

Review paper**ROLE OF COMPRESSION IN TREATMENT OF
LEG ULCERS****Monica Sikka*, S. Ghosh and A. Mukhopadhyay**

Department of Textile Technology, Dr. B R Ambedkar NIT Jalandhar, Punjab (INDIA)

*Received October 01, 2013**Accepted January 10, 2014***ABSTRACT**

Compression delivery systems play an important role in the treatment of leg ulceration since they can reduce venous reflux, increase venous and arterial blood flow, improve microcirculation and reduce ankle oedema. But the exact mechanism and the science behind the process of compression remains poorly understood. Also the techniques employed for measuring the sub bandage pressure through different types of sensors needs careful selection and application method. This paper highlights the compression mechanism, pathophysiology behind the process, factors affecting sub bandage pressure measurement and bench marks for an ideal compression system.

Key Words : Compression, Bandage, Oedema, Sub bandage pressure, Ideal compression system

INTRODUCTION

The majority of wounds in lower extremities are the results of venous hypertension, arterial insufficiency or a combination of both.¹ Compression has been successfully applied to the management of oedema and other venous and lymphatic disorders of the lower limb^{2, 3} since the time of Hippocrates. The physiological and biochemical effects of compression can very well be explained using Starlings equation. If an oncotic pressure gradient exists across a semi-permeable membrane, such as a capillary wall, water is drawn across the barrier until the concentrations on both sides are equal. (Oncotic pressure is the osmotic pressure created by protein colloids in plasma). The relationship between these factors is summarized in Starling's equation.⁴

$$F=c(P_c-P_t)-(\pi_c-\pi_t)$$

F represents net filtration force (which is the origin of lymph)
c is the filtration coefficient

P_c is capillary blood pressure

P_t is tissue pressure

π_c is capillary oncotic pressure

π_t is tissue oncotic pressure

The amount of lymph formed in the human

body depends upon the permeability of the capillary wall (filtration coefficient) and the gradient of hydrostatic and oncotic pressure between blood and tissue. The hydrostatic pressure difference causes filtration, while the oncotic pressure difference causes reabsorption (**Fig. 1**). Starling's equation suggests that the application of external compression will counteract the loss of capillary fluid by increasing local tissue pressure and reinforce reabsorption by squeezing fluid into the veins and lymph vessels. This in turn will help to resolve oedema (swelling of the limb) (**Fig. 1**)

DISCUSSION**Pathophysiology**

Oedema is the accumulation of fluid in extra-vascular tissue in the body. Depending upon the amount of pressure applied, a compression bandage may influence the internal volume of veins, arteries and lymph vessels. Structures near the surface of the skin are compressed more than the deep vessels. This is because the compressive force is partly dissipated by compression of the surrounding tissues. Nuclear medical investigations have shown that compression removes more water than protein from the tissue, increasing oncotic tissue pressure. This results in a rapid reaccumulation of oedematous fluid if

*Author for correspondence

compression is not sustained . The efficiency of the treatment depends to a great degree on

the level of interface pressure applied and the sustenance of the same during the treatment.

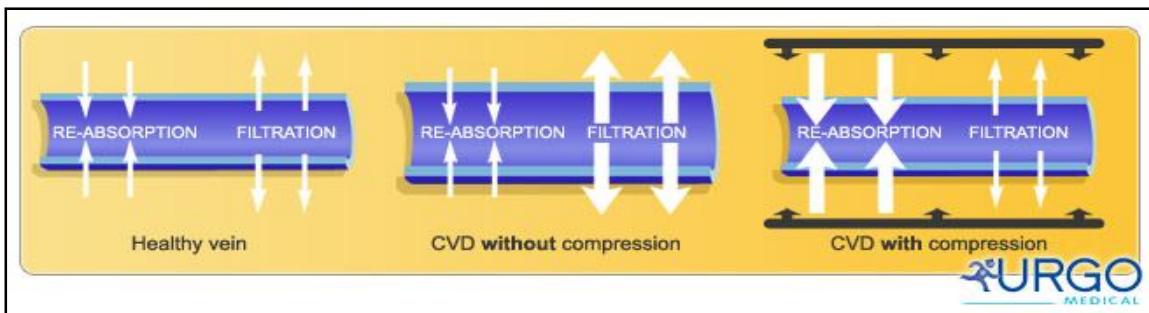


Fig. 1 : Working mechanism of the external applied compression⁵

Provided the right level of pressure that does not affect the arterial flow and the right level of application technique and materials used, the effects of compression can be dramatic,

which could reduce oedema and pain and also could promote healing of ulcers caused by venous insufficiency.^{6,7} The causes of oedema can be summarized as shown in **Table 1**.

