Breast Cancer Research and Treatment **86:** 95–106, 2004.

Report

The addition of manual lymph drainage to compression therapy for breast cancer related lymphedema: a randomized controlled trial

Margaret L. McNeely[1], David J. Magee[2], Alan W. Lees[3,4], Keith M. Bagnall[5], Mark Haykowsky[2], and John Hanson[6]

[1]*Department of Rehabilitation Medicine, Cross Cancer Institute;* [2]*Faculty of Rehabilitation Medicine, Department of Physical Therapy;* [3]*Department of Radiation Oncology, Cross Cancer Institute;* [4]*Faculty of Medicine, Department of Oncology;* [5]*Faculty of Medicine, Division of Anatomy;* [6]*Division of Epidemiology, Cross Cancer Institute, Edmonton, Alberta, Canada*

Key words: breast cancer, compression bandaging, compression therapy, lymphedema, manual lymph drainage, physical therapy

Summary

Purpose. The purpose of this investigation was to compare the reduction in arm lymphedema volume achieved from manual lymph drainage massage (MLD) in combination with multi-layered compression bandaging (CB) to that achieved by CB alone.

Methods and materials. Fifty women with lymphedema (mean age of 59 years $\pm$ 13 years) were randomly assigned to 4 weeks of combined MLD/CB or CB alone. The primary study endpoint was the reduction in arm lymphedema volume, which was determined by water displacement volumetry and measurement of circumference. Independent assessors, blinded to subject treatment assignment, performed the outcome measurements.

Results. Arm lymphedema volume decreased significantly after 4 weeks irrespective of treatment assignment ($p < 0.001$). Individuals with mild lymphedema receiving combined MLD/CB had a significantly larger percentage reduction in volume compared to individuals with mild lymphedema receiving CB alone, and compared to individuals with moderate or severe lymphedema receiving either treatment.

Conclusion. These findings indicate that CB, with or without MLD, is an effective intervention in reducing arm lymphedema volume. The findings suggest that CB on its own should be considered as a primary treatment option in reducing arm lymphedema volume. There may be an additional benefit from the application of MLD for women with mild lymphedema; however, this finding will need to be further examined in the research setting.

Introduction

A major sequela associated with breast cancer treatment is lymphedema. Lymphedema is a swelling of the arm on the surgical side that occurs as a result of an accumulation of lymphatic fluid [1,2]. The etiology of lymphedema in breast cancer is primarily related to the extent of the axillary dissection at surgery and to the exposure of the axilla to radiotherapy [3]. Though the majority of lymphedema cases are reported to develop within 1 year following breast cancer treatment [4], lymphedema can develop at any time after the original cancer treatment [5]. Lymphedema may be mild to severe, and, if left untreated, has been found to have a significant tendency to increase with time, both in the volume of edema and in stage of tissue fibrosis [6].

While the true incidence of lymphedema is unknown, the estimated objective incidence is

about 20% [7]. Although lymphedema is not a life-threatening disorder, it is a chronic condition that can create considerable disability with recurrent infections in the limb [8], functional impairment [9] and pain [10]. In addition, research has demonstrated significant psychosocial morbidity [9,11,12], and poorer quality of life in breast cancer survivors who develop lymphedema [13,14].

There are numerous physical therapy interventions that are potentially effective in treating lymphedema including various compression therapies, massage techniques, electrophysical agents, exercise, and education [15–18]. Unfortunately, there has been little research in the area of lymphedema treatment and as a result treatment is not standardized [15,19,20] . Complex physical therapy (CPT) is a combined treatment program that has been recommended by a consensus panel of experts [16]. CPT consists of education (specifically with an emphasis on meticulous skin care), manual lymph drainage massage (MLD), multilayered compression bandaging (CB) and exercise [21,22]. Previous case reports reveal impressive reductions in lymphedema following CPT treatment with return of the limb to a normal or near normal state [22–24] and the reported average lymphedema volume reduction from CPT is approximately 50% [22,25]. The central treatment of this program is manual lymph drainage, a costly, labor intensive, specialized massage technique. It is unclear, however, whether the reductions in lymphedema from this program are mainly due to the MLD or the other components of CB and exercise. A recent systematic review of physical therapy interventions for lymphedema after breast cancer highlighted the need for studies of high methodological quality to establish evidence concerning the efficacy of methods such as manual lymph drainage [20]. The continuing focus on rising health care costs and fiscal restraint has also resulted in a need for cost-effective intervention programs. The relatively high cost of MLD, as compared to CB, for example, provides impetus to evaluate the potential benefit of these individual components of CPT to determine their efficiency and effectiveness.

The purpose of this study was to compare the reduction in arm lymphedema volume achieved from MLD in combination with CB (MLD/CB) to that achieved by CB alone. We hypothesized that a significantly larger lymphedema reduction would occur over the 4 weeks treatment period in the group receiving MLD/CB when compared to CB alone. Measurements were taken on a weekly basis to examine the effect of treatment over time and to determine if there was a difference in the rate of lymphedema volume reduction between the two groups. Both water displacement volumetry and measurement of circumference were used to assess lymphedema volume and to allow for comparison of results to other studies.

Method and materials

Settings and participants

The study was conducted at the Cross Cancer Institute in Edmonton, Canada. The study was approved by the Research Ethics Committee of the Alberta Cancer Board and the Health Research Ethics Board of the University of Alberta. Written informed consent was obtained from all subjects.

