CADTH RAPID RESPONSE REPORT: SUMMARY OF ABSTRACTS

Sequential Compression Devices: Clinical Effectiveness, Cost-Effectiveness and Guidelines

Service Line: Rapid Response Service
Version: 1.0
Publication Date: October 16, 2018
Report Length: 17 Pages
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Acknowledgments:

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About CADTH: CADTH is an independent, not-for-profit organization responsible for providing Canada’s health care decision-makers with objective evidence to help make informed decisions about the optimal use of drugs, medical devices, diagnostics, and procedures in our health care system.
Research Questions

1. What is the comparative clinical effectiveness of sequential/pneumatic compression devices (SCDs) with or without anticoagulant protocols versus anticoagulant protocols only in adult inpatients?

2. What is the cost-effectiveness of sequential/pneumatic compression devices (SCDs) with or without anticoagulant protocols versus anticoagulant protocols only in adult inpatients?

3. What are the evidence-based guidelines regarding the use of sequential/pneumatic compression devices?

Key Findings

One health technology assessment, three systematic reviews, three meta-analyses, three randomized controlled trials, and nine non-randomized studies were identified regarding the clinical effectiveness of sequential/pneumatic compression devices (SCDs) with or without anticoagulant protocols versus anticoagulant protocols only in adult inpatients. Two economic evaluations were identified regarding cost-effectiveness. Two evidence-based guidelines were identified regarding the use of sequential/pneumatic compression devices.

Methods

A limited literature search was conducted on key resources including PubMed, The Cochrane Library, University of York Centre for Reviews and Dissemination (CRD) databases, Canadian and major international health technology agencies, as well as a focused Internet search. Methodological filters were applied to limit retrieval to health technology assessments, systematic reviews, meta-analyses, randomized controlled trials, randomized controlled trials, non-randomized studies, economic studies, and guidelines. Where possible, retrieval was limited to the human population. The search was also limited to English language documents published between January 1, 2008 and September 29, 2018. Internet links were provided, where available.

Selection Criteria

One reviewer screened citations and selected studies based on the inclusion criteria presented in Table 1.
### Table 1: Selection Criteria

<table>
<thead>
<tr>
<th>Population</th>
<th>Adult inpatients (any age or surgery/hospital unit included)</th>
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<tbody>
<tr>
<td>Intervention</td>
<td>Sequential or pneumatic compression devices (SCDs) with or without anticoagulant protocol(s)</td>
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<tr>
<td>Comparators Q1:</td>
<td>Anticoagulant protocols (e.g., heparin, warfarin)</td>
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<td>Q2:</td>
<td>No comparison</td>
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<tr>
<td>Outcomes Q1:</td>
<td>Clinical effectiveness i.e., benefits (e.g., prevention of deep vein thrombosis), harms</td>
</tr>
<tr>
<td>Q2:</td>
<td>Cost-effectiveness</td>
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<tr>
<td>Q3:</td>
<td>Guidelines</td>
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<tr>
<td>Study Designs</td>
<td>Health technology assessments, systematic reviews, meta-analyses, randomized controlled trials, non-randomized studies, economic evaluations, evidence-based guidelines</td>
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</table>

### Results

Rapid Response reports are organized so that the higher quality evidence is presented first. Therefore, health technology assessment reports, systematic reviews, and meta-analyses are presented first. These are followed by randomized controlled trials, non-randomized studies, economic evaluations, and evidence-based guidelines.

One health technology assessment, three systematic reviews, three meta-analyses, three randomized controlled trials, and nine non-randomized studies were identified regarding the clinical effectiveness of sequential/pneumatic compression devices (SCDs) with or without anticoagulant protocols versus anticoagulant protocols only in adult inpatients. Two economic evaluations were identified regarding cost-effectiveness. Two evidence-based guidelines were identified regarding the use of sequential/pneumatic compression devices.

Additional references of potential interest are provided in the appendix.

### Overall Summary of Findings

One health technology assessment, six systematic reviews (three with meta-analyses), three randomized controlled trials, and nine non-randomized studies were identified regarding the clinical effectiveness of sequential/pneumatic compression devices (SCDs) with or without anