A Comparison of Multilayer Bandage Systems During Rest, Exercise, and Over 2 Days of Wear Time

Jürg Hafner, MD; Ioannis Botonakis, MD; Günter Burg, MD

Objective: To study the interface pressure between the leg and 8 different multilayer bandage systems during postural changes, exercise (walking), and over 2 days of wear time.

Design: Comparison of 8 different compression bandages under standardized conditions.

Setting: Department of Dermatology, University Hospital of Zurich, Zurich, Switzerland.

Participants: A series of 10 healthy volunteers, 5 females and 5 males, aged 26 to 65 years.

Intervention: An electropneumatic device was used to measure interface pressure at 12 points of the leg.

Main Outcome Measures: (1) Pressure changes from the standing to the sitting and supine position at rest, (2) pressure amplitude during exercise (200-m treadmill walk at 3.2 m/s, 0° incline), and (3) pressure decrease over 2 days of wear time.

Results: Results are given as median with the 10% to 90% confidence intervals. Multilayer bandages of short and medium stretch showed a larger pressure decrease when the patient was supine (eg, 3 short stretch bandages: 18.0 mm Hg [reference range, 15.5-19.5 mm Hg]) than systems of medium and long stretch bandages (eg, 4-layer bandage, 6.0 mm Hg [reference range, 4.5-7.0 mm Hg]) (P=.005). The amplitude of pressure waves during exercise was comparable among most multilayer bandage systems. The pressure loss over time was the smallest in elastic bandages (eg, 4-layer bandage, 6.0 mm Hg [reference range, 0.0-10.5 mm Hg]), compared with short stretch bandages (eg, 3 short stretch bandages, 18.0 mm Hg [reference range, 16.5-20.5 mm Hg]) (P=.005).

Conclusions: Highly elastic multilayer bandage systems showed the smallest pressure loss over several days, but the small pressure decrease when the patient was supine makes them potentially hazardous to patients with arterial occlusive disease. Short stretch bandages and the Unna boot with an inelastic zinc plaster bandage generate large pressure waves while walking and showed a marked pressure decrease when the patient was supine, but they lose a lot of their pressure within the first hours of wear. Multilayer systems composed of short stretch and cohesive medium stretch bandages represent a good compromise between elastic and inelastic bandage systems (moderate pressure loss over time, large pressure decrease on lying down). The clinical effectiveness of the different types of compression still remains to be studied.

Arch Dermatol. 2000;136:857-863

Compression therapy is the mainstay in conservative treatment of venous ulcers. Healing rates under compression therapy have been reported at 40% to 70% over 3 months and at 50% to 80% over 6 months, depending on the initial ulcer size and the previous duration of ongoing ulceration, respectively. Clinical trials have been performed using firm short stretch bandages and multilayer bandage systems composed of elastic medium stretch and long stretch bandages. Both have their advantages and disadvantages that will be discussed in this article.

Compression bandages can be subdivided into 3 categories: short stretch (<70% extensibility), medium stretch (70-140% extensibility), and long stretch (>140% extensibility). The extensibility of a bandage can be simply determined by stretching it out along a ruler. A recent study using air plethysmography has shown that short stretch bandages are more effective in reducing the venous volume and the venous filling time when the patient stands up. Moreover, short stretch bandages have the advantage that they show a marked pressure decrease when the patient lies down. This makes them less dangerous for iatrogenic damage in peripheral arterial occlu-
PARTICIPANTS AND METHODS

An electropneumatic device (Oxford Pressure Monitor MK II; Talley Instruments, Romsey, England) was used to measure interface pressure at 12 points of the leg. The monitor is portable (weight, 8 kg; dimensions, 40 × 30 × 15 cm) and battery operated. It allows for the registration of 12 electropneumatic sensors. One sensor consists of a flat pneumatic bladder (0.3 mm high, 2 cm in diameter) and a 2-mm-diameter connecting tube. The sensors 1 to 12 are operated consecutively, resulting in approximately 16 serial readings per minute. The suppliers indicate that readings obtained have an accuracy of ±5 mm Hg.

