Feeling the pressure: how can we be sure we are getting it right?

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The application of compression is a mainstay in the treatment of acute and chronic oedema and lymphoedema (Moffatt et al, 2012; Scheer, 2017), as well as in some of their associated comorbidities, such as ulcers (Dumville et al, 2015). We do not always make a clear diagnosis prior to starting treatment and, therefore, do not always get the outcome we expect or achieve an optimal result for the patient. Consideration of differential diagnoses, our diagnostic skills and the time required to make a clear diagnosis are common issues in practice.

When the word 'pressure' is used, most of us automatically think of positive pressures and pressure gradients. There are a number of key points that should be considered prior to using compression and positive pressures. These are:

- Changes to/loss of applied pressure over time, which is affected and determined by:
  - The knit and type of fabric
  - The number of times it is washed
  - The activity and position of the patient being managed
  - Time after application
  - Patient adjustments to compression wraps.
- The creation of an appropriate pressure gradient
- The clearance of any proximal areas prior to the application of any garment or bandaging
- Consideration of lymphatic load minimisation
- What we want to compress:
  - Deep or superficial systems
  - Lymphatics or veins
  - Lymphatics and veins.
- The risks of over-compression:
  - Ulcers
  - Inappropriate closure of the venous or lymphatic systems.
- Timing and sequencing of compression — what is best and when
- Objective measurement of the success (or otherwise) of compression — evidence for what we do or do not compress (Parkinson et al, 2017).

Unfortunately, we often ignore or are unaware of these points or their importance, meaning compression therapy does not result in the benefit we would expect.

We also have to consider negative pressure and its benefits. We are generally aware that negative pressure can have a role in helping ulcer healing. It also comes into play in other situations, however, such as inspiration (there are momentary negative pressures in the thoracic and abdominal areas) and in treatments such as LPG, Endermologie, cupping, LymphaTouch, Kinesio and lymph taping (Gott et al, 2018). We must ask ourselves what the uses and benefits of negative pressure are and how they should best be determined. A recent Cochrane review (Dumville et al, 2015) suggested that the quality of evidence available for negative pressure use in the promotion of ulcer healing is relatively poor, but perhaps searching for and acknowledging only randomised controlled trials is not the only way of moving forward here (Piller, 2018); in other areas, the evidence is even weaker, but every now and then we see a glimmer of what might be possible.

For this debate, experts in their fields have been invited to give us their personal and evidenced views on compression therapy in the management of lymphoedema. They were asked to comment on a number of questions and, hopefully, their responses will inspire critical studies in this area of practice, as well as a deeper consideration of when and how to apply compression and, thus, improve the acceptance of compression, as well as the outcomes for individuals with a lymphoedematous limb.

Neil Piller

References

Dumville J, Webster J, Evans D, Land L (2015) Negative pressure wound therapy for treating pressure ulcers. *Cochrane Database Syst Rev* 20(5): CD011334

Gott FH, Ly K, Piller N, Mangion A (2018) Negative pressure therapy in the management of lymphoedema. *Journal of Lymphoedema* 13(1): 43–8

Moffatt C, Partsch H, Schuren J et al (2012) *Compression Therapy: A Position Document on Compression Bandaging. International Lymphoedema Framework.* Available at: https://bit.ly/2JRD69j (accessed 29.04.2019)

Parkinson LA, van Zanten M, Piller N, Arkwright JW (2017) A high-resolution tape sensor improves the accuracy of applied pressure profiles during lower-leg bandaging — results from a study using a fibre-optic sensing tape. *Int Wound J* 14(6): 973–7

Piller N (2018) Decisions: they are never easy! But this is what we would like to do and here are the reasons why. *Journal of Lymphoedema* 13(1): 5–6

Scheer R (2017) Compression garments in the management of lymphoedema. *Journal of Lymphoedema* 12(1): 39–45

We have a patient whose chronic oedema of the legs, subsequent to radiotherapy and bowel surgery, developed into lymphoedema 2 years ago. She is in her mid-50s, is reasonably active and working in a job that requires standing for a significant part of the day. What level of pressure would be appropriate for the management of this patient?

GM I would apply an adjustable compression wrap (ACW) at a pressure of 40–50 mm Hg.

BL Before we review various issues relating to pressure, I would like to remind everyone that in this patient, compression therapy is part of the regimen to manage complications associated with bowel cancer treatment. Although the aim of this debate is to verify proper, if not ideal, compression to negate lymphoedema, we cannot ignore the wider picture here. We have to make an appropriate general assessment of the patient's cancer status before considering compression therapy because the long-term treatment strategy for this relatively young person needs to be tailored to reflect the outcome of surgery and radiotherapy and her prognosis.

