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# INFLUENCE OF COMPRESSION CYCLE TIME AND NUMBER OF SLEEVE CHAMBERS ON UPPER EXTREMITY LYMPHEDEMA VOLUME REDUCTION DURING INTERMITTENT PNEUMATIC COMPRESSION

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*ABSTRACT*

*The cycle time and number of chambers in the pneumatic sleeve may influence the outcome of lymphedema therapy with intermittent compression devices. The aim of our study was to assess efficacy of several commonly used different IPC protocols on edema volume reduction in women with postmastectomy lymphedema. Fixty-seven (57) women with secondary arm lymphedema (age 39-80) were selected to the study. Women were randomly assigned to two study groups with different IPC cycle times: I – 90:90s and II – 45:15s. Both groups were then randomly divided into two subgroups with different sleeves: A – 1 chamber sleeve (28 women) and B – 3 chamber sleeve (29 women). All women underwent IPC treatment for 5 weeks, 5 times a week for 1 hour (25 sessions). Arm volume measurements were performed before and after each IPC session. Significant reduction of edema volume was observed in all therapeutic subgroups, regardless of cycle times and number of chambers. In the group with short IPC cycle, better efficacy was noticed with 3-chamber sleeve. IPC is an effective method of volume reduction in women with postmastectomy arm lymphedema regardless of cycle times and number of sleeve chambers.*

**Keywords:** compression pumps, upper extremity edema, breast cancer

Intermittent pneumatic compression (IPC) represents a recognized therapeutic procedure in lymphedema. In such a procedure, periodic compression exerted on tissues of affected extremity facilitates lymph flow to collecting lymphatic vessels and, when the compression is released, filling of the vessels. The rhythmical periodicity of compression facilitate outflow of venous blood without affecting inflow to tissues of arterial blood. On the other hand, other studies indicate that IPC-induced reduction of edema results rather from a decreased capillary filtration of plasma (reduced formation of the lymph) than from facilitated outflow of the lymph. Perhaps the differences may reflect application of various IPC pumps (1-4).

The available IPC pumps differ in their potential of applying various compression parameters and in sleeve structure. Some of them permit only to control compression pressure while the other ones allow to control duration of compression and of intervals of decompression (5-7). The applied sleeves vary from single chamber and multi-chamber sleeves, most frequently 3-, 5-, 11- and 12-chamber sleeves (5). Using multi-chamber sleeves, compression commences at peripheral parts of the extremity and progresses proximally, developing an ascending wave of compression. Studies on IPC using the multi-chamber sleeve demonstrated that due to mechanical interactions (tension of the sleeve material, rigidity of the walls) the pressure which develops in the sleeve may exceed even by 80% the apparatus manometer readouts, which may exert deleterious effect on lymph circulation and may make the treatment more difficult. This induces the need to employ much lower pressure values than those used in clinical practice (8).

In view of the absence of uniform criteria for selection of the parameters, such variability of equipment for intermittent pneumatic compression results in a certain freedom in selecting methods of applying the procedure, which on one hand may explain absence of reduction of lymphedema and, on the other, may bring about risk of complications and of worsening the lymphedema.

The variable methodology of applying intermittent pneumatic compression in the aim of reducing lymphedema is paralleled by absence of randomized studies which would evaluate efficacy of the procedure. As the example, Manjuli et al (9) demonstrated over 26% reduction of lymphedema after application of sequential IPC from distal to proximal parts of an extremity using a 12-chamber sleeve but failed to compare the results with those in a control group or reference group. Also in studies of Miranda et al (1) no such a comparison was provided.

Results of randomized studies on efficacy of IPC in reduction of lymphedema following treatment of breast cancer presented by few authors were completely divergent. Dini et al (10) demonstrated a fourfold more pronounced decrease in lymphedema following IPC, as compared to untreated control group. However, the result was insignificant, perhaps due to low numerical force of studied groups as well as due to extensive variability in perimeters in preliminary studies as well as in IPC-induced alterations. On the other hand, one of the authors (Szuba) demonstrated a significantly higher reduction in lymphedema in women following treatment of breast cancer who in addition were subjected to IPC (11).