For our examinations of compression bandages, the points of measurement were distributed as follows: 3 points along the medial aspect of the leg, 2 points along the lateral aspect, 1 point at the medial and lateral retromalleolar space, and 1 point at the distal dorsum of the foot, over the wrist, at the pretilial area, at the Achilles tendon, and at the calf. We chose an interface pressure of 35 to 45 mm Hg (sitting position, medial gaiter area) to examine different multilayer bandage systems at rest and during exercise. An interface pressure of 40 mm Hg at the medial gaiter area is generally accepted as clinically most effective while still widely tolerated by the patients. An initial interface pressure of 45 to 55 mm Hg was chosen for the studies over a wear time of 2 days, presuming a pressure decrease of approximately 10 mm Hg during the first 6 hours. Attention was paid to a graduated pressure profile, ie, the interface pressure below the knee was approximately 70% of that at the gaiter area.

Seven different multilayer bandage systems and Unna boots with an inelastic zinc plaster bandages (Ulcosan; Flawa, Flawil, Switzerland) were investigated during this study (Tables 1, 2, and 3). All bandages were tested on 10 legs (1) in different postures at rest (sitting, standing, supine), (2) during exercise (200-m treadmill walk at 3.2 m/s; inclination 0°), and (3) over extended periods of time (2 days and nights of continuous wear). For measurements at rest and on the treadmill, the bandages were compared on the right leg of 10 healthy volunteers (5 females, 5 males, aged 26-65 years). For the 2 days of wear time, every participant wore the 8 different bandages on either one of his or her legs. Readings were taken at the beginning and after 6, 24, and 48 hours.

Continuous data were expressed as median (10%-90% confidence interval). StatView 5.0 software (Abacus Concepts, Berkeley, Calif) was used for statistical calculations. The Friedman test for repeated measurements of paired data was used to compare the 8 different bandages. If there were significant differences among a group of 8 bandages (Friedman test, P < .05), the Wilcoxon signed rank test was used as post hoc test to compare paired data in 2 groups (comparison of a standard bandage [FLB] vs the other 7 bandages). According to the Bonferroni correction (0.05/7, P < .007 was considered statistically significant.

sive disease and for patients with diabetes mellitus, and these bandages are better tolerated during several days' wear. During ambulation the leg cannot expand under a firm short stretch bandage as well as under a long stretch bandage. Therefore, short stretch bandages generate a larger pressure amplitude during exercise, which makes them particularly useful in patients who ambulate. The main disadvantage of short stretch bandages is that they tend to become loose after a few hours of wear time and tend to slip down the leg. Long stretch bandages have the advantage that they are more easily molded around the heel and ankle, and that they sustain compression better than inelastic materials. As a rule, the correct use of short stretch bandages requires the skills of experienced health care professionals, whereas long stretch bandages can also be applied by the patients and their relatives.

Furthermore, bandages can be subdivided according to their adherence: they can be nonadherent, cohesive, or adhesive. Cohesive (or self-adhesive) bandages adhere to themselves, usually because of a fine layer of latex microparticles. Adhesive bandages stick to every dry surface, ie, on themselves, on other textiles, and on the skin. They have a layer of glue, usually polyacryl or zinc oxide.

During the last 15 years several investigators have recognized that nonadherent elastic short stretch bandage systems lose 50% of their initial interface pressure within the first few hours of wear. This lead to the development of the 4-layer bandage (FLB) that is widely used in community clinics in the United Kingdom. The FLB system consists of an initial layer of orthopedic padding wool (Velband; Johnson & Johnson, Arlington, Tex; or Sofban; Smith & Nephew, Solothurn, Switzerland), a second layer of a short stretch bandage (Crepe); a third layer of a long stretch bandage (Elset, Seton, England), and a fourth layer of a cohesive middle stretch bandage (Coban; 3M, Ruschlikon, Switzerland). Modifications have been used for legs with a wide ankle size of 26 cm or larger and additional layers of orthopedic padding wool are advisable to protect the bony and tendinous prominences of legs with a small ankle size of 18-cm or less circumference. Outside the United Kingdom, the individual elements of the FLB are not readily available; however, an analog of the FLB has recently been commercialized (Profore; Smith & Nephew). The FLB is predominantly composed of elastic long stretch and medium stretch bandages. Therefore, it can be predicted that the pressure decrease from the standing to the supine position must be rather small, which may cause problems in patients with peripheral arterial disease. Theoretically, a multilayer bandage composed of a core of short stretch bandages that warrant high-pressure amplitudes during walking and an outer layer of an adherent bandage that prevents a pressure loss over a prolonged wear time should result in an optimal performance combining high-pressure amplitudes while walking, a marked pressure decreased in the supine position, and little interface pressure loss over time. To clarify these questions, we investigated a series of multilayer bandage systems at rest, during exercise, and over time by means of interface pressure measurement.
**RESULTS**

