Original Article

# Efficacy of Intermittent Pneumatic Compression on Blood Flow in Patient with Varicose Veins

**Wessam A. Ismail Mohamed[1]*, Nagwa Mohamed Badr[2], Bassem Elzarif Fouad[3], Mariam Elsayed Mohamed Abd Alaal[2]**

[1] Department of Physical Therapy for Internal Medicine at Horus University, New Damietta, Egypt. [2] Physical Therapy for Cardiovascular/Respiratory Disorder and Geriatrics. Faculty of Physical Therapy, Cairo University, Egypt. [3] Consultant cardiologist, National heart institute, Cairo, Egypt.

## Abstract

Background and Objective: Although compression therapy is applied extensively in the treatment of varicose veins, we still don't have enough evidence on its effectiveness. Varicose veins with or without active venous ulceration can lead to serious complications resulting in more governmental financial loads. The aim of this study was to investigate the effect of intermittent pneumatic compression on blood flow in patients with varicose veins, the mean flow volume and pulsality index in both femoral and popliteal veins, pain level, and ankle girth measurement. Methodology: forty women with varicose veins were selected and randomly assigned into two equal groups. Group A, which included 20 patients who were treated with pneumatic compression therapy five times per week for 8 weeks and Group (B), which included 20 patients who were instructed to continue receiving their medical treatment based on their medical prescription. Selected parameters related to Venous blood flow were assessed using Doppler ultra-sound device, in addition to evaluating pain by a visual analogue scale and ankle girth measurements as edema assessment. Results: After 8 weeks of treatment with intermittent pneumatic compression, all selected parameters showed significant improvements in subjects enrolled in group A in comparison to subjects enrolled in group B. Conclusion: The results of this study revealed that intermittent pneumatic compression therapy with the applied parameters can be considered as valuable method for increasing venous blood flow, as well as decreasing ankle girth measurement and pain in patient with varicose veins.

**Keywords:** Intermittent Pneumatic Compression, Blood Flow, Varicose Veins

## INTRODUCTION

### Significant statement:

This study investigated one method of early interventions for assisting patients with varicose veins, and prevents its complications and therefore decreases national resources. Ulcers and varicose veins can be an extraordinary remarkable economic load to the community and patients themselves. Varicose veins and related deteriorates can develop impairment, chronic pain, diminished quality of life (QOL), loss of working days and early retirement. In the United States,it has been valued that medical expenses of cardiovascular diseases (CVD), which is one of the main health issues, are between $150 million and $1 billion annually [1]. Intermittent pneumatic compression has a positive mechanical effect on blood flow velocity and valves movement. It can also affect biochemically through increasing fibrinolysis, therefore, prevent thrombus formation[2, 3].

A varicose vein is an extremely widespread problem influencing about 30% of the adult population most commonly in women more than men. Pregnancy increases blood volumes and elevates the levels of female sex hormones, which affects the function of the venous system and its tone [4, 5]. The incidence of varicose veins rises with age, more likely in obese individuals and in those with professions requires standing for a long time [6].

Patients with lower extremity varicose veins commonly complain of sensory abnormalities (itching, pain, and tingling), leg ache, heaviness, fatigue, edema, and restless leg syndrome as a result of standing for a long time [7].

Varicose veins is a complicated illness with multifactorial etiology; it is difficult to definitively state what are the real causes or the precipitating factors of varicose veins

**Address for correspondence:** Wessam A. Ismail Mohamed, Department of Physical Therapy for Internal Medicine at Horus University, New Damietta, Egypt.
Email: wesmail @ horus.edu.eg
wessamabdelftah11 @ gmail.com



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developments, and their complication may result from the imbalance of multiple variables. Recent available data stay uncertain, with convincing contentions to be made for the two sides. It is clear that valvular incompetence and hemodynamic variable are important factors, in spite of heterogeneity in study results and the absence of clear information for a specific pattern of valvular incompetence as an inciting factor. Several factors can be associated with the development of varicose veins on the cellular level, including lack of oxygen, mismatched apoptosis and changes occurring in the extracellular matrix [8].

Varicose veins are not only a common esthetic issue, as they are usually considered simply as a cosmetic issue, but also, they affect the quality of life. Insurance agencies might also be reluctant about their cost of treatment. In the past, many physicians had limited evaluating and management tools for varicose veins in addition to their poor abilities to understand the pathophysiology of venous disorder. Consequently, patients felt disappointed [9].

Duplex ultrasound represents as a standard reference in assessing the hemodynamics and morphology of the veins of lower limbs [10]. Color flow Doppler also represents the first evaluation line in examining the vascular problems. With validity and reliability reaching 89-100% compared to venography and accuracy of 95% to 98% in DVT detection in lower limb [11].

Management of Varicose veins usually depends on the severity of conditions and the associated sign and symptoms. A wide range of modalities is generally utilized. Compression stockings help in squeezing the blood back to the heart. The stocking may decrease edema and leg pain. There is no proof to indicate whether they help to stop varicose veins progression, or getting more varicose veins[12].

