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Intermittent pneumatic compression pump in upper extremity impairments of breast cancer-related lymphedema

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Aim: To investigate the effect of intermittent pneumatic compression (IPC) pumps on upper extremity impairments in breast cancer-related lymphedema.

Materials and methods: Twenty-five patients with lymphedema were randomized into 2 groups. For 3 weeks, the pneumatic compression group (n = 12) underwent a treatment program including skin care, compression bandage, exercise therapy, manual lymph drainage (MLD), and IPC. The control group (n = 13) participated in the same program, but without IPC. The range of motion (ROM) of the upper extremities was measured with goniometry, and dysfunction of the shoulder was assessed with the Constant-Murley scale.

Results: Significant improvements were observed in the ROM of the shoulder when we evaluated pre- and posttreatment values within both groups, and the improvements were still significant at 1-month follow-up. Likewise, we found significant differences in the visual analogue scale (VAS) and the Constant-Murley scores in both groups when we compared pre-treatment and posttreatment values, and significant differences were still present at 1-month follow-up. However, there were no significant differences between the groups in the upper limb's ROM, the VAS, or the Constant-Murley scale after the therapy or at the 1-month follow-up.

Conclusion: Upper extremity impairments may improve with conservative treatment of lymphedema. However, the addition of IPC to the therapy may not provide any additional benefit for upper extremity impairments.

Key words: Upper limb, lymphedema, pneumatic compression, manual lymph drainage, rehabilitation

1. Introduction

Breast cancer has been the most common form of cancer in women (1), but its incidence has decreased with increasing diagnosis and treatment options in the last few years (2,3). However, illness-induced functional impairment still constitutes a problem.

Breast cancer patients develop some complications because of both the nature of the cancer itself and the treatment of the cancer, including cosmetic, psychological, and physical problems, such as dysfunction of the shoulder and lymphedema (4–6). Daily activities, such as reaching above the head or moving one's hands behind one's back for putting on clothing, become more difficult for patients. The reported prevalence of impairments in the shoulder's range of motion (ROM) has been reported to vary from 1% to 67% (7). For example, the shoulder's ROM was reported to be limited in up to 45% of patients who underwent sentinel node biopsy and in 86% of patients who underwent axillary dissection (8). Lymphedema can be defined as an abnormal accumulation of interstitial fluid that occurs primarily as a consequence of malformation or acquired disruption of the lymphatic circulation system (9). Breast cancer-related lymphedema refers to a swelling of the arm caused by damage to the axillary lymph drainage routes during breast cancer treatment (10). Lymphedema is one of the predominant physical sequelae, and it has an impact on the physical function of the shoulder; shoulder impairment is higher in patients with lymphedema than in patients without lymphedema (11). Currently, complex decongestive physical therapy is accepted as an international standard treatment approach for the treatment of lymphedema (12). Such treatment occurs in combination with skin care, manual lymph drainage (MLD), compression bandages, compression garments, and exercises. The application of intermittent pneumatic compression (IPC) as part of a complex decongestive physical therapy remains controversial (13). MLD is a massage technique that is performed from

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distal to proximal directions (14). IPC, which involves gradual pressure gradients on the lymph vessels, helps the lymph flow (15). Of studies regarding the use of IPC for reducing lymphedema (13,15–17), we found only one study that compared the effect of MLD and IPC on arm mobility in patients with lymphedema (17). To the best of our knowledge, our study is the first controlled trial investigating the effect of IPC on functional limitations of the upper limbs.

2. Materials and methods

The study was performed at the Physical Medicine and Rehabilitation Department of Atatürk University Faculty of Medicine and Erzurum Research and Training Hospital. Twenty-five patients with upper extremity lymphedema following mastectomy with no history of physical therapy were enrolled in this randomized, controlled trial. All the participants were informed of the study protocol and, in accordance with the Declaration of Helsinki, their written informed consent was obtained.

Patients who had a history of unilateral lymphedema for at least 3 months and no history of physical therapy were recruited. Patients who had bilateral lymphedema, current metastases, continuing radiotherapy, elephantiasis, infection, lymphangiosis carcinomatosa, cellulitis, venous thrombosis, or congestive heart failure, or who were using any medications that affect the body fluid or the electrolyte balance were excluded.

The patients were sequentially randomized into 2 groups: a pneumatic compression group and a control group. The treatment of the pneumatic compression group (n = 12) included skin care, MLD, IPC (MARK III Plus MK400 model, 6 outlets), compression bandages, and exercises; the IPC was applied after the MLD. The control group (n =13) underwent the same program, but without IPC. Both groups were treated 5 times per week for 3 weeks, for a total of 15 sessions. After the therapy, the patients were instructed to continue the exercises and to use their compression bandages. The same physician assessed the patients initially, after the therapy, and 1 month after completing the therapy. The physician who assessed the patients was blind to the treatment groups.

