

# Intermittent compression for the treatment of the oedematous hand in hemiplegic stroke: a randomized controlled trial

T. A. ROPER, SYLVIA REDFORD<sup>1</sup>, RAYMOND C. TALLIS<sup>2</sup>

Elderly Services Directorate, St James's Hospital, Beckett Street, Leeds LS9 7TF, UK

<sup>1</sup>Department of Physiotherapy Ladywell Hospital, Eccles New Road, Salford M5 2AA, UK

<sup>2</sup>University Department of Geriatric Medicine, Clinical Sciences Building, Hope Hospital, Eccles Old Road, Salford M6 8HD, UK

Address correspondence to: T. A. Roper. Fax: (+44) 113 242 9195

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## Abstract

**Objective:** to evaluate the efficacy of intermittent pneumatic compression in treating oedema in the hemiplegic hand of stroke patients.

**Design:** single-blind randomized control trial.

**Setting:** acute and rehabilitation elderly care wards in a teaching district.

**Subjects:** 37 subjects with a first ever hemisphere stroke were randomized to treatment with standard physiotherapy either alone or combined with intermittent pneumatic compression.

**Main outcome measures:** the effect of treatment on oedema was assessed using measures of the hand volume of the hemiplegic hand. The impact on function was assessed using the motricity index.

**Results:** the treated group showed no change in the mean stroke hand volume. In the control group the mean stroke hand volume decreased by 3.2 ml. There was no statistically significant difference between the groups. The median scores for the motricity index increased for both groups but there was no significant difference between the groups and any improvement in motor function was independent of any treatment effects.

**Conclusion:** intermittent pneumatic compression at the prescribed pressure and duration of this study is not an effective treatment for the oedematous stroke hand.

**Keywords:** *hemiplegia, oedematous hand, pneumatic compression, randomized controlled trial, stroke*

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## Introduction

In patients with hemiparesis or a hemiplegia following hemispheric stroke, swelling of the affected hand is a recognized phenomenon. The frequency of arm oedema has not been determined in an unselected population of stroke patients, although one series reported a frequency of 15% [1]. The mechanism of the swelling is uncertain, but it has been attributed to a combination of immobility and dependency, impairing venous return, and paralysis of the sympathetic control of vasculature [2]. Irrespective of the mechanism, oedema causes pain and disfigurement, and in chronic cases may predispose to contractures. This, combined with the increased weight of the arm, may interfere with rehabilitation of the upper limb.

Treatments used have included limb elevation, compression bandaging [3] and cold immersion [4]. The results have been disappointing, showing no improvement or only transient benefit. Intermittent pneumatic compression (IPC) has been used to treat lymphoedema [5–9] and it is employed on an empirical basis in stroke patients. However, its use in this context has never been formally evaluated. In contrast to lymphoedema, in hemiplegia the lymph vessels of the hand are intact and functional and theoretically there should be no obstruction to the removal of oedema fluid. An earlier pilot study showed encouraging improvements in hand volume following IPC.

The aim of the present study is to evaluate the efficacy of IPC in patients with oedema of the hemiparetic hand.

## Method

### Patient selection

Subjects were recruited from patients admitted to the elderly care service in Ladywell and Hope Hospitals, Salford over 18 months. All patients with a first ever hemisphere stroke (as defined by WHO criteria) and oedema of the hemiparetic hand were considered for the study.

To establish the presence of oedema, hand volumes were measured on two occasions one week apart, using the technique described below. If the stroke hand volume was 20 ml greater than the unaffected hand after the second reading, a patient was considered to have sufficient oedema to warrant treatment and was therefore entered in the trial. Exclusion criteria included other upper limb conditions associated with oedema (lymphoedema, trauma etc.), medical conditions associated with fluid retention (e.g. uncontrolled cardiac failure, hypoalbuminaemia), the consumption of drugs likely to cause fluid retention or diuresis, the dosage of which was likely to alter during the trial, and a mental or physical condition making co-operation impossible.

