Regulating the Pressure under Compression Bandages for Venous Leg Ulcers

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A simple method for regulating the highest comfortable sub-bandage pressure is described. One way of regulating the pressure under the bandage is to vary the stretch of the bandage and the other way is to alter the number of bandage layers. With constant stretch, the pressure is proportional to the number of layers. The method with constant degree of stretch and gradually increasing number of layers was tested on 30 patients. Initially the patients received two layers of bandage. One layer was added each time the patient came for treatment, up to five layers. If the patient felt pain or any other discomfort the number of layers was decreased to the former number. About 27% of the patients preferred five layers, 60% four layers and 13% three layers. (Received September 15, 1987.)

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Compression bandages are known to be effective in the treatment of venous leg ulcers (1). The exact pressure needed to prevent capillary transudation in legs with venous disease is not known. The most commonly quoted theoretically calculated optimal pressure is between 35 and 40 mmHg of external pressure at the ankle (2, 3). Elastic stockings and bandages should exert a higher pressure at the ankle level and lower on the calf up to the knee (2). Both nurses and patients show considerable variations in bandaging technique, resulting in unpredictable pressures under the bandages (4). To be able to instruct nurses and patients how to apply a bandage in the best way, it is necessary to have a simple and reproducible method.

In this study, we have investigated the possibility of using a constant degree of stretch of the elastic bandage and regulating the pressure by using different numbers of turns of the bandage.

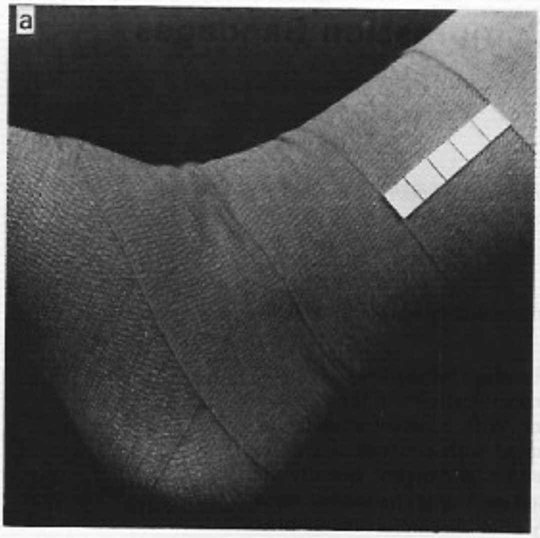
MATERIAL, METHODS AND PATIENTS

Two different types of compression treatment were used.

The Wero Lastic normal non-adhesive elastic bandage (Wernli AG, Switzerland) is usually put on each morning and taken off at night. It can be re-used for several weeks, depending on ulcer secretion. Wero Lastic normal contains 81% cotton and 19% Lycra (synthetic polyurethane elastomer).

The Coban Self-Adherent Wrap elastic bandage (Medical Products Division/3M, USA) is adhesive and stays in place for a long period of time. Coban wrap contains a natural rubber latex and a polyurethane elastomer.

Coban wrap together with an inner layer forms a double bandage, usually changed once a week. The inner layers used have been ACO Medicated Stocking or Zincaband N. ACO Medicated Stocking (ACO, Sweden) is a tubular knitted stocking impregnated with 20% zinc oxide and soft and liquid paraffin. Zincaband N (Seton Products, England) is a gauze bandage impregnated with 15% zinc oxide, boric acid and starch in water. The double bandage is also called a double elastic bandage (5) or a double layer bandage (6).