Intermittent pneumatic compression (IPC) as a basic modality that can be considered as a significant option in the treatment of patients suffering from lymphatic and chronic venous insufficiency, limb ischemia, and acute cases like extremity injury or cholesterol embolism, the IPC ought to be incorporated and suggested among treatment modalities of these vascular conditions as it has low cost and can be used easily either in the hospital or portable at home through well-trained subjects. It can be used as a long-term treatment because of its variable applications and almost no side effects[13].

## Materials and Methods

### Area of study and sampling:

The study protocol and design were approved by the Local Ethics Committee of the Faculty of Physical Therapy, Cairo University. Forty women with varicose veins were selected randomly from the vascular outpatient clinic in El-Mahalahospital, Egypt with height ranged from 160 to 180 $cm^2$, their body weights ranged from 70 to 80 kg. And their age ranged from 30 to 50 years old. All participants were diagnosed as having symptomatic varicose veins ($c_2$,$c_3$ clinical severity class of CEAP classification), and they did not complain of any medical problem that prevents using compression therapy including vein ligation, recent skin graft, dermatitis, gangrene, severe edema of lower limb, severe leg arteriosclerosis disorders, severe leg deformity, severe medical disorders such as diabetes mellitus, uncontrolled hypertension, untreated cardiac diseases or psychiatric condition. Participants were randomly divided into two groups: Group A included 20 patients who were treated with pneumatic compression therapy five times per week for 8 weeks. And Group (B) included 20 patients who were instructed to continue receiving their medical treatment based on their medical prescription. All subjects were able to withdraw from the study at any time. All participants provided their consent form after receiving a detailed explanation of the study's protocol and procedures.

### Evaluated parameters:

The duplex was used to measure the following parameters: ***flow volume, and peak pulsality*** index for both common femoral and popliteal veins, where the measurements were recorded before, mid (4 weeks), and after (8 weeks) the treatment by intermittent compression therapy for group A and medical treatment only for group B.

The Visual Analogue Scale (VAS) was used to assess pain severity. VAS consists of a horizontal line on which pain severity is represented by a point between the extremes of (no pain) and (worst pain). The patient located the point representing his pain on the scale using a marker[14]. Pain assessment was done in the same way as a vascular assessment regarding the timing for both groups.

Ankle girth measurements were performed by the figure of eight methods. The assessment was done from a long sitting position with slight flexion in the knee (for easy evaluation) and the ankle in neutral Doris flexed position and out of the plinth. The measuring tape was placed midway between tibialis anterior tendon and lateral malleolus, it was pulled medially toward navicular tuberosity crossing 5th metatarsal. The tape was then pulled across the tibialis anterior tendon continuously around the ankle joint to the medial malleolus. Finally, the tape was drawn across the tendoachillis circling the ankle joint till reaching the lateral malleolus [15]. Ankle girth measurement was done in the same way as vascular and pain assessment as regarding the timing for both groups.

### Treatment protocol by intermittent pneumatic compression:

Participants in group 1 (study group) received the program of intermittent pneumatic compression 5 days/week with a total period of 60 min per session for 8 weeks. With pressure ranged from 60 to 90 mmHg during the whole sessions under close supervision and continuous assessment of each patient's complains during all sessions. The study procedures were carried out at the Outpatient Clinic of El-mahalla hospital.

## Results and Statistical Analysis

Data were expressed as mean and slandered deviations and the statistical analysis was performed by SPSS version 23 for Windows (SPSS, Inc., Chicago, IL). The student t-test was used to compare the basic characteristics of the subjects included in both groups as regarding age, body mass and height that showed statistically nonsignificant differences between the two groups (Table 1)

MANOVA test was used to compare the measurements taken before and in the middle of the treatment and after completing the treatments as regarding the vascular parameters and ankle girth in addition to the visual analog scale.

Statistical analysis of the data also revealed that IPC had significant effects on venous blood flow parameters among subjects complaining of varicose veins in addition to significant improvements of the ankle girth measurements and pain as shown in Tables 2, 3, and 4.

**Table 1.** Baseline characteristics of the patients in both groups

| Items | Group A | Group B | Comparison | | S |
|---|---|---|---|---|---|
| | Mean ± SD | Mean ± SD | t-value | P-value | |
| **Age (years)** | 46.4±3.01 | 46.3±3.01 | 0.105 | 0.917 | **NS** |
| **weight (Kg)** | 79.8±3.28 | 79.2±3.23 | 0.196 | 0.845 | **NS** |
| **Height (cm)** | 164.75±5.57 | 164.4±5.70 | 0.582 | 0.564 | **NS** |

