Delivery of Compression Therapy for Venous Leg Ulcers

Kian Zarchi, MD; Gregor B. E. Jemec, MD, DMSc

**IMPORTANCE**  Despite the documented effect of compression therapy in clinical studies and its widespread prescription, treatment of venous leg ulcers is often prolonged and recurrence rates high. Data on provided compression therapy are limited.

**OBJECTIVE**  To assess whether home care nurses achieve adequate subbandage pressure when treating patients with venous leg ulcers and the factors that predict the ability to achieve optimal pressure.

**DESIGN, SETTING, AND PARTICIPANTS**  We performed a cross-sectional study from March 1, 2011, through March 31, 2012, in home care centers in 2 Danish municipalities. Sixty-eight home care nurses who managed wounds in their everyday practice were included.

**MAIN OUTCOMES AND MEASURES**  Participant-masked measurements of subbandage pressure achieved with an elastic, long-stretch, single-component bandage; an inelastic, short-stretch, single-component bandage; and a multilayer, 2-component bandage, as well as, association between achievement of optimal pressure and years in the profession, attendance at wound care educational programs, previous work experience, and confidence in bandaging ability.

**RESULTS**  A substantial variation in the exerted pressure was found: subbandage pressures ranged from 11 mm Hg exerted by an inelastic bandage to 80 mm Hg exerted by a 2-component bandage. The optimal subbandage pressure range, defined as 30 to 50 mm Hg, was achieved by 39 of 62 nurses (63%) applying the 2-component bandage, 28 of 68 nurses (41%) applying the elastic bandage, and 27 of 68 nurses (40%) applying the inelastic bandage. More than half the nurses applying the inelastic (38 [56%]) and elastic (36 [53%]) bandages obtained pressures less than 30 mm Hg. At best, only 17 of 62 nurses (27%) using the 2-component bandage achieved subbandage pressure within the range they aimed for. In this study, none of the investigated factors was associated with the ability to apply a bandage with optimal pressure.

**CONCLUSIONS AND RELEVANCE**  This study demonstrates the difficulty of achieving the desired subbandage pressure and indicates that a substantial proportion of patients with venous leg ulcers do not receive adequate compression therapy. Training programs that focus on practical bandaging skills should be implemented to improve management of venous leg ulcers.
Venous leg ulcers have been recognized since Hippocrates described the association between varicose veins and leg ulcerations more than 2300 years ago.1,2 Nevertheless, venous leg ulcers continue to be a major health burden because treatment is often prolonged, recurrence rates are high, and the economic effect on health care systems is large.3-4 Managing venous leg ulcers in the United States has been estimated to cost $2.5 billion to $3.5 billion yearly.5 Venous insufficiency is the most common cause of leg ulceration, and sustained healing is a major challenge.6-8 Furthermore, the prevalence of venous leg ulcers increases markedly with age,9,10 and the demographics of most Western countries, therefore, make it necessary to evaluate and improve current management of the disease.

Compression is the cornerstone of therapy for venous leg ulcers. Much attention has been directed toward finding the most effective and efficient compression system and much less toward the actual application of bandages in routine use. It is well recognized that the effectiveness of specific drugs in routine treatment of disease significantly differs from that described in randomized clinical trials. These differences may be explained by variation in patient and physician behavior. For physical treatments, such as bandaging, it is, however, speculated that variations in procedural proficiency among health care staff primarily influence efficacy. The subbandage pressure is the dosage of the pressure therapy and the most important determinant of its effect.11-13 Compression bandages are applied primarily by nurses in everyday practice, and most patients with venous leg ulcers are treated in a home care setting.7,13

Because of the documented effect of compression therapy, the consequent widespread prescription of compression therapy, and the paradoxically high recurrence rates of venous leg ulcers, specific efforts at assessing and addressing bandaging skills are necessary. Despite this, data on bandaging skills are limited. Therefore, we investigated the ability of home care nurses to achieve adequate subbandage pressure under standardized conditions and correlated ability with possible predictors of their performance.