**INTERFACE PRESSURE AT REST**

The results of the first part of the study are given in Table 1 and shown in Figure 1. The FLB as well as the system of 3 cohesive long stretch bandages and the system of 2 short stretch bandages and a cohesive long stretch bandage as outer layer showed the smallest pressure decrease when the patient was supine (median, 4-6 mm Hg). When the outer layer of the FLB (cohesive medium stretch bandage, Coplus; Smith & Nephew) was replaced by an adhesive short stretch bandage, this resulted already in a significantly larger pressure decrease from the standing to the supine position. Unna boot (inelastic zinc plaster) is particularly suitable for the treatment of edema in arterially compromised legs. 1 indicates 4-layer bandage (Profore [Smith & Nephew, Solothurn, Switzerland] with a cohesive middle stretch bandage [Coplus; Smith & Nephew] as the outer layer); 2, modified 4-layer bandage (Profore with an adhesive short stretch bandage [Isoplast, Iostrab, Brugg, Switzerland] as the outer layer); 3, three cohesive long stretch bandages (Nylexogrip; Vigo, St Blaise, Switzerland) and a cohesive long stretch bandage (Nylexogrip) as the outer layer; 5, core of 2 short stretch bandages (Rhena Varidress) and a cohesive medium stretch bandage (Coban; 3M, Rüschlikon, Switzerland) as the outer layer; 6, core of 2 short stretch bandages (Rhena Varidress) and an adhesive short stretch bandage (Isoelast) as the outer layer; 7, three nonadherent short stretch bandages (Rhena Varidress); and 8, Unna boot with an inelastic zinc plaster bandage (Ulcosan).

**INTERFACE PRESSURE DURING EXERCISE**

The results of the second part of the study are given in Table 2 and shown in Figure 2. Most multilayer bandage systems showed comparable amplitudes of pressure waves while walking on a treadmill. The FLB generated amplitudes of pressure decrease as 3 short stretch bandages, namely, between 17 and 18 mm Hg. In direct comparison, the multilayer system of 3 short stretch bandages showed a pressure decrease of 18.0 mm Hg (15.5-19.5 mm Hg) vs 6.0 mm Hg (4.5-7.0 mm Hg) with the FLB (P = .005). Unna boots are made of inelastic zinc plaster. They exert significantly lower interface pressure than other bandage systems (sitting: Unna boot vs FLB, P = .005), and the interface pressure decrease from 25.5 mm Hg (20.0-32.0 mm Hg) to 14.5 mm Hg (10.0-20.5 mm Hg) when patients lie down.

### Table 1. Postural Changes*

<table>
<thead>
<tr>
<th>Bandage</th>
<th>Standing</th>
<th>Sitting</th>
<th>Supine</th>
<th>Pressure Decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>44.0 (37.0-48.0)</td>
<td>42.5 (35.0-46.5)</td>
<td>38.0 (31.5-41.5)</td>
<td>6.0 (4.5-7.0)</td>
</tr>
<tr>
<td>2</td>
<td>50.5 (44.0-59.0)</td>
<td>46.5 (43.0-53.5)</td>
<td>36.0 (25.0-47.0)</td>
<td>14.5 (7.5-19.0)</td>
</tr>
<tr>
<td>3</td>
<td>43.0 (35.5-44.5)</td>
<td>43.0 (35.5-45.0)</td>
<td>38.0 (32.0-41.0)</td>
<td>4.0 (3.0-6.0)</td>
</tr>
<tr>
<td>4</td>
<td>45.0 (42.0-48.0)</td>
<td>44.0 (40.5-45.0)</td>
<td>39.5 (35.5-43.0)</td>
<td>5.5 (5.0-7.0)</td>
</tr>
<tr>
<td>5</td>
<td>46.0 (42.5-58.0)</td>
<td>41.0 (36.0-44.5)</td>
<td>28.0 (23.5-36.5)</td>
<td>18.0 (16.5-23.5)</td>
</tr>
<tr>
<td>6</td>
<td>50.5 (43.5-53.5)</td>
<td>43.5 (38.0-45.0)</td>
<td>33.5 (28.5-35.5)</td>
<td>17.0 (14.0-19.0)</td>
</tr>
<tr>
<td>7</td>
<td>47.0 (41.0-49.5)</td>
<td>41.5 (36.0-45.0)</td>
<td>28.5 (23.5-32.5)</td>
<td>18.0 (15.5-19.5)</td>
</tr>
<tr>
<td>8</td>
<td>25.5 (20.0-32.0)</td>
<td>20.5 (14.5-30.5)</td>
<td>14.5 (10.0-20.5)</td>
<td>10.0 (8.0-16.0)</td>
</tr>
</tbody>
</table>