The subjects who participated in this study were females with diagnosed breast cancer who had undergone unilateral breast surgery including an axillary node dissection. Subjects were required to have a medical diagnosis of lymphedema determined by their primary care physician, surgeon and/or oncologist. Clinically significant lymphedema was defined as a minimum of a 150 ml difference between the affected and unaffected arms. This definition was chosen, as it is known that in 95% of normal subjects, the normal asymmetry of the limbs does not exceed 150 ml [26]. None of the subjects had received active treatment for lymphedema within the 6 month period prior to entering the study. No subject was excluded if they were using a compression sleeve for maintenance. However, to control for any potential treatment effect from the sleeve, a minimum 4-month wait period was observed.

Subjects were ineligible for the study if: (1) they had evidence of distant cancer metastases or local cancer recurrence; (2) they were undergoing radiotherapy or chemotherapy treatment; (3) there were signs of infection in the affected limb (redness, rash, red streaks, heat, pain); or (4) there was evidence of contraindications to treatment: uncontrolled hypertension, heart disease, renal insufficiency, and venous thrombosis.

Experimental design and recruitment

The study was a prospective, randomized controlled trial. Potential subjects were identified by referral to the Rehabilitation Department at the Cross Cancer Institute. A physical therapist was responsible for screening subjects for eligibility and the referring physician was contacted for approval. Subjects were randomized to one of the two treatment groups by use of a computer-generated code. The allocation sequence was concealed from research personnel involved in screening, scheduling and enrolling participants. Measurements were taken on admission to the study and at the end of week 1–4 (Figure 1).

Blinding

Two independent assessors (IA), blinded to the subjects' treatment assignment, administered the outcome measurements. The independent assessors were qualified physical therapists familiar with, and trained in, the measurement procedure. The same IA was responsible for all measurements of a single subject. IA-1 measured subjects 1 through 42. Due to the length of the study, a second assessor (IA-2) was required to provide holiday relief. IA-2 measured subjects 43–50.

Interventions

All subjects received 4 weeks of their allocated treatment, which also included standard education on proper arm and skin care. Subjects allocated to the MLD/CB group received 45 min of daily MLD (Monday through Friday) each week. MLD is a gentle specialized massage technique that stimulates lymph flow by applying gentle pressure and stretch to the tissues. In the present study, the neck, contralateral and ipsilateral upper quadrants were massaged first, to stimulate lymph flow. The massage sequence commenced proximally, with massage strokes applied in a distal to proximal direction (in the direction of normal lymph flow). The limb was then massaged in segments starting proximally at the shoulder and moving progressively down the limb. The Vodder method of manual lymph drainage was used in this trial and treatments were provided primarily by one physical therapist trained in the Vodder method of MLD [27].

Both groups received CB. Short stretch bandages were used and were applied in a supportive manner. Gradient pressure was achieved by applying more layers distally, and gradually reducing the number, and overlap, of the bandages as applied proximally along the arm. At the start, cotton tube stockinet was placed on the arm. A primary layer of gauze was applied to the fingers and hand. A layer of 1/2 cm foam padding was placed on the hand and wrapped around the arm. Three or four bandages (4, 6, 8 and 10 cm) were used and were sequentially placed around the limb with the first bandage starting at the hand, the second bandage starting at the wrist and the third bandage starting just below the elbow (a fourth bandage was necessary for larger arms). All bandages were applied in a figure of eight fashion. Bandages were left in place continuously and were not removed until the next scheduled treatment. The same practitioner (Physical Therapist Assistant) bandaged subjects in both groups, Monday through Friday of each week.

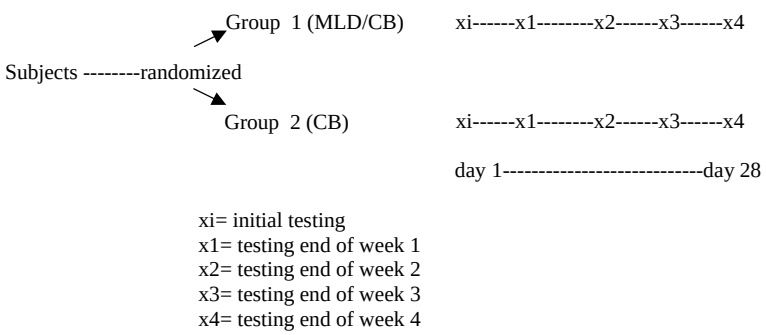

Figure 1. Study design.

Outcomes

Two measurement methods were used for assessing lymphedema volume. The primary outcome in this study was the volume of lymphedema in the affected arm, which was determined by comparing the difference in arm volume between the affected and unaffected arms. Thus, each subject's unaffected arm served as a control. The difference in lymphedema volume from initial measurement to the final measurement, at the end of week 4, represented the change score. The changes in lymphedema volume were expressed in both milliliters and percentage reduction. The percentage reduction (percentage of the excess volume reduced by treatment) was calculated as follows:

$$\frac{\text{Difference initial} - \text{Difference week 4}}{\text{Difference initial}} \times 100$$

where difference = affected arm volume minus unaffected arm volume.

To control for intervening variables that may have accounted for variations in arm volume, the volume of each arm (affected and unaffected) was measured and compared at each assessment, body weight recorded, and measurements were made at approximately the same time of day, each time.

Water displacement volumetry

Volumetry is a measurement technique based on the principle of water displacement. This method is considered the 'gold standard' as measurements have consistently proven to be reproducible with an error of less than 1% [28–30]. For the present study, the limb was slowly immersed in a water-filled plexi-glass tank to a controlled depth. The overflow was collected and weighed. The accuracy of the volumeter was established prior to study initiation and was found to be accurate within 1%, with a standard error of measurement of ±10 ml.

