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*Original Article*

# Vascular boot warming improves clinical outcomes of patients with deep vein thrombosis in lower extremities

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**Abstract:** Objective: Vascular boot warming can increase venous return from the lower extremities, which may improve clinical outcomes of patients with deep vein thrombosis (DVT). In this study, we included vascular boot (Boot) warming in the standard of care (SOC) of patients with DVT and explored its safety and efficacy. Methods: Subjects diagnosed with acute DVT of the lower extremities were included in this study. The subjects (n=104) were then randomized into the SOC group (n=51) and the SOC + Boot group (n=53) and followed up for 3 months. All subjects received anticoagulants as standard of care. The patients in the SOC + Boot group wore vascular boots for a minimum of 3 times in a day, for 45 minutes each time for the first 14 days. Pain, swelling, major bleeding, pulmonary embolism (PE), extended proximal DVT, and mortality were evaluated at day 1, day 14 and at 3 months. Results: Compared with the patients in the SOC group, the patients in the SOC + Boot group had a lower rate of pain (3.8±1.5 vs 5.4±0.9 by 14 days, 2.3±0.9 vs 3.1±1.2 by 3 months, all P<0.05), faster swelling reduction (circumference difference compared to day 1 at the ankle level was -0.29±0.44 cm vs 1.21±0.63 cm by 14 days, -0.45±0.43 cm vs 0.15±0.19 cm by 3 months, all P<0.05), lower incidence of PE (1.9% vs 3.9%, RR 2.0% by 14 days, 2.8% vs 5.9%, RR 3.1%, by 3 months, both P<0.05), lower incidence of proximal DVT (1.9% vs 5.9%, RR 4%, by 14 days, 3.8% vs 7.8%, RR 4% by 3 months, both P<0.05), and lower mortality (1.9% vs 3.9% by 14 days and 3 months, P<0.05). No major bleeding was observed in either group. These results suggest that implementing vascular boot warming in SOC can improve clinical outcomes in patients with lower extremity DVT. Conclusion: Vascular boot warming, as an add-on to SOC, is safe and effective for patients with lower extremity DVT and can help to prevent post-thrombotic events.

**Keywords:** Vascular boot warming, deep venous thrombosis, lower extremity, outcome

## Introduction

Deep vein thrombosis (DVT) is a common cause of death for inpatients. Regardless of the effort for prevention, the incidence of DVT remains high, and the clinical outcomes of treating lower extremity DVT are not excellent [1]. Compared with bed rest, intermittent pneumatic compression (IPC) plus walking can achieve better outcomes, especially for pain relief and swelling reduction, in patients with DVT. However, it doesn't seem to reduce the risks of pulmonary embolism, extended DVT, or mortality [2]. Therefore, more effective mechanical methods are needed to improve the clinical outcome of DVT in the lower extremities.

Vascular boot, also known as a Rooke boot, was first introduced in 1987 [3]. It was designed to warm the cold extremities after surgery. Later on, it was used to boost distal skin perfusion and off-load lower extremity pressure to reduce ulcers. Vascular boot warming helps to vasodilate the distal arterial bed, improves perfusion, raises tissue pressure, and increases venous blood return from the lower extremities, thus improving clinical outcomes of DVT [3]. So far, no data on vascular boot warming for DVT is available. In this study, we included vascular boot warming (Boot) in the standard of care (SOC) to explore its safety and efficacy.

## Materials and methods

### *Study design*

This study was approved by the institutional review board and the Ethics Committee of