*Interface pressure at the distal medial calf (gaiter area, 10 healthy volunteers) in the standing, sitting, and supine position. Values are expressed as median (10%-90% confidence interval). Bandages were applied to exert a compression of 35 to 45 mm Hg in the sitting position (except for the Unna boot with inelastic zinc plaster [Ulcosan; Flawil, Switzerland] where such strong compression is not achieved). Multilayer bandages with a cohesive long stretch bandage as the outer layer show the smallest pressure decrease from the standing to the supine position. Unna boot (inelastic zinc bandage) is particularly suitable for the treatment of edema in arterially compromised legs. 1 indicates 4-layer bandage (Profore [Smith & Nephew, Solothurn, Switzerland] with a cohesive middle stretch bandage [Coplus; Smith & Nephew] as the outer layer); 2, modified 4-layer bandage (Profore with an adhesive short stretch bandage [Isoplast, Iostrab, Brugg, Switzerland] as the outer layer); 3, three cohesive long stretch bandages (Nylexogrip; Vigo, St Blaise, Switzerland) and a cohesive long stretch bandage (Nylexogrip) as the outer layer; 5, core of 2 short stretch bandages (Rhena Varidress) and a cohesive medium stretch bandage (Coban; 3M, Rüschlikon, Switzerland) as the outer layer; 6, core of 2 short stretch bandages (Rhena Varidress) and an adhesive short stretch bandage (Isoelast) as the outer layer; 7, three nonadherent short stretch bandages (Rhena Varidress); and 8, Unna boot with an inelastic zinc plaster bandage (Ulcosan).

### Table 2. Interface Pressure During Exercise (Walking on a Treadmill)*

<table>
<thead>
<tr>
<th>Bandage</th>
<th>Average</th>
<th>Maximum</th>
<th>Minimum</th>
<th>Amplitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>42.5 (32.5-47.5)</td>
<td>48.5 (35.0-56.0)</td>
<td>32.0 (26.5-38.0)</td>
<td>15.0 (4.0-26.5)</td>
</tr>
<tr>
<td>2</td>
<td>46.0 (41.0-55.5)</td>
<td>54.5 (45.5-76.0)</td>
<td>36.0 (32.0-42.5)</td>
<td>17.0 (9.5-41.0)</td>
</tr>
<tr>
<td>3</td>
<td>43.0 (35.0-49.5)</td>
<td>43.5 (40.5-52.0)</td>
<td>32.5 (29.0-39.5)</td>
<td>12.5 (3.5-18.0)</td>
</tr>
<tr>
<td>4</td>
<td>45.0 (40.5-50.5)</td>
<td>50.0 (41.0-58.0)</td>
<td>35.5 (27.5-45.5)</td>
<td>15.0 (3.5-22.0)</td>
</tr>
<tr>
<td>5</td>
<td>46.0 (38.5-55.5)</td>
<td>54.0 (47.5-70.5)</td>
<td>36.5 (29.0-46.5)</td>
<td>19.0 (9.0-36.5)</td>
</tr>
<tr>
<td>6</td>
<td>44.5 (37.0-50.0)</td>
<td>52.0 (42.0-59.0)</td>
<td>34.5 (25.0-41.0)</td>
<td>18.0 (8.5-28.5)</td>
</tr>
<tr>
<td>7</td>
<td>41.5 (35.5-47.0)</td>
<td>52.5 (46.0-59.5)</td>
<td>36.0 (28.0-40.5)</td>
<td>18.0 (9.0-27.0)</td>
</tr>
<tr>
<td>8</td>
<td>20.5 (14.5-30.5)</td>
<td>32.0 (20.0-47.0)</td>
<td>12.0 (7.0-13.5)</td>
<td>21.0 (8.5-35.0)</td>
</tr>
</tbody>
</table>