Other experience with application of IPC is variable. This reflects the fact that they pertained small, mixed populations (with lymphedema of upper and/or lower extremities), with absence of control groups or parameters permitting to evaluate pain or consistency of the edema (7,12,13).

The lack of randomized studies on efficacy of IPC in reduction of lymphedema, basic differences in views of the few authors dealing with the subject, widespread use of the procedure in practice, and variability of the applied equipment requires that efficacy of the procedure should be evaluated and most effective parameters of employing IPC should be defined.

We examined the efficacy of intermittent pneumatic compression to reduce upper extremity lymphedema in women following breast cancer therapy with two different cycles and two different sequences of the compression.

## *MATERIALS AND METHODS*

The study was conducted on 57 women aged 39 to 80 years with lymphedema of upper extremity following treatment of breast cancer. The studied women were randomly allocated into four groups with different cycles and sleeves:

I – one-to-one cycle of compression and interval (90 s : 90 s) with a single chamber sleeve (N = 17),

II – one-to-one cycle of compression and interval (90 s : 90 s) with a three-chamber sleeve (N = 9),

III – three-to-one cycle of compression and interval (45 s : 15 s) with a single chamber sleeve (N = 11),

IV – three-to-one cycle of compression and interval (45 s : 15 s) with a three-chamber sleeve (N = 20).

Before commencing and after termination of IPC (5 weeks) volumes of both upper extremities were measured by water displacement. For each subject, the distance between the tip of the third finger and bottom of axillary fossa was determined for each extremity. Each subsequent measurement was repeated to this distance. All measurements were repeated and mean value was recorded.

The degree of lymphedema (V%) represented a difference in volume between the swollen upper extremity (s.u.e.) and the healthy upper extremity (h.u.e.), expressed in percents:

$$V_1\% \ \frac{V_{1.s.u.e.} - V_{h.u.e.}}{V_{h.u.e.}} \ x\ 100 \text{ – before IPC}$$

$$V_{25}\% \ \frac{V_{25.s.u.e.} - V_{h.u.e.}}{V_{h.u.e.}} \ x\ 100 \text{ – following 25 IPC procedures}$$

where:
$V_{1\ s.u.e.}$ = volume of swollen upper extremity before IPC,
$V_{h.u.e.}$ = volume of healthy upper extremity,
$V_{25\ s.u.e.}$ = volume of swollen upper extremity after IPC.

The relative reduction of lymphedema following IPC was calculated as follows:

$$V_1 - V_{25}\% = \frac{V_1\% - V_{25}\%}{V_1\%} \ x\ 100$$

where:
$V_1\%$ = %volume of lymphedema before IPC,
$V_{25}\%$ =%volume of lymphedema after IPC.

Absolute reduction of lymphedema following IPC was calculated as follows:
$V_{1\text{-}25}\ \% = V_1\% - V_{25}\%$
where:
$V_1\%$ = %volume of edema before IPC,
$V_{25}\%$ = %volume of edema after IPC.

*IPC Method*

In all the subjects preliminary evaluation was followed by 25 procedures of IPC within 5 weeks. The procedures were performed 5 days a week, excluding Saturdays and Sundays. Each treatment was performed before noon and lasted 1 hour.

In Groups I and II, a Flowtron Plus apparatus (model AC 200/2, Huntleigh Healthcare, Great Britain) was employed. This device provided 3 minute cycles of 90 s of compression and 90 s of decompression. In Groups III and IV, a Flowtron Flowpac Plus apparatus (model FP 2000, Huntleigh Healthcare, Great Britain) was used. This device allowed variable cycles and we utilized compression cycles of 45 s, followed by a pause of 15 s (3:1).