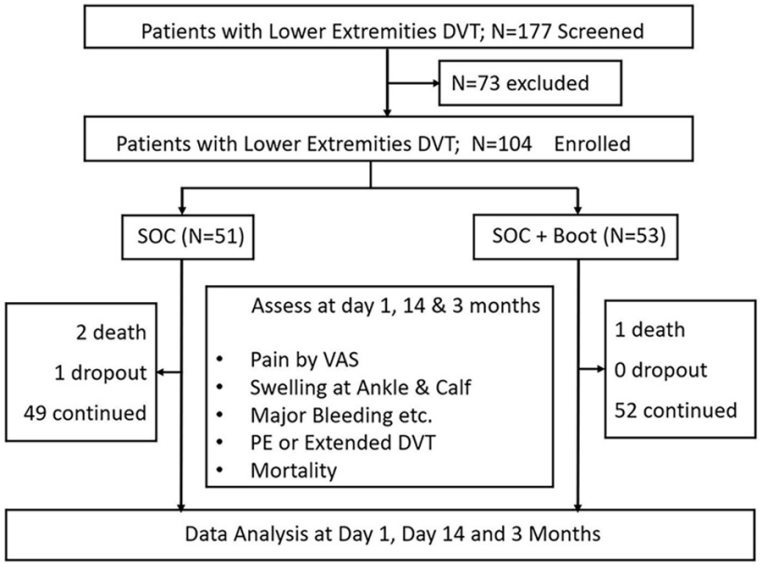


**Figure 1.** Study design and flowchart. DVT: deep vein thrombosis; SOC: standard of care; VAS: Visual Analogue Scale.

Clinical Medical College & Affiliated Hospital of Chengdu University. Informed consent was obtained from all subjects. From January 6th, 2016 to June 26th, 2020, all subjects who were diagnosed with acute lower extremities DVT were identified with phlebography or ultrasound scan.

Inclusion criteria: 1) Patients over 21 years old; 2) Patients who were expected to tolerate the vascular boot; 3) Patients diagnosed with acute DVT and anticoagulant therapy was initiated within 24 hours.

Exclusion criteria: 1) Patients weighed over 150 kg; 2) Patients who had history of DVT or pulmonary embolism (PE); 3) Patients who were on anticoagulants for other reasons; 4) Patients who had thrombectomy; 5) Patients who had severe concomitant diseases such as liver diseases, cardiovascular diseases, or cancer.

Eligible subjects were enrolled and scheduled for baseline tests. The baseline tests included medical history, lower extremities ultrasound, and blood test. **Figure 1** shows the overall study design and flowchart.

Based on a computerized randomization schedule with a ratio of 1:1, the eligible subjects (n=104) were randomized into the standard of care (SOC) group (n=51) and the SOC + Boot group (n=53) and were followed up for 3 months. All subjects (median age of 52 years) received anticoagulants as per doctor's decisions immediately after diagnosis, without particular intention related to this study. All received subcutaneous injections of dalteparin 200 IU/kg once daily for a minimum of 7 days and oral anticoagulants (Marcoumar) to maintain international normalized ratio (INR) between 2.0 and 3.0.

About 24 hours after diagnosis, the subjects in the SOC + Boot group started wearing vascular boots (Osborn Medical, USA) for a minimum of 3 times a day, 45 minutes each time, for the first 14 days or until drop-out or thrombi resolved. These boots were one-size-fits-all. They had insulated fleece padding and cell foam to enhance and maintain the warmth of lower extremities and had no pressure points on the limbs [3]. Skin temperature was measured with FDA approved digital infrared skin temperature scanner (ICI, Inc., USA) at the insteps of both feet in the morning before and immediately after walking with boots on day 1 and day 14.

*Primary and secondary outcome measures*

Primary outcome measures included pain, incidences of pulmonary emboli and extended DVT, and mortality. Secondary outcome measures included occurrences of bleeding and swelling. Pain was evaluated at the same time of the day on day 1 and day 14 and in the 3rd month using Visual Analogue Scale (VAS). The scale range was on a scale of 0 to 10, with 0 representing the least pain and 10 representing the worst pain. Swelling was observed by measuring leg circumference at the ankle and calf level using a soft tape in the early mornings on day 1 and day 14 and in the 3rd month. Incidence of major bleeding and mortality were collected. Pulmonary emboli and extension of DVT were evaluated with ventilation-perfusion (V/Q) scans and sonography in a blinded manner on day 1 and day 14, in the 3rd month, and whenever patients were suspected to have PE. The distance from the saphenofemoral junction to the thrombus tip was measured to determine

**Table 1.** Characteristics of the patients at baseline

| | SOC (n=51) | SOC + Boot (n=53) | P |
|---|---|---|---|
| Age (years) | 51.7±7.5 | 52.1±6.9 | 0.48 |
| Weight (kg) | 81.2±5.5 | 83.1±4.7 | 0.39 |
| Female/male | 25/26 | 26/27 | 0.87 |
| Proximal/Calf | 45/6 | 47/6 | 0.86 |
| Left side | 22 | 25 | 0.29 |
| Current smoker | 4 | 5 | 0.97 |
| Immobility, trauma or surgery or travel | 3 | 4 | 0.45 |
| Cancer | 2 | 3 | 0.47 |
| Oral contraceptive | 1 | 1 | 1 |
| Dyspnea upon admission | 1 | 1 | 1 |

Note: SOC: standard of care; DVT: deep venous thrombosis; PE: pulmonary embolism.

**Table 2.** Boot wearing information for patients in the SOC + Boot Group

| | Boot wearing |
|---|---|
| Days ($\bar{x}$ ± sd) | 13.5±0.9 |
| Days (Median, range) | 13, 8-14 |
| Times 3 or 4 (%) | 92% |
| Duration (>45 minutes) % | 89% |

Note: SD: standard deviation.

if DVT was extended, and a distance over 1 mm indicated extension of DVT [2].

