
Compression Therapy

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Compression therapy, either active or passive, is the cornerstone of treatment for all venous and lymphatic disorders. Its major limitations are poor patient compliance, difficulty to apply in the elderly, and insufficient knowledge and skill in the

majority of physicians. New modalities, such as four-layer bandage, tubular gradient compression, or new textile technologies, may secure a better application in difficult cases such as leg ulcers.

COMPRESSION THERAPY (CT) is the cornerstone of treatment for venous and lymphatic disorders. It is essential in acute alterations, such as deep vein thrombosis (DVT) and superficial phlebitis, as well in chronic conditions [chronic venous insufficiency (CVI), gravitational dermatitis, lipodermatosclerosis, leg ulcers, lymphedema]. Further indications include thromboembolic prevention and edema prevention in pregnancy, long and microgravity flights, or softening of burns scars among others.¹⁻⁶ Underestimated, or even totally ignored by many physicians, CT is often poorly prescribed and demonstrated to the patients, who may then discard the most effective and economical treatment of their condition.

What is Compression?

Compression, either active or passive, mainly aims to reduce or control venous reflux and peripheral edema, by applying bandages or stockings. The pressure induced by compression is defined by Laplace's law: $P = T/R$. Then the pressure (P) exerted by an elastic bandage is proportional to the tension of the bandage (T) and the inverse of the radius of the skin surface area (R). Thus when the surface area is markedly convex (ankle, Achilles' tendon), compression is stronger than when it is only rounded (middle leg, thigh). Compression should be completed using rolled pads over concave areas, as retromalleolar gutters. It may also be locally enhanced by placing a cushion over an ulcer or a perforator under the elastic bandage (selective compression).^{1,2}

Confusion reigns in the mind of most physicians between passive and active compression. Passive compression ("support") is produced by inelastic bandages, which counteract the increase in muscle volume resulting from muscle contraction. At rest, the bandage delivers little or no pressure force. Therefore it is well tolerated for several days and may be applied in patients suffering from moderate arterial insufficiency. By muscle contraction, the inelastic bandage restrains the increasing muscle volume, creating a pressure force. Passive compression is therefore most active during muscle contraction, as in walking ("working pressure"), and almost totally inactive at rest ("resting pressure").

Active compression is delivered by an elastic orthosis both at rest and during exercise. The more or less powerful recoil forces of the elastic fibers exert an active pressure on the limb, which is enhanced by muscle contraction. Then both "working" and "resting" pressure are elevated. Active compression may be intolerable for bedridden or inactive patients. It is contraindicated in arterial insufficiency. Active and passive compression may be combined, as in multilayer bandages.

Which Effects of Compression?

The beneficial effects of CT have been well known for several centuries.¹⁻¹⁰ CT's effects on vessels and tissues have also been investigated. CT's mechanisms of action may be classified as follows:

- ◆ venous: compression may achieve narrowing of veins, restoration of valvular competence, partial regression of parietal degenerative changes,¹¹ reduction or suppression of superficial and deep venous reflux,¹² diminution of venous pressure, acceleration of venous flow, improvement of venous pumping, diminution of venous pool, and blood shift into central compartment.
- ◆ arterial: reduction of cutaneous arterial perfusion

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in a first step, then paradoxical improvement of arterial flow as a result of edema reduction.

- ◆ lymphatic: improvement of lymphatic function and drainage.
- ◆ microcirculatory: decrease of edema, acceleration of capillary blood flow, diminution of inflammatory mediators.
- ◆ tissular: increase of intratissular pression, edema resorption, decrease of proteins tissular concentration, softening of lipodermatosclerosis.
- ◆ hematological: enhancement of fibrinolysis.

Numerous investigation techniques have been used to demonstrate these effects of CT, including echography, duplex, phlebography, various plethysmographic devices, foot volumetry, peripheral venous pressure measurements, isotopic lymphography, xenon 133 clearance, studies of skin distensibility,¹³ radioactive tracers as labeled erythrocytes and albumine among others.¹⁻¹³

Compression Modalities

Compression may be achieved by different modalities (Table 1) as inelastic bandages (Unna boot), multilayered wrapped dressings, short, medium, and long stretch bandages, compression stockings, or legging orthosis. External pneumatic compression devices and mercury baths are alternative modalities.²

Bandages

Inelastic or short stretch bandages exert passive compression and are indicated in the treatment of edema, deep vein thrombosis, or trophic lesions of CVI. A properly trained staff must fit them. As they remain on the leg for several days, they are indicated in patients who cannot fit their bandage alone because of hands, hip, or knee arthrosis or in the elderly. However, they loose a lot of their pressure within the first hours of wear.¹⁴

Long stretch elastic bandages are far easier to use.

Table 1. Major Types of Compression Devices

Bandages
Inelastic or short stretch bandage
Long stretch elastic bandage
Other bandages
Four-layer bandage
Stockings
Stockings, classes I-IV
Tubular gradient compression
New stockings for leg ulcers
Thrombosis prophylaxis stockings
Support stockings

Their high resting pressure effectively compresses superficial veins after surgery, sclerotherapy, or thrombophlebitis. However, working pressure may be less effective than with short stretch bandages. Superimposition of spirals enables an improvement in working pressure. These bandages are poorly tolerated when resting and have to be removed during the night.

