymphedema-related symptoms, including numbness, tightness, stiffness, pain and heaviness, *etc.* was used to evaluate the occurrence of lymphedema-related symptoms in patients at the present time, in the past 1 mo and in the past 1 year. The patients answered "1" or "0". The internal consistency coefficient of the questionnaire was 0.785, and the retest reliability was 0.98018. This study was analyzed and discussed by members of the research group according to the conditions of patients in this study. Six items of tightness, pain, numbness, stiffness, swelling, and limited shoulder movement were selected and evaluated by lymphedema specialist nurses before and after each course of treatment, *i.e.*, after the 20th cycle.

Statistical methods

SPSS version 25.0 (IBM Corporation, Armonk, NY, United States) was used for statistical analysis. The Mann-Whitney U test, χ^2 test, and Fisher exact test were used to analyze the differences between the two groups.

RESULTS

Comparison of bioelectrical impedance and extracellular moisture ratio between the two groups

In both groups, the body water content was compared before treatment and after the 20th session. The results of the study showed that the body water content was significantly improved after treatment in the experimental group as compared with the control group ($P < 0.05$, Table 2).

Comparison of subjective symptoms of affected limbs

The subjective symptoms were compared between the experimental group and the control group before and after treatment. The results of the study found that the subjective symptoms were improved in both groups. After treatment, the body tension and swelling were more effectively reduced in the experimental group compared with the control group ($P < 0.001$; Table 3).

DISCUSSION

Lymphedema is a chronic progressive disease associated with a high rate of recurrence and

Table 2 Comparison of bioelectrical impedance and extracellular moisture ratio between the two groups

Group	50-Hz electrical bioimpedance (Ω)			Extracellular moisture ratio (%)		
	Pre-treatment	Post-treatment	d1	Pre-treatment	Post-treatment	d2
Control group (<i>n</i> = 50)	128.06 ± 27.83	213.34 ± 33.14	85.28 ± 26.10	0.393 ± 0.012	0.384 ± 0.006	-0.008 ± 0.006
Experimental group (<i>n</i> = 50)	128.54 ± 26.17	264.54 ± 40.43	136.00 ± 32.13	0.394 ± 0.011	0.371 ± 0.007	-0.023 ± 0.011
U	1217	401	227.5	1134.5	130	216
P	0.82	< 0.01	< 0.01	0.42	< 0.01	< 0.01

Table 3 Comparison of the number of cases with subjective relief of affected limb symptoms between the two groups

Time	Group		Tightness	Pain	Numbness	Stiffness	Limited swelling	Shoulder movement
Before treatment (0 time)	Control group (<i>n</i> = 50)	yes	49	13	20	15	50	8
		no	1	37	30	35	0	42
	Experimental group (<i>n</i> = 50)	yes	50	11	23	17	50	10
		no	0	39	27	33	0	40
	χ^2	--	0.219	0.367	0.184	--	0.271	
	P	> 0.999 ^b	0.640 ^a	0.545 ^a	0.668 ^a	1.000 ^c	0.603 ^a	
Post-treatment (20 times)	Control group (<i>n</i> = 50)	yes	10	3	5	4	18	3
		no	40	47	45	46	32	47
	Experimental group (<i>n</i> = 50)	yes	2	1	1	3	4	1
		no	48	49	49	47	46	49
	χ^2	6.061	--	--	--	11.422	--	
	P	0.014 ^a	0.617 ^b	0.204 ^b	> 0.999 ^b	0.001 ^a	0.617 ^b	

^aThe difference between the two groups was analyzed by χ^2 test;

^bThe difference between the two groups was analyzed by Fisher exact probability method;

^cSince the limited swelling was a constant, no statistics were calculated.

progressively worsening acute episodes. Mild lymphedema of the upper extremity can be gradually alleviated *via* restoration of the collateral circulation, but serious upper extremity lymphedema is frequently a lifelong condition due to a "vicious cycle" of recurrence. In such cases, the patient will likely suffer from an abnormal appearance of the limb, susceptibility to fatigue, repeated infection and limb dysfunction, which can seriously affect the patient's quality of life after surgery[7]. Miller *et al*[18] revealed that although the progress in radiotherapy technology will bring about an improvement in the curative effect, it will increase the risk of upper limb lymphedema in breast cancer patients. Therefore, prevention and treatment of lymphedema should receive considerable attention.