What is the sequence of treatments?

BL Throughout the initial period of intensive decongestive lymphatic therapy (DLT), bandaging systems should be selected based on a trial with various 'levels' of compression using sub-bandage pressure measurement. There is no clear guidance stating how long bandaging should be used for, when it should be stopped and, if so, on what criteria this decision should be based.

The fluid (volume) reduction achieved during the initial treatment period is often greater than later on. Many patients require a long initial care period to ensure their condition has stabilised before moving onto long-term 'maintenance' with an appropriate combination of compression hosiery and/or devices. You should follow current guidelines and adjust/modify recommendations to meet patients' individual needs.

Applied pressure decreases with time. What can we do about this issue?

GM Since the patient can adjust an ACW, if he or she received a proper education, the pressure should always be within a reasonable and acceptable range.

BL Inelastic bandages are associated with rapid pressure loss despite initially being applied very tightly, so timely reapplication is warranted to stop them becoming too loose to apply effective compression. In general, if the bandages can be changed/reapplied twice a day, a low-pressure bandage is much more effective than an infrequently changed high-pressure bandage. Bandages changed at longer time intervals require a higher initial pressure to provide longer periods at an optimal pressure.

LP In the absence of continuous monitoring by experienced practitioners and the re-application of bandages or new garments, simple limb circumference measurements made by nurses or the patients themselves, combined with the use of validated tables indicating bandage/garment performance (incorporating foam layer performance) over time, may allow pressure to be estimated and monitored. If manufacturers were to extensively validate the elastic performance of their products over time, a simple product-specific software calculation tool (perhaps as a phone app) would enable limb circumference measurements to be entered into an embedded algorithm that accounts for these material properties. This would enable easy monitoring of compression over time. Ultimately, it would be desirable for the patient to have the ability to safely adjust the degree of compression in response to changes in limb volume.

How can we be sure we have the right pressure and pressure gradient?

LP Misunderstanding relating to the means of pressure application and how pressure is exerted upon a limb in the clinical community has muddied the water with respect to the value of pressure measurement. Since the application of pressure has a very direct effect on flow and perfusion through the lymphatic and vascular structures, as well as the tissues themselves, the 'dose' of applied pressure is of critical importance. There is a need to establish a routine and validated means of measuring interfacial pressure AND determine how this relates to the underlying tissues.

To increase the clinical community's faith in pressure measurement and how these data can be used, we need to increase the level of understanding of measurements provided by pressure sensors placed on the skin surface. These measurements are the result of pressure or force placed on the transducer during measurement and the sensor's response during calibration, e.g. air pressure on a flat surface during calibration versus compression on a curved surface by a tensioned piece of cloth during measurement. The size and shape of the sensor are, therefore, critically important to the behaviour of the sensor.

Even a sensor that performs perfectly will only measure pressure at the point at which it is placed. To reflect the average pressure applied at the core of the limb, local curvature must reflect the average curvature around that point of the limb when pressure is supplied by a tensioned bandage or garment. While an oedematous limb is likely to have less variation in circumference than a healthy limb, sensor placement is important.

To improve our ability to quantify the effects of pressure on the limbs, further work must be done to relate the pressure measured at the surface to the internal structures. Since the propagation of pressure into the limb from the skin is dependent on both the distribution and mechanical properties of the tissues, such measurements should be made for different disease states.

BL The pressure required by compression when standing should be sufficient to compensate for the hydrostatic pressure and venous hypertension combined, although the pressure while lying down should be no higher than 30 mmHg. Hence, working pressure of 60–90 mmHg delivered by an inelastic bandage is adequate for the lower extremity. With Static Stiffness Index (SSI) in the 20–30 mmHg range, this bandage (or an elastic bandage with an SSI of 5 mmHg) will deliver a tolerable pressure of 30–60 mmHg while the patient is lying down. Inelastic bandages with compression pressure beyond the upper limit (30 mmHg on the upper extremity and 50–60 mmHg on the lower extremity) can be counterproductive.

GM The patient must 'feel' a tight, but not painful, sensation. As an alternative, a

pressure measuring system is incorporated in some ACWs.

How can we be sure we are compressing the right structures, be they tissues, lymphatics or veins?