The IPC procedures employed 1- or 3-chamber sleeves. The design of a single chamber sleeve allowed for simultaneous filling of the entire sleeve. Application of a three-chamber sleeve was cyclic beginning with filling of the distal and ending with filling of the proximal chamber and provided a centripetal sequence of compression.

Compression pressure was established individually for every subject depending of consistency of her edema. For solid edemas, lower compression pressures were applied; edemas of soft consistency were compressed with higher pressures, but always lower than diastolic blood pressure. The compression pressures ranged from 30 to 50 mm Hg for all subjects.

Arithmetic means, standard deviations, variability coefficients as well as minimum and maximum values were calculated. Significance of differences between the mean values was evaluated using the MANOVA binomial analysis of variance. Detailed comparisons were executed using the NIR test of the lowest significant differences. Mean values of relative differences (%) in volume between edematous or normal extremities between preliminary and final tests in individual Groups were evaluated using Student's t-test for dependant samples. In all statistical tests, significance of differences was tested at $p < 0.05$.

*RESULTS*

**TABLE 1**
**Characteristics of Experimental Groups**

| Variable | Group I (n=17) 90 s compression cycle, single-compartmental sequence | | | Group II (n=9) 90 s compression cycle, three-compartmental sequence | | | Group III (n=11) 45 s compression cycle, single compartmental sequence | | | Group IV (n=20) 45 S compression cycle, three-compartmental sequence | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\bar{x}$ | s | v | $\bar{x}$ | s | v | $\bar{x}$ | s | v | $\bar{x}$ | s | v |
| Age [years] | 57.59 | 9.60 | 16.67 | 58.00 | 7.57 | 13.05 | 60.09 | 12.17 | 20.25 | 55.30 | 9.92 | 17.94 |
| Body weight [kg] | 78.50 | 16.62 | 21.17 | 74.33 | 8.19 | 11.01 | 75.09 | 10.78 | 14.36 | 73.95 | 10.33 | 13.97 |
| Body height [cm] | 162.00 | 4.96 | 3.06 | 162.11 | 2.85 | 1.76 | 162.64 | 5.70 | 3.50 | 161.45 | 4.65 | 2.8 |
| BMI | 29.86 | 5.94 | 19.91 | 28.28 | 3.03 | 10.70 | 28.41 | 4.03 | 14.20 | 28.42 | 4.16 | 14.64 |
| Systolic BP [mm Hg] | 135.59 | 14.24 | 10.50 | 130.00 | 11.18 | 8.60 | 138.64 | 18.32 | 13.21 | 137.75 | 19.57 | 14.20 |
| Diastolic BP [mm Hg] | 83.53 | 7.66 | 9.17 | 83.89 | 6.51 | 7.76 | 80.00 | 11.18 | 13.98 | 82.75 | 9.80 | 11.84 |
| Compression pressure [mm Hg] | 38.82 | 4.16 | 10.71 | 39.44 | 3.00 | 7.62 | 36.36 | 5.52 | 15.18 | 36.25 | 4.25 | 11.73 |

$\bar{x}$ = Mean value, S = Standard Deviation, V=Variance

**TABLE 2**
**Binomial Analysis of Variance Used to Evaluate Mean Values Obtained Using Various Cycles and Compression Sequences**