Demographic features of the patients, including age, number of rounds of chemotherapy and radiotherapy, duration of lymphedema, and number of lymph node dissections, were recorded. Lymphedema was measured with the water-immersion method, which is still the gold standard (18). The volumes of the affected and unaffected limbs were calculated, and the difference between these 2 values was recorded. Lymphedema was defined as more than a 10% volume difference between the arms.

Goniometry was used to measure the ROM of the upper extremities. The shoulder's flexion, abduction, external rotation, and internal rotation; the elbow's flexion and extension; and the wrist's flexion and extension were all measured according to the neutral-zero method.

The dysfunction of the shoulder was assessed with the Constant-Murley scale, which was designed to assess upper extremity disability (19). This scale evaluates pain, activities of daily living (ADL), working conditions, sleep comfort, ability to use the arm, the shoulder's ROM, and muscle strength. Pain was evaluated on a 0–15 point scale (none: 15 points, mild: 10 points, moderate: 5 points, and severe: 0 points). The ADL score is divided into 4 items: sleeping: 2 points; levels of activity: 10 points; hobby/sport: 4 points; positioning of the hand: 10 points. The ROM is evaluated in terms of the flexion, abduction, and internal and external rotation of the shoulders, with 10 points assigned to each. Finally, strength is evaluated as pounds of pull that the patient can resist in abduction, to a maximum of 25 points. The total possible score is 100 points (pain: 15 points; ADL: 20 points; ROM: 40 points; and strength: 25 points), indicating an asymptomatic and healthy person, while the worst score is 0 points.

In addition, the patients were questioned about arm pain complaints. Pain was measured by the visual analogue scale (VAS) of 0–100 mm, ranging from no pain to very severe pain.

Statistical analysis was performed using SPSS version 15.0 for Windows (SPSS Inc., Chicago, IL, USA). Differences between the groups were tested using the Mann–Whitney U test. The repeated measures ANOVA test was used to determine angle changes over time and to examine the differences between the treatment groups. The Friedman analysis of variance was used when the sphericity assumption was not met. Wilcoxon's test was used to evaluate pre- and posttreatment values within the groups. Correlation analysis between the parameters was performed by Pearson's correlation test. The level of statistical significance was set at $P < 0.05$.

3. Results

The demographic variables, such as age, body mass index, duration of lymphedema, number of lymph node dissections, and lymphedema volume were similar between the 2 groups ($P > 0.05$) (Table 1). There were no significant differences in the shoulder's flexion/abduction, the shoulder's external/internal rotation, the elbow's flexion/extension, the wrist's flexion/extension, the Constant-Murley scale, or the VAS score between the 2 groups before the treatment ($P > 0.05$).

When we examined the correlation between the lymphedema volume and the upper limb's ROM, we found that only flexion and internal rotation of the shoulder were correlated with the lymphedema volume ($P < 0.04$, $P < 0.01$, respectively). However, we did not find any

Table 1. Demographic characteristics of patients in both groups [median (minimum–maximum)].

	Control group	Pneumatic compression group	P
Age (years)	54 (37–65)	56 (43–75)	>0.05
Weight (kg)	78 (61–93)	77 (60–91)	>0.05
Height (cm)	157 (140–165)	158 (140–165)	>0.05
BMI (kg/m^2)	32.7 (26–41)	31.7 (23.8–40.8)	>0.05
Number of lymph node dissections	10 (8–23)	11 (3–22)	>0.05
Volume difference (cm^3)	580 (180–1780)	850 (260–1560)	>0.05

BMI: Body mass index

correlation between the lymphedema volume and the Constant-Murley scale or the VAS. In addition, we tested the correlation between the Constant-Murley scale and movement restrictions of the upper limbs, and there were significant correlations between the Constant-Murley scale and the shoulder's ROM. The correlations for the ROM of the shoulder had $P < 0.001$ values.

In the pneumatic compression group, a significant improvement was observed in the ROM of the shoulder, except for external rotation, when we evaluated pre- and posttreatment values (Table 2). This significant difference was also seen at the 1-month follow-up after the therapy (Table 2). In addition, the VAS and Constant-Murley scores were decreased after the therapy in the pneumatic compression group ($P = 0.01$, $P = 0.002$, respectively), and those decreases continued at the 1-month follow-up when compared to the baseline ($P = 0.01$, $P = 0.002$, respectively).

In the control group, significant improvements were detected after the treatment in the ROM of the shoulder. These improvements were also observed 1 month later (Table 3). Significant differences were observed in the VAS and the Constant-Murley scores pre- and posttreatment in

Table 2. Comparison of measurements pre- and posttreatment and 1 month after in the pneumatic compression group [median (minimum–maximum)].