**Methods**

**Participants**

All home care nurses from 2 Danish municipalities (with a total population of 81,000) who managed wounds in their everyday practice were invited to participate in this study. To obtain homogeneity among the participants, certified wound care nurses were excluded. The nurses were approached during gatherings arranged by their employers from March 1, 2011, through March 31, 2012. Oral informed consent was obtained from all participants. Institutional review board approval was not required for this study according to the Regional Ethics Committee for Region Zealand.

**Questionnaire**

The participants were asked to complete a short questionnaire, designed to obtain baseline information and data on their knowledge of compression. In the questionnaire, ranges of subbandage pressure were provided from which the participants were asked to select the one representing the optimal range (in the supine position) for treating an otherwise healthy patient with a venous leg ulcer and an ankle-brachial index above 0.9. The selection could be made from the following categories: 0 to 15 mm Hg, 15 to 25 mm Hg, 25 to 35 mm Hg, 35 to 45 mm Hg, 45 to 55 mm Hg, 55 to 70 mm Hg, and more than 70 mm Hg. Subsequently, participants were asked to indicate their level of confidence regarding their ability to apply bandages exerting optimal pressure, on a scale of 1 to 10, with 1 indicating the least confidence and 10 the most.

The participants reported the number of years in the profession, categorized as the following: 0 to 4 years, 5 to 9 years, 10 to 14 years, 15 to 19 years, and 20 years or more. In addition, they reported whether they had participated in any wound care educational programs or courses and whether they had previously worked in a hospital department with an advanced wound care clinic.

**Compression Bandages and Pressure Measurements**

After completing the questionnaire, participants were individually asked to apply 3 types of compression bandages as they would do in their everyday practice, aiming to achieve optimal subbandage pressure. The following bandages were applied: an elastic, long-stretch, single-component bandage (Lastodur; Paul Hartmann [width, 10 cm]); an inelastic, short-stretch, single-component bandage (Pütterbinde; Paul Hartmann [width, 10 cm]); and a multilayer, 2-component bandage (Coban 2; 3 M Health Care [width, 10 cm]). The selected bandages were representative of those used in home care settings in Denmark. To simulate real-life use, no restriction was placed on the amount of bandage material used, layers applied, or excessive bandage material cut with a scissors and discarded. The order of application was determined by the individual participants.

Every compression bandage was applied on the same leg of the same volunteer throughout the study. The volunteer was a woman in her 40s (body mass index [calculated as weight in kilograms divided by height in meters squared], 22.0) with no sign of lymphedema or venous deficiency. Pressure was measured by the Kikuhime measuring device (TT Media Trade). The device was selected from a number of pressure-measuring devices that used different sensing technologies, such as pneumatic, force, and resistive, each with advantages and limitations, because of its documented accuracy, reliability, and ease of performance.14,15 The pressure probe (a flexible air-filled bladder that measured 30 × 38 mm and was 3-mm-thick when calibrated to zero) was placed on the same location, 13 cm proximal to the medial malleolus of the volunteer at the site of the transition of the gastrocnemius muscle into the Achilles tendon (corresponding to the B1 region according to a consensus report of the European Committee for Standardization).15,16 Subbandage pressure was measured with the volunteer in the supine position. After each measurement, the calibration of the Kikuhime device was checked, and, when necessary, adjustments were made. The bandages were applied consecutively, and the results of the measurement...
mmHg is also reported.

**Defining the Optimal Subbandage Pressure**

The international guidelines and recommendations lack consistency in the optimal subbandage pressure for treating patients with venous leg ulcers. Some recommend that pressure of approximately 30 mm Hg is adequate, others recommend pressure of approximately 40 mm Hg as proper, and some studies refer to the range of 35 to 45 mm Hg as optimal. However, in this study, we chose a relatively wide range of 30 to 50 mm Hg as the optimal pressure range for all 3 bandages based on the current evidence, representing effective compression levels with no significant risk of damage while maintaining high patient adherence. By choosing a wide pressure range, we aimed to avoid underestimating nurses’ ability to exert optimal pressure. The proportion of nurses achieving pressure in the narrower range of 35 to 45 mm Hg is also reported.