The difference between short and long stretch bandages depends largely on the skill of the practitioner. Therefore comparative studies are difficult to evaluate.¹⁵ Inelastic material and four-layer bandages may be more effective at reducing deep vein refluxes than elastic bandages¹⁶ or in healing ulcers.¹⁷ In other studies, long stretch appear to be more effective than short stretch bandages¹⁸⁻²⁰ and no differences between maximum and minimum subbandage pressures during walking could be demonstrated.²¹ One may conclude that well-applied long stretch bandages may be as effective as short stretch bandages.

Other bandage materials include the four-layer bandage, adhesive dressing, zinc-coated bandages, and cohesive bandages. The four-layer bandage provides permanent pressure to the leg in patients with CVI, in particular with leg ulcers. It consists of four superimposed layers: padding with orthopedic wool, absorbing exudates and protecting bony prominences; cotton crepe bandage, holding the former in place; long stretch elastic bandage; cohesive bandage, strengthening support and holding it all in place for 5-7 days.

The multilayer system represents a good compromise between elastic and inelastic systems, securing a moderate loss of pressure over time and a large pressure decrease on lying down.¹⁴ It is as effective as short stretch compression bandages.^{16,22}

Stockings

Stockings provide intermediate support between short and long stretch bandage. Depending on the pressure exerted at the ankle, there are four compression classes, I being the weakest, IV the strongest. The choice of a stocking depends on both indication and the patient's tolerance and acceptance.^{2,23}

Types of Stockings. The compression classes vary from one country to another, while a European norm is awaited. We present here the classification proposed by the European Standardization Commission:

- ◆ Class I, 15-21 mmHg: minor varicose veins, functional venous insufficiency.
- ◆ Class II, 23-32 mmHg: slight CVI, or after surgery.
- ◆ Class III, 34-46 mmHg: more advanced CVI, leg ulcers, lymphoedema.

- ◆ Class IV, >49 mmHg: lymphedema, very severe CVI.

Various lengths exist in each class:

- ◆ Socks (designated as A–D),
- ◆ Thigh-length stockings (A–F), either simple, requiring a garter or a supporter, or self-maintaining through a silicone band sewn into the upper part of the stocking, adhering to the thigh skin.
- ◆ Tights, widely used as it adapts well to a broad range of feminine anatomic morphologies.
- ◆ Maternity tight, with an adapted panty to the morphology of pregnant women.

A wide range of ready-to-wear stockings are commercially available, enabling perfect fit in the vast majority of the cases. Stockings may also be made to measure in the case of marked anatomic abnormalities or when the circumferences are very small.

Stockings must be put on before getting up or, at the latest, immediately after the morning shower. Devices have been developed to assist in putting on stockings.

Elderly patients often have difficulty putting their stocking on. Mild to intermediate compression stockings are easier to put on than strong support stockings. Superimposition of two pairs of stockings can resolve this difficulty. Wearing of two superimposed class I stockings is at least the same as a class II stocking. Stockings deteriorate after repeated wearing and washing. Two to three pairs are necessary for 1 year as pressure progressively diminishes and becomes ineffective.²⁴

The negative image of compression stockings is changing. Well-tolerated, elegant, and comfortable new textile fibers, such as microfibers, are replacing anesthetic, thick, drab-colored garments. The addition of thermal or pharmacologic properties may revolutionize compression.²

In leg ulcers, CT with bandages is seldom correctly adjusted. Class II stockings may induce a too low pressure at the supramalleolar region.²⁵ Class III are difficult to wear for the elderly. Therefore new modalities have been regularly developed, including

- ◆ Selective additive compression with pelottes or foam pads.^{1,2,25}
- ◆ Tubular gradient compression, an innovative compression product, which overcomes the drawbacks of bandaging for the treatment of ulcers (constriction, folds, instability during walking, “operator-dependant” pressure, etc.). It is divisible. As it has no heel, it is adjustable depending on the ulcer situation, delivering an ankle pressure of 35–40 mmHg. A specific patented flexible device facilitates the installation of the tubular compression,

whatever the nature and volume of the dressings.

- ◆ CircAid, an adjustable, easy-to-apply device consisting of a series of interlocking, nonelastic bands that encircle the leg and are held in place by hook and loop fasteners, and a foot piece made of very low stretch bands. Effectiveness and favorable costs have been demonstrated.²⁶
- ◆ UlcerCare, associating an understocking (liner) and a modified compression stocking including a zip fastener. It exerts a pressure equivalent to that of a class III medical compression stocking.¹⁰
- ◆ Venotrain Ulcertec, combining an understocking holding the bandage of the wound, to be worn overnight, and a second elastic overstocking, with a special weaving (rhomboid knit), to secure an active day compression.