| Variable | MANOVA Sequence | | MANOVA Cycle | | MANOVA Interaction | | Detailed inter-group comparison using NIR test | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F | P | F | P | F | P | I-III | II-IV | I-II | III-IV | I-IV | II-III |
| Age | 0.62 | 0.435 | 0.00 | 0.972 | 0.87 | 0.354 | 0.520 | 0.503 | 0.921 | 0.207 | 0.490 | 0.643 |
| Body weight | 0.59 | 0.446 | 0.30 | 0.586 | 0.19 | 0.663 | 0.480 | 0.939 | 0.419 | 0.807 | 0.271 | 0.892 |
| Body height | 0.17 | 0.686 | 0.00 | 0.993 | 0.24 | 0.626 | 0.730 | 0.730 | 0.955 | 0.508 | 0.727 | 0.807 |
| BMI | 0.37 | 0.546 | 0.26 | 0.610 | 0.38 | 0.540 | 0.420 | 0.943 | 0.411 | 0.995 | 0.348 | 0.953 |
| Systolic BP | 0.48 | 0.491 | 1.34 | 0.253 | 0.25 | 0.617 | 0.640 | 0.254 | 0.422 | 0.888 | 0.697 | 0.257 |
| Diastolic BP | 0.38 | 0.541 | 0.85 | 0.360 | 0.22 | 0.638 | 0.319 | 0.755 | 0.924 | 0.422 | 0.795 | 0.344 |
| Compression pressure | 0.04 | 0.835 | 5.47 | **0.023** | 0.09 | 0.762 | 0.149 | 0.072 | 0.730 | 0.945 | 0.078 | 0.120 |

Analysis of age, height, body weight, body mass index (BMI), systolic and diastolic blood pressures found no differences between the studied groups (*Tables 1 and 2*). Differences between mean compression pressures in IPC procedures with short cycles (45 s) compared to longer cycles (90 s) were significant at $p = 0.023$. Detailed comparisons of mean values between cycles and sequences manifested no significant differences (*Tables 1 and 2*).

Mean values of healthy and affected

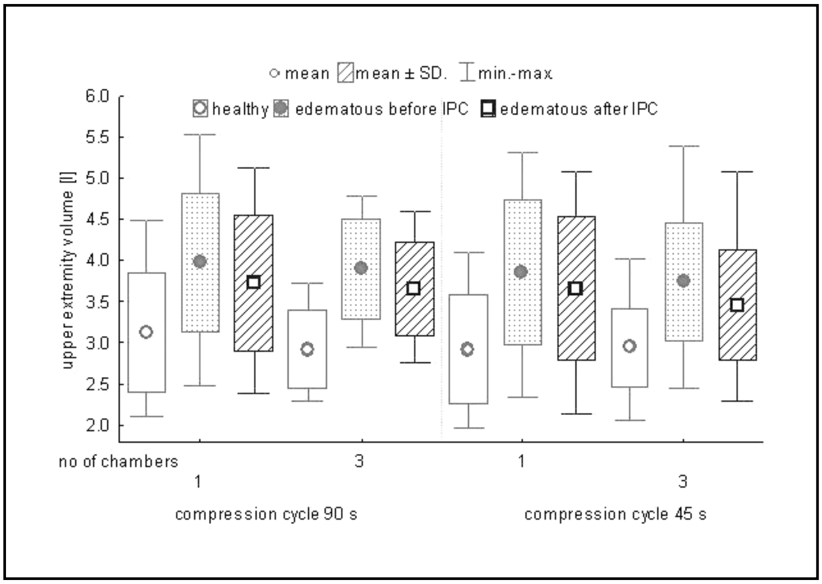


*Fig. 1. Volume measurements of healthy limbs and edematous limbs before and after one or three chamber compression using either the 90 s or 45 s treatment cycles.*

extremity volumes showed no significant differences between the groups (*Fig.1, Tables 3 and 4*). Significant differences in relative edema were found in all groups after treatment ($p < 0.05$) (*Fig. 2, Table 5*). Comparison of mean values for edema reduction in groups detected no significant differences between both 90 s cycles with 1- or 3-compartment sleeves and 45 s cycles with 1- or 3-compartment sleeves (*Tables 3 and 4*). The most extensive absolute decrease in extremity volume on the lymphedematous arm was observed in Group IV while the least pronounced reduction in edema was observed in women of Group III. In Groups I and II, mean values of edema reduction were similar (*Table 3, Fig. 3*). Analysis of the relative decrease in edema demonstrated that the most pronounced decrease in lymphedema was seen in women of Group IV. Detailed comparisons of the smallest significant differences demonstrated that the 45 s cycle with a three compartmental sleeve was almost twice as effective as compared to 45 s cycle with a single compartment sleeve ($p = 0.040$, *Table 3 and 4*).