### Trial design

All patients who met inclusion criteria and were willing to participate in the trial and able to give informed consent were randomized to receive IPC plus standard physiotherapy or standard physiotherapy alone. The patients were randomized by a person unconnected with the trial using a randomization schedule obtained from the statistics department.

### Treatment

All patients received physiotherapy during the period of observation. It was impossible to standardize therapy and a pragmatic approach was adopted. All patients were prescribed therapy on an individual basis by their physiotherapist. This included correct positioning of hemiplegic limbs to prevent spasticity, and passive movement of the limbs. The only treatments forbidden were those, such as the application of ice, that could influence hand volume.

Patients randomized to IPC were treated with an intermittent compression machine (Pression Model 4323). A stockinet layer was applied to the hemiplegic limb to absorb moisture and a full arm-inflatable sleeve was applied over this and attached to the compression pump. The parameters of intermittent compression were determined after preliminary experimentation to investigate the maximum pressures and duration of treatment that patients could tolerate comfortably. A pressure of 50 mmHg was applied with a 30-s inflation and 20-s deflation duty cycle. Treatment comprised two sessions of 2 h a day for 1 month.

### Outcome assessment

The primary outcome measure was hand volume, assessed by an individual blind to the treatment group to which the patient had been assigned. To minimize the effect of preceding exercise and movement, patients were rested in the research room for 30 min before assessment. Observations were made at approximately the same time of day because of the known propensity of hand volume to vary by as much as 15 ml during the course of a 24-h cycle [9].

Hand volume was measured by recording the volume of water displaced by the immersed hand [4, 10]. A perspex cylinder of water with a spout was filled to the level of the spout. It was placed on a scissor jack in order to stabilize it. The patient's hand was immersed in the cylinder to a point marked by an elastic band at the level of the distal wrist crease. The water displaced by the immersed hand was collected through the spout into a measuring cylinder. Three measurements were made in both the hemiplegic hand and the unaffected hand and the average taken of the measurement on each side. Hand volumes were measured weekly during the 4-week treatment period.

The impact of treatment on function was assessed using the motricity index, a validated index of motor function after stroke [11]. Essentially this assesses the pattern with which various movements are executed: in the upper limb, pinch grip, elbow function and shoulder abduction were tested. Each movement was graded according to a standardized scale. The motricity index was measured at the same time as hand volume.

### Ethical considerations

The study was approved by the Salford Health Authority research ethics committee.

### Statistical analysis

The distribution of the data was examined using the Kolmogorov-Smirnov goodness-of-fit test. The data for changes in oedema were normally distributed but the data for the motricity index were non-normally distributed.

Changes in oedema are represented by the differences between pre-treatment arm volume measurements and values obtained after 4 weeks of treatment. Results are expressed as means with standard deviation (SD).

Between-group analysis was performed using the unpaired Student's *t*-test and within group analysis by the Student's *t*-test for paired observations.

For the motricity index, results are expressed as median scores with interquartile ranges (IQR). Between-group analysis was performed using the Mann-Whitney *U* test and within-group analysis by the Wilcoxon signed rank test. The level of statistical significance was set at a *P*-value of 0.05.

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Table 1. Characteristics of stroke patients in the treated and control groups

	Group	
	Treated (n = 20)	Control (n = 17)
Mean age, years	74.5 (61–85 <sup>a</sup> )	72.0 (65–83)
Sex (M/F)	8/12	8/9
Hemiplegic side		
Left	9	8
Right	11	9
Mean time since stroke, weeks	3.5 (1–10)	6.0 (1–20)

<sup>a</sup>Range.

## Results

Of 60 patients assessed, 17 failed to reach the volume criteria after the second week of assessment (the difference in volume between the stroke and normal hands was <20 ml). Therefore, 43 patients were recruited. A further six patients were lost during the trial. In the treatment group, one died and one developed a methicillin-resistant *Staphylococcus aureus* infection and was unable to leave the ward to be measured. In the control group, three died and one refused to leave the ward to be measured.

Thirty-seven patients completed treatment (see Table 1 for patient details). Twenty patients were in the treatment group and 17 were in the control group. The results are summarized in Figure 1 and Tables 2 and 3. The treatment was acceptable to all patients.

### Hand volume measure

In the treated group there was no change in mean stroke hand volume after treatment ( $P = 1.0$ ). In the control group there was a decrease in the mean stroke hand volume of 3.2 (SD 33.2) ml ( $P = 0.69$ ). In neither

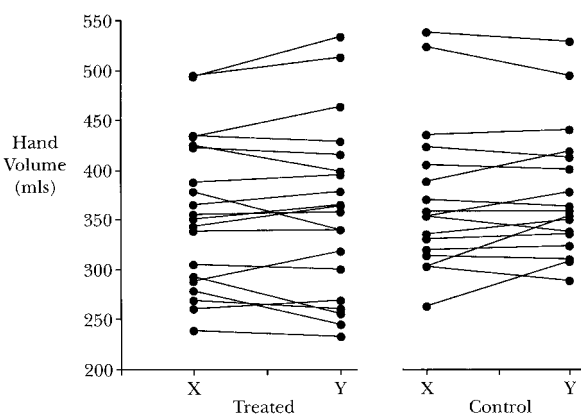


Figure 1. Changes in hand volume for individuals before treatment (X) and after treatment (Y) in the treated and control groups.

Table 2. Mean volume of oedema<sup>a</sup> of the stroke hand before and after treatment for treated and control groups

Group	Mean volume of oedema (ml)			P-value
	Pretreatment	Post-treatment	Change	
Treated	52.7 (27.2 <sup>b</sup> )	52.7 (36.9)	0	1.0
Control	63.7 (23.7)	60.5 (32.7)	3.2	0.7

<sup>a</sup>Oedema = affected hand volume - unaffected hand volume.

<sup>b</sup>Standard deviation.

t-test: treated group *versus* control group  $P = 0.59$ .

group was this change significant. There was no statistically significant difference between the two groups ( $P < 0.65$ ).

### Motricity index

In the treated group there was an increase in the median score for the motricity index of 28 (IQR = 28) after treatment ( $P = 0.02$ ). In the control group there was an increase in the median score for the motricity index of 17 (IQR = 18) after treatment ( $P = 0.02$ ). In both groups the increases were statistically significant. There was, however, no statistical difference between the groups ( $P = 0.43$ ).

## Discussion

Treatment of the oedematous stroke hand with IPC at the prescribed pressure and duration did not influence either oedema or upper limb function. After 4 weeks of treatment with IPC and physiotherapy there was no change in the mean volume of the stroke hand. There was a small decrease in the mean stroke hand volume of the control group. In neither group were the changes statistically significant and there was no significant difference between the groups.

IPC has been used to treat a variety of conditions including lymphoedema, so why was it unsuccessful in this study? One possible reason is that the parameters chosen for the operation of the compression machine were inadequate. The working pressure of 50 mmHg and the treatment duration of 4 h per day were chosen following a preliminary study because higher pressures or longer durations caused discomfort to some of our

Table 3. Median motricity scores before and after treatment for treated and control group

Group	Median motricity index score			P-value
	Pretreatment	Post-treatment	Change	
Treated	5 (39 <sup>a</sup> )	33 (62)	28	0.02
Control	0 (16)	17 (18)	17	0.02

<sup>a</sup>Interquartile range.

Mann-Whitney U-test: treated group *versus* control group  $P = 0.43$ .

patients. Pressures of between 80 and 130 mmHg [6] and durations of up to 6 h [5, 6] have been used in the treatment of lymphoedema. It is possible that, if higher pressures had been used for a longer period, the treatment may have been effective.