**Statistical Analysis**

Categorical variables are summarized by frequency and percentage and continuous variables by mean and range. Dichotomous data were analyzed with the χ² test and continuous data with the t test. We used a multivariate logistic regression model to identify factors predictive of achieving optimal subbandage pressure. Application of compression was categorized as optimal if the subbandage pressure range was 30 to 50 mm Hg. If the pressure was outside this range the application of compression was categorized as a failure. Years in the profession, attendance at wound care educational programs or courses, and previous experience in a department with an advanced wound care clinic were selected as potentially important predictors. Moreover, to investigate whether confidence is predictive of achieving optimal pressure, we performed a univariate logistic regression analysis with the nurses’ confidence as the independent variable. P < .05 was used as the significance level for all statistical tests. All analyses were performed with the statistical program R, version 2.15.2 (R Development Core Team, 2013).

**Results**

Table 1 presents the characteristics of the 68 participating home care nurses. The group was considered experienced because most nurses (42 [62%]) had been in the profession for more than 10 years and one-third (23 [34%]) had more than 20 years of experience in the field. Approximately half of the group (32 [47%]) reported having participated in wound care educational programs or courses, and almost one in six (10 [15%]) reported previous work experience in a department with an associated advanced wound care clinic. Most (42 [62%]) reported moderate confidence in their ability to apply proper subbandage pressure (scores of 4–6 on a scale of 1–10), whereas 8 (12%) reported low confidence (scores of 1–3). The mean reported confidence score was 5.4. Despite individual preferences and some variation in experience levels with the 3 compression bandages, all 3 bandages were used to the same extent. All 68 nurses applied the elastic and inelastic bandages; however, because of a transitory supply shortage, 6 nurses did not apply the 2-layer bandage, thereby limiting the number of nurses applying the 2-layer bandage to 62.

**Distribution of Subbandage Pressure Exerted by the 3 Bandages**

Table 2 presents the subbandage pressures obtained by the 3 compression bandages with the volunteer in the supine position. The percentage of nurses achieving a subbandage pressure within the optimal range, defined in this study as 30 to 50 mm Hg, was the highest for the 2-component bandage (n = 39 [63%]); less than half of the nurses achieved optimal subbandage pressure with the elastic and inelastic bandages (elastic bandage: 28 [41%]; inelastic bandage: 27 [40%]). Although no statistically significant difference emerged between the single-component bandages (elastic vs inelastic, P = .86), the differences between the 2-component bandage and the elastic and inelastic bandages were statistically significant (2-component vs inelastic: P = .01; 2-component vs elastic: P = .008). With the inelastic bandage, more than half of the nurses (38 [56%]) obtained a pressure less than 30 mm Hg.

**Table 1. Characteristics of the 68 Participating Home Care Nurses**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. (%) of Nurses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time in the profession, y</td>
<td></td>
</tr>
<tr>
<td>0–4</td>
<td>9 (13)</td>
</tr>
<tr>
<td>5–9</td>
<td>17 (25)</td>
</tr>
<tr>
<td>10–14</td>
<td>13 (19)</td>
</tr>
<tr>
<td>15–19</td>
<td>6 (9)</td>
</tr>
<tr>
<td>≥20</td>
<td>23 (34)</td>
</tr>
<tr>
<td>Previous attendance at wound care educational programs or courses</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>32 (47)</td>
</tr>
<tr>
<td>No</td>
<td>36 (53)</td>
</tr>
<tr>
<td>Previous work experience in an advanced wound care clinic</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>10 (15)</td>
</tr>
<tr>
<td>No</td>
<td>58 (85)</td>
</tr>
<tr>
<td>Confidence in ability</td>
<td></td>
</tr>
<tr>
<td>Low (score range, 1–3)</td>
<td>8 (12)</td>
</tr>
<tr>
<td>Moderate (score range, 4–6)</td>
<td>42 (62)</td>
</tr>
<tr>
<td>High (score range, 7–10)</td>
<td>18 (26)</td>
</tr>
<tr>
<td>Nurses’ selections of the optimal subbandage pressure ranges, mm Hg</td>
<td></td>
</tr>
<tr>
<td>0–25</td>
<td>14 (21)</td>
</tr>
<tr>
<td>25–35</td>
<td>13 (19)</td>
</tr>
<tr>
<td>35–45</td>
<td>22 (32)</td>
</tr>
<tr>
<td>45–55</td>
<td>4 (6)</td>
</tr>
<tr>
<td>55–70</td>
<td>3 (4)</td>
</tr>
<tr>
<td>&gt;70</td>
<td>1 (2)</td>
</tr>
<tr>
<td>None of the above</td>
<td>11 (16)</td>
</tr>
</tbody>
</table>
and for only 3 nurses (4%), a pressure higher than 50 mm Hg was measured (range, 11-57 mm Hg). Similarly, with the elastic bandage, 36 nurses (53%) achieved a pressure less than 30 mm Hg, and for 4 nurses (6%), a pressure higher than 50 mm Hg was measured (range, 18-78 mm Hg). However, the distribution for the 2-component bandage differed markedly because only 11 nurses (18%) obtained a pressure less than 30 mm Hg, whereas 12 (19%) achieved a pressure higher than 50 mm Hg (range, 19-80 mm Hg). A considerably smaller proportion of home care nurses obtained pressure within the narrower range of 35 to 45 mm Hg, with 23 (37%), 16 (24%), and 11 (16%) exerting pressure within this optimal range with the 2-component, inelastic, and elastic bandages, respectively.

