Providing optimal sub-bandage pressure in compression therapy

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If left untreated, leg ulcers can descend into a cycle of tissue breakdown and healing, resulting in chronic venous leg ulcers, which are associated with considerable morbidity and impaired quality of life. Compression therapy is widely held up as the 'gold standard' for management of venous leg ulcers, and the provision of safe and effective compression is one of the vital skills of the community nurse. However, to provide this level of treatment it is essential that the bandage system used provides the correct amount of sub-bandage pressure, as too little will be ineffective; whereas too great a pressure may cause constriction and patient discomfort (Moffatt, 2005; Milic et al, 2010). This article highlights a study that investigated the efficacy of a two-layer bandaging system (HERO H-2®, H&R Healthcare), which was tested by a group of clinicians for its ability to provide optimum compression alongside ease of application and patient comfort.

KEYWORDS:
■ Compression ■ Wound care ■ Skin care ■ Two-layer bandaging

One of the most common problems community nurses will come across in their day-to-day practice are leg ulcers. Of these, venous ulcers are easily the most common, outstripping arterial and diabetic foot ulcers (Scottish Intercollegiate Guidelines Network [SIGN], 2010). According to SIGN (2010) 'venous ulcers develop as a result of venous valve incompetence and calf muscle pump insufficiency which leads to venous stasis and hypertension'.

The calf muscle pump refers to the muscles in the back of the lower limb which contract on exertion, squeezing the popliteal and tibial veins and forcing the blood upward towards the heart. Valves in these veins prevent the blood from flowing back down into the lower limb.

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However, as people age and become less mobile, these valves will begin to fail — a process accelerated in those who have conditions like deep vein thrombosis (DVT). This inability to transport the blood back to the heart will result in the development of problems such as varicose veins or widening of the deeper veins in the lower limb.

This is known as chronic venous insufficiency (CVI) and will eventually cause changes in the microcirculation of the leg and result in localised tissue ischaemia, eventually causing ulceration (Grey et al, 2006).

If left untreated, these ulcers can descend into a cycle of tissue breakdown and healing, resulting in chronic venous leg ulcers which are associated with considerable morbidity and impaired quality of life (SIGN, 2010).

When the condition of the patient's lower limb has worsened to such an extent that leg ulcers have begun to develop, it is important that the community nurse has the right strategies in place to combat this. Without prompt action, these wounds can swiftly progress to chronicity, resulting in pain and poor quality of life for the patient, as well as incurring significant healthcare costs (SIGN, 2010). As well as the routine wound care needed to manage leg ulcers themselves, community nurses also need to be familiar with the physiology of the underlying tissue swelling (oedema), mainly a result of venous insufficiency.

Compression therapy is widely held up as the 'gold standard' for management of venous leg ulcers (National Institute for Health and Care Excellence [NICE], 2012), aiming to reduce limb oedema and reverse the symptoms of underlying venous hypertension.

WHAT IS COMPRESSION THERAPY?

Compression is essentially the application of external pressure to the lower limb in order to facilitate the return of excess blood to the heart (Moffatt, 2007). It has a similar effect on excess fluid (oedema) that can collect in the tissues of the lower limb, partly as a result of venous insufficiency.

Therapeutic compression is measured in millimetres of mercury (mmHg), and the strength of its action against the blood in the veins and fluid in the tissues depends on the amount of pressure delivered. This is also affected by the type of material used in the manufacture of the compression product and how it is applied, i.e. four-layer bandaging, two-layer bandaging, hosiery, etc (Moffatt, 2007).

The pressure exerted on the limb when a bandage is applied is governed by the tension of the bandage fabric, the curvature of the leg, and the width and number of layers of bandage (Partsch et al, 2008). The safety of compression bandages is largely focussed on the sub-bandage interface pressure value and this is calculated based upon Laplace's law of tension and pressure (Thomas, 2003). While the original Laplace's law described the forces exerted on a curved surface, it did not take into account the variations of applying this to a 'live' patient, with different types of bandages and limb widths, etc.