This study improved upon the international standard four-step CDT method by adding scar tissue relief and a foam granule bandage combined with air wave pressure therapy. The six-step CDT was shown to effectively alleviate the symptoms of upper limb lymphedema after breast cancer surgery. Maintaining skin integrity can prevent infection, reduce local skin complications, and ensure the continuity of CDT[19]. Relieving scar tissue can loosen connective tissue, reduce the adhesion of subcutaneous tissue at the incision, and alleviate the obstruction of lymphatic reflux caused by lymphatic compression and deformation caused by scar contracture, effectively preventing axillary nodule dysfunction[13]. Manual lymphatic drainage involves draining lymph from the affected side to the nearest healthy lymphatic pathway. A foam roll bandage combined with air wave pressure therapy can produce gradual compression from the distal end to the proximal end and promote lymph reflux. The foam particle bandage creates a round bubble produced by small particles, using Laplace's law[20]. This is highly effective at increasing the effective pressure to obtain the required level of contact pressure to promote lymphatic circumfluence used in partial filling pressure and further to reduce blood capillary leakage, prevent fluid accumulation, and promote lymph circumfluence[20], to prevent

protein decomposition and absorption, reduce colloid osmotic pressure in the tissue, achieve the effect of softening tissue, and reduce edema[15,21]. Functional exercise after bandaging, combined with respiratory training and muscle activities can rhythmically squeeze venous vessels, improving blood circulation and promoting lymphatic reflux, so as to reduce lymphedema. When the upper limb is static, a bandage of low elasticity can exert constant and moderate pressure. At night, patients can remove the outermost high elastic bandage. The rest of the bandage could continue to maintain the pressure to improve the comfort in the affected limb and allowing a longer-duration of dressing[22,23]. Table 2 shows the body water content in the two groups before and after 20 treatment sessions, and the body water content in the experimental group was significantly better than that in the control group ($P < 0.05$), indicating that the six-step CDT strategy can effectively alleviate upper limb lymphedema after breast cancer surgery. Thus, it can improve the therapeutic effect of air pressure wave therapy. In this study, 15 cases were complicated by tissue fibrosis. Ten cases of medial upper arm fat deposition and six cases of forearm fat deposition were also observed. Three patients had severe fibrosis in the back of the hand. After this technique, the affected limb showed granular depression, which was relatively soft to touch, and no blood flow problems such as bruising or dark redness were observed on the skin. Unarmed lymphatic drainage was used to promote the lymphatic reflux.

The six-step CDT method is helpful for alleviating the subjective symptoms of patients with upper limb lymphedema after breast cancer surgery. Most patients with lymphedema will feel subjective symptoms to varying degrees before the affected limb shows obvious changes in circumference, and thus, this condition is easy for patients and their families to ignore until it progresses to obvious swelling. The results in Table 3 show that after a course of six-step CDT, the subjective symptoms of patients in both groups were significantly improved. Compared with the control group, the experimental group had reduced sensations of tension and swelling ($P < 0.001$). These findings show that the six-step CDT introduced in this study can effectively alleviate upper limb lymphedema after breast cancer surgery, and the subjective symptoms in patients were also reduced or disappeared, resulting in improvements in their self-care ability, which corresponds to improved quality of life of patients.

Limitations

In this study, the sample size was small; the collection time and follow-up time were short; and the long-term effect was unclear. In addition, it was controversial whether climate was a factor affecting the therapeutic effect for lymphedema. In the future, multi-center studies must be carried out with an increased sample size, a comparison of lymphedema in different stages, extension of the follow-up time, use of additional relevant scales for quality of life and treatment compliance, and use of better observation indicators, so that more powerful clinical evidence can be obtained.

CONCLUSION

The six-step CDT method introduced in this study was shown to effectively reduce lymphedema, promote lymphatic circulation, and alleviate the subjective symptoms of patients with CDT, and thereby improve the quality of life and treatment compliance among patients.