## *DISCUSSION*

Intermittent pneumatic compression (IPC) has been used for many years in treatment of disturbed function of the vascular system. Numerous studies also point to its efficacy in treatment of lymphedema, sometimes comparable to the efficacy of manual lymphatic drainage. Nevertheless, significance of principal variables which characterize IPC, such as compression pressure, ratio of duration of compression to that of interval, timing, and frequency of IPC procedures, and general duration of the treatment, has not been sufficiently documented. This situation pertains also to the types of equipment used and the pressure exerting sleeve, the extensive variability of which may make the selection even much more difficult (5,8,11,14). There are a growing number of pneumatic compression devices with multiple programs of compres-sion and multiple options for both number of chambers and sequences of inflation/deflation and there is a need for future studies for direct comparisons among these devices.

**TABLE 3**
**Statistical Characteristics of Parameters for Healthy and Edematous Extremities Following IPC of Various Cycles and Compression Sequences in Studied Groups**

| Variable | Procedure | Group I 90 s compression cycle, single-compartmental sequence | | Group II 90 s compression cycle, three-compartmental sequence | | Group III 45 s compression cycle, single compartmental sequence | | Group IV 45 S compression cycle, three-compartmental sequence | |
|---|---|---|---|---|---|---|---|---|---|
| | | $\bar{x}$ | s | $\bar{x}$ | s | $\bar{x}$ | s | $\bar{x}$ | s |
| Volume of healthy upper extremity [l] | 1 and 25 | 3.13 | 0.72 | 2.93 | 0.47 | 2.93 | 0.66 | 2.95 | 0.47 |
| Volume of edematous upper extremity [1] | 1 | 3.98 | 0.84 | 3.90 | 0.60 | 3.86 | 0.88 | 3.74 | 0.72 |
| | 25 | 3.73 | 0.82 | 3.66 | 0.56 | 3.67 | 0.86 | 3.46 | 0.66 |
| Extent of edema [%] | 1 | 28.96 | 21.42 | 34.64 | 19.75 | 34.14 | 28.25 | 27.78 | 21.98 |
| | 25 | 20.65 | 20.69 | 26.52 | 19.87 | 27.30 | 27.61 | 18.15 | 21.11 |
| Relative extent of edema [%] | 1-25 | 37.58 | 19.95 | 30.30 | 20.74 | 29.39 | 18.00 | 47.35 | 27.47 |
| Absolute extent of edema [%] | 1-25 | 8.31 | 5.40 | 8.12 | 4.70 | 6.84 | 2.35 | 9.62 | 4.32 |

$\bar{x}$ = Mean, S = Standard Deviation

**TABLE 4**
**Binomial Analysis of Variance for Evaluation of Mean Values Obtained in Various Compression Cycles and Sequences**

| | | MANOVA | | | | | | Detailed inter-group comparison using NIR test | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Procedure | Sequence | | Cycle | | Interaction | | | | | | | |
| | | F | P | F | P | F | P | I-III | II-IV | I-II | III-IV | I-IV | II-III |
| Volume of healthy upper extremity | 1 and 25 | 0.31 | 0.581 | 0.31 | 0.580 | 0.46 | 0.501 | 0.378 | 0.934 | 0.408 | 0.928 | 0.351 | 0.999 |
| Volume of edematous upper extremity | 1 | 0.21 | 0.651 | 0.43 | 0.517 | 0.01 | 0.918 | 0.695 | 0.602 | 0.813 | 0.680 | 0.354 | 0.903 |
| | 25 | 0.45 | 0.506 | 0.42 | 0.520 | 0.13 | 0.723 | 0.835 | 0.489 | 0.833 | 0.449 | 0.270 | 0.989 |
| Extent of edema | 1 | 0.00 | 0.957 | 0.02 | 0.895 | 0.89 | 0.349 | 0.561 | 0.457 | 0.549 | 0.461 | 0.875 | 0.961 |
| | 25 | 0.07 | 0.792 | 0.02 | 0.890 | 1.47 | 0.230 | 0.442 | 0.352 | 0.524 | 0.277 | 0.734 | 0.938 |
| Relative extent of edema | 1-25 | 0.71 | 0.403 | 0.49 | 0.488 | 3.97 | 0.052 | 0.356 | 0.067 | 0.441 | **0.040** | 0.198 | 0.929 |
| Absolute extent of edema | 1-25 | 1.09 | 0.300 | 0.00 | 0.992 | 1.43 | 0.237 | 0.396 | 0.405 | 0.919 | 0.102 | 0.376 | 0.523 |