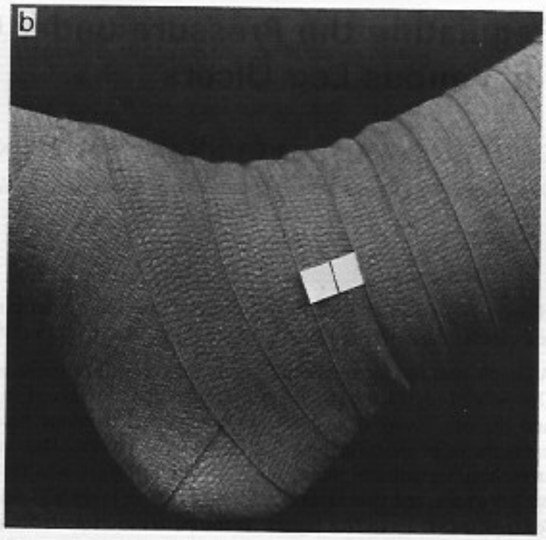


Fig. 1. (*a*) Two layers of Wero Lastic elastic bandage with 5 cm overlap. (*b*) Five layers of Wero Lastic elastic bandage with 2 cm between consecutive turns.

The stretch force was measured with a dynamometer on the Wero Lastic and on the Coban wrap elastic bandages. Both bandages are 10 cm wide.

The pressure under the elastic bandages was measured in mmHg with a thin rubber balloon, 9 cm long and 1.7 cm wide, connected to a manometer. The balloon can hold 4 ml of air when fully inflated.

The balloon was filled with 0.5 ml of air during the measuring of pressures.

Pressure measuring experiments with varying numbers of layers of the Coban wrap were performed on a hard circular cylinder of 3 cm radius.

The elastic bandages were put on from the foot to the knee, in circular turns above the malleoli. The patients started with two layers, which means a distance between consecutive turns of 5 cm (Fig. 1 *a*). The number of layers was increased by one each time the patient came for treatment until five layers was attained (Fig. 1 *b*).

If the patient complained of pain or discomfort, the number of layers was reduced. To obtain the same degree of bandage stretch, its surface pattern was compared with that of a bandage already stretched and stapled to a piece of hard cardboard. The Coban wrap was stretched 50% and the Wero Lastic bandage 80%.

To test the reproducibility after brief instructions, the bandaging was tested on one healthy volunteer. Four different nurses applied the Wero Lastic normal non-adhesive elastic bandage. Directly after each other, the nurses put the bandage on five times each. The bandage was put on with 2 and 4 layers. The stretch of the bandage was intended to be 80%. The test balloon was placed longitudinally during the bandaging on the lateral side of the calf where the circumference of the leg was 27 cm. The Wero Lastic was chosen, since this dauer type of elastic bandage is intended to be re-used several times.

The pressure was also measured under the ACO Medicated Stocking three times in the same place on the same volunteer.

Thirty chronic venous ulcer patients (18 women and 12 men) with a mean age of 72 years were treated for 1–6 months (mean 2.3 months) with compression bandages as indicated below. Patients that bandaged themselves or had the bandage put on by nurses outside the outpatient dermatology department were excluded. None of the patients had significant arterial insufficiency when tested with systolic ankle and arm pressures.

Ten of the patients were treated with Wero Lastic normal elastic bandages changed three times weekly at the outpatient clinic.

Twenty patients were treated with double bandages, changed weekly, with Coban Self-Adherent Wrap as the external compressive treatment.

Ten patients had the ACO Medicated Stocking as the inner bandage and ten patients had Zincaband N.

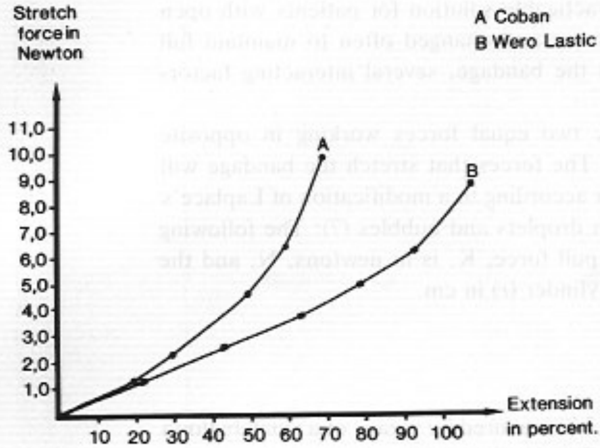


Fig. 2. Extension in per cent of two different elastic bandages in relation to the stretch force in newtons.

