An Introduction to Compression Therapy

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Abstract: *Several studies have confirmed the hemodynamic benefits of compression therapy in patients with chronic venous insufficiency. In patients with venous ulcers, compression is effective in both healing and preventing recurrence of ulceration. This article is intended to provide the clinician with a practical guide to the principles, methods, and prescription of external compression therapy.*

From the Dawn of Man to Boston Marathon

The use of compression in the treatment of venous diseases is not a new idea. The earliest evidence of compression dates back to the beginning of mankind. Mural paintings in the Tassili caves (Sahara) dating back to the Neolithic Age (5000 – 2500 B.C) depict illustrations of what is believed to be compression dressings.[1] Hippocrates wrote about compression treatment in the 4th century BC. Roman soldiers who marched for days at a time learned that applying tight strappings to the calves reduced leg fatigue. 2000 years later, calf compression sleeves are extremely popular with long-distance runners. In 1839, Dr. John Watson reported on using elastic stockinsg to treat varicose veins in a 23-year-old woman with Klippel-Trenaunay syndrome.[2] Chronic Venous Insufficiency (CVI), affects up to 13 million people in the United States. Peak incidence occurs in women aged 40-49 and men aged 70-79 years, however these numbers are probably very underestimated due to misdiagnosis, lack of knowledge and education.[3]

Basic Principles of Compression

In a standing individual the venous hydrostatic pressure, which equals the weight of the blood column between the foot and right atrium, is about 80-100 mmHg. During walking blood flow is accelerated by the combined action of the calf muscle pump and the foot pump, which decreases the volume of venous blood and reduces venous pressure to about 10-30 mmHg.

If the valves in the large veins become incompetent due to primary degeneration or post-thrombotic damage, blood will oscillate up and down in those segments lacking functional valves. The resulting retrograde (backward) flow in the veins of the lower leg (venous reflux) leads to venous hypertension. This causes fluid loss into the tissues, edema, and chronic venous stasis tissue changes. Compression of veins with incompetent valves provides a ridged sheath around the vessels so that blood flow will be propelled upward toward the heart instead of laterally against the wall. The objective is to oppose the hydrostatic forces of venous hypertension. Bandages and, to a lesser degree, graduated compression stockings provide the external support needed to produce this effect.

The application of adequate compression reduces the diameter of major veins, which increases blood flow velocity.[4] The clinical significance depends upon the relationship between the intravenous hydrostatic pressure and the applied external compression. In a supine individual, a pressure of 10 mmHg applied to the calf is sufficient to reduce venous stasis by producing a marked decrease in blood volume accompanied by a corresponding increase in blood velocity. This is the basis of anti-embolism T.E.D. (Thrombo Embolic Deterrent) stockings, which are designed for the non-ambulatory supine patient. However, T.E.D. compression is not graduated and is ineffective in the treatment of ambulatory venous insufficiency. In the upright position, the pressure in the lower leg fluctuates during walking between 20-100 mmHg, and therefore much higher levels of compression are required to exert a marked effect upon blood flow.[5]

Compression initiates a variety of complex physiological and biochemical effects involving the venous, arterial and lymphatic systems.[4,6,7] Several studies have confirmed the hemodynamic benefits of compression therapy in patients with CVI. If the correct technique and materials are used, edema and pain are reduced. In patients with venous ulcers, compression is effective in both healing and preventing recurrence of ulceration.

Microcirculation

Compression also accelerates blood flow in the microcirculation and normalizes cutaneous blood flow. Improvement in cutaneous oxygenation has been demonstrated with the use of compression in patients with venous stasis after only 10-15 min.[8] Capillary filtration is also reduced and reabsorption is increased due to enhanced tissue pressure. In lipodermatosclerotic areas where skin perfusion may be reduced due to high tissue pressure, the use of compression therapy can increase this gradient and improve blood flow. This leads to softened skin. Effects on mediators involved in the local inflammatory response may explain both the immediate pain relief that occurs with good compression and subsequent ulcer healing.

Compression bandages and walking exercises can improve lymph transport. The morphological changes of the lymphatics in lipodermatosclerotic skin can be normalized with long-term compression. The dramatic reduction of edema by compression therapy can be explained by the reduction of lymphatic fluid in the tissue, rather than by an improvement of lymphatic transport.[9]

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Compression Bandages and Compression Stockings

A number of compression methods are available. (*Table 1*) The main categories of compression concern the elastic properties of the materials. Extensibility is the ability of the material to increase in length in response to an applied force.

In general, compression bandages are able to achieve higher pressures than compression stockings.[10] Bandages are best indicated when temporary compression is required, such as in the acute phase of DVT, superficial phlebitis, venous ulcers, lymphedema, and phlebolymphedema. Another benefit of bandages is that they can be reapplied to maintain the optimal compression as edema in the affected limb is reduced.

Graduated compression stockings (GCS) provide a convenient method of maintaining pressure while allowing ambulation. The graduated compression garment, combined with the pumping effect of the leg muscles (especially the calf muscles), aids venous and lymphatic return. Graduated compression applies the maximum amount of pressure to the ankles, which gradually tapers off over the length of the stocking, e.g. a 20-30mmHg knee-high stocking will apply 30mmHg to the ankle and taper to 20mmHg at the knee.