Differences in the Mean Subbandage Pressures
The lowest mean of subbandage pressure was obtained with the inelastic bandage (pressure of 30.4 mm Hg) closely followed by the elastic bandage (pressure of 31.8 mm Hg). The difference between the means for the elastic and inelastic bandages was not statistically significant (P = .26). However, applying the 2-component compression bandage led to a considerably higher mean pressure (pressure of 41.9 mm Hg) compared with the elastic and inelastic bandages. The differences between the 2-component bandage and the elastic and inelastic bandages were statistically significant (2-component bandage vs inelastic: P < .001; 2-component bandage vs elastic: P < .001).

Theoretical Knowledge of Subbandage Pressure
When asked to select the optimal range of subbandage pressure for treating an otherwise healthy patient with a venous leg ulcer and an ankle brachial index above 0.9, 39 nurses (57%) answered within the range of 25 to 55 mm Hg, distributed as follows: 25 to 35 mm Hg: 13 (19%), 35 to 45 mm Hg: 22 (32%), and 45 to 55 mm Hg: 4 (6%). The range of 0 to 25 mm Hg was selected by 14 nurses (21%), 4 (6%) answered above 55 mm Hg, and 11 (16%) did not answer. Every fourth to fifth nurse succeeded in achieving a subbandage pressure within the predefined range: 17 (27%) with the 2-component bandage, 17 (25%) with the elastic bandage, and 14 (21%) with the inelastic bandage. The differences were not statistically significant (2-component vs inelastic: P = .36, 2-component vs elastic: P = .75, and inelastic vs elastic: P = .54).

Predicting Factors
Table 3 presents the results of the multivariate logistic regression analysis performed for all 3 bandages, with optimal subbandage pressure (30-50 mm Hg) as the dependent variable and years in the profession, attendance at wound care educational programs or courses, and previous experience in a department with an advanced wound care clinic as the independent variables. As indicated in Table 3, none of the factors was significantly associated with obtaining optimal pressure with the elastic and inelastic bandage. For the 2-component bandage, the effect of being more than 20 years in the profession compared with less than 5 years in the profession was significant (P = .049). However, the analysis also revealed a negative insignificant effect for being 15 to 19 years in the profession compared with being less than 5 years in the profession (odds ratio, 0.36), indicating the lack of a trend across the experience groups for this bandage as well.

The results of the univariate analyses for all 3 compression bandages with the achievement of optimal subbandage pressure as the dependent variable and the nurses’ confidence level as the independent variable are presented in Table 3. No significant association was found, indicating that the nurses’ confidence level was not predictive of their ability to obtain optimal pressure.