Calculated volume as determined from measurement of circumference

The secondary outcome of interest was lymphedema volume as calculated from limb circumference measurements. Circumference (girth) measurements are simple, efficient and more convenient in the clinical setting. Circumference measurements also provide information on the measurements at the upper-most aspect of the arm, the location of the lymphedema, and on where changes in girth occur during treatment. For the present study, circumference measurements were taken of both arms, starting at the finger MCP joints, across the hand including the thumb MCP, and at the wrist. As well, circumference measurements at 4-cm intervals from the wrist to axilla were taken, with an adjustment made to include the elbow. Arm volume was then calculated based on a variation in the formula for a truncated cone [$V = (h)(C^2 + C_c + c^2)/12(\pi)$ where h = perpendicular height of the segment; C = top of the cone; c = bottom of the cone and $\pi = 3.1416$] [30]. For the present study, a non-stretch fiberglass tape measure, with intervals of 0.1 cm, was used to measure both the circumference and the length of the upper extremity.

Reliability

Intra-rater and inter-rater reliability of the IA's were established through a series of pilot studies. An intraclass correlation coefficient (ICC) above 0.9 was considered acceptable [31]. The ICC for water displacement volumetry was 0.990 for IA-1 and 0.998 for IA-2. The ICC for the volume calculated from circumference measurements for both assessors was 1.00. The ICC's for inter-rater reliability of the two assessors was 0.990 for the water volume measurement and 0.985 for the volume calculated from circumference measurements.

Sample size and statistics

The required sample size for the study was 42 subjects or 21 subjects per group to detect a difference of 20% in the reduction of lymphedema between the two groups and was based on an alpha of 0.05 and a power of 80% [32]. The effect size was determined from clinical results and from the review of the literature, with the estimated reduction of 45% for the combined MLD/CB group and an estimated reduction of 25% for the CB group. Based on the time commitment of four weeks of treatment and the requirement of constant bandaging, an attrition rate of 20% was anticipated. Therefore, four subjects per group were added, giving a starting sample size of 50 subjects.

Data were analyzed using SPSS version 10.0 software (SPSS Inc., Evanston, Ill). We compared baseline characteristics using independent samples t-tests for continuous data and Pearson's χ^2 for categorical data. Outcome data were analyzed utilizing the independent samples *t*-tests to compare changes between groups in outcomes from baseline to post-intervention (4 weeks treatment period). The rate of reduction was analyzed using a two-way ANOVA repeated measures. The alpha level was set, *a priori*, at $p < 0.05$.

Exploratory analysis: percent reduction by degree of lymphedema severity and duration

For the purposes of exploratory subgroup analysis, data were further analyzed by severity of lymphedema (mild, moderate and severe) and duration of lymphedema (early versus chronic). The severity of lymphedema was assessed by placing subjects into one of three groups (mild, moderate and severe) based on the percent volume increase in the affected arm on commencement of the study. As the classification of lymphedema by degree of lymphedema severity remains subjective, the subgroups represented a modified version of previously reported classification systems [28,33]. For the purposes of the present study, the relative percentage volume increase of the affected arm when compared to the unaffected arm was calculated [(affected arm/unaffected arm) $- 1 \times 100$]. An affected arm volume of up to 15% larger than the unaffected arm was classified as mild lymphedema, a volume between 16 and 37% larger was classified as moderate lymphedema, and a volume greater than 37% was classified as severe lymphedema. Subjects were defined as having early lymphedema if the duration of the lymphedema was 11 months or less. Subjects with a lymphedema that had been present for 12 months or greater were defined as having chronic lymphedema.

Results

Participant recruitment took place between November 2000 and December 2001. A total of 74 subjects were screened for eligibility and 63 subjects were initially deemed eligible to participate in the study. Ten subjects elected not to take part in the study. The primary reasons for non-participation included the time commitment and/or the requirement of constant bandaging. Three subjects who had a medical diagnosis of lymphedema were subsequently ineligible, as they did not fulfill the requirement of a minimum of 150 ml of fluid volume difference between the arms. Therefore, of eligible subjects, the agreement to participate was 83%. Fifty subjects were enrolled in the study with 25 subjects randomly assigned to each group.

A total of 45 subjects completed the study. Two subjects withdrew as a result of adverse events. One subject in the MLD/CB group withdrew after she developed a skin reaction to the bandaging. One subject in the CB group withdrew in the second week of treatment due to discomfort in the elbow region from the constant CB. Three other subjects in the CB group withdrew from the study: one due to illness of a family member and two as a result of dissatisfaction with treatment response. One subject in the MLD/CB group, though completing the study, was excluded from analysis for the water displacement volumetry as an error was found in the recording of the arm volume. Figure 2 presents the flow of participants through each stage of the study. Table 1 summarizes the baseline characteristics of the subjects.

Body weight was monitored throughout the study and no significant differences in average weight change were found between groups or between the initial and final weight of the subjects.

Water displacement volumetry

The milliliter and percent reductions in lymphedema volume following 4 weeks of treatment, determined by water displacement volumetry, are presented in Tables 2 and 3, respectively. A significant reduction in lymphedema volume was found over the 4-week period for both MLD/CB and CB groups. No significant difference was found between the groups in milliliter reduction ($p = 0.812$) or percent reduction ($p = 0.297$). Therefore a reduction in lymphedema volume occurred over the time period irrespective of the treatment assignment.

Circumference measurements

The findings from the calculated volume determined from circumference measurements were consistent with the findings of water displacement

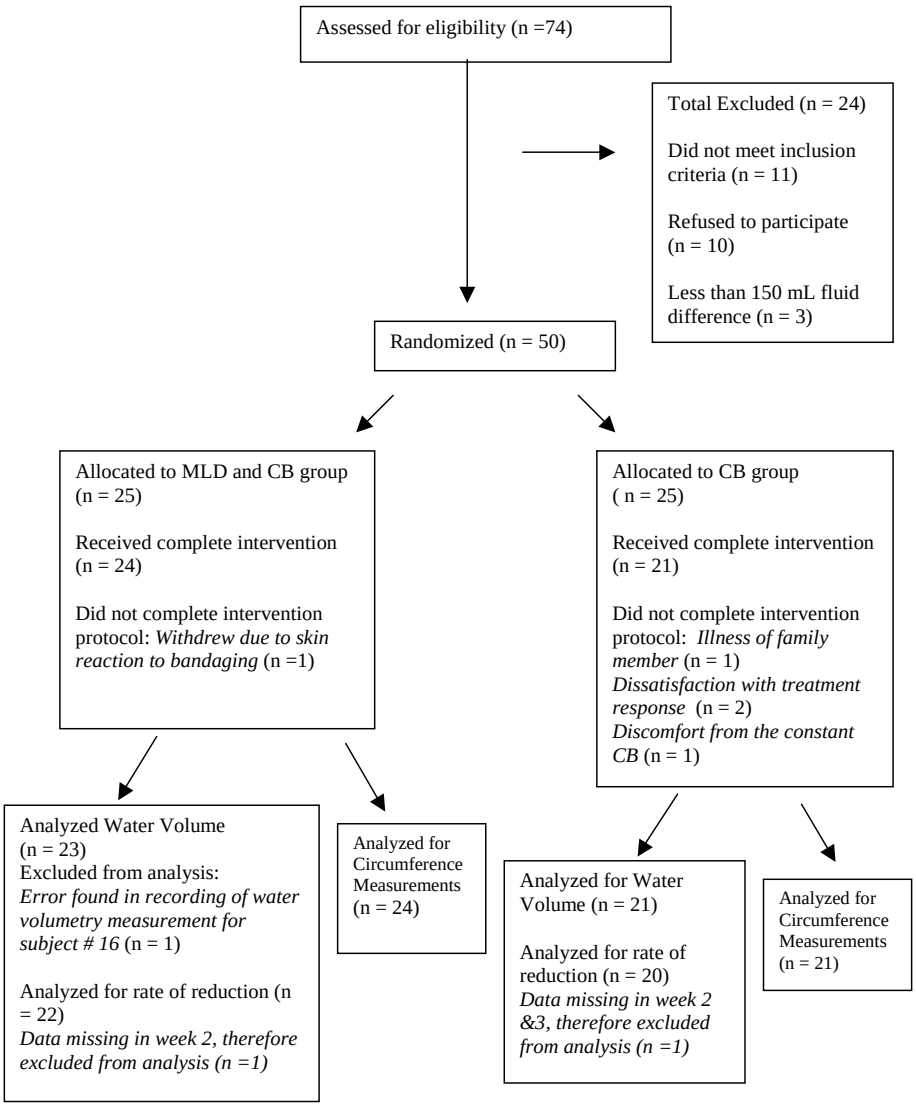

Figure 2. Flow of participants through the study trial.

volumetry. The milliliter reduction is presented in Table 2 and the percent reduction is presented in Table 3. Again, a significant lymphedema volume reduction occurred following 4 weeks of treatment, however, no significant difference was found between the groups in milliliter reduction ($p = 0.88$) or percent reduction ($p = 0.368$).

Percent reduction by classification: mild, moderate and severe

Figure 3 presents the specific data for percent reduction by classification for water volumetry and circumference measurements, respectively. The major finding was a significantly larger reduction in the MLD/CB group for subjects with mild lymphedema when compared to subjects in all other subgroups.

Percent reduction by lymphedema duration: early versus chronic

Figure 4 presents the data for the percent reduction by duration of lymphedema for each measurement method. A statistically significant difference was found in favor of the MLD/CB early group when compared to the CB chronic group.

Table 1. Demographic information

Variable*		MLD/CB n = 24	CB n = 21
Age (years)	Mean (±SD) and range	58 (± 13)	63 (± 13)
		33–78	40–87
Cancer type	Ductal	19	14
	Lobular	5	5
	Mixed	0	2
Cancer stage	Stage 1	7	8
	Stage 2	15	10
	Stage 3	2	3
Type of surgery	Radical mastectomy	0 (0%)	1 (5%)
	Modified mastectomy	12 (50%)	11 (52%)
	Segmental resection	12 (50%)	9 (43%)
Lymph nodes	Number removed	12 (± 6)	10 (± 5)
Radiation treatment	Breast radiation only	6 (25%)	7 (33%)
	Axillary radiation	15 (63%)	11 (52%)
Chemotherapy treatment	(yes)	14 (61%)	6 (29%)
Post-operative infection	(yes)	$n = 5$ (21%)	$n = 2$ (10%)
Time from surgery (months)	Median/range	39/2–281	45/3–386
	quartiles	20/62	14/141
Duration of lymphedema (months)	Median/range	21/2–219	19/1–194
	quartiles	6/34	4/103
Arm dominance	Dominant/nondominant	11/13	10/11
Initial volume of lymphedema (ml)[a]	Median/range	535/165–3420	630/180–1395
	quartiles	245/720	382/892
Classification[a]	Mild	$n = 7$	$n = 5$
	Moderate	$n = 12$	$n = 11$
	Severe	$n = 4$	$n = 5$
Early versus chronic lymphedema[a]	Early	$n = 8$	$n = 10$
	Chronic	$n = 15$	$n = 11$

[a] Data available for 23 subjects in MLD/CB group.
* No significant difference between groups $p > 0.05$ for all variables.

Rate of reduction

Measurements were taken on a weekly basis to determine if there was a difference in rate of reduction between the groups. There were no significant differences in the rate of reduction between the groups; however, there was a reduction in lymphedema over time. As the main effect was time, data are presented for the total group. Figure 5A presents the data on the rate of reduction by water volumetry and Figure 5B presents the rate of reduction calculated from circumference measurements. A significant reduction in lymphedema volume occurred between initial measurement and week 1, week 1 and week 2, and week 3 and week 4. Though a reduction occurred between week 2 and week 3, it was not significant. The rate of diminution was decreasing at 4 weeks although clinically most of the benefit was seen in the first 2 weeks.

Discussion

The major finding of this study is that four weeks of CB, with or without MLD, resulted in a significant reduction in lymphedema volume. The lack of significance between the groups in lymphedema volume reduction is consistent with previous studies [34, 35]. For example, Andersen et al. [34] in a study examining a modified version of CPT, using compression sleeves in place of CB,

Table 2. Effect of 4 weeks of MLD/CB versus CB on lymphedema volume in milliliters[a]

Variable	Baseline volume	*p* Value[b]	Post intervention volume	Mean change lymphedema volume	Difference between groups in mean change (95% CI)	*p* Value[c]
Water displacement volumetry						
MLD/CB group	695 ± 696		435 ± 535	260* ± 217		
CB group	672 ± 672	$p = 0.891$	426 ± 283	246* ± 159	+14 (−103 to 301)	$p = 0.812$
Calculated volume determined by measurement of circumference						
MLD/CB group	666 ± 693		425 ± 481	241* ± 228		
CB group	656 ± 403	$p = 0.957$	412 ± 283	244* ± 197	−3 (−133 to 125)	$p = 0.956$

Data are presented as the mean ± standard deviation.
[a] Lymphedema Volume MLD/CB Group ($n = 23$ for water displacement, $n = 24$ for circumference measurements); CB Group ($n = 21$).
[b] *p* Value for difference between the groups at baseline.
[c] *p* Value for change between groups from baseline to post intervention.
* Significant difference for change within group $p < 0.001$.

Table 3. Relative percent reduction[a] in lymphedema volume after 4 weeks: MLD/CB versus CB[b]

Variable[c]	Mean relative reduction post intervention	Difference between groups in mean change (95% CI)	*p* Value
Water displacement volumetry			
MLD/CB group	46.1% ± 22.6*		
CB group	38.6% ± 16.1*	+7.5% (−4.54 to 19.5)	$p = 0.217$
Calculated volume determined by measurement of circumference			
MLD/CB group	44.1% ± 21.7*		
CB group	37.2% ± 17.9*	+6.9 (−5.3 to 18.9)	$p = 0.264$

Data are presented as the mean ± standard deviation.
[a] The percentage reduction represents the mean of the relative reduction in lymphedema volume of each individual subject.
[b] MLD/CB Group ($n = 23$ for water displacement, $n = 24$ for circumference measurements); CB Group ($n = 21$).
[c] *p* Value for change between groups from baseline to post-intervention.
* Significant difference for change within group $p < 0.001$.

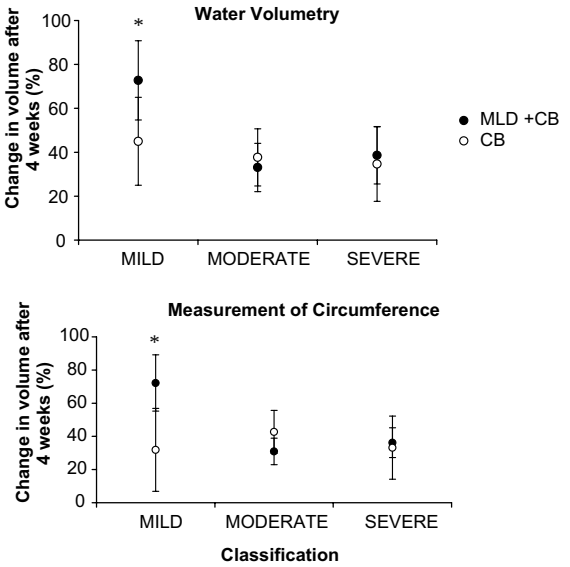

Figure 3. Percent reduction in lymphedema volume over the 4 weeks treatment period. Water volumetry: MILD: MLD/CB $n = 7$, CB $n = 5$; MODERATE: MLD/CB $n = 12$, CB $n = 11$; SEVERE: MLD/CB $n = 4$, CB $n = 5$. Calculated volume from circumference measurements: MILD: MLD/CB $n = 7$, CB $n = 5$; MODERATE: MLD/CB $n = 13$; SEVERE: MLD/CB $n = 4$, CB $n = 5$. *$p < 0.05$ for Mild-MLD/CB group versus all other groups.