*Interface pressure at the distal medial calf (gaiter area, 10 healthy volunteers) while walking on a treadmill during 1 minute (3.2 m/s; 0° incline). Values are expressed as median (10%-90% confidence interval). Bandages were applied to exert a compression of 35 to 45 mm Hg in the sitting position (except for the Unna boot with inelastic zinc plaster [Ulcosan; Flawil, Switzerland] where such strong compression is not achieved). The more inelastic the bandages, the higher the pressure amplitudes (amplitude = maximum − minimum) during exercise. 1 indicates 4-layer bandage (Profore [Smith & Nephew, Solothurn, Switzerland]) with a cohesive middle stretch bandage [Coplus; Smith & Nephew] as the outer layer; 2, modified 4-layer bandage (Profore with an adhesive short stretch bandage [Isoplast, Iostrab, Brugg, Switzerland] as the outer layer); 3, three cohesive long stretch bandages (Nylexogrip; Vigo, St Blaise, Switzerland) and a cohesive long stretch bandage (Nylexogrip) as the outer layer; 5, core of 2 short stretch bandages (Rhena Varidress) and a cohesive medium stretch bandage (Coban; 3M, Rüschlikon, Switzerland) as the outer layer; 6, core of 2 short stretch bandages (Rhena Varidress) and an adhesive short stretch bandage (Isoelast) as the outer layer; 7, three nonadherent short stretch bandages (Rhena Varidress); and 8, Unna boot with an inelastic zinc plaster bandage (Ulcosan).
15.0 mm Hg (4.0–26.5 mm Hg) as compared with 3 short stretch bandages that generated amplitudes of 18.0 mm Hg (9.0–27.0 mm Hg) (P = .41). The multilayer bandage system that consisted only of long stretch bandages (3 cohesive long stretch bandages), however, generated lower pressure amplitudes of 12.5 mm Hg (3.5–18.0 mm Hg) (3 long stretch bandages vs 3 short stretch bandages, P = .03).

### INTERFACE PRESSURE OVER 2 DAYS OF WEAR TIME

The results of the third part of the study are given in Table 3 and shown in Figure 3. The FLB and the modified FLB showed the smallest pressure loss of 6.0 to 8.0 mm Hg (median) over 48 hours. Replacing the original outer layer of the FLB (a cohesive medium stretch bandage) with an adhesive short stretch layer resulted in a slightly larger pressure loss after 2 days (P = .07). The bandage systems with a core of 2 short stretch bandages and a cohesive medium stretch or cohesive long stretch bandage as outer layer showed a moderate pressure decrease of 10.5 to 12.0 mm Hg (2 short and 1 medium stretch bandages vs FLB, P = .02). The bandage systems composed of 3 nonadherent short stretch bandages or with an adhesive short stretch bandage as outer layer showed the largest pressure decrease (16.5–18.5 mm Hg) (3 short stretch bandages vs FLB, P = .003).

### INTERFACE PRESSURE AT BONY AND TENDINOUS PROMINENCES

These results are given in Table 4. Measurements were taken while the patient was sitting, while the interface pressure at the distal medial gaiter area was 35 to 45 mm Hg. At the wrist, the elastic multilayer bandage systems showed interface pressures between 69.5 and 102.0 mm Hg, while the interface pressure in the Unna boot with inelastic zinc plaster bandage was 48.5 mm Hg (FLB vs Unna boot, P = .01).
bandages that are purely composed of long stretch material exert smaller amplitudes during ambulation.