Thomas (2003) used Laplace's law but altered it to reflect the importance of the number of layers of bandaging applied and the width of the bandages — this made it more applicable to clinical practice (Schuren and Mohr, 2008) (see *Figure 1*). Similarly, the first reference to graduated compression and the now widely accepted 'ideal' pressure of 40mmHg originates from the work of Blair et al (1988) and is based upon the original four-layer 'Charing Cross' bandage system.

$$\text{Pressure (mmHg)} = \frac{\text{Tension (KgF) x number of layers x 4620}}{\text{Circumference (cm) x bandage width (cm)}}$$

Figure 1.
Laplace's law of compression as adapted by Thomas (2003).

Despite disparity in the literature regarding the true value of Laplace's law and sub-bandage interface pressure, most clinicians still base their practice upon achieving 40mmHg of pressure at the ankle to achieve 'optimal' compression.

However, in reality, the effective use of compression bandaging relies on the clinician balancing the amount of sub-bandage pressure applied — too little pressure and the bandage will not deliver adequate compression; while too much pressure may damage the skin and constrict the blood supply, meaning the patient may simply not tolerate the bandaging (Partsch et al, 2008; Milic et al, 2010). It is also crucial that nurses take care when applying compression bandaging over bony prominences as this can result in pressure ulceration (NICE, 2012).

Figure 2.
Layers 1 and 2 of HERO H-2 compression bandaging system.

HOW TO CHOOSE

As Thomas et al (2007) point out, community nurses now have a multitude of dressings to choose from, all of them designed to facilitate wound healing or improve the quality of life of patients with intractable non-healing wounds.

However, when trying to decide which compression products to use, there are some key areas for community nurses to consider:

- Is it safe?
- Does it offer additional patient benefits and improve quality of life?
- Is it easy to use?
- Is it easy to teach/learn?
- Is it cost effective?
- Is it clinically effective and able to improve long-term patient outcome?

HERO H-2 SYSTEM

HERO H-2® (H&R Healthcare) is an inelastic compression bandage system that also helps reduce odour and moisturises. It consists of two hypoallergenic layers which are latex, paraben and chlorine-free (*Figure 2*). This makes them safe for patients who have known sensitivities.

Layer one

The first layer of the dressing comprises a gentle, conformable and cohesive foam bandage — it also contains pure Aloe and cyclodextrin.

Aloe

The moisturising properties of Aloe are well-known (www.ncbi.nlm.nih.gov/pubmed/17026654) — it has been incorporated into the HERO H-2 system to help reduce the dry skin associated with venous ulcers. This means that the dressing also contributes to a patient's skin care regimen.

Cyclodextrin

As well as being naturally present in Aloe, cyclodextrin is a well-known odour-reducing agent — together with Aloe its inclusion in the dressing helps to bind odour and release a fresh scent.

This first layer of HERO H-2 is designed to be easy for clinicians to apply and uses a 50% overlap. It conforms well to the shape of the limb as well as offering a low-profile protective layer, staying in place due to its cohesive nature and providing a secure base for layer two.

Layer two

Layer two of the dressing comprises a light tan-coloured, hypoallergenic, cohesive and inelastic compression bandage. This is designed to 'lock' mechanically with layer one for

secure application. Layer two is easy to apply to the limb straight from the roll — it can even be torn by hand without needing scissors.

Wear time

The HERO H-2 compression bandaging system can be worn for up to seven days. It is also available in a variety of sizes (*Table 1*) — this provides community nurses with greater choice and helps to make sure that the correct size is applied.

Community application

The properties of HERO H-2 kits make them an ideal choice for patients who require a compression regimen in the community. Not only is the system comfortable for the patient (being lightweight and non-bulky) and easy to apply, it also reduces odour, protects the patient's skin from dryness and stays in place for up to a week. This is crucial for nurses who may have busy caseloads and who need to feel confident that a bandage will remain effective between visits, while also being comfortable for the patient to wear.