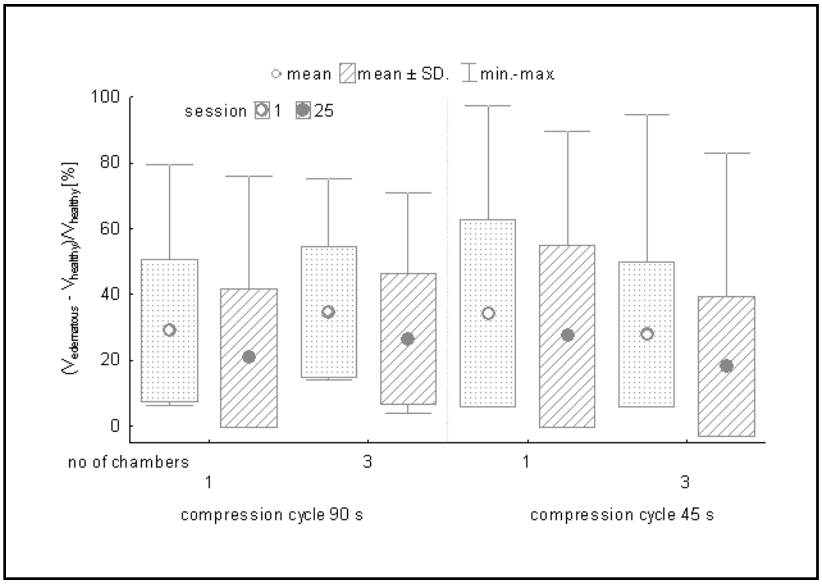


*Fig. 2. Treatment results (percent increase in lymphedema volume) after one or twenty-five sessions on edematous limbs using one or three chamber compression with either the 90 s or 45 s treatment cycles.*

**TABLE 5**
**Evaluation of Significance of Mean Differences in the Extent of Eedema Before and after IPC**

| | | | | Before IPC | | After IPC | | Before IPC - after PIC difference | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Compression cycle | Compression sequence | N | $\overline{x}$ | s | $\overline{x}$ | s | $\overline{x}$ | s | t | p |
| Volume of edematous upper extremity [liters] | | | | | | | | | | | |
| | 90 s | 1-comp. | 17 | 3.98 | 0.84 | 3.73 | 0.82 | 0.25 | 0.14 | 7.33 | **0.000** |
| | | 3-comp. | 9 | 3.90 | 0.60 | 3.66 | 0.56 | 0.24 | 0.14 | 5.03 | **0.001** |
| | 45 s | 1-comp. | 11 | 3.86 | 0.88 | 3.67 | 0.86 | 0.19 | 0.06 | 9.87 | **0.000** |
| | | 3-comp. | 20 | 3.74 | 0.72 | 3.46 | 0.66 | 0.28 | 0.14 | 8.83 | **0.000** |
| Extent of edema [%] | | | | | | | | | | | |
| | 90 s | 1-comp. | 17 | 28.96 | 21.42 | 20.65 | 20.69 | 8.31 | 5.40 | 6.35 | **0.000** |
| | | 3-comp. | 9 | 34.64 | 19.75 | 26.52 | 19.87 | 8.12 | 4.70 | 5.19 | **0.001** |
| | 45 s | 1-comp. | 11 | 34.14 | 28.25 | 27.30 | 27.61 | 6.84 | 2.35 | 9.67 | **0.000** |
| | | 3-comp. | 20 | 27.78 | 21.98 | 18.15 | 21.11 | 9.62 | 4.32 | 9.97 | **0.000** |

