The Journal of Arthroplasty 30 (2015) 2279–2284

Contents lists available at ScienceDirect

The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

A Current Review of Mechanical Compression and Its Role in Venous Thromboembolic Prophylaxis in Total Knee and Total Hip Arthroplasty

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ARTICLE INFO

Article history:
Received 18 March 2015
Accepted 20 May 2015

Keywords:
venous thromboembolic prophylaxis
mechanical compression prophylaxis
guidelines
complications
mechanical compression devices

ABSTRACT

Interest in mechanical compression for venous thromboembolic disease prophylaxis has increased over the last several years because of concerns related to bleeding complications associated with chemoprophylaxis. However, the research evaluating compression is clearly not definitive. Therefore, this review aims to: (1) summarize methods of compression; (2) compare AAOS, ACCP, and SCIP guidelines; and (3) make recommendations regarding usage. Below-the-knee devices have demonstrated the most efficacy with multiple guidelines recommending usage. Efficacy and compliance may be improved with the use of mobile devices.

Venous thromboembolic disease (VTED) is a serious post-operative complication after lower extremity total joint arthroplasty (TJA) [1]. Without prophylaxis, asymptomatic deep vein thrombosis (DVT) risk ranges from 33% to 46% [2–4]. Even with prophylaxis, risk ranges from 0.3% to 3% [5–8]. Therefore, VTED remains a marked source of post-operative morbidity [9,10]. The etiology of VTED is associated with Virchow's triad for DVT (venous stasis, hypercoaguable status, and endothelial injury). Hence, it is reasonable to select a prophylaxis regimen that targets one or more of these factors. In general, pharmacotherapy minimizes VTED formation by addressing hypercoagulability, activating anti-coagulation factors, or preventing platelet aggregation. Despite the efficacy of these anticoagulants, there are serious concerns regarding bleeding events.

Mechanical compression devices are commonly used to reduce venous congestion and stasis by squeezing the lower extremities (the foot or as high as the thigh) in a symmetrical or asymmetrical fashion [11–14]. They are often used as adjuncts to pharmacotherapy [11,15]. Guidelines of the American Academy of Orthopaedic Surgeons (AAOS), the American College of Chest Physicians (ACCP), and the Surgical Care Improvement Project (SCIP) recommend using either mechanical or chemoprophylaxis (Table 1) [16–20]. The most recent ACCP guidelines suggest that mechanical compression be combined with chemoprophylaxis. Although mechanical devices have been studied, there remains a paucity of reviews regarding efficacy. The purpose of this review is the following: (1) summarize methods of compression; (2) compare AAOS, ACCP, and SCIP guidelines; and (3) make recommendations regarding usage.

Methods

A query of PubMed, EMBASE and Ovid databases of relevant reports from January, 1990 until July, 2014 was performed. Search strings were: mechanical[title], prophylaxis[title], compression[title], thromboembol*[title], arthroplasty*[title], total[title], replacement*[title], cost[title], and stocking*[title]. This yielded 260 reports. Exclusions were: (1) non-English; (2) animal studies; (3) case reports, and (4) less than 20 subjects. After applying the aforementioned exclusion criteria, 34 were not in English, 33 were not conducted on humans, 18 were case reports, and 31 included less than 20 subjects. After reviewing the remaining 144 reports, we found that 104 reports did not report sufficiently either the efficacy or compliance of the device they studied. This left a total of 40 reports. Cross-referencing for additional sources yielded 5 studies for 45 total (Appendix A). All were level of evidence classified [21]. We separated devices into four groups: compression stockings, and above-the-knee/below-the-knee mechanical compression devices, and foot pumps.

Compression Stockings

Compression stockings differ from mechanical compression devices in that they apply a constant pressure to the lower extremities, thus decreasing the amount of venous stasis [22]. The ACCP does not recommend their use [19]. A single institution prospective study that assessed

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to http://dx.doi.org/10.1016/j.arth.2015.05.045.

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http://dx.doi.org/10.1016/j.arth.2015.05.045
0883-5403/

Table 1
AAOS Guidelines for Preventing VTED [16,18].

Grade of Recommendation	Recommendation
Strong	Do not routinely perform post-operative Duplex ultrasonography screening after TKA or THA
Consensus	Patients should be assessed for known bleeding disorders or the presence of liver disease
	Those who have a history of VTED should receive both pharmacological prophylaxis and mechanical compressive devices
	If patient has a history of known bleeding disorder, he or she should receive mechanical prophylaxis only
	Patient should undergo early mobilization following THA and TKA
	Patients and physicians should discuss the duration of prophylaxis
Moderate	Discontinue antiplatelet agents before undergoing THA or TKA
	Use pharmacological agents and/or mechanical compression devices for the prevention of VTED if the patient is not at elevated risk beyond that of the surgery itself for VTED or bleeding
	Use neuraxial anesthesia to limit blood loss (even though evidence suggests this anesthesia has no effect on the occurrence of VTED
Limited	Practitioners may further assess the risk of VTED by determining if the patient had a previous VTE.
Inconclusive	Cannot recommend for or against routinely assessing patients for VTE
	Cannot recommend for or against further risk stratification of bleeding beyond those with liver disease or known bleeding disorder
	Cannot recommend for or against the use of inferior vena cava filters in those in which chemoprophylaxis is contraindicated

TKA, total knee arthroplasty; THA, total hip arthroplasty; VTED, venothromboembolic disease.

pressure gradients produced by below-knee compression stockings in 52 THAs and 20 TKAs patients found that 98% of the stockings failed to produce an ideal pressure gradient, with 54% producing a reverse gradient (opposite normal venous flow towards heart) [23]. This led to higher DVT incidences than seen in patients with correct gradient (25.6 versus 6.1%; $P = 0.026$) [23,24]; however, one weakness of this study is they did not differentiate between THA or TKA patients. There are multiple retrospective case control studies that have shown that compression stockings are not effective VTE prophylaxis agents when compared to chemoprophylaxis alone or when used in conjunction with chemoprophylaxis following both THA and TKA [25–29].