**Table 2.** Statistical analysis of venous blood flow variables within and between groups

| | | Pre-treatment (Mean ±SD) | Post 1 of treatment (Mean ±SD) | Post 2 of treatment (Mean ±SD) |
|---|---|---|---|---|
| ***Flow Volume in Common femoral vein* (L/min)** | **Group A** | 0.62±0.2 | 1.08 ±0.57 | 1.46±0.54 |
| | **Group B** | 0.59 ±0.2 | 0.59±0.2 | 0.59±0.2 |
| | | **Pre-treatment (Mean ±SD)** | **Post 1 of treatment (Mean ±SD)** | **Post 2 of treatment (Mean ±SD)** |
| ***Flow Volume in Popliteal vein* (L/min )** | **Group A** | 0.26±0.13 | 0.34 ±0.15 | 0.45±0.15 |
| | **Group B** | 0.26 ±0.12 | 0.26±0.12 | 0.26±0.12 |
| | | **Pre-treatment (Mean ±SD)** | **Post 1 of treatment (Mean ±SD)** | **Post 2 of treatment (Mean ±SD)** |
| ***Pulsality Index in Common Femoral Vein*** | **Group A** | 0.68±0.12 | 0.78 ±0.14 | 0.87±0.04 |
| | **Group B** | 0.69 ±0.12 | 0.69±0.12 | 0.69±0.12 |
| | | **Pre-treatment (Mean ±SD)** | **Post 1 of treatment (Mean ±SD)** | **Post 2 of treatment (Mean ±SD)** |
| ***Pulsality Index popliteal vein*** | **Group A** | 0.37±0.06 | 0.45 ±0.1 | 0.51±0.13 |
| | **Group B** | 0.38 ±0.07 | 0.38±0.07 | 0.38±0.07 |

**Table 3:** Descriptive statistics and 2×3 mixed design MANOVA for visual analogue scale (VAS) at different measuring periods at both groups.

| | | Pre-treatment (Mean ±SD) | Post 1 of treatment (Mean ±SD) | Post 2 of treatment (Mean ±SD) |
|---|---|---|---|---|
| ***VAS*** | **Group A** | 7.52±0.84 | 5.42 ±1.3 | 3.05±1.2 |
| | **Group B** | 7.45 ±1.05 | 7.45±1.05 | 7.45±1.05 |

**Table 4.** Descriptive statistics and 2×3 mixed design MANOVA for Ankle Girth Measurement at different measuring periods at both groups.

| | | Pre-treatment (Mean ±SD) | Post 1 of treatment (Mean ±SD) | Post 2 of treatment (Mean ±SD) |
|---|---|---|---|---|
| ***Ankle Girth Measurement* (Cm)** | **Group A** | 61.1±1.72 | 58.73 ±1.75 | 57.89±1.5 |
| | **Group B** | 61.05 ±1.7 | 61.05±1.7 | 61.05±1.7 |

## Discussion

Varicose veins are generally regarded as a minor medical problem and worthless the priority for treatment [16]. Varicose veins by itself without advanced complication, as chronic venous insufficiency, can decrease the quality of life [17]. Varicose veins is one of the chronic venous disease spectra and include true varicosities, reticular veins, and spider telangiectasia. About 23% of the US adult population complains of varicose veins [18]. This study was designed to investigate the effects of IPC therapy on venous blood flow, ankle girth measurement, and pain level in patients with varicose veins.

The significant improvements of the selected parameters in this study could be attributed to the physiological effect of the intermittent compression therapy on decreasing the intravenous blood volume and increasing venous return velocity at any time by stimulating nitric acid production from endothelial cells and creates shear stress on blood vessels walls. Enhancement of nitric acid production prohibits the aggregation of platelet and neutrophil adherence, which are the major physiologic mechanism for the formation of secondary hypoxic damage. Additionally, Nitric oxide is a neurotransmitter that may increase blood flow by influencing vascular tone [19-21].

Intermittent pneumatic compression used in clinics and medical facilities designed to enhance venous circulation in patients suffering from limb swelling, pulmonary embolism or people exposed to get DVT. It consists of inflatable auxiliary sleeves, an air pump, and boots or gloves in a system [22]. IPC is noninvasive and painless modality which approved its valuable effects in managing and helping subjects with arterial, venous, and lymphatic problems [23].
The results of this study could also be demonstrated in fact that compression therapy increases the arteriovenous pressure gradient as compression cause emptying the venous system and hence reducing venous pressure. This enhances perfusion of the extremities by increasing blood flow through the capillary bed [24]. IPC also mediates the release of nitric oxide (NO) from the endothelial cells. This increases the shear stress of blood in the diseased vessel. NO is a potent vasodilator as the primary endothelium-derived relaxing factor (EDRF). Furthermore, it prevents the activation of platelet and its aggregation, so it can prevent thrombosis formation [25].

The reduction of pain noted in this study after treatment with IPC could be explained by the reduction of swelling and tissue tension in the varicose vein. Compression can improve lymphatic drainage and the function of the venous pump. It can also improve venous return counteracting venous hypertension. Edema can be decreased through decreasing pressure in the superficial veins and increasing the hydrostatic pressure thus causing improved cutaneous blood flow and fibrinolysis, additionally, it prevents the leakage of macromolecules and fluids [22]. These results can be supported by Stavros et al., 2018 who reported that using high compression stocking with pressure 18 to 21 mmHg, for one week reduced pain and the associated aching in varicose veinspatients[23].

## Conclusion

This study demonstrated that using intermittent pneumatic compression with the applied parameters can be considered an effective intervention for increasing venous blood flow, decreasing ankle girth measurement and pain in patients with varicose veins.

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