Discussion
In this cross-sectional study investigating the levels of subbandage pressure achieved by home care nurses applying 3 different compression bandages under standardized conditions, the applied compression does not reflect the prescribed treatment. The measured subbandage pressures ranged from 11 mm Hg exerted by an inelastic bandage to 80 mm Hg exerted by the 2-component bandage. Applying the elastic and inelastic bandages led to similar subbandage pressures, with both bandages giving a mean slightly above 30 mm Hg (31.8 and 30.4 mm Hg, respectively). The mean value reflects a substantial variation because more than half of the inelastic and elastic bandage applications resulted in a subbandage pressure of less than 30 mm Hg. These values were measured immediately after application of the bandage. The problem is further compounded by the fact that the subbandage pressure...
The distribution of the subbandage pressure with the 2-component bandage was markedly different. A significantly higher mean subbandage pressure (41.9 mm Hg) was measured, and a greater proportion of the nurses (63%) achieved a subbandage pressure within the optimal range. Nonetheless, every fifth measurement with the 2-component bandage was above 50 mm Hg. If the subbandage pressure is too high, discomfort can occur, resulting in markedly decreased adherence. Moreover, there is a potential risk of damage, especially in frail patients, because it has been reported that blood perfusion of the foot and toes decreases significantly with increasing compression levels. Our results suggest that home care nurses achieve higher pressure using multicomponent bandages than single-component bandages, which provides one explanation for why venous leg ulcers in trials heal faster with multicomponent bandages, such as 4-layer bandages, than with single-component bandages. However, this study does not allow any specific conclusions about bandages, only about their application.

We explored covariables to identify factors in training and background that might be predictive of better treatment and therefore the focus of organizational intervention, such as training courses. Three factors were chosen as potentially important: (1) the number of years in the profession, (2) attendance at wound care educational programs or courses, and (3) previous work experience in a department with an advanced wound care clinic.

In this study, none of these factors had a significant effect on the ability to obtain optimal subbandage pressure. The number of years in the profession did not prove itself a significant predictor, which might be surprising because it is often assumed that experience improves skills. However, in the absence of appropriate feedback, as is the case in many clinical settings, repetition may lead to reinforcement of bad habits rather than improved skills. “Attendance at wound care educational programs” and “previous work experience in a department with an advanced wound care clinic” were both vaguely defined factors. Our findings suggest that previous work experience in a department with an advanced wound care clinic does not indicate better bandaging skills. This finding is consistent with the results of a study that reported 35% of bandages (a short-stretch compression bandage) applied by 21 experienced nurses from a department with an advanced wound care clinic did not exert pressure above 20 mm Hg. As for the case of educational programs, they vary substantially in their aim, duration, and quality. Moreover, they often focus on improving theoretical knowledge rather than practical skills, which might explain the nonsignificant effect found in this study. Although the nurses’ selection of the subbandage pressure ranges in the questionnaire shows room for improvement of their theoretical knowledge, the shortcomings to obtain the desired subbandage pressure are mainly a consequence of insufficient practical abilities. Future technological solutions permitting pressure measurements by sensors integrated in compression bandages would allow nurses to regulate the pressure in every case, leading to appropriate compression therapy. Until then, frequent training programs focusing on practical bandaging skills could improve the quality of the current management of patients with venous leg ulcers and should be implemented by organizational leadership and supported by health care policy makers to precede the use of compression bandages in home care settings. Furthermore, our results reveal that confidence is not predictive of bandaging
skills. Confidence is a subjective belief not always consistent with reality and objective assessments. Consequently, regular feedback and frequent training programs that focus on practical bandaging skills are necessary.

The strengths of the study include the standardized setup that mimics the real-life situation and the assessment of 3 different types of compression bandages representative of the participants’ everyday practice. Further strengths are the documented accuracy of the Kikuhime subbandage pressure-measuring device, the implementation of consistent and participant-masked measurements, and the selection of a wide optimal subbandage pressure range. By including all home care nurses who provide wound management in their everyday practice in 2 Danish municipalities, the study provides a representative evaluation of the knowledge base and skill sets of those who most commonly implement the most crucial part of therapy for venous leg ulcers. Certified wound care nurses who had a postgraduate academic degree in wound management were not included because (1) they are not present in all home care organizations and countries and (2) their results must be reported separately to make the evaluation meaningful. We had only 2 certified wound care nurses among the participating home care centers, making the sample too small and the results unreliable. By allowing nurses to apply compression bandages as they would in their everyday practice, including permitting them to apply as many layers as they wished and to cut bandage material, the study gives a realistic picture of the levels of subbandage pressure provided in real life. Application of bandages on the same leg on the same volunteer, who had no sign of lymphedema or venous deficiency, allowed for uniform conditions for every measurement without the risk of fluctuating levels of edema in the volunteer during the study.