LP The limb is comprised of several components (skin, adipose, vascular, muscle and fascia) with distinct mechanical properties that prevent the even distribution of pressure applied by a bandage. While we cannot apply positive pressure to one structure without also compressing others, knowledge of the underlying vascular physiology allows creative padding and bandage structures to distribute compression so in cases where reduced pressure is desirable, the tensioned bandage (or elastic garment fabric) lays flatter than in other regions (i.e. it has a larger radius of curvature). Other structures may prevent or relieve the degree of contact of the bandage/garment over a particular area, reducing the pressure applied.

It must be remembered that pressure superficially relieved from one region results in elevated pressure in another region. Any gains from reduced or negative pressure application must be weighed against any negative effects resulting from the compensatory elevation in pressure in adjacent regions.

BL Despite lymphoedema initially representing lymphatic system failure, BOTH the venous and lymphatic systems should be targeted. These systems are 'mutually interdependent' and perform a physiological drainage function; if one system fails, the other system compensates to prevent insufficiency as a whole. We have to remain alert, however, as this is only feasible in normal conditions when there are sufficient compensatory reserves. When one system fails (e.g. in chronic venous hypertension or lymphoedema), without adequate compensation by the other system, such mutual interdependence overloads the functioning system, resulting in total failure of the dual system. By only treating the lymphatic system for lymphoedema/chronic lymphatic insufficiency (CLI) or the venous system for chronic venous insufficiency (CVI), the patient's overall condition may progress from the failure of one system to veno-lymphatic system failure, which is known as phlebolymphoedema.

What comorbidities would affect what you would do?

TG Compromised arterial status and general functional ability require a modified approach to care, depending on the severity.

GM Arterial disease.

BL Immobility and obesity/lipoedema are two major extrinsic causes that make the overall condition worse.

Which is worse: too much or too little pressure in a patient whose job requires him to stand for long periods of time?

TG There are several important issues to consider when assessing patients with lymphoedema for correct compression. The patient's lifestyle, fit of the garment and the pressure, which must be adequate to manage the oedema.

In this patient, we must consider the effect on the venous system. Oedema accumulation in the lower limb can be significantly impacted by gravity and reduced mobility, as the muscle pump is not working effectively. Too little compression allows oedema to accumulate during the day. A mixed-product approach, e.g. a 34–46 mmHg (RAL level 3) compression stocking and layering with a wrap, may be more beneficial than one high-compression garment as the wrap can be readjusted throughout the day to maintain pressure. It is important to consider the stiffness of the garment used, as well as the pressure level. I would consider a fabric with greater stiffness, e.g. flat knit, to emphasise this. It is also worth considering 24-hour compression to reduce the cumulative effect of oedema over the day.

With this patient, I believe that exercise is key to enhancing his therapy, in order to improve venous and lymphatic flow. Simple exercises performed throughout the day to promote the calf pump would be beneficial.

A combination of these approaches would be the ideal scenario. However, compression needs to be managed carefully as part of the wider management plan for it to be effective and safe.

GM Too little!

BL Too much pressure is not beneficial as it may curtail the patient's mobility and further lower his quality of life. Too little pressure will fail to provide the minimum mandatory pressure to assist the veno-lymphatic system.

Besides, lymphoedema requires continuous compression day and night to compensate for damage to the lymphatic system; NOT like venous oedema. This is unlike chronic oedema caused by CVI where daytime compression while standing would be sufficient.

Sustained compression is mandated to lymphoedema because the lymphatic transport is primarily responsible for draining interstitial fluid. Poor drainage leaves higher concentrations of protein molecules, resulting in the oncotic pressure of the interstitial tissue remaining high after initial successful decongestion therapy.

What would you do differently if a patient had lymphatic failure in the abdominal area?

TG I would consider a garment with a body section and possibly foam padding to stimulate superficial drainage of the tissues. Deep breathing is a good example of an easy therapy that the patient can attend to him- or herself. Deep breathing aims to indirectly exert central negative pressure on the lymphatic system (Gott et al, 2018) and is an easy task for the patient to undertake.

Manual lymphatic drainage (MLD) may also be considered and could be enhanced by the use of negative pressure therapy massage, which can be targeted to the areas of need.

LP I would check that their health insurance would cover a plane fare to visit one of the other panel experts before recommending this action and scurrying from the clinic!

BL I would consider more aggressive MLD-based care if available, especially when Indo Cyanine Green (ICG)-based assessment proves effective drainage through the superficial collateral lymphatic vessels along the abdominal wall.