Table 1 : Causes of oedema

Physiology	Possible cause	Effect
↑ Capillary permeability (c)	Cellulitis, arthritis, hormonal cyclic oedema	Inflammatory oedema, 'idiopathic oedema'
↑ Venous (capillary) pressure (P_c)	Heart failure, venous dependency syndrome	Cardiac, venous oedema
↑ Oncotic tissue pressure (π_t)	Failure of lymph drainage	Lymphoedema
↓ Oncotic capillary pressure (π_c)	Hypoalbuminaemia, nephrotic syndrome	Hypoproteinaemic oedema

Effect of compression

Compression of veins with incompetent valves produces an increase in orthograde (towards the heart) flow and a reduction in venous reflux. The application of adequate levels of compression reduces the diameter of major veins. This has the effect of reducing local blood volume, by redistributing blood towards central parts of the body. As this can lead to an increase in the preload of the heart and affect cardiac output by about 5%, hence bilateral bandaging of the thighs and lower legs should be avoided in patients with borderline cardiac function.

Bandage performance

The degree of compression produced by any bandage system over a period of time is determined by complex interactions between four principle factors – the physical structure and elastomeric properties of the bandage, the size and shape of the limb to which it is applied, the skill and technique of the bandager

and the nature of any physical activity undertaken by the patient.⁸ The mechanism by which compression is achieved and maintained is a complex interaction of all these factors.

Mechanism of pressure generation

The pressure generated by a bandage immediately following application is determined principally by the tension in the fabric, the number of layers applied and the degree of curvature of the limb. The relationship between these factors is governed by Laplace's Law. The use of this law to calculate or predict sub-bandage pressure has been described by Thomas⁹, although this remains a controversial issue.¹⁰

$$P \propto T/R$$

P represents pressure

T is tension developed in the bandage fabric

R is radius of bandaging surface

Role of tension¹¹

The tension in a bandage is determined initially by the amount of force applied to the

fabric during application. The ability of a bandage to sustain a particular degree of tension (and therefore sub-bandage pressure) is determined by its elastomeric properties and these in turn are a function of the materials used and the method of construction.

Role of extensibility

The ability of a bandage to increase in length in response to an applied force is described as its extensibility (ability to stretch). During stretching of bandage fabric, at some point, the physical structure of a bandage will prevent further stretching once a certain degree of extension is achieved. This condition is called 'lock-out'.

Role of power

The amount of force required to cause a specific increase in the length of elastic bandage is an indicator of the bandage's power, this characteristic determines the amount of pressure a bandage will produce at a predetermined extension.

Role of elasticity

The elasticity of a bandage determines its ability to return to its original (unstretched) length as the tension is reduced.

Determining sub bandage pressure

On a normal leg the circumference of the ankle is generally substantially smaller than that of the calf, and it follows from Laplace's Law that if a bandage is applied with constant tension and overlap, the pressures achieved at the gaiter and the calf will be lower than those applied at the ankle. As the circumference of the leg progressively increases, a compression gradient is produced with the highest pressure on the most distal part of the limb (i.e. the ankle). The consistent formation of this ideal pressure gradient has been difficult to demonstrate practically.¹² The failure to demonstrate graduated compression may reflect poor operator technique, the practical problems of maintaining constant tension throughout the bandage during the application process and poor measurement technique. Hence, the factors affecting the measurement of sub-bandage pressure should be considered wisely.

Pressure sensors

Large diameter sensors tend to provide an average value of pressure applied over a large

surface area and so do not report peak pressures. Inflexible sensors may record artificially high pressures given their inability to conform to the surface of the leg (point loading of the sensor).

Site of sensor application

A sensor placed over a soft tissue (calf) may return lower pressure readings than a similar sensor placed over a hard site (ankle).

Method of application

The application technique¹³ (Fig.-of-eight or spiral), the number of layers applied and the degree of overlap between layers will affect the pressure applied to the leg.

Position of limb

Pressures are higher when standing and significantly altered during walking.

Some of the practical problems associated with bandage application have been addressed by manufacturers who have included various visual guides to help operators achieve the required tension within the bandage. But this does not cater for the change in circumference of the leg during use due to reduction in oedema. Advances in textile technology may also help to reduce both inter- and intra-bandager variability. One very promising concept is the development of elastomeric yarns which enables a bandage to achieve relatively constant sub-bandage pressures regardless of minor variations in extension.

Choosing an ideal compression system

In putting together a number of criteria are proposed that should be considered as benchmarks for the ideal compression system in patients with uncomplicated venous ulcers as :

- Clinical effectiveness
- Sustained compression
- Enhances calf muscle pump function
- Non-allergenic
- Ease of application and ease of training
- Conformable and comfortable (non-slip)
- Durable

CONCLUSION

The bandage type, bandaging procedure and the measurement technique used for predicting the sub bandage pressure needs to be carefully selected keeping in view the parameters

affecting their efficacy. Compression generation is a science in itself and needs a thorough understanding before application. Nurses must be aware of this scientific principle and it has to be taken into account when instituting a regimen of compression if therapeutic pressures are to be achieved in larger limbs and pressure necrosis is to be avoided in those patients with smaller limbs.

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Senator John Kerry