Real-life evaluations of different types of bandage are valuable for clinician decision making. Inclusion of other types of bandages would have provided more insight into this topic. However, because other types of bandage, such as 4-component bandages, were not used in the home care communities, the lack of experience would have resulted in a potentially biased evaluation of those bandages. In addition, the objective of this study was to determine the ability of home care nurses rather than the effectiveness of the bandages.

The optimal subbandage pressure range is arbitrary, and no absolute guideline exists. Some reports have indicated that subbandage pressure higher than 50 mm Hg shortens healing time. Nevertheless, high compression levels are also associated with markedly decreased patient adherence and a potential risk of damage. Arguments could also be made for selecting a unique pressure range for each compression bandage because of the different static stiffness index values. However, in this study, we chose to operate with one pressure range, which would be applicable for the elderly and frail patients of home care nurses. Furthermore, real-life application does not involve identification of individually unique pressure goals. Other limitations include the vague definitions of the potentially predicting factors: “attendance at wound care educational programs or courses” and “previous work experience in a department with an advanced wound care clinic.”

Conclusions

This study provides benchmarking information about the current status of compression therapy of patients with venous leg ulcers, indicating that a substantial proportion of the patients do not receive adequate compression therapy. It is hypothesized that similar conditions affect the quality of wound management in other countries. Training programs that focus on practical bandaging skills should be implemented to improve the quality of management of venous leg ulcers.

REFERENCES

PRACTICE GAPS

Compression of Venous Ulcers
Standardizing Standard Care

Robert S. Kirsner, MD, PhD

Venous leg ulcers (VLUs) are common, affecting upward of 1% of adults and with increasing incidence and prevalence with advancing age. Venous leg ulcers are associated with reduced quality of life and significant health care costs in addition to valve disease, affecting the superficial, perforator, or deep veins. As a result, calf muscle pump dysfunction ensues, leading to ulcer formation. Standard care with multilayered compression wraps is aimed at reversing these changes, and application of well-delivered compression achieves healing in up to 75% of patients.

Applying compression, however, is a challenge. Often viewed by patients and practitioners as cumbersome, uncomfortable, and oppressive, compression interrupts patients’ lives by altering their bathing habits and the clothes and shoes they wear. In this issue of JAMA Dermatology, Zarchi and Jemec\(^1\) report that even those with moderate confidence in their ability to apply compression vary substantially in compression application, with less than one-third applying optimal compression, suggesting patients may not be getting the treatment prescribed.\(^2\)

Given that dermatologists often see patients with VLUs, addressing the gap of providing substandard compression is important. The initial barrier toward change is for practitioners to appreciate the importance of compression in healing VLUs. Without optimal compression, substandard care is provided. Practitioners should understand compression systems and recommend the appropriate system. For example, elastic compression (Coban2 [3M] or Profore [Smith and Nephew]) provides compression when patients are either walking or resting and differs from inelastic compression (Unna Boot), which applies compression only when patients are walking (the latter is more desirable in patients with mild arterial insufficiency). Next, it is critical, given the variability in compression applied, that well-trained and experienced personnel apply compression. This need typically causes patients to visit a physician’s office, seek treatment at a wound center, or use home health services once or twice weekly, depending on the amount of exudate. Application of compression by patients or untrained caregivers, such as family members, risks inappropriate provision of care; however, recent work suggests firm compression stockings (30-40 mm Hg) may result in similar outcomes for selected patients.\(^3\)

Education and training of practitioners, staff, and patients about the importance and application of compression are key.

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Related article page 730

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