THE EVALUATION

Aim

The aim of this evaluation was to establish if the HERO H-2 bandage system was easy to learn how to use; easy to apply; and whether it delivered a safe and reproducible interface sub-bandage pressure.

Method

Six nurses considered experts in the field of leg ulceration or compression therapy were invited to take part in this experimental study, all of whom were lead specialist nurses (bands 7 and 8) from leg ulcer, tissue viability and lymphoedema services.

As well as being asked for their overall opinion of the HERO H-2 system, each nurse was asked a series of questions relating to their expectation of applied bandage interface pressure with their usual compression system:

- What is your most frequently used bandage system?
- What sub-bandage interface pressure are you aiming to achieve?
- What is this figure based upon?
- How achievable is this pressure?
- Do you ever measure this pressure in daily practice?
- How many patients do you apply compression bandages to per week?

The limb of a healthy volunteer was used to test the HERO H-2 system and data was collected in three venues — Hull, Birmingham and the British Lymphology Society (BLS) conference (also in Birmingham). The participating nurses reviewed the results after the readings were taken.

The volunteer's limb had an ankle circumference of 20cm. Three sensors were placed on the limb at the ankle (sensor 1), mid-calf (sensor 2) and upper-calf (sensor 3) — these were marked at 10cm intervals from the ankle in line with the internationally agreed consensus statement for interface pressure measurement (Partsch et al, 2006). The PicoPress® (Medigroup) monitor was used to measure interface pressure.

Three of the six clinicians applied their usual preferred bandage systems (KTwo® [Urgo Medical]; Actico® [Activa Healthcare]; K-Four® [Urgo Medical]) to the limb; while all six also applied the HERO H-2 system — the pressure measurements were then recorded three times for each system.

After an application demonstration by an independent clinical consultant and one trial application of the HERO H-2 system, the bandages were applied and the interface pressures recorded. Additional comments from the nurses and feedback on the pressures achieved were taken down at the end of the evaluation.

Table 1: HERO H-2 two-layer bandage system sizes

	Ankle size in cm	Level of compression applied
HERO H-2 Lite two-layer kit*	18–25	25–30mmHg
HERO H-2 two-layer kit*	18–25	35–40mmHg
HERO H-2 XL two-layer kit*	25–32	35–40mmHg

Note: extra padding can be added if necessary to protect bony prominences
** Bandages are also available as single components*

Results

The six participants stated that they used a variety of compression bandage systems, which included traditional four-layer and two-layer systems (K-Four, KTwo and Actico).

All participants stated that they aimed for 40mmHg interface pressure at the ankle sensor, which they then expected to graduate on the limb quoting figures of 40mmHg, 30mmHg and 20mmHg as the expected graduation profiles. All participants based their pressure expectations on Laplace's law and the training they had received during degree-level-or-above courses.

However, when asked how achievable the ideal pressure was in clinical practice, all participants were hesitant, stating that it was often difficult to achieve. Sub-bandage interface pressure measurements were not employed routinely by any participant during clinical activity, although two of the six participants regularly used interface pressure measurement when training others. All of the participants applied in excess of 10 bandages per week in clinical practice.

Table 2 shows sub-bandage pressure results for the HERO H-2 system versus the K-Four, four-layer bandage. Sensor 1 recorded ankle pressure of 52–54mmHg achieved by the K-Four bandage and 34–44mmHg achieved by the HERO H-2 bandage system. Therefore, the HERO H-2 bandage system results were closer to the 'ideal' interface pressure of 40mmHg.

Tables 3 and *4* show that sensor 1 readings for ankle pressure in the KTwo, two-layer bandage system were 43–48 mmHg compared to 24mmHg–37mmHg in the Actico two-layer and 32–43mmHg in the HERO H-2 system. This shows that all of the

Table 2: Results of the four-layer bandaging versus HERO H-2 two-layer system

Four-layer bandage user results	Sensor 1 (in mmHg)	Sensor 2 (in mmHg)	Sensor 3 (in mmHg)
K-Four four-layer	54	51	47
K-Four four-layer	52	58	56
K-Four four-layer	53	56	54
HERO H-2 two-layer	34	26	20
HERO H-2 two-layer	42	38	26
HERO H-2 two-layer	44	34	31

two-layer bandage system pressure profiles were within safe parameters for interface pressure (Blair et al, 1988; Thomas, 2003; Moffatt, 2007).