RESULTS

Fig. 2 shows the stretch force necessary for a certain extension. The force increases linearly within a limited range of bandage extension, up to about 50% of extension for the Coban and to about 80% extension of the Wero Lastic.

The pressures measured beneath one, two and three layers of bandage (Coban) on a circular cylinder of 3 cm radius with 50% stretch were 14, 26 and 39 mmHg, respectively.

The pressures measured beneath the non-adhesive elastic bandage when four different nurses were bandaging are given in Fig. 3. The pressure beneath the ACO Medicated Stocking only was negligible (<5 mmHg).

Of the 30 patients bandaged according to the method, 8 tolerated 5 layers, 18 four layers and 4 patients 3 layers (Table I).

DISCUSSION

The manner of applying compression bandages varies within a wide range, giving unpredictable pressures (4). It is therefore important to find a simple method of regulating the

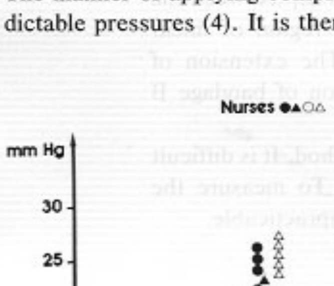


Fig. 3. The pressure measured on the lateral side of the calf (diameter 27 cm) beneath 2 and 4 layers of Wero Lastic normal elastic bandage (80% stretched) applied five times each by four different nurses.

pressure. Elastic stockings are usually not a practicable solution for patients with open ulcers. Elastic bandages should be of good quality and changed often to maintain full elasticity. To obtain a sufficient pressure from the bandage, several interacting factors must be considered.

The extension of the bandage is caused by two equal forces working in opposite directions, applied at each end of the bandage. The forces that stretch the bandage will cause pressure on the surface of a leg or cylinder according to a modification of Laplace's Law concerning the effect of surface tension on droplets and bubbles (7). The following formula gives the pressure in mmHg (p) if the pull force, K, is in newtons, N, and the width of the bandage (b) and the radius of the cylinder (r) in cm.

$$P_{\mathrm{mmHg}} = \frac{\mathrm{K} \cdot 10^4}{b \cdot r \cdot 133}$$

Pressure under elastic bandages or stockings can be measured by means of a small balloon connected to a manometer. The presence of an inflated balloon under the bandage deforms the bandage and stretches it locally and the pressure is thereby increased (8). By using a balloon only inflated with 0.5 ml of air, a negligible deformation of the bandage will be obtained and a reasonably accurate pressure measurement can be obtained. The measured pressure beneath an elastic bandage around a circular cylinder with a radius of 3 cm is almost doubled if 2 ml of air is used for the inflation of the balloon instead of 0.5 ml. If too small a volume for inflation of the balloon is used, the highest pressure that can be measured is decreased. This depends on how large the dead-space is in the system. Inflation with 0.5 ml of air gives no notable deformation of the bandage over the balloon.

There is always a small error in the pressure measurement, because of the deformation of the bandage by the balloon. This error might be different in a highly edematous leg compared with a fibrotic leg. The measurements we have made on a hard cylinder and on the soft part of a healthy leg do not indicate that the error is of importance for the purpose of this study. The pressure under a uniformly stretched bandage varies with the radius of the leg, as will be seen from the formula above (7). The pressure should be highest at the ankle and lower from the calf to the knee. The larger diameter of the calf automatically gives a lower pressure under the bandage than just above the ankle.

The elasticity of the bandage is often characterised by a linear relationship between the extension and the force for lower degrees of extension. Outside the region of linear relationship, the stretch force cannot be easily predicted (Fig. 2). The extension of bandage A (Coban) should therefore not exceed 50% and the extension of bandage B (Wero Lastic) should not exceed 80%.

