Test and Evaluation of Compression Bandages Using a Human Tissue Equivalent Mannequin Model

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Introduction

The Iraq and Afghanistan conflicts have taken a significant human toll on our military forces across services. An analysis of over 4,500 casualties occurring between 2001 and 2011 revealed that greater than 90% of the potentially survivable injuries were associated with hemorrhage (Eastridge, 2012). Though simple in form, medical compression bandages are a vital instrument for hemorrhage control in battlefield trauma care, and direct pressure on the bleeding site is critical for treatment (Cloonan, 2004).

Compression bandages slow or stop bleeding, optimally allowing normal blood clotting to occur without compromising distal blood flow. The bandage also protects the wound site from contaminants, which may cause infection or renew bleeding. With many compression bandage variations available, each with individual features and strengths, quantitative functional data is needed to evaluate these devices and ensure fielding of effective bandage systems.

Objective

To evaluate the operational characteristics of six compression bandages using the SynDaver™ Synthetic Human (SSH) Mannequin. The results will aid the DoD selection process and improve quality of care in combat environments.

Methods

The AirWrap™, Battle Wrap™, Emergency Bandage, H-Bandage, Honeycomb Lite, and Olaes® compression bandages were evaluated. Five of each bandage design (n = 5) were applied over a 2" x 2" simulated wound site at mid-thigh on the SSH leg. The bandages were applied with a target pressure of 90 mmHg over the wound site, a pressure sufficient to overcome peak blood pressures in the smaller arteries, arterioles, capillary beds, and venous vasculature, and a typical pressure generated by compression bandages when applied by medical personnel (Naimer, 2004). Application times were recorded and pressure exerted on the wound site was measured using a pressure mapping sensor. SSH blood flow measurements were taken to detect changes in distal blood flow after bandage application.

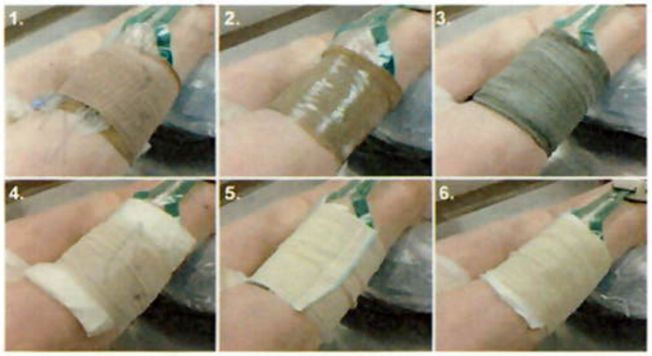

Figure 1. The AirWrap™ (1), Battle Wrap™ (2), Emergency Bandage (3), H-Bandage (4), Honeycomb Lite (5), and Olaes® (6) compression bandages are shown applied over the simulated wound site on the SSH thigh.

Results

The average application time across compression bandages was 65 ± 15 sec (Figure 1). The Battle Wrap™ application time was significantly shorter than the other bandages (47 ± 10 sec; $p<0.05$). The pressure distributions exerted on the SSH simulated wound site reflected the shape of each device's pressure pad (Figure 2). The Emergency Bandage, H-Bandage, and Olaes® each have rigid mechanical features to focus pressure over the wound site, while the AirWrap™, Battle Wrap™, and Honeycomb distributed pressures more uniformly (Figure 3). All of the bandages exerted within 10% of the 90 mmHg target application pressure with the exception of Battle Wrap™ (50.2 ± 25.8 mmHg, Figure 4). The peak pressures The Honeycomb bandage was the only device to significantly reduce distal blood flow (20.0 ± 16.7 %; $p<0.05$; Figure 5).