Another possible explanation is that the subjects may not have received the full treatment regimen. The study depended on nursing staff applying the inflatable garments and switching on the pre-set machines. During the pilot study some nurses were reluctant to apply the treatment. This possibility was minimized by educating them about the importance of the trial and, as a further safeguard, one of the researchers became 'unblinded' and frequently inspected the patients treated with IPC as well as being available to help with any problems that arose with the equipment. This researcher was not involved with measuring or recording hand volumes.

During the pilot phase it was noticed that some stroke arms did improve visibly immediately following treatment. One patient showed a dramatic decrease in the stroke hand volume immediately following treatment, followed by a rapid reaccumulation of fluid over a 24-h period (Figure 2). In their study, Pohjola and co-workers commented that the greatest benefit was obtained during the first 2 h of compression [6]. This indicates that IPC has immediate short-term effects but they are not sustained. This also suggests the mechanism causing oedema remains active.

Although there was little change in mean volumes in both groups, this has obscured the fact that some individuals in both groups did improve (see Figure 1).

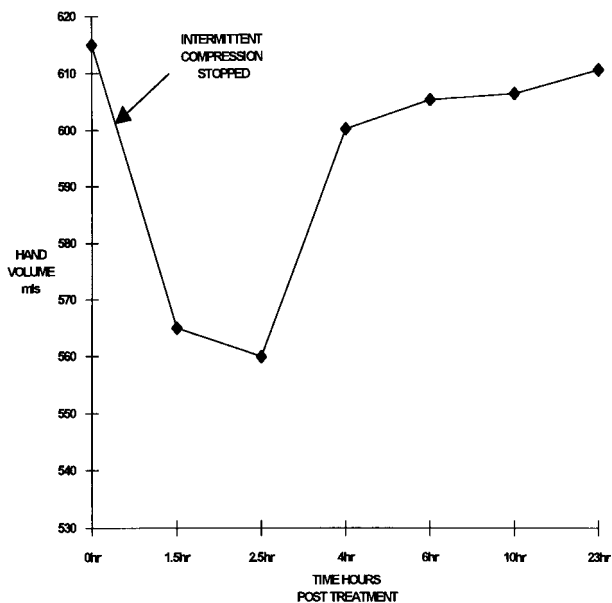


Figure 2. Hand volume changes over the 24 h immediately after treatment with intermittent compression in a stroke patient. (The time scale is non-linear to enable changes over a long period to be seen more readily.)

Further evidence that oedema can improve spontaneously is that 17 patients failed to meet the recruitment criteria after the second week of assessment.

The motricity index was chosen to investigate the impact of treatment on function. In both groups there was a statistically significant improvement in median scores of the motricity index but there was no significant difference between the groups. This was to be expected as the greatest improvement in motor function is usually seen in the first 3 months after a stroke [12]. The improvement in the motricity index occurred despite the lack of improvement in arm oedema in both groups following treatment. Although oedema did not prevent improvements in motor function, it still is possible that there could be greater improvement had oedema not been present.

Further research is needed to elucidate the mechanisms causing the oedematous stroke hand. Once these are better understood, it may be possible to tailor treatment to the underlying cause. Also, research is needed on the use of IPC at different pressures and durations of treatment. Meanwhile, IPC at the prescribed pressure and duration of this study cannot be recommended for the treatment of the oedematous stroke hand.

### Key points

- Oedema of the hemiparetic hand is a complication of stroke which, in some individuals, can resolve spontaneously.
- Intermittent pneumatic compression can reduce hand volumes within 2–4 h but its effects are short-lived with reaccumulation of oedema fluid.
- Intermittent pneumatic compression (at the pressure and duration used in this study) cannot be recommended for the treatment of the oedematous stroke hand.

### Acknowledgements

We would like to thank David Evans for his help in producing the perspex cylinder and providing equipment for measuring hand volumes, Syam Rithalier for the provision of the intermittent compression machines, Sally Hollis who provided the statistical expertise and analysed the data for us, and Anne Forster and John Young for their invaluable help and advice. Finally, we would like to thank the patients, nurses and physiotherapists who made this study possible.

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Received 1 August 1997; accepted 31 October 1997



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