Table 5 shows the total of 18 pressure profiles that were obtained for the HERO H-2 system — overall, this demonstrates a consistency in application as well as optimal sensor 1 ankle pressure profile. Graduated compression was seen in only one participant (she was using both the four-layer and the HERO H-2 system). The 'ideal' pressures for graduated compression are 40mmHg at the ankle; 30mmHg at the mid-calf; and 20mmHg at the upper-calf — this provides ascending graduated compression rising up the lower limb.

However, in line with other studies graduation was not seen in the limbs of the remaining five participants, who recorded a higher-pressure value at the calf (sensor 2) (Partsch et al, 2008). Some of the participant comments at the end of the experiment are shown in *Table 6*.

DISCUSSION

The HERO H-2 bandage system offers significant patient benefits including a low profile, the ability for patients to wear 'normal' footwear and clothes, increased comfort, reduced slippage, odour reduction and skin moisturisation.

This experimental data confirms that the sub-bandage interface pressure delivered at the ankle is in line with other two-layer bandage systems available on the market and can be deemed safe to use. A limitation to this work is that all participants were very experienced bandage users and more work is required in general clinical use.

Table 3: Results of the KTwo two-layer bandaging versus HERO H-2 two-layer system

KTwo user results	Sensor 1 (in mmHg)	Sensor 2 (in mmHg)	Sensor 3 (in mmHg)
KTwo two-layer	43	46	19
KTwo two-layer	48	50	22
KTwo two-layer	46	49	18
HERO H-2 two-layer	32	38	24
HERO H-2 two-layer	36	46	27
HERO H-2 two-layer	37	49	28

Table 4: Results of the Actico two-layer bandaging versus HERO H-2 two-layer system

Actico two-layer user results	Sensor 1 (in mmHg)	Sensor 2 (in mmHg)	Sensor 3 (in mmHg)
Actico two-layer	32	34	28
Actico two-layer	37	38	22
Actico two-layer	24	22	18
HERO H-2 two-layer	43	47	28
HERO H-2 two-layer	35	38	19
HERO H-2 two-layer	37	41	22

Table 5: All 18 ankle pressure readings for HERO H-2 two-layer system

HERO H-2 two-layer system	34
	42
	44
	32
	36
	37
	43
	35
	37
	39
	38
	33
	42
	46
	47
	38
	45
	42

Each participant found the bandaging technique very easy to learn following one demonstration and similarly easy to apply, showing that this system would be easy to transfer to clinical practice. There are also significant financial benefits related to the unit cost of the HERO H-2 bandage system and the reduction in other material costs such as cotton liners needed with other techniques.

The author is now undertaking a phase-two study to assess the clinical efficacy and long-term patient and wound closure outcomes of the HERO H-2 bandage system.

CONCLUSION

It is commonly acknowledged that if left untreated, leg ulcers often

Table 6: Participant comments

'It's so easy to apply'
'It goes on well and doesn't make the leg look big'
'Smells nice'
'Looks neat'
'Conforms well'
'Sub-bandage pressure figures are better with the new system'
'So easy and looks so nice'

become chronic, resulting in poor-healing and distress to patients, as well as significant treatment costs.

Compression therapy is widely acknowledged as the gold standard for management of venous leg ulcers, however it is essential that the bandage system used provides the correct amount of sub-bandage pressure — too little and the bandage will not provide optimum compression; too much and the skin may be damaged and the blood supply constricted.

This study has shown that the HERO H-2 compression bandage system provides effective compression when compared with other types of bandages currently used by a selection of compression-bandaging experts. JCN

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