Table 1 Types of Compression Devices

Graduated Compression Stockings
- Ready-made retail stockings manufactured in fixed sizes
- Custom-made stockings

Bandages
- Inelastic
  - No stretch (~zero extensibility) e.g. Unna boot, Circ-Aid
  - Short stretch (<100% extensibility)
- Elastic
  - Long stretch (100% extensibility)
  - Cohesive, adhesive
  - Single component or multi-layer

Compression boots
- Water, air
- Inelastic band devices

Intermittent Pneumatic Compression
- Single chamber
- Sequential chambers

(Adapted from Reference 12)

Prescription of a Stocking

A prescription for elastic compression stockings requires information about both tension and length. Proper fitting of the stockings is essential and requires accurate limb diameter measurements. Individual measurements for a compression stocking should be taken while the patient is standing and at the beginning of the day when the leg is less edematous. The most important measurement is at the ankle, where a graduated stocking exerts the greatest pressure. Measurements should conform to the manufacturers' guidelines. Compression stockings are widely available. Most vein centers keep a supply in the office. They can also be obtained by prescription at a medical supply store. The stockings can be bought at some pharmacies; however, it is not advisable to purchase over-the-counter stockings due to the lesser quality of the material and improper fit.

Proper fit of compression stockings is imperative. Patient compliance and satisfaction is higher with quality, properly sized stockings. Vein centers that supply stockings have been educated on measuring patients for an accurate fit, as have medical supply stores.

Treatment with 20-30 mmHg compression (Class II) is adequate for mild to moderate venous insufficiency. Patients with more advanced disease may require Class III 30-40 mmHg compression. (*Table 2, p.41*)

Stocking Styles and Lengths

Ready–made, off-the-shelf stockings are manufactured in fixed sizes. Most manufacturers have numerous sizes, varying in both length and width at various points on the ankle, calf, and thigh. Although the sizes are somewhat standardized, there may be considerable variations between the different manufacturers. Up to six styles of medical compression stockings are available, depending on the manufacturer: Knee–high, mid–thigh, or high–thigh, pantyhose, one–leg pantyhose, thigh with waist attachment, and maternity pantyhose. Some manufacturers have open–toed hose available, especially the single-leg, thigh–thigh variety. Regardless of the style, most stockings are available in three lengths: Knee-high, mid thigh, and high thigh.

The most common length is knee–high because patient adherence is greater and symptom relief may be adequate; however, some feel that knee–high stockings have a tourniquet effect on the great saphenous venous return and may actually worsen proximal venous congestion. Thigh-high or waist-high stockings provide a greater benefit; however, the stockings are more difficult to use and compliance is reduced. Stockings need to be changed every 6-9 months if worn daily to avoid loss of the elastic tension.

Patient Compliance

Noncompliance is the most important factor limiting the use of compression stockings. Patient's compliance in wearing their compression stockings is frequently underestimated by their physicians. The reported rates of non-compliance range from 30-65%.[11] The stockings are hot, difficult to put on, difficult to remove, may be uncomfortable, may fall down the leg, or may cause skin irritation. The elderly,

Table 2 CVI, DVT, PTS Treatment

8-15mmHg	15-20mmHg (Class I)	20-30mmHg (Class II)	30-40mmHg (Class III)	>40mmHg (Class IV)
	Minor varicose	Moderate to severe varicose	Severe varicose	Severe varicose
Minor swelling	Minor swelling	Moderate edema	Lymphatic edema	Lymphatic edema
DVT prophylaxis	DVT prophylaxis	DVT prophylaxis	DVT prophylaxis	DVT prophylaxis
	Post-Sclerotherapy	Post-Sclerotherapy	Post-Sclerotherapy	
		CVI	CVI	CVI
		Prevent ulcer recur	Manage active ulcer or Prevent ulcer recur	Manage active ulcer
		Post-venous procedure	Post-venous procedure	
		Superficial thrombophlebitis	Manage PTS	Manage PTS
		Orthostatic hypotension	Orthostatic hypotension	

(Adapted from Reference 12)

who usually present with the most advanced venous disease, are often unable to adequately utilize standard compression garments due to frailty and arthritis. It is difficult to obtain adequate fitting in the obese patient. Some obese patients will need custom manufactured stockings, which are expensive, and not covered by insurance. Patients who cannot tolerate class II stockings should be fitted with class I stockings; mild compression is better than no compression.

Compression hose treatment is palliative. The patient's chronic venous disease will remain and the clinical benefits are only realized while wearing the garment. Patients with symptomatic venous insufficiency should be referred for definitive treatment; this usually requires endovenous thermal ablation and adjuvant sclerotherapy. Most 3rd party payers require 45 to 90 days of compression therapy prior to authorizing treatment. There is no data supporting this requirement, and it has not been proven that stockings will prevent progression of venous disease.

Another potential obstacle to compression is arterial disease. Although it is accepted that compression should never be allowed to impede arterial inflow, there is currently no convincing clinical data to indicate the level of compression that may be safely applied to a limb with arterial insufficiency. It is accepted that a systolic ankle pressure below 50-80 mmHg is a contradiction for high compression therapy, as is an ankle-brachial pressure index (ABPI) of less than 0.5.

Conclusion

The physiological basis of compression therapy on the lymphatic, venous and arterial systems is well established. Patients may experience substantial improvements in pain, mobility, and quality of life. It remains a mainstay treatment for venous ulceration. However, compression treatment remains plagued by practical limitations and poor patient compliance; however, the literature is also clear that any compression is more effective than no compression.

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