**Pressure Profile of Pneumatic CAM Walker Boot: Implications in Venous Stasis**

Charles G. Carlson[1]; Thomas A. Bedard[1]; Matthew G. Scuderi[1]; Nathaniel R. Ordway[1]
[1]SUNY Upstate Medical University, Syracuse, NY, USA
carlsoch@upstate.edu

**Disclosures:** C.G. Carlson: None; T.A. Bedard: None; M.G. Scuderi: None; N.R. Ordway: 5; Stryker Spine.

INTRODUCTION: Venous thromboembolism (VTE) is a major concern for patients following lower limb trauma and surgery with reported incidence rates ranging from 0.22% to 40%. Immobilization and recommendation to not bear weight have been identified as significant risk factors for VTE. Immobilization via a cast or a Controlled Ankle Movement (CAM) walker boot limits ankle motion, impeding the action of the venous pump in the lower limb. Therefore, it is recommended that to reduce the risk for VTE, patients return to weight bearing movements as soon as possible. Pneumatic CAM boots have potential to provide increased stability and comfort for earlier weight bearing via the mechanism of an inflatable bladder. However, there has been substantial evidence demonstrating that the application of external pressure ranging from 10-20 mm Hg to the lower limb results in reduced arterial and venous blood flow. The characteristics of pressure to the lower limb associated with the use of pneumatic CAM boots has not been investigated. The purpose of the present study was to evaluate the skin surface pressure characteristics resulting from a commonly prescribed pneumatic CAM boot in a healthy, adult population to better understand the potential impact that pneumatic CAM boots may have on blood flow in the lower leg.


METHODS: Following IRB approval, nineteen healthy volunteers gave consent and were included in this study (10 males, 9 females; avg age 26.5 years, range 22-52). Three skin surface pressure sensors (Tekscan Inc.) were positioned circumferentially around the lower limb eight inches from the base of the foot. The first sensor was taped directly anterior over the tibia while the subsequent two sensors were placed posteriorly, medially and posteriorly, laterally 120° from the first. The two posteriorly placed sensors approximately aligned with the location of the bladder in the CAM boot (Figure 1). Prior to use, each sensor was calibrated according to the manufacturer's recommendation using a material test machine. While sitting, the CAM boot was donned to each subject according to the manufacturer's recommendation and straps fastened subjectively by the subject based on comfort level. Prior to inflation, baseline (pre-pump) pressure measurements were recorded from each of the 3 sensors while sitting. Each subject was then instructed to inflate the boot to a comfortable pressure as per the manufacturer and pressure measurements (post-pump) were again recorded while sitting. Pressure measurements were also recorded with subjects standing in 3 static positions: equal weight on both feet, full weight (single leg stance on the foot with the boot), no weight (single leg stance on contralateral side). Pressure measurements were then repeated in opposite order following a 15-minute rest period. All pressure measurements were recorded for 2 seconds at 10Hz. The average object pressure and area of contact was determined for each sensor and condition. A one-way ANOVA along with Tukey's multiple comparisons test was performed to determine the differences present in mean pressure across the 10 conditions tested. A two-way repeated measures ANOVA was performed to examine gender differences between conditions.

Figure 2. Skin Surface Pressure based on Test Condition

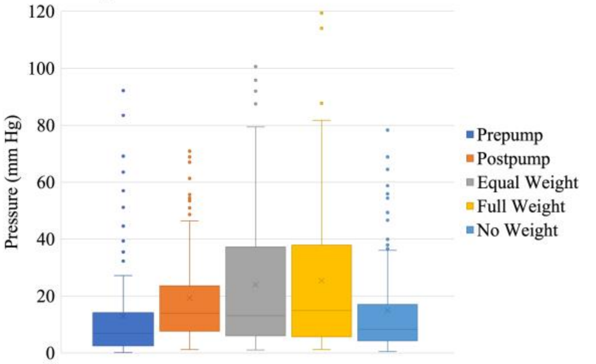
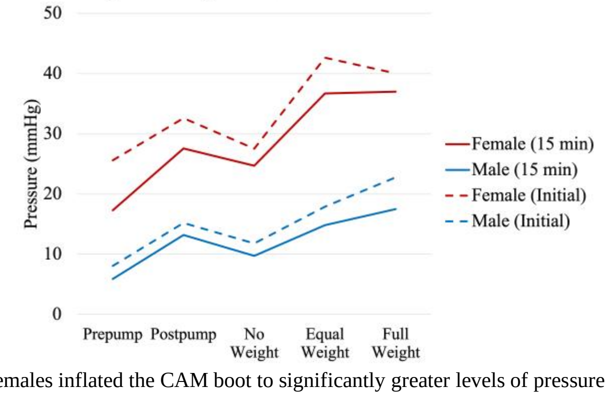



Figure 3. Change in Pressure: Gender & Condition




RESULTS: Descriptive statistics showed mean pre-pump and post-pump skin surface pressures was found to be 15.4 ± 21.1 mm Hg and 20.8 ± 18.6 mm Hg, respectively (Figure 2). Following inflation, skin surface pressure was highest in the full weight condition (27.5 ± 26.7 mm Hg) and lowest in the no weight condition (16.1 ± 18.5 mm Hg). Significant differences were noted when comparing the full weight and equal weight conditions to the no weight ($p<0.05$) and pre-pump ($p<0.05$) conditions. A significant decrease ($p<0.05$) in pressure of 3.7 mm Hg was observed following the 15-minute rest when compared to all initial pressure measurements. Females were found to have significantly greater pressure for all conditions when compared to males ($p<0.05$, Figure 3).

DISCUSSION: The skin pressures observed in some subjects exceeded those known to result in decreased venous blood flow in the lower extremity. Substantial variability in pressure was seen with and without inflation of the bladder in our sample of volunteers. This indicates the subjective nature of "comfortable" when using the inflatable bladder and therefore it's use should be a consideration when prescribing the CAM boot. While we observed differences in pressure when comparing conditions, the most striking finding was found when looking at gender. Females inflated the CAM boot to significantly greater levels of pressure compared to male counterparts. This indicates that morphometry may play a role in the resulting pressure of the CAM boot on the lower limb. The magnitude of external pressure applied to the leg which may result in VTE is unknown, so the current findings require further research. Likewise, further research is needed to define pressure values that result in clinical risk of venous stasis. Another limitation of this study was the results are based on healthy volunteers with no existing lower extremity pathology. However, the findings are compelling regardless of population and worthy of additional inquiry.

SIGNIFICANCE/CLINICAL RELEVANCE: The results highlight the potential impact that pneumatic CAM boots may have on venous blood flow in the lower extremity. There was substantial variability in pressure that healthy volunteers deemed to be comfortable, but the pressures recorded were within the window of pressure that has been documented to reduce arterial and venous blood flow.