ARTICLE HIGHLIGHTS

Research background

Patients with lymphedema following breast cancer surgery are likely to suffer from an abnormal appearance of the limb, susceptibility to fatigue, repeated limb infections, and limb dysfunction, which further seriously affects their quality of life. Active and effective treatment for upper limb lymphedema is very important for improving the health and quality of life of patients after breast cancer treatment. Complex decongestive therapy (CDT) is currently recommended as the standard treatment for lymphedema. CDT is a four-step detumescence therapy that can effectively treat upper limb lymphedema after breast cancer surgery, and is considered non-invasive, painless and without side effects. CDT typically involves manual lymphatic drainage, elastic bandage compression, limb function exercises, and personalized skin care. However, for the purposes of reducing scar formation and preventing axillary reticulum syndrome, this study added two steps to create a six-step comprehensive deswelling therapy combined with the use of a foam type granule bandage, which was applied in the treatment of upper extremity lymphedema pressure.

Research motivation

At present, there are few studies on the treatment of lymphedema after breast cancer surgery in China, and most of the relevant studies focus on the efficacy of single or composite methods. This study is based on the international standard four-step CDT with improvements, and the treatment mode is standardized and reasonable. The six-step CDT method was found to effectively treat upper limb

lymphedema after breast cancer surgery, without trauma, pain, or side effects. At the same time, this study found for the first time that in the early stage of CDT, edema of the affected limb was temporarily aggravated, and the clinical nursing staff need to provide targeted education for patients in order to improve treatment compliance.

Research objectives

The six-step CDT developed in this study effectively alleviated upper limb lymphedema after breast cancer surgery, and the subjective symptoms of patients were reduced or disappeared. Moreover, patients' self-care ability was improved, which will lead to improvements in the quality of life and treatment compliance among patients. Lymphedema is a chronic and long-term process that requires patients to adhere to the treatment for the curative effect to be stabilized. However, in real life, patients often cannot adhere to the treatment for a long period, and the symptoms of lymphedema may return or be aggravated. At the same time, treatment fatigue is possible, and then treatment compliance gradually decreases. Therefore, good treatment methods and obvious treatment effects can further improve patient compliance. Lymphedema therapists have further investigated methods to improve treatment compliance and the follow-up rate of patients with lymphedema.

Research methods

No six-step approaches to CDT for the treatment of upper limb lymphedema pressure have been reported in the literature, and most related studies have focused on the treatment effect of each individual method. This study adopted six-step CDT for the pressure treatment of upper limb lymphedema, which was found to effectively treat upper limb lymphedema and improve the quality of life of patients, which is worthy of discussion and further research. The results of this study provide a basis for the prevention and treatment of lymphedema in a specialist nursing clinic, and provide a talent basis for the study class of lymphedema specialist nurses, which can be used as a reference for future generations.

Research results

The newly introduced six-step CDT can improve the symptoms of upper limb lymphedema after breast cancer surgery and takes full advantage of the ability of nurses to treat lymphedema. Thus, it is a practice that should be referenced and promoted. Lymphedema treatment is a long process, and our future research will expand upon this study by increasing the sample size, extending the follow-up time, and observing the curative effect of therapy, in order to develop better treatment methods for lymphedema.

Research conclusions

This study put forward a new theory regarding scar care and the effect of a foam rolled bandage combined with the use of an air pressure wave therapeutic instrument. The new method included two new steps in addition to those of the international standard four-step treatment.

Research perspectives

In the future, multi-center studies are needed that include a larger sample size, compare lymphedema at different stages over a longer follow-up time, apply additional relevant scales for quality of life and treatment compliance, and improve the observation indicators, so that more powerful clinical evidence can be obtained.

FOOTNOTES

Author contributions: Zhang HZ and Zhong QL contributed equally to this work; Zhang HZ, Zhang LJ, and Zhong QL conceived and designed the research; Zhang HZ, Zhong QL and Luo QH collected the data and conducted the research; Zhang HZ, and Tang HL analyzed and interpreted the data; Zhang HZ and Zhong QL wrote the initial paper; Zhang LJ and Zhang HT revised the paper; Zhang LJ had primary responsibility for final content; all authors read and approved the final manuscript.

Institutional review board statement: This study was approved by the Ethics Committee of Sun Yat-sen University Cancer Center. All procedures performed in studies involving human participants were in accordance with the ethics standards of the institutional and national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethics standards.

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