INTERFACE PRESSURE OVER 2 DAYS OF WEAR TIME

Pressure loss is influenced both by the stretch and the adherence properties of bandages. Medium stretch and long stretch bandages lose less of interface pressure over time.\(^9,10\) As a rule, adherent bandages in the outer layer of multilayer bandage systems help prevent loss of interface pressure. Adding a cohesive (self-adhesive, nonsticky) medium stretch or long stretch bandage as the outer layer to the core of 2 short stretch bandages effectively prevented pressure loss, whereas an adhesive (sticky) short stretch bandage was ineffective in achieving this result (\(P = .05\)).

Cohesive bandages are easier to use than the sticky adhesive bandages, since they can be removed and

Figure 1. Multilayer bandages with medium stretch or short stretch bandage as outer layer show the larger pressure drop. Bandages that lose pressure when the patient is supine are generally better tolerated and less hazardous in arterially compromised legs. Multilayer bandages containing long stretch material show the smallest pressure decrease. 1 indicates 4-layer bandage (Profore [Smith & Nephew, Solothurn, Switzerland] with a cohesive middle stretch bandage [Coplus; Smith & Nephew] as the outer layer); 2, modified 4-layer bandage (Profore with an adhesive short stretch bandage [Isolast; Isoplast, Brugg Switzerland] as the outer layer); 3, three cohesive long stretch bandages (Nylexogrip; Viso, St Blaise, Switzerland); 4, core of 2 short stretch bandages (Rhena Varidress; IVF, Neuhausen, Switzerland) and a cohesive long stretch bandage (Nylexogrip) as the outer layer; 5, core of 2 short stretch bandages (Rhena Varidress) and a cohesive medium stretch bandage (Coban; 3M, Rüschlikon, Switzerland) as the outer layer; 6, core of 2 short stretch bandages (Rhena Varidress) and an adhesive short stretch bandage (Isoelast) as the outer layer; 7, three nonadherent short stretch bandages (Rhena Varidress); and 8, Unna boot with an inelastic zinc plaster bandage (Ulcosan; Flawa, Flawil, Switzerland).

Figure 2. Interface pressure during exercise (200-m treadmill walk at 3.2 m/s; inclination 0\(^\circ\)). The more inelastic the bandages, the higher the amplitude of the pressure waves during exercise. The line charts show the pressure waves during 1 step: average, maximum, average, minimum, average. 1 indicates 4-layer bandage (Profore [Smith & Nephew, Solothurn, Switzerland] with a cohesive middle stretch bandage [Coplus; Smith & Nephew] as the outer layer); 2, modified 4-layer bandage (Profore with an adhesive short stretch bandage [Isolast, Isoplast, Brugg, Switzerland] as outer layer); 3, three cohesive long stretch bandages (Nylexogrip; Viso, St Blaise, Switzerland); 4, core of 2 short stretch bandages (Rhena Varidress, IVF, Neuhausen, Switzerland) and a cohesive long stretch bandage (Nylexogrip) as the outer layer; 5, core of 2 short stretch bandages (Rhena Varidress) and a cohesive medium stretch bandage (Coban; 3M, Rüschlikon, Switzerland) as the outer layer; 6, core of 2 short stretch bandages (Rhena Varidress) and an adhesive short stretch bandage (Isoelast) as the outer layer; 7, three nonadherent short stretch bandages (Rhena Varidress); and 8, Unna boot with an inelastic zinc plaster bandage (Ulcosan; Flawa, Flawil, Switzerland).
wrapped again for corrections. Together with their ability to prevent pressure loss, this makes them ideal candidates for the outer layer of multilayer bandage systems. In the special situation of the FLB that contains a long stretch bandage in its core, an adhesive short stretch bandage (Isoelast; Isoplast, Brugg, Switzerland) as the outer layer; 3, three cohesive long stretch bandages (Nylexogrip; Viso, St Blaise, Switzerland); 4, core of 2 short stretch bandages (Rhena Varidress; IVF, Neuhausen, Switzerland) and a cohesive long stretch bandage (Nylexogrip) as the outer layer; 5, core of 2 short stretch bandages (Rhena Varidress) and a cohesive medium stretch bandage (Coban; 3M, Rüschlikon, Switzerland) as the outer layer; 6, core of 2 short stretch bandages (Rhena Varidress) and an adhesive short stretch bandage (Isoelast) as the outer layer; 7, three nonadherent short stretch bandages (Rhena Varidress); and 8, Unna boot with an inelastic zinc plaster bandage (Ulcosan; Flawa, Flawil, Switzerland).

