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Graduated Compression Stockings for the Prevention of Post-operative Venous Thromboembolism

Introduction

Graduated compression stockings are used for the prophylaxis of deep vein thrombosis. Despite the advantages of graduated compression stockings over other forms of prophylaxis such as, low cost, convenience, and minimal side effects, their use is highly variable[1].

This information sheet summarises the best available information related to the effectiveness of graduated compression stockings for the prevention of venous thrombosis in post-operative patients. Recommendations are based on two systematic reviews,[1,2] with the discussion supplemented by other relevant papers.

This Information Sheet Covers the Following Concepts:

- Thromboembolism
- Those at Risk
- Prophylaxis
- Graduated Compression Stockings
- Associated Complications
- Indications
- Effectiveness
- Management Issues

Levels of Evidence

All studies were categorised according to the strength of the evidence based on the following classification system.

Level I - Evidence obtained from a systematic review of all relevant randomised controlled trials.

Level II - Evidence obtained from at least one properly designed randomised controlled trial.

Level III.1 - Evidence obtained from well designed controlled trials without randomisation.

Level III.2 - Evidence obtained from well designed cohort or case control analytic studies preferably from more than one centre or research group.

Level III.3 - Evidence obtained from multiple time series with or without the intervention. Dramatic results in uncontrolled experiments.

Level IV - Opinion of respected authorities, based on clinical experience, descriptive studies, or reports of expert committees.

Thromboembolism

Pathophysiology

Factors that contribute to the development of post-operative venous thromboembolism relate to venous stasis, vessel injury and coagulation factors. Intra-operative venodilatation reduces blood flow in the veins causing venous stasis.[3] This venodilatation can stretch the endothelium beyond the support of the tunica media resulting in intimal tears. Intimal tears, in the presence of venous stasis, activate platelets, clotting factors and other thrombogenic products of tissue injury.[3] The interaction of these factors, combined with the trauma of the surgical procedure and post-operative immobility, increases the risk of blood clots developing in the venous system. Termed Deep Vein Thrombosis (DVT), this disorder most commonly occurs in the deep veins of the legs.[4] The major complications of DVT are pulmonary emboli and post thrombotic syndrome.[4]

Those at Risk

The risk of developing a DVT is associated with a wide range of possible factors. Within the context of post-operative care, surgery and immobility are perhaps the most important. General surgery brings with it a moderate risk of formation of a thrombus, while some orthopaedic surgery such as hip surgery or knee replacement are considered high

Table 1 - Classification of Risk of Venous Thromboembolism[10]	
Low Risk Groups	Minor surgery (< 30 minutes), no risk factors other than age. Major surgery (> 30 minutes), age < 40 years, no other risk factors. Minor trauma or medical illness.
Moderate Risk Groups	Major general, urological, gynaecological, cardiothoracic, vascular, or neurological surgery, age 40 years or other risk factor. Major medical illness, heart or lung disease, cancer, inflammatory bowel disease. Major trauma or burns. Minor surgery, trauma or illness in patients with a history of DVT, pulmonary embolism or thrombophilia.
High Risk Groups	Fracture or major orthopaedic surgery of pelvis, hip or lower limb. Major pelvic or abdominal surgery for cancer. Major surgery, trauma or illness in patients with a history of DVT, pulmonary embolism or thrombophilia. Lower limb paralysis such as hemiplegic stroke or paraplegia. Major lower limb amputation.

risk. Immobility during the post-operative recovery period adds to these risks. Without prophylaxis, the risk of DVT ranges from 25% to 30% for general surgical patients and up to 70% following some orthopaedic procedures.[3]

Prophylaxis

DVT prophylaxis addresses the causes of thromboembolism, specifically venous stasis and coagulation defects. A range of approaches to prophylaxis are available including anticoagulants, such as heparin or low-molecular weight heparin, and mechanical methods such as compression stockings or intermittent pneumatic compression devices. The combination of both mechanical and pharmaceutical prophylaxis is also common. The simplest method of prophylaxis is early ambulation of the post-operative patient, as muscle contractions in the leg minimise venous stasis.

Graduated Compression Stockings

Elastic stockings have been used to treat varicose veins and their complications for over 150 years.[11] In more recent times, graduated pressure has been used to encourage venous blood flow. Graduated pressure refers to the application of varying degrees of pressure, with pressure greatest at the ankle and decreasing proximally.[3]

Compression stockings attempt to prevent DVT by affecting the three aetiological factors, venous stasis, vessel injury and coagulation. External compression reduces the cross sectional area of the limb and increases the velocity of blood flow in both superficial and deep veins.[3] This increased velocity of blood reduces venous stasis and decreases the risk of thrombus formation by reducing venous wall distension, local contact time, and the concentration of coagulation reactants.[3] External compression also improves venous valve function, reducing stasis of blood in the cusps.