Pneumatic compression group	Pre-treatment	Posttreatment	After 1 month	P_1	P_2
Shoulder flexion	152 (45–180)	170 (50–180)	170 (50–180)	0.018	0.017
Shoulder abduction	130 (50–180)	165 (50–180)	165 (50–180)	0.017	0.018
Shoulder internal rotation	57 (20–80)	70 (20–80)	70 (20–80)	0.01	0.01
Shoulder external rotation	90 (20–90)	90 (20–90)	90 (20–90)	ns	ns
Elbow flexion	150 (150–150)	150 (150–150)	150 (150–150)	ns	ns
Elbow extension	0 (0–0)	0 (0–0)	0 (0–0)	ns	ns
Wrist flexion	80 (0–80)	80 (80–80)	80 (80–80)	ns	ns
Wrist extension	70 (70–70)	70 (70–70)	70 (70–70)	ns	ns
Constant-Murley	54 (2–63)	59 (2–63)	59 (10–65)	0.002	0.002
VAS	20 (0–100)	5 (0–70)	0 (0–70)	0.01	0.01

VAS: Visual analogue scale
P_1: P value of pre- and posttreatment
P_2: P value of pretreatment and 1 month after
ns: not significant

Table 3. Comparison of measurements pre- and posttreatment and 1 month after in the control group [median (minimum–maximum)].

Control group	Pre-treatment	Posttreatment	After 1 month	P_1	P_2
Shoulder flexion	160 (80–180)	160 (80–180)	170 (110–180)	0.018	0.018
Shoulder abduction	160 (10–180)	170 (110–180)	170 (105–180)	0.018	0.017
Shoulder internal rotation	60 (40–80)	80 (40–80)	80 (40–80)	0.008	0.01
Shoulder external rotation	75 (20–90)	90 (20–90)	90 (20–90)	0.041	0.042
Elbow flexion	150 (150–150)	150 (150–150)	150 (150–150)	ns	ns
Elbow extension	0 (0–0)	0 (0–0)	0 (0–0)	ns	ns
Wrist flexion	80 (40–80)	80 (45–80)	80 (45–80)	ns	ns
Wrist extension	70 (55–70)	70 (70–70)	70 (70–70)	ns	ns
Constant-Murley	52 (10–63)	57 (23–65)	57 (23–65)	0.001	0.001
VAS	40 (0–70)	20 (0–50)	10 (0–50)	0.004	0.004

VAS: Visual analogue scale
P_1: P value of pre- and posttreatment
P_2: P value of pretreatment and 1 month after
ns: not significant

the control group (P = 0.004, P = 0.001, respectively), and those improvements continued at the 1-month follow-up (P = 0.004, P = 0.001, respectively).

Comparing the 2 groups, there were no significant differences in the upper limb's ROM, the VAS, or the Constant-Murley scale after the therapy or 1 month after completing the therapy. However, there were significant improvements immediately after the therapy and 1 month after completing the therapy in both groups.

4. Discussion

Breast cancer-related lymphedema may cause upper limb ROM impairments because of scar tissue formation, radiation-induced fibrosis, and protective posturing due to pain or disuse. Few studies in the literature have investigated the association among upper extremity limitations, treatment, and disability in patients with breast cancer (20,21). Therefore, we aimed to evaluate the functional limitations of the upper limbs and the efficacy of IPC in secondary breast lymphedema. This is the first controlled study to investigate the efficacy of IPC for functional limitations of the upper limbs. Previous studies of the ability of IPC pumps to reduce lymphedema have reported different results (16,22,23). Dini et al. used IPC pumps at a pressure of 60 mmHg, as we did. They reported that IPC has a limited clinical role in the treatment of postmastectomy lymphedema. However, they did not evaluate the functional limitations of the upper limbs. In our study, we found that IPC and MLD were both effective for improving the ROM of the upper limbs (mainly the shoulder), ADL, and pain.

Besides the treatment modalities, we examined the correlation between the lymphedema volume and quality of life. We assessed ADL using the Constant-Murley scale, and we did not find any correlation between lymphedema volumes. However, we found a correlation between the lymphedema volume and movement restriction of the shoulder. Nesvold et al. conducted a study on the relationship between shoulder problems and quality of life in breast cancer (24), using the SF-36 to evaluate quality of life; our results were similar to theirs.

To the best of our knowledge, one study in the literature has compared treatment modalities on shoulder function in patients with lymphedema. Johansson et al. compared MLD and IPC in 28 patients over 2 weeks (17). They applied MLD to one group and IPC to the other group, and they found that treatment with MLD or IPC did not change the arm's mobility. Those findings were contrary to our results, because we observed significant improvements in the shoulder's ROM. Johansson et al.'s study did not have an active or a placebo control group, whereas our study included an MLD control group. On the other hand, our study also had some limitations, such as a lack of long-term follow-ups and a small sample size.

In conclusion, complex decongestive physical therapy seems to be effective in both lymphedema reduction and in improvement of upper extremity impairments, and the addition of IPC to the therapy may not provide any additional benefit. To the contrary, IPC may increase the total cost and time. Further controlled studies involving a larger number of patients over a longer period are needed to investigate the effects of IPC on functional limitations of the upper limbs.

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