In summary, 3 level II, 4 level III, and 1 level IV studies assessed usage of compression stockings following THA or both THA and TKA. Given the difficulties regarding creating an ideal flow gradient as well as their inability to show superior efficacy to chemoprophylaxis, we cannot recommend their routine use alone.

Symmetrical Above-the-Knee Compression Devices

Above-knee devices extend from the feet to thigh. In a prospective cohort study of 502 THA patients, the incidence of asymptomatic DVT diagnosed with a venogram on post-operative day 6 was 5% (n = 23). The symptomatic PE rate was 0.6% (n = 3) [7]. Lachiewicz and Soileau [30] retrospectively analyzed above-the-knee devices in 1032 THAs, and found a symptomatic PE rate of 0.7% (n = 7) and overall DVT incidence of 3.9% (n = 41) with only 0.4% (n = 4) symptomatic. Additionally, Hull et al [31], compared these devices to no prophylaxis following THA in a prospective randomized clinical trial (n = 152 and 158 patients). At 3-month follow-up, they found substantially more asymptomatic DVTs in the control cohort (49 versus 24%; $P = 0.00001$).

Studies have found that these devices may not be as efficacious as foot pumps or the below-the-knee devices. Proctor et al [32] assessed efficacy of 5 different pneumatic compression devices (n = 1350 cases) following multiple surgical procedures, including THA, in a prospective cohort study. They found a markedly higher risk of acquiring DVTs in the patients treated with an above-the-knee devices cohort when compared to below-the-knee devices, but this difference did not achieve significance (71 versus 52%; $P = 0.21$). Westrich et al [33] found above-the-knee devices raised venous velocity by 87 to 260% compared to over 300% with below-the-knee devices. Hence, above-the-knee devices may not be as efficacious as below-knee counterparts.

In summary, there are 1 level II, 2 level III and 2 level IV studies on symmetrical above-the-knee devices following THA only. Unfortunately, there were no studies regarding compliance or efficacy following TKA. In addition, there is a paucity of randomized clinical trials evaluating these devices. These devices may be considered following THA, but given their inability to show comparable efficacy to other devices, we cannot make a strong recommendation for them.

Below-the-Knee Devices

Sequential Symmetric Intermittent Compression Devices

These devices improve venous blood flow by inflating multiple cuffs around the lower extremity in a sequential manner, starting at the foot with each ascending cuff progressively tightening in a peristaltic manner followed by simultaneous deflation. This mode may improve the ability to increase venous return more than foot pumps. Since the calf contains nearly three times the foot venous volume, when compressed it affects venous blood flow greater [33,34].

Following THA

Sugano et al [6], in a retrospective case control study, demonstrated intermittent compression devices alone prevented VTED (n = 3016 hips) after THA, pelvic osteotomy, or femoral osteotomy with DVT incidence of 0.13% (n = 4), and PE incidence of 0.03% (n = 1). Yokote et al [4], in a prospective randomized control trial, compared mechanical prophylaxis to two pharmacological agents (n = 255 patients). At 11-day follow-up, there was no difference in VTED between the cohorts.

In addition, there have also been studies that have examined the efficacy of the devices in conjunction with chemoprophylaxis. Daniel et al [35] retrospectively assessed a multimodal approach involving two cohorts with and without below-the-knee devices (n = 229 and 258). After 12 weeks, there were significantly less DVTs in the below-the-knee devices cohort (4.6 versus 10.2%; $P = 0.03$). Della Valle et al [36], in a prospective cohort study, evaluated a multimodal protocol for VTED prevention after using below-the-knee devices and some form of chemoprophylaxis: aspirin (82%) or warfarin if considered high risk for VTED (18%) (n = 1947 patients). After 3-month follow-up, symptomatic PE incidence was 0.6% (n = 12) and DVT incidence was 3% (n = 56).

Following TKA

Similar outcomes regarding efficacy have been seen following TKA as well. Lachiewicz and Soileau [37] prospectively assessed calf compression in conjunction with aspirin in 702 TKAs, demonstrating 90-day mortality rate of 0.14% (n = 1). Symptomatic PE incidence was 0.5% (n = 3) and symptomatic DVTs were 1.5% (n = 9). Chin et al [38] compared the efficacy of these devices (n = 110) to no prophylaxis (n = 110) and above-the-knee compression stockings (n = 110) in a prospective randomized clinical trial. At 1-month follow-up, they found that below-the-knee devices had a lower asymptomatic DVT incidence than no prophylaxis or compression stockings (8% versus 22% versus 13%; $P = 0.001$).

In summary, 3 level II, 3 level III, and 5 level IV studies reported on below-the-knee devices. These devices have been reported to be efficacious and certainly may be considered following THA or TKA. However, there are no appropriately performed randomized control trials comparing this type of mechanical compression to an effective chemoprophylaxis regimen, which we look forward to in future studies.