There has been some debate over the length of compression stockings. Thigh length compression stockings are more expensive, are more difficult to put on and less well tolerated than the shorter knee length stockings.[3] However, as most studies have used thigh length stockings, further research is needed to determine if knee length stockings achieve the same results.

Associated Complications

While compression stockings are considered to be relatively complication free, there are some potential risks with their use. The main risk is a reduction in cutaneous blood flow as a result of the pressure which may lead to impaired subcutaneous tissue oxygenation. Patients with peripheral arterial disease and diabetics with neuropathy are at particular risk.[3] Complications reported in

the literature include arterial occlusion, thrombosis and gangrene.[12] The complications reported were linked to extended periods of sitting whilst wearing compression stockings, and in another case, to the tourniquet effect of multiple layers of bunched-up stocking combined with a swelling of the leg. Ouside of these reports, graduated compression stockings are generally viewed as being relatively free of complications when compared to other prophylactic measures.

Indications

It has been recommended that for patients at low risk of DVT, graduated compression stockings may be used as the sole prophylactic agent, and for patients at moderate to high risk of DVT, compression stockings should be used in conjunction with anti-coagulation therapy.[3] With the increasing trend towards early discharge, compression stockings may have a role post discharge,[3] although currently there is little evidence addressing this issue. Graduated compression stockings may be contra-indicated for people with peripheral arterial disease or peripheral neuropathy.

Effectiveness

Two systematic reviews have evaluated the effectiveness of graduated compression stockings for the prevention of DVT.[1,2] These reviews are described below (see table 2 for summary of findings).

Systematic Review Summary I

A systematic review was conducted in 1994 to determine the effectiveness of graduated compression stockings for the prevention of post-operative venous thromboembolism.[1] Of the 12 Randomised Controlled Trials (RCTs) summarised in this review, 11 involved moderate risk non-orthopaedic patients, and one RCT, which was analysed separately, involved high risk orthopaedic surgical patients.

Findings

The meta-analysis of 11 studies involving a total of 1752 moderate risk surgical patients clearly demonstrated that graduated compression stockings reduced the incidence of DVT formation in this group of patients.

The single study in high risk orthopaedic surgical patients involved a total of 90 patients, however no definitive conclusions could be made regarding the effectiveness of graduated compression stockings in this population.

Two studies compared the effectiveness of below knee graduated compression stockings with above knee graduated compression stockings. While no difference was detected, both studies were small and no conclusions could be made regarding the effectiveness of below knee stockings. (see table 2)

Implications of Findings

Combining all studies for meta-analysis provides further interpretation of the findings. The review found taht 6.2% of patients wearing stockings developed DVT, compared to 17.6% who did not wear stockings.

These findings can be used to calculate the Numbers Needed to Treat (NNT).[13] The NNT refers to how many post-operative patients you would have to treat using graduated compression stockings to prevent one DVT. The findings show that for every 9 patients (8.8 patients) treated with compression stockings, one DVT would be prevented.

Systematic Review Summary II

A more recent systematic review also evaluated the effectiveness of graduated compression stockings for the prevention of venous thromboembolism.[2] Studies were placed into one of two groups:

- studies evaluating graduated compression stockings versus no compression stockings (with both groups having no other form of prophylactic therapy), and
- studies evaluating stockings combined with some other type of prophylactic therapy versus prophylactic therapy and no compression stockings.

Findings

A meta-analysis of 9 RCTs evaluating stockings versus no stockings, and involving a total of 1,205 surgical patients, supported the effectiveness of the graduated compression stockings for the prevention of DVT.

The second meta-analysis consisted of 7 RCTs and involved a total of 1006 surgical patients This meta-analysis compared compression stockings versus no compression stockings, with both groups having a background of additional antithrombotic measures. The effectiveness of graduated compression stockings was supported for the prevention of DVT. However, because of differences between studies, the reviewers recommend caution when interpreting these findings.

Table 2 - Summary of the findings of the Two Systematic Reviews

- Above knee stockings are effective in reducing the risk of DVT in moderate risk surgical (non-orthopaedic) patients.
- No conclusion could be made regarding the effectiveness of graduated compression stockings in high risk surgical patients (eg. orthopaedic, history of DVT or hypercoaguable states).
- No conclusions could be made regarding the effectiveness of below knee compression stockings compared to above knee stockings.
- There is some suggestion that graduated compression stockings are more effective when used in combination with other antithrombotic measures, however more research is required.
- No evidence regarding the effectiveness of graduated compression stockings in preventing pulmonary embolism.
- No evidence on the effectiveness of graduated compression stockings for low risk patients.
- There is little evidence on the effectiveness of graduated compression stockings for medical patients.
- There is little evidence on the effectiveness of graduated compression stockings compared to other prophylactic antithrombotic measures.
- There is little evidence related to the cost implications to health care providers using graduated compression stockings, and comparison with other prophylactic measures.