Figure 3. Pressure decrease over time. The more elastic (medium stretch or long stretch) bandages are used, the smaller the pressure decrease over time. An adherent (cohesive and adhesive) outer layer helps sustain compression over time. 1 indicates 4-layer bandage (Profore [Smith & Nephew, Solothurn, Switzerland] with a cohesive middle stretch bandage [Copius; Smith & Nephew] as the outer layer); 2, modified 4-layer bandage (Profore with an adhesive short stretch bandage [Isoelast; Isoplast, Brugg, Switzerland] as the outer layer); 3, three cohesive long stretch bandages (Nylexogrip; Viso, St Blaise, Switzerland); 4, core of 2 short stretch bandages (Rhena Varidress; IVF, Neuhausen, Switzerland) and a cohesive long stretch bandage (Nylexogrip) as the outer layer; 5, core of 2 short stretch bandages (Rhena Varidress) and a cohesive medium stretch bandage (Coban; 3M, Rüschlikon, Switzerland) as the outer layer; 6, core of 2 short stretch bandages (Rhena Varidress) and a cohesive long stretch bandage (Nylexogrip) as the outer layer; 7, core of 2 short stretch bandages (Rhena Varidress) and a cohesive medium stretch bandage (Coban; 3M, Rüschlikon, Switzerland) as the outer layer; 8, Unna boot with an inelastic zinc plaster bandage (Ulcosan).
be used for several days as soon as the leg is edema free. On theoretical grounds, 3 precautions should help avoid hazards of compression therapy in patients with mixed venous-arterial leg ulcers and in patients with dependency edema in peripheral arterial disease: (1) reduction of interface pressure, (2) protection of bony and tendinous prominences with sufficient orthopedic padding wool, and (3) the use of Unna boots with inelastic zinc plaster bandages or little extensible short stretch bandages. This approach has never been confirmed by the means of a systematic clinical study, but it seems that at least some of the complications of compression therapy that were reported by Scottish surgeons were attributed to the use of elastic bandages that were applied with high interface pressure.

CONCLUSIONS

Multilayer bandage systems should be composed of short and medium stretch bandages to generate high—pressure wave amplitudes while the patient is walking and a significant pressure decrease when the patient is supine. The FLB (composed of medium and long stretch material) exhibits the smallest pressure loss over 2 days of wear time, but the pressure decrease is small when the patient is supine. Therefore, the FLB system is particularly suitable for patients with chronic venous insufficiency who do not have concomitant peripheral arterial disease. As a compromise, a multilayer bandage composed of a core of short stretch bandages and an outer layer of a cohesive medium stretch bandage can be recommended. This type of composition shows a marked pressure decrease when the patient is supine, high pressure amplitudes during exercise, and sustains compression after an initial decrease of approximately 10 mm Hg in the first 6 hours. Therefore, it can be applied with a slightly elevated initial pressure, to reach the therapeutic range after some hours. As a matter of fact, a randomized controlled trial comparing the FLB with a multilayer system of short stretch bandages applying a cohesive bandage as the outer layer has shown the same healing rates (55% vs 57% at 1 year) with both systems. Instead, a smaller interface pressure (20 mm Hg), sufficient protection of the bony and tendinous prominences of the leg by orthopedic padding wool, and the use of short stretch bandages or Unna boots with inelastic zinc plaster bandages should be encouraged in the treatment of mixed venous-arterial leg ulcers and of dependency edema in peripheral arterial disease. The same precautions can be recommended in patients with diabetic neuropathy who may be unable to recognize hazardous pressure sites under their compression bandages.

Accepted for publication January 11, 2000.

We greatly acknowledge B. Seifert, PhD, for statistical advice and E. P. Scheidegger, MD, for proofreading the manuscript.

Corresponding author: Jürg Hafner, MD, Department of Dermatology, University Hospital of Zurich, Gloriastrasse 31, CH-8091 Zurich, Switzerland (e-mail: jhafner@derm.unizh.ch).

REFERENCES