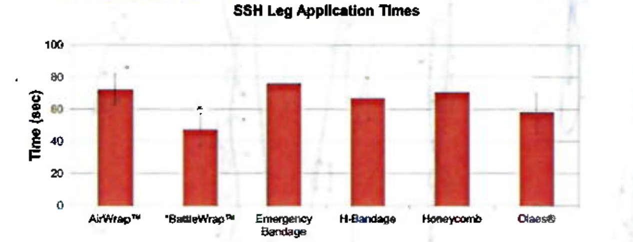

Figure 2 Application times are shown for each bandage applied to a simulated wound site on the SHH thigh. Error bars indicate one standard deviation (n=5). The Battle Wrap™ application times were significantly shorter than the other bandages, although the Battle Wrap™ did not achieve the target 90 mmHg pressure over the wound site.

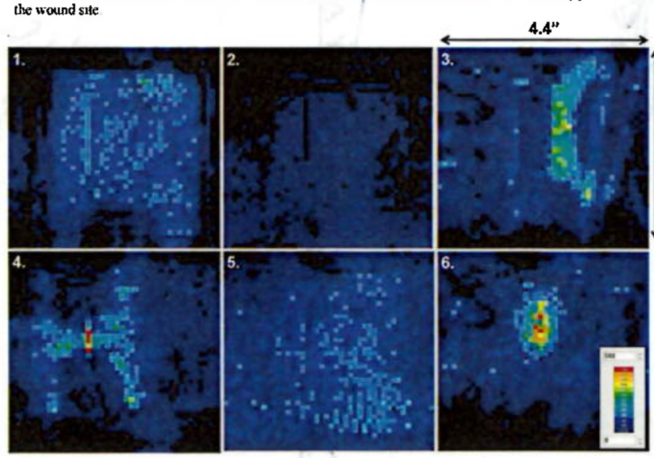

Figure 3 Representative pressure distributions exerted by the compression bandages. 1. AirWrap™ focused pressure beneath the pneumatic bladder. 2. Battle Wrap™ generated a relatively uniform pressure distribution. 3. Emergency Bandage produced concentrated pressures under the applicator. 4. H-bandage focused pressure beneath the H-shaped cinch. 5. Honeycomb generated a uniform pressure distribution. 6. Olaes® produced focused pressure beneath the domed pressure bar.

Results (cont.)

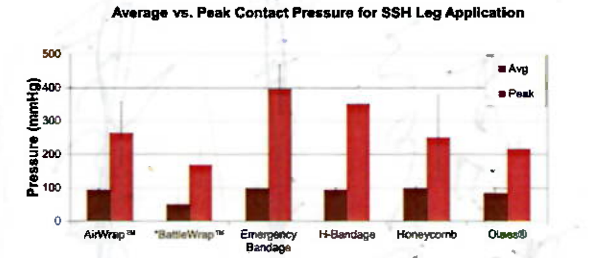

Figure 4 Average pressures exerted by the compression bandages across the simulated wound site on the SSH thigh are depicted by dark bars, and peak pressures are depicted by light bars. Error bars indicate one standard deviation (n=5).

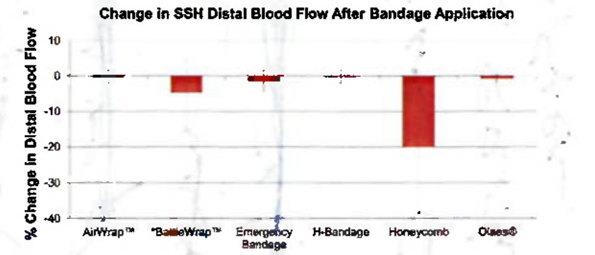

Figure 5 SSH distal blood flow measurements are shown normalized to blood flow with no bandage applied. Error bars indicate one standard deviation (n=5). Honeycomb significantly reduced distal blood flow, while the other bandages did not significantly alter blood flow.

Conclusions

The compression bandages tested in this study included a variety of sizes, materials, and features. Some consisted solely of bandage material while others utilized mechanical features to focus applied pressure. Bandage designs which incorporated a mechanical pressure focus were consistently able to achieve high peak pressures over a target area without inadvertently occluding blood flow to the distal limb. Evaluating the physical and operational characteristics of compression bandages is a critical step in highlighting strengths and areas of improvement for currently available devices. The results from this evaluation provide metrics for comparison and can help to define performance criteria for emerging designs.

References

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__Disclaimers__

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