As most RCTs in this review used above knee compression stockings, no firm conclusions could be drawn on the effectiveness of below knee stockings. There was no evidence on the use of compression stockings for patients at low risk of DVT.

Implications of Findings

For RCTs evaluating graduated compression stockings alone 12.9% of patients wearing stockings developed DVT, compared to 26.5% who did not wear stockings.

For RCTs evaluating graduated compression stockings against a background of additional antithrombotic measures, the incidence of DVT was much lower for both stocking and no-stocking groups. This review found that 3.5% of patients wearing stockings developed DVT, compared to 14.6% who did not wear stockings.

The calculated NNT from this review are similar to those of the 1994 systematic review.[1] For compression stockings used alone, 7.4 patients must be treated to prevent one DVT. For compression stockings used in addition to additional antithrombotic measures, 9.0 patients must be treated to prevent one DVT. The difference in the NNT between these two comparisons is a result of the lower base line levels of DVT for all patients receiving additional anti-thrombotic measures.

Management Issues

There is very little evidence available related to the management of post-operative patients wearing compression stockings, and this lack of information is reflected in the wide variation in current practice. However given the nature of compression stockings, and the potential complications, management issues of importance will relate to ensuring that stockings are fitted and worn correctly, that the patient's skin condition and perfusion are monitored and that protocols

for the use of stockings are followed. (see table 3)

Given the potential complications related to poorly fitted stockings, care should be taken when selecting the appropriate size stocking for patients. To ensure correct fit, measurement and fitting should be according to the manufacturers recommend-ations. Leg measurements and stocking size should be documented to serve as a baseline for future assessment of the patient's legs and of the appropriateness of the size of the stocking. It should be noted that graduated compression stockings are also used for venous insufficiency, however these stockings have a much higher compression range. There is little information on when the use of stockings should commence, however it has been suggested that they should be applied at least two hours prior to surgery, and then be continued during and after surgery until the person is fully mobile.[3]

Once fitted, stockings should be checked frequently to ensure they are worn correctly, and that there is no bunching-up of the stocking. Leg measurements may need to be reviewed regularly, particularly when leg swelling is present, as an increase in leg circumference of 5cm can double the amount of pressure being applied by the stocking.[3]

Skin care is important during the period that stockings are in use. Stockings must be removed to assess skin condition and to provide skin care. While there is no evidence on the optimal frequency for providing skin care and for monitoring the skin condition of patients wearing stockings, expert opinion suggests this should be undertaken at least once per day. However, for some patients, more frequent care may be required depending on the condition of their skin. The feet and legs should be dried before application of stockings. Regular monitoring of perfusion is required. This can be undertaken during skin care and at other times through the inspection hole in stockings.

Ensuring adherence to prophylactic regimes is also important. One sudy found protocol violation in DVT prophylaxis to be a common occurrence with compression stockings often not being worn by the patient.[14] This highlights the fact that the effectiveness of compression stockings, anti-coagulation or early mobilisation to prevent DVT, relies on compliance by patients and health care workers.

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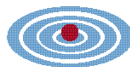

Table 3 - Graduated Compression Stockings

Clinical Recommendations

Based on the findings of the two systematic reviews summarised in this information sheet, the following recommendation can be made.

- Above knee graduated compression stockings are effective for the prevention of post-operative deep vein thrombosis in moderate risk surgical patients. **Level I**

Management of the Patient Wearing Graduated Compression Stockings

Because of the lack of evidence related to the management of patients using graduated compression stockings, the following suggestions are proposed by the panel of experts to serve as guiding principles for clinical practice. This evidence has been rated at **Level IV** (expert opinion).

- If compression stockings are to be part of a patient's post-operative care, then stockings should be applied prior to surgery whenever possible.
- To ensure correct fit of stockings, measure and fit according to the manufacturer's recommendations.
- Document measurements and size of the stockings at initial wear to serve as baseline measures.
- Leg measurements may need to be reviewed regularly to avoid potential complications related to swelling of the leg causing excessive pressure from the stockings.
- Feet and legs should be dry before stockings are applied.
- Stockings should be removed at least daily to allow for skin care, hygiene and assessment of skin. For some patients it may be necessary to remove stockings more frequently.
- For long term use of compression stockings, more than one pair of stockings may be required to allow for cleaning.
- Compression stockings should be checked regularly to ensure correct placement, and that there is no bunching up or restrictions to perfusion caused by the stocking.
- Neurovascular status should be checked regularly during skin care and at other times via the inspection hole in the compression stocking.
- Monitor patients sitting out of bed to ensure stockings are not compromising perfusion by acting as a tourniquet at the knee.
- Education of the patient should be an important part of the care provided, and must encompass issues such as the reason for using compression stockings, the application and correct fit of stockings, care of the skin and the need to monitor for swelling of the legs.
- Education of health care workers is necessary to ensure correct use of stockings and to minimise protocol violations.

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