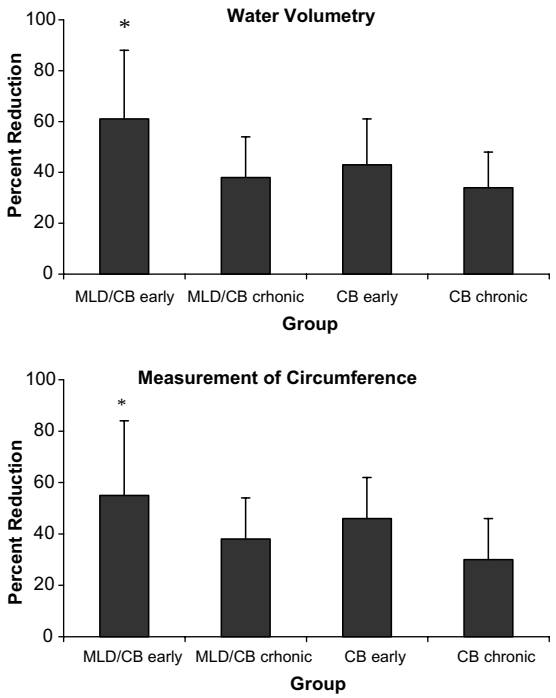

Figure 4. Percent reduction in lymphedema volume by duration of lymphedema (early = 11 months or less; chronic = 12 months or greater). MLD/CB early group $n = 8$; MLD/CB chronic group $n = 15$ water volumetry and $n = 16$ measurement of circumference; CB early group $n = 10$; CB chronic group $n = 11$. *MLD/CB early group significantly greater reduction compared to CB chronic group $p < 0.05$.

found no statistically significant difference between the volume reduction achieved by treatment with or without MLD. Johansson et al. [35] in a non-randomized study found no significant difference in absolute lymphedema volume reduction between individuals receiving MLD in combination with CB to those receiving CB alone. Contrary to our findings, however, Johansson et al. [35] found a significant difference ($p = 0.04$) in the additional percentage volume reducing effect of MLD (11%) to that of CB (4%).

CB has been found to be an effective treatment technique in previous reports [35, 36]. Badger et al. [36] in a randomized trial reported a significantly larger reduction in limb volume at 24 weeks in the intervention group receiving 18 days of CB followed by a compression garment (31%) when compared to the comparison group receiving treatment with only a compression garment (15.8%). In the present study, the mean lymphedema reduction of 38% in the CB group exceeded the reduction reported in the literature [35,36]. This finding may, in part, be explained by differences in treatment protocol. In conventional CB, bandages are applied in a spiral fashion on the limb [36,37], whereas in the present study, we utilized a figure of eight method. Clinically, we have found that the figure of eight method is more effective in maintaining the bandaging position and is more comfortable for the patient. Secondly, we replaced the bandages 5 days per week over a 4 weeks period. In the Johansson study, the CB was replaced every second day over a 3 weeks period [35]. As the bandaging loosens with use of the arm, and over time, daily application of CB and a figure of eight bandaging technique may have minimized any potential for lymphatic fluid to re-accumulate in the arm, and may account for the larger reduction from CB in the present study.

Exploratory subgroup analyses

We examined the data by the severity of the lymphedema and by the duration of the lymphedema. While the MLD/CB early group had a

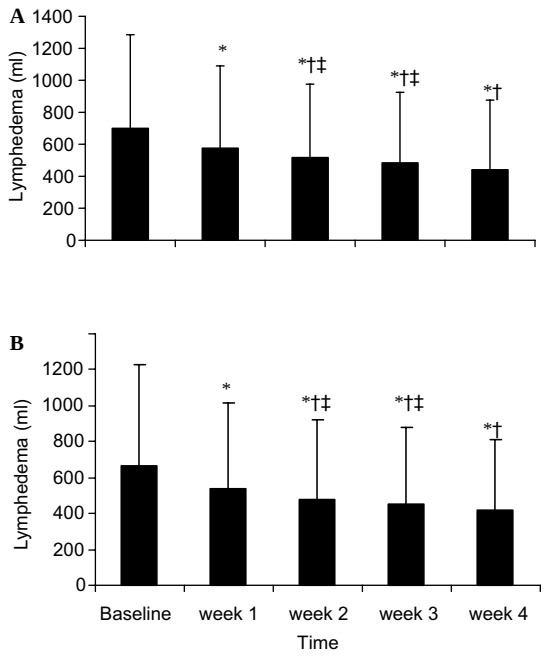

Figure 5. Remaining lymphedema volume by week. A: Water volumetry: $n = 42$. B: Calculated volume from circumference measurements: $n = 45$. $^{*}p < 0.05$ versus Baseline; $^{\dagger}p < 0.05$ versus week 1; $^{\ddagger}p < 0.05$ versus week 4.

significantly greater reduction than the CB chronic group, no statistically significant differences were found between the two early groups or between the two chronic groups. A notable finding was that subjects with mild lymphedema in the MLD/CB group were found to have a significantly larger relative reduction with treatment than subjects in all other subgroups. Ramos et al. [38], performed a retrospective study of 69 women treated with CPT and concluded that the initial volume of lymphedema, not the timing, was critical in predicting the success of treatment. In their study, the authors found that patients with a lymphedema volume of 250 ml or less had a mean reduction of 78%, while patients with initial volumes of between 250 and 500 ml had a mean reduction of only 56%. The findings of the present study, while limited, support this conclusion. In theory, the lymphatic system in subjects with mild lymphedema would still be functioning to a larger extent when compared to subjects with moderate or severe lymphedema, regardless of lymphedema duration. Functioning lymphatic vessels would be necessary for MLD to be effective in stimulating lymphatic flow and in establishing collateral drainage routes, and may explain the significantly larger reduction in the subjects with mild lymphedema receiving MLD/CB.