After brief instruction, four nurses tested the reproducibility of the method. It is difficult without practice to know how much stretch to apply to a bandage. To measure the bandage each time in order to find the right amount of stretch is also impracticable.

Table I. *Type of treatment in relation to the number of elastic bandage layers tolerated*

	5 layers	4 layers	3 layers
Wero Lastic bandage	3	6	1
Double bandage (Coban wrap and S[a])	4	4	2
Double bandage (Coban wrap and Z[b])	1	8	1

[a] S = ACO Medicated Stocking. [b] Z = Zincaband N.

In an attempt to find an easier way of determining the right degree of stretch, a piece of ready-stretched bandage was fixed to cardboard with a stapler for comparison of the surface pattern with that of the bandage being put on. This procedure would be facilitated if bandage manufacturers included threads of different colour so that when the bandage was stretched correctly a certain, easily recognisable pattern (for instance squares) appeared. Instructions with pressures attainable with different amounts of stretch and numbers of layers should also be provided.

The simplest way to regulate the pressure is by applying extra layers of the bandages. The forces exerted by each layer add up and two layers of the bandages give double the pressure compared with a single layer if the stretch force is the same.

The four nurses showed variation in the pressure applied after the first instructions, but within acceptable margins (Fig. 3). The pressures were measured below the Wero Lastic non-adhesive elastic bandage since this bandage is intended to be re-used several times.

When using a double bandage, an extra pressure can be exerted by the inner layer. The ACO Medicated Stocking is soft and elastic and the pressure was found to be less than 5 mmHg. The Zincaband N is a bandage that stiffens after a while. This imposes certain problems for pressure measurements.

Four layers doubled the pressure under the bandage compared to two layers (Fig. 3). To see how the patients with chronic venous insufficiency could tolerate an increasingly higher pressure, the number of layers was increased each time the patient came for treatment, from two layers until they had five layers. Two layers meant a distance between consecutive turns of 5 cm and five layers meant 2 cm, for a 10 cm wide bandage (Fig. 1 *a, b*). If the patient experienced pain or discomfort, the number of layers was reduced.

The patients gradually became used to and accepted higher pressures when the number of layers was increased. Before this method was introduced in our department, most patients had had two layers.

Of 30 patients bandaged according to the method, 26.7% tolerated 5 layers, 60% 4 layers and 13.3% 3 layers (mean 4.1 layers) without any adverse effects. Applying the highest comfortable pressure probably constitutes the most efficient treatment of the patient with venous insufficiency.

REFERENCES

1. Myers MB, Rightor M, Cherry G. Relationship between edema and the healing rate of stasis ulcers of the leg. Am J Surg 1972; 123: 666–668.
2. Blair SD, Backhouse CM, McCollum CN. Br Med J 1986; 293: 448.
3. Burnand KG, Layer GT. Graduated elastic stockings. Br Med J 1986; 293: 224–225.
4. Millard LG, Blecher A, Fentem PH. The pressure at which nursing staff apply compression bandages when treating patients with varicose ulcers. In: D Negus, G Jantet, eds. Phlebology 1985. Proceedings of the First United Kingdom Meeting of the Union Internationale de Phlébologie. 1986. John Libbey & Co. Ltd, pp 682–685.
5. Gundersen J. A new, double, elastic bandage for the lower limb. Läkartidn 1980; 77: 2045–2046.
6. Eriksson G, Eklund AE, Lidén S, Zetterqvist S. Comparison of different treatments of venous leg ulcers: a controlled study using stereophotogrammetry. Curr Ther Res 1984; 35: 678–684.
7. van der Molen HR. Gummistrumpfprobleme. Ergebn Angiolog 1970; 4: 169–180.
8. van den Berg E, Borgnis FE, Bolliger AA, Wupperman T, Alexander K. A new method for measuring the effective compression of medical stockings. VASA 1982; 11: 117–123.