*Statistical analysis*

SAS v9.2 (SAS Institute Inc, Cary, NC, USA) was used for analysis. One-way ANOVA was used for numerical data, and $\chi^2$ tests were used for nominal data. Data are presented as mean ± standard deviation ($\bar{x}$ ± sd). P<0.05 was regarded as statistically significant.

## Results

*Baseline characteristics of the subjects*

As shown in **Table 1**, the baseline characteristics were well balanced in the two groups. The past medical history was well matched. No differences were observed between the two groups in the risk factors for DVT, such as smoking, cancer, and immobility.

*Boot wearing for patients in the SOC + Boot group*

**Table 2** shows the data about the patients' walking with vascular boots. Most subjects walked in the morning and 30 minutes after each meal. The mean duration of boot wearing was 13.5 days (SD 0.9 days) and the median was 13 days (range 8-14 days). About 92% of the patients walked 3 or 4 times a day with the boots, and 89% of the patients walked at least 45 minutes each time.

*Skin temperature*

Compared with the skin temperature before wearing the boots, there was an increase in the skin temperature in the patients after wearing the boots (Day 1: 0.25±0.06°C, P=0.047; Day 14: 0.27±0.09°C, P=0.049). There was no difference in the temperature between the foot with DVT and foot without DVT. There was no change in skin temperature of the patients in the SOC group.

*Pain scores*

As shown in **Table 3**, compared with the pain score on day 1, both groups had decreased pain on day 14 and in the third month (P<0.05). Compared with the SOC group, the Boot group had significantly less pain on day 14 (3.8±1.5 vs 5.4±0.9, P=0.023) and in the 3rd month (2.3±0.9 vs 3.1±1.2, P=0.034).

*Swelling*

Differences in the swelling reduction between the SOC group and the SOC + Boot group were observed from day 14 to the 3rd month (**Table 4**). The circumferences at calf and ankle levels were shorter in the SOC + Boot group compared with the SOC group (compared to day 1 at ankle level, the change was -0.29±0.44 cm vs 1.21±0.63 cm by day 14, -0.45±0.43 cm vs 0.15±0.19 cm by 3 months, P=0.002, P<0.001 respectively; compared to day 1 at calf level, the change was 0.05±0.09 cm vs 1.11±0.14 cm by day 14, -0.21±0.07 cm vs 0.18±0.10 cm by 3 months, P=0.001, 0.001 respectively). Compared to day 1, the SOC + Boot group had significant reductions of ankle and calf circumferences, while the changes in the SOC group were not statistically significant.

*Side effects*

Two patients in the SOC + Boot group (3.8%) and five patients in the SOC group (9.4%) reported local irritation (Risk reduction of 5.6%,

**Table 3.** Pain Scores by VAS

| Pain score by VAS | SOC | SOC + Boot | P (SOC vs SOC + Boot) | P (vs Day 1 for SOC) | P (vs Day 1, for SOC + Boot) |
|---|---|---|---|---|---|
| Day 1 | 7.3±1.2 | 7.7±1.0 | 0.095 | | |
| Day 14 | 5.4±0.9 | 3.8±1.5 | 0.023 | 0.031 | 0.013 |
| Months 3 | 3.1±1.2 | 2.3±0.9 | 0.034 | 0.025 | 0.011 |

Note: VAS: Visual Analogue Scale; SOC: standard of care.

**Table 4.** Circumference differences at ankle and calf levels compared to day 1

| | SOC (cm) | SOC + Boot (cm) | P (SOC vs SOC + Boot) | P (vs Day 1 for SOC) | P (vs Day 1, for SOC + Boot) |
|---|---|---|---|---|---|
| Ankle Day 14 | 1.21±0.63 | -0.29±0.44 | 0.002 | 0.12 | 0.03 |
| Calf Day 14 | 1.11±0.14 | 0.05±0.09 | 0.001 | 0.08 | 0.04 |
| Ankle, 3 Months | 0.15±0.19 | -0.45±0.43 | <0.001 | 0.23 | <0.001 |
| Calf, 3 Months | 0.18±0.10 | -0.21±0.07 | 0.001 | 0.11 | 0.002 |

Note: SOC: standard of care.

**Table 5.** Adverse events by day 14 and 3 months

| | SOC | SOC + Boot | RR | P |
|---|---|---|---|---|
| New PEs day 14 (n, %) | 2 (3.9) | 1 (1.9) | 2% | 0.032 |
| New PEs months 3 (n, %) | 3 (5.9) | 2 (2.8) | 2.1% | 0.021 |
| Extended DVT day 14 (n, %) | 3 (5.9) | 1 (1.9) | 3.0% | 0.037 |
| Extended DVT months 3 (n, %) | 4 (7.8) | 2 (3.8) | 4.0% | 0.016 |
| Death by day 14 (n, %) | 2 (3.9) | 1 (1.9) | 2.0% | 0.039 |
| Death by months 3 (n, %) | 2 (3.9) | 1 (1.9) | 2.0% | 0.039 |

Note: SOC: standard of care; PE: pulmonary emboli; DVT: deep vein thrombosis; RR: Risk Reduction.

P<0.001). No major bleeding or skin breaks were observed.

*PE or extension of DVT*

As shown in **Table 5**, by day 14, 1 patient developed PE (1.9%) and 1 had extended DVT (1.9%) in the SOC + Boot group, while 2 patients developed PE (3.9%) and 3 had extended DVT (5.9%) in the SOC group, revealing a significant risk reduction in the SOC + Boot group compared with the SOC group (2.0% and 4.0%, P=0.032, 0.037 respectively). By 3 months, 2 patients had PE in the SOC + Boot group and 3 had PE in the SOC group (2.8% vs 5.9%, RR 3.1%, P=0.021). Lower incidence of proximal DVT was also observed in the SOC + Boot group. (2 vs 4, 3.8% vs 7.8%, RR 4%, P=0.016).

*Mortality*

There was 1 death in the SOC + Boot group and 2 in the SOC group by day 14 and 3 months (1.9% vs 3.9%, RR 2.0%, P=0.039). No death was associated with boot wearing.

## Discussion

Subcutaneous low-molecular-weight heparin for treating uncomplicated DVT or PE can achieve safe and effective outcomes [4]. Wearing compression stockings plus walking can significantly reduce the post-thrombotic syndromes [5]. Yet, due to the fear of PE and pain, bed rest and immobilization are still common in most medical centers [6, 7]. Vascular boot warming can increase blood flow and venous return from the peripheral branches and lower compartmental pressure, thus ameliorating pain [8].

The present study has been the first study so far to evaluate the safety, efficacy and impact of vascular boot warming on post-thrombotic syndrome in DVT. Pain and swelling are two critical concerns for patients and are closely correlated to their quality of life. In line with previous studies on walking with compression, our results suggest that vascular boot warming can reduce pain and swelling much faster than SOC alone, and it doesn't increase bleeding.

There was no difference in pulmonary embolism (PE) at the baseline between the two groups. No fatal PE was detected in our study. More incidences of PE and extended DVT were detected in the SOC group compared with the SOC + Boot group. Vascular boot warming can reduce the incidences of PE or extended DVT possibly through regulating the levels of inflammatory cytokines and fibrinolytic factors [9]. Moreover, our results suggest that vascular

boot warming can reduce mortality. However, due to the relatively small sample size, this pilot study warrants further investigation.

Compared to other mechanical methods such as intermittent compressing stocking, the vascular boot is relatively more comfortable to wear as it has less pressure on the heel and other bony areas. Walking around with a vascular boot is like receiving an external foot "massage" with warming pads [10]. This message has physical effects. Thrombus propagation can happen in 20% of patients, but only in 1% if they start walking around early [11-13]. To prevent thrombus progression, it is very important to start intravenous heparin within 24 hours [14-16]. Thrombus propagation depends on anticoagulation but is influenced by venous stasis [17-20]. Walking while wearing the warming boot helps with the rhythmic acceleration of venous flow and promotes thrombi degradation, while preventing venous stasis, and reducing swelling and pain [21-23]. Walking with this effective warming boot can be helpful for primary prevention and is strongly recommended. The warming boot is similar to intermittent compression but it also has unique convenience. Including vascular boot warming in the SOC can be performed on an outpatient basis at any time. It improves the quality of care. This has lots of economic advantages and may change the practice of DVT treatment in the hospital [24-26].

The study still has some limitations. As these boots were visible for technicians and caregivers, it was hard to be blind in the analysis, and there may be some bias in the assessments. More studies are needed in the future to verify impact of vascular boot warming on clinical scores, the relationship of the sources or location of DVT, and the comorbidities.

To sum up, including vascular boot warming in SOC is a safe, effective method for patients with lower extremities DVT. It can ameliorate pain, reduce swelling, lower the risk of pulmonary embolism or extended DVT, and potentially decrease mortality, and as such can be recommended for most patients with lower extremity DVT.

## Disclosure of conflict of interest

None.

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