What are the things we do best, what we do poorly and what should we be doing to improve patient outcomes?

TG In general, I think we consider the patient's abilities and attitude when devising his or her individual care plans. Sometimes, we may be a little too forgiving

or dismissive of the patient who is seen as non-compliant. Patient education is pivotal to a successful outcome, and providing patients with the information required to make an informed choice regarding their care is essential.

LP I think the compression community has done well to use the clinical observations of experienced practitioners to direct their science and patient treatment in the historical absence of a reliable means of quantifying this treatment. I feel the measurement of clinical outcomes for patients remains the most important thing to do well. A means of reliable pressure measurement to quantify the treatment provided would reduce variations in reported outcomes that are due to incorrect pressure measurements.

Not being a clinician, I do not know the extent to which patient feedback is currently used to evaluate or modify the application of pressure or monitor its effect. However, I would expect that a patient that had been sufficiently educated in their own compression therapy would be able to provide invaluable information. I believe there is a need for compression technologies that facilitate self-management by the patient, so that with sufficient education and safeguards they can provide rigorous monitoring of their own treatment or even comfort. This would be of particular benefit in maintaining pressure over time as limb volume declines and as the limb changes shape in response to compression.

BL We provide good DLT-based care as part of basic management; however, there is 'limited' coordination between the two main treatment regimens (DLT-based conservative care and surgical, reconstructive and palliative care). The two different treatment modalities do not contradict each other, but are a mutually complementary regimen, so a guideline actively incorporating both is sorely needed to improve patient outcomes.

If there is one thing on the horizon (or around currently) you think is going to make a real difference to our treatment and management of lymphoedema, what is it and why?

TG I truly believe that surgery is going to have a big impact on future lymphoedema management/treatment, but we will still need conservative approaches to complement it. I do not see compression ever being excluded from treatment regimens, due to the cause and impact of the lymphatic system.

I believe that we should continue to strive for compression garments that are easier to wear. Perhaps these could be made of thinner materials that maintain the stiffness of more rigid garments. We should consider the use of such garments to enhance the effects of surgery.

LP The pressure applied by practitioners can vary wildly (Parkinson et al, 2017). I feel that a very significant improvement in the care of the average lymphoedema patient would be seen if we were to provide a means of regularly monitoring the performance of bandaging/compression. This may be in the form of accurate *in vivo* pressure sensor arrays (with sufficient resolution to reveal small and local variations in pressure that may lead to regions where lymphatic flow is trapped or where a high pressure point may lead to a pressure wound) or instrumented manikins of varying shapes and sizes so the practitioner can learn first-hand the effects of limb size, bandage tension, padding, wedges, layering and the like. Frequent 'calibration' of the practitioners' trained hands I think would be of tremendous benefit in improving outcomes for patients. In a clinical setting, it is unlikely that every application of compression bandaging will be performed with the assistance of a pressure sensor; more likely, this is done only in critical cases. However, reliable quantification of pressure during training and subsequently at regular intervals for established practitioners would provide great benefit as our science develops.

Patient education on their own compression and the development of compression technologies that enable the patient to monitor their own compression safely would be great steps forward.

GM I believe that ACWs could change something: they are easy to manage, even by patients, can provide sufficient pressure and stiffness to reduce oedema and can involve the patient in his or her own treatment.

BL Effective control of infection and the prevention of progressive tissue fibrosis remain ultimate challenges in lymphoedema management. With regards to the latter issue, anti-inflammatory strategies based on mounting evidence for the role inflammation plays in the pathogenesis of lymphoedema are on the horizon. Indeed, there is considerable evidence for the up-regulation of genes related to acute inflammation and subsequent fibrosis among lymphoedema patients. Targeted inhibition of the inflammatory pathways on lymphoedema has shown significant structural and functional amelioration (Rockson et al, 2018).

References

Gott FH, Ly K, Piller N, Mangion A (2018) Negative pressure therapy in the management of lymphoedema. *Journal of Lymphoedema* 13(1): 43–7

Parkinson LA, van Zanten M, Piller N, Arkwright JW (2017) A high-resolution tape sensor improves the accuracy of applied pressure profiles during lower-leg bandaging — results from a study using a fibre-optic sensing tape. *Int Wound J* 14(6): 973–7

Rockson SG, Tian W, Jiang X et al (2018) Pilot studies demonstrate the potential benefits of anti-inflammatory therapy in human lymphedema. *JCI Insight* 3(20): e123775

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