The effects of CB, on the other hand, are likely at the microvascular level. CB enhances tissue pressure, thereby limiting the filtration of fluid from the arterial capillary into the tissues and enhancing fluid return into the venous capillary. Perhaps for subjects with more extensive damage to the lymphatic system, compression remains the only effective means of reducing and controlling the edema.

The rate of reduction in lymphedema volume

There were no significant differences in the rate of reduction between the groups; however, there was a reduction in lymphedema volume over time. The results of the study showed that the greatest reduction in lymphedema occurred in the first week, slowly diminished over the middle weeks of treatment and very slightly improved again in the final week. The results suggest that CB with or without MLD is most effective in the first 2 weeks. Leduc et al. [39], found that the most important reduction in lymphedema occurred during the first week of a 10-day intensive treatment program that included MLD, CB, exercise and compression pump treatments. Johansson et al. [35], reported significant reductions in lymphedema volume during the first 2 weeks of CB treatment. No significant reduction was obtained from CB treatment in the third week and thus, the authors concluded that CB is most effective when administered daily for 2 weeks. Subjectively, we found that the majority of subjects in the present study had a rapid volume reduction in the first 2 weeks of treatment. Some subjects, however, had a less dramatic and/or delayed response to treatment. Clinically, these subjects were thought to have more extensive tissue fibrosis, which may have negatively influenced the rate and magnitude of the treatment response.

Study limitations

There are a number of limitations of the present study that need to be acknowledged. The study was designed to determine the effect of treatment on lymphedema volume over a 1-month period

with no further follow-up. Upper extremity range of motion was not assessed as part of the present study. Future studies should consider monitoring upper extremity range of motion as subjects with significant shoulder range of motion impairment are likely to have less anti-gravity benefits from daily activity and less muscle pump action to assist in lymphatic and venous return. The effects of treatment on pain, function, body image and quality of life were also not assessed and would be essential components in determining clinical significance.

Conclusions

Overall, it is evident that CB is an effective treatment technique. CB is a simple and time efficient intervention for arm lymphedema in women with breast cancer. While the time required for application of MLD/CB is approximately 1 h, the time required for the practitioner to apply CB is from 10 to 15 min. Practitioners in the hospital, clinic and homecare setting can be trained in the appropriate CB technique. Moreover, family members and/or even patients themselves, can, over time, be taught to effectively apply CB. The findings of this study suggest that CB on its own should be considered as a primary treatment option in reducing arm lymphedema volume. The findings also suggest that efforts toward the treatment of lymphedema should be implemented as soon as possible after onset of the condition, when treatment is more likely to be effective. Subjects with mild lymphedema would appear to benefit from the additional application of MLD; however, this finding will need to be further examined in the research setting.

Acknowledgements

This research was supported in part by grants from the Cross Cancer Institute Clinical Trials Committee and the Canadian Breast Cancer Foundation: Alberta Chapter. We would like to acknowledge the assistance of Terry Kaasa, Janice Yurick, Colleen Lazoruk and Marilyn Sutherland, from the Rehabilitation Medicine Department of the Cross Cancer Institute, without whose help this project would not have been possible.

References

1. Jungi WF: The prevention and management of lymphoedema after treatment for breast cancer. Int Rehabil Med 3: 129–134, 1981
2. Brennan MJ, Weitz J: Lymphedema 30 years after radical mastectomy. Am J Phys Med Rehabil 71: 12–14, 1992
3. Petrek JA, Lerner R: Lymphedema. In: Harris JR, Lippman ME, Morrow M, Helman S, (eds) Diseases of the Breast. Lippincott-Raven, Philadelphia, 1996, pp 896–900
4. Erickson VS, Pearson ML, Ganz PA, Adams J, Kahn KL: Arm edema in breast cancer patients. J Natl Cancer Inst 93: 96–111, 2001
5. Brennan MJ: Lymphedema following the surgical treatment of breast cancer: a review of pathophysiology and treatment. J Pain Sympt Manage 7: 110–116, 1992
6. Casley-Smith JR: Alterations of untreated lymphedema and it's grades over time. Lymphology 28: 174–185, 1995
7. Petrek JA, Heelan MC: Incidence of breast carcinoma-related lymphedema. Cancer 83: 2776–2781, 1998
8. Simon MS, Cody RL: Cellulitis after axillary lymph node dissection for carcinoma of the breast. Am J Med 93: 543–548, 1992
9. Passik SD, McDonald MV: Psychosocial aspects of upper extremity lymphedema in women treated for breast carcinoma. Cancer 83: 2817–2820, 1998
10. Brennan MJ, DePompolo RW, Garden FH: Focused review: postmastectomy lymphedema. Arch Phys Med Rehabil 77: S74–80, 1996
11. Mirolo BR, Bunce IH, Chapman M, Olsen T, Eliadis P, Hennessy JM, Ward LC, Jones LC: Psychosocial benefits of postmastectomy lymphedema therapy. Cancer Nurs 18: 197–205, 1995
12. Tobin MB, Lacey HJ, Meyer L, Mortimer PS: The psychological morbidity of breast cancer-related arm swelling. Cancer 72: 3248–3252, 1993
13. Velanovich V, Szymanski W: Quality of life of breast cancer patients with lymphedema. Am J Surg 177: 184–187; 1999
14. Voogd AC, Ververs JM, Vingerhoets AJ, Roumen RM, Coebergh JW, Crommelin MA: Lymphoedema and reduced shoulder function as indicators of quality of life after axillary lymph node dissection for invasive breast cancer. Br J Surg 90: 76–81, 2003
15. Brennan MJ, Miller LT: Overview of treatment options and review of the current role and use of compression garments, intermittent pumps, and exercise in the management of lymphedema. Cancer 83: 2821–2827, 1998
16. Rockson SG, Miller LT, Senie R, Brennan MJ, Casley-Smith JR, Foldi E, Foldi M, Gamble GL, Kasseroller RG, Leduc A, Lerner R, Mortimer PS, Norman SA, Plotkin CL, Rinehart-Ayres ME, Walder AL: American Cancer Society Lymphedema Workshop. Workgroup III: Diagnosis and management of lymphedema. Cancer 83: 2882–2885, 1998