$\overline{x}$ = Mean, S = Standard Deviation, t = t-test result

In our studies, IPC has been found to be effective in reducing lymphedema of the upper extremities in women following treatment of breast cancer. Independent of the cycle type and compression sequence, edema has been found to be significantly reduced by 29 to 47%. It should be noted that any type of applied IPC clearly reduced the extent of edema, with no significant differences between the applied types of IPC. Our

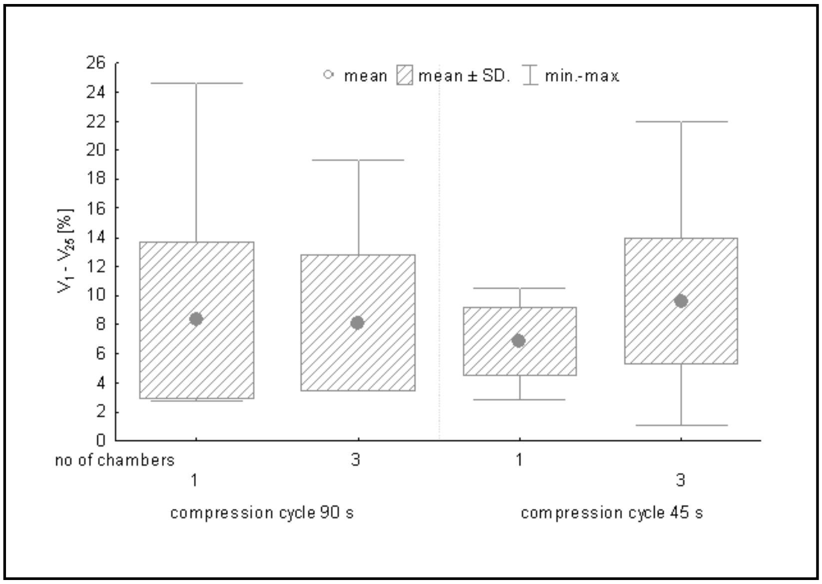


*Fig. 3. Treatment results (percent absolute volume decrease) in upper extremity edematous limbs following one or three chamber compression with either the 90 s or 45 s treatment cycles.*

study compared use of single- and three-compartment sleeves. Despite the principles of action of the three-compartment sleeve (a centripetal pressure wave moving from distal to proximal parts of the extremity), results of treatment could be different if the number of compartments was even higher. In publications on the subject, a relatively general contention prevails, although it has not been supported by sufficient experimental evidence (which involved small populations of patients), that a sequential compression of an extremity using a multi-compartmental sleeve is more effective in treatment of lymphedema compared to simultaneous compression of an entire extremity using a single compartment sleeve (1,9). The contention reflects a specific design of the sleeve which develops compression in the form of a centripetal wave, beginning at the distal parts of the extremity. In theory, this action should promote lymph flow toward proximal parts of the extremity and to collecting lymphatic vessels. In addition, the linear pressure wave restricts fluid accumulation in the hand region. A similar situation pertains to various cycles of IPC. In general, shorter duration of compression and interval cycles has been thought to be more effective. However, in our studies similar results have been obtained independently of the type of IPC cycle. Our comparative results may indicate that compression is paramount and how this is applied may be less important.