Thrombosis prophylaxis stockings are designed to reduce the risk of DVT in bedridden patients, with special compression features adapted to reclining position. They are exclusively reserved for prolonged bed rest and must not be used in standing.

Support stockings are not regulated by standards. They are usually classified by the fineness of their thread, expressed in deniers, with higher values indicating increasing product thickness. Support stockings have been considered ineffective for a long time. Recent studies demonstrate their effectiveness.^{27,28}

Principal Indications

As discussed in major textbooks and articles devoted to CT or phlebology^{1–10,15} the principal indications for CT use include the following:

- ◆ Functional venous insufficiency (heavy legs, edema), slight varicose veins, prevention of varicose veins: Support stockings relieve most patients. Class I stockings are indicated for traveling (prevention of edema and DVT) in airplane, car, or bus, and for prolonged standing activities.²⁹
- ◆ More severe varicose veins: Surgery, phlebectomy, sclerotherapy or other procedures should be considered first. Symptoms respond positively to wearing class I–II stockings.
- ◆ CVI: CT is essential and must be worn for life. Passive compression is indicated in the acute phase (edema, inflamed lipodermatosclerosis), provided that the patient walks regularly. Following resorption of edema and inflammation, patients can use class II or III stockings. Do not forget that elastic material deteriorates and that the stockings must be replaced at least two or three times a year.
- ◆ Leg ulcer: CT is the cornerstone of the treatment. It is much more important than local therapies.³⁰ Pas-

sive or active compression, elastic stockings,³¹ Tubulcus, four-layer bandage, or other devices will be used depending on the patient's ability to secure his bandage, the aspect of the ulcer, and the presence of a simultaneous arteriopathy, among others.¹⁵

- ◆ Sclerotherapy: The interest of CT after sclerotherapy of leg telangiectases is debatable.¹ CT greatly improves the results of sclerotherapy of medium and large varicose veins, and prevents iatrogenic hyperpigmentation.^{1,2,4,7,32} Selective compression enhances the result of sclerotherapy.³³
- ◆ Surgery: Elastic support prevents the formation of hematomas along the course of the removed veins and reduces postoperative pain. The duration and type of support varies according to teams from 1 to more than 6 weeks.^{1,2,4,7} It also depends on the number of postoperative hematomas. Some surgeons fit elastic support tights or two superimposed tights directly on the skin at the end of surgery instead and in place of dressings.³⁴
- ◆ Pregnancy: CT should be worn early in pregnancy, as venous distension and increased venous pressure start at the onset of pregnancy. Class I–II stockings are indicated, as calf, tights, or pregnancy tights. CT prevents development of varicose veins and their complications.^{1,4,35,36}
- ◆ Prevention of DVT: Antithrombosis stockings exert 18 mmHg at the ankle and 8 mmHg at the thigh. Strictly designed for bedridden patients, they objectively reduce the diameter of the deep veins and increase the speed of blood flow. They are indicated in all situations where there is a risk of thromboembolic disease. Antithrombosis stockings should not be used in standing patients.^{1,2,4}
- ◆ Superficial thrombophlebitis: Selective compression of the course of a vein with phlebitis is achieved by wearing a short or long stretch elastic bandage. Stockings are a valuable alternative. Both induce rapid relief of pain and secure the resorption of the disorder.^{1,2,4}
- ◆ Deep vein thrombosis (DVT): CT is essential in the management of outpatients suffering from DVT. It has an analgesic and antiedema effect, increases flow in deep veins, and enhances thrombus adhesion. During the acute phase, patients should wear adhesive, short, or long stretch bandages until resorption of edema, and then stockings (II or III) for at least several months, and in many cases for life.^{1,2,4}
- ◆ Prevention of postthrombotic syndrome: Valve damage continues to develop for years after the acute episode of DVT. Patients require long-term clinical and therapeutic follow-up. CT is the best preven-

tion of the development of postthrombotic syndrome.^{1,2,4,37–40}

Contraindications, Side Effects, and Limitations

Stage III and IV of obliterative arterial disorders, or a systolic arterial pressure at the ankle of less than 80 mmHg, and phlegmasia cerulea dolens contraindicate elastic supports. Adhesive bandages may be considered in arterial patients with extreme caution and only if resting pressure is nil. Other relative contraindications include poorly compensated heart failure and abscesses.

Complications such as nerve damage, skin necrosis, induced arterial hypoxia, and DVT are exceptional, if both indications and the CT technique are correct.^{2,5,41,42} True allergies to CT materials are rare.⁴³ First placing a cotton stockinette may prevent irritation of sensitive skin by CT.

The major limitations of CT are patient compliance and difficulty in applying hosiery or bandages in the elderly.

Conclusion

Elastic support is and will remain the cornerstone of treatment in phlebology. CT is highly cost effective. CT should be better known and taught to physicians who are only seldom aware of the major importance of these techniques. Further fundamental and clinical research is also mandatory. As CT is not always well tolerated and accepted by patients, the success of treatment depends on the physician's knowledge and training in compression, and the quality of his explanations. Development of new technologies, in particular in textiles and comfort, will also contribute to better acceptance of this major treatment modality.

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