17. Casley-Smith JR, Boris M, Weindorf S, Lasinski B: Treatment for lymphedema of the arm-the Casley–Smith method. Cancer 83: 2843–2860, 1998
18. Harris SR, Hugi MR, Olivotto IA, Levine M: Clinical practice guidelines for the care and treatment of breast cancer: 11. Lymphedema. Can Med Assoc J 164: 191–199, 2001
19. Megens A, Harris SR: Physical therapist management of lymphedema following treatment for breast cancer: a critical review of its effectiveness. Phys Ther 78: 1302–1311, 1998
20. Karki A, Simonen R, Malkia E, Selfe J: Efficacy of physical therapy methods and exercise after a breast cancer option: a systematic review. Crit Rev Phys Rehabil Med 13: 159–190, 2001
21. Casley-Smith JR: Modern treatment of lymphoedema. I. Complex physical therapy: the first 200 Australian limbs. Australas J Dermatol 33: 61–68, 1992
22. Ko DS, Lerner R, Klose G, Cosimi AB: Effective treatment of lymphedema of the extremities. Arch Surg 133: 452–458, 1998
23. Foldi E, Foldi M, Clodius L: The lymphedema chaos: a lancet. Ann Plast Surg 22: 505–515, 1989
24. Boris M, Weindorf S, Lasinski B, Boris G: Lymphedema reduction by noninvasive complex lymphedema therapy. Oncology (Huntington) 8: 95–106, 1994
25. Morgan RG, Casley-Smith JR, Mason MR: Complex physical therapy for the lymphoedematous arm. J Hand Surg – British Volume 17: 437–441, 1992
26. Godal R, Swedborg I: A correction for the natural asymmetry of the arms in the determination of the volume of oedema. Scand J Rehabil Med 14: 193–195, 1982
27. Kasseroller RG: The Vodder School: the Vodder method. Cancer 83: 2840–2842, 1998
28. Tracey GD, Reeve TS, Fitzsimons E, Rundle FF: Observations on the swollen arm after radical mastectomy. Aust N Z J Surg 30: 204, 1961
29. Engler HS, Sweat RD: Volumetric arm measurements: technique and results. Am Surg 28: 465–468, 1962
30. Karges JR: Assessing the relationship between water displacement and circumferential measurements in determining upper extremity volume in women with lymphedema. Krannert School of Physical Therapy, University of Indianapolis, Indianapolis, USA, 1996
31. Portney LG, Watkins MP: Foundations of Clinical Research Applications to Clinical Practice. Appleton and Lange, East Norwalk, Connecticut, 1993
32. Warren S: Statistical Analysis. In: Bartlett D (ed) Research Theory in Rehabilitation. Faculty of Rehabilitation Medicine, University of Alberta, Edmonton, 1994.
33. Stillwell GK: Treatment of postmastectomy lymphedema. Mod Treat 6: 396–412, 1969
34. Andersen L, Hojris I, Erlandsen M, Andersen J: Treatment of breast-cancer-related lymphedema with or without manual lymphatic drainage – a randomized study. Acta Oncol 39: 399–405, 2000
35. Johansson K, Albertsson M, Ingvar C, Ekdahl C: Effects of compression bandaging with or without manual lymph drainage treatment in patients with postoperative arm lymphedema. Lymphology 32: 103–10, 1999
36. Badger CM, Peacock JL, Mortimer PS: A randomized, controlled, parallel-group clinical trial comparing multilayer bandaging followed by hosiery versus hosiery alone in the treatment of patients with lymphedema of the limb. Cancer 88: 2832–2837, 2000
37. Klose G: Lymphedema Bandaging. Lohmann & Rauscher, Germany, 1998, pp 14–23
38. Ramos SM, O'Donnell LS, Knight G: Edema volume, not timing, is the key to success in lymphedema treatment. Am J Surg 178: 311–315, 1999
39. Leduc O, Leduc A, Bourgeois P, Belgrado JP: The physical treatment of upper limb edema. Cancer 83: 2835–2839, 1998

Address for offprints and correpondence: Margaret McNeely, Department of Rehabilitation, Cross Cancer Institute, 11560 University Avenue, Edmonton, Alberta, Canada T6G 1Z2; *Tel.:* +1-780-492-2829; *Fax:* +1-780-492-8003; *E-mail:* mmcneely@ualberta.ca