Studies on fluid behavior in swollen tissues have demonstrated that its mobility is greater in swollen than in tissues free of edema and that it decreases following application of IPC. Mobility of the fluid has been found to be greater in distal compared to proximal parts of the extremity. The movement of edematous fluid and its reaction to IPC might provide sound rationale for higher efficacy of sequential compression with the use of multi-compartmental sleeves as compared to a single compartmental sleeves. In addition, IPC speeds up lymph flow depending on the site of the applied compression (5,7,15,16).

The present results have not confirmed the presumption, which prevails in the literature, that sequential compression using a multi-compartmental sleeve is more effective than application of a single-compartment sleeve in reducing lymphedema of upper extremity. The contention reflects the higher probability that the wave of compression, ascending from distal to proximal parts of the extremity, may imitate physiological conditions for lymph outflow. However, the similar result we obtained using the single-compartment sleeve supports revision of these views and perhaps the theoretical foundations of the sequential pneumatic compression are not fully justified. The hypothesis has stemmed from analysis of assumptions and principles of execution in manual lymphatic drainage. This technique is also applied centripetally but starting at proximal and ending at distal parts of an extremity. In the case of upper extremity, it starts with arm, followed by forearm, hand and then the entire upper extremity. Such a sequence of drainage is based on the perceived need to empty lymph from proximal extremity parts in order to facilitate the flow from distal parts and this is consistent with the physiology of lymph circulation (2-4). These principles are not followed in cases of IPC, in which the compression wave is directed centripetally but it starts in distal parts of the extremity. Therefore, if any mechanical block hampers lymph outflow, its shift to proximal extremity parts may even hamper lymph drainage if it is not preceded by emptying of the proximal lymphatic vessels. Perhaps this consideration has resulted in the absence of significant differences in edema reduction between application of various compression sequences.

Another reason for the significant reduction in lymphedema, independent of the compression sequence, might involve the physiological mechanism of intermittent pneumatic compression. Some authors point to the similarity of its action to the "muscle pump" which facilitates lymph flow in lymphedema. During compression of the extremity by the sleeve, lymphatic vessels collapse and their content of lymph is shifted toward proximal parts of the extremity while the release of compression during interval allows refilling of lymph vessels with lymph. The mechanism resembles that of muscular contraction, which compress lymphatic vessels, narrow their lumen, while relaxing, permitting them to distend, which sucks in tissue fluid to lymphatic vessels. Such a sequence has been confirmed by experimental studies using IPC in anaesthetized sheep. In these studies, IPC has been found to effectively promote lymph flow, particularly in the region of compression and at higher frequency of compressions. However, it should be kept in mind that the studies involved anaesthetized animals and in conscious animals the mechanism may be somewhat different (4,5,17).

Publications on the subject contain also another view according in which the effective reduction in lymphedema under IP results not from augmented lymph flow, but rather from decreased filtration of blood in capillaries (decreased formation of lymph) (1). The significant decrease in lymphedema independently of the compression sequence may provide indirect evidence for such a mechanism.

It has been reported and widely cited that IPC only transports the water and that the remaining protein remains which will again attract more water (18). Although not much investigation has been focused on this area, two other studies have demonstrated that proteins and glycosaminoglycans are transported with the fluid and we must realize that many imaging studies use protein bound to tracers (19,20). The movement of these tracers has been shown to be augmented by treatment including IPC (19).

Our results using IPC have been independent of alterations in compression sequence (sleeves) and cycle. The effects were similar and significant both when the sequential compression was applied using the three-compartment sleeve and a shorter or a longer cycle of compressions and when a single-compartment sleeve was used during either cycle of the procedure.

*CONCLUSIONS*

1. Intermittent pneumatic compression is an effective method to decrease lymphedema of the upper extremities in subjects following treatment of breast cancer independent of cycle type and compression sequence.
2. Changes in number of sleeve chambers induced no significant differences in efficacy of IPC between its various cycles.
3. In the course of the shorter compression cycle, higher efficacy of the IPC procedure has been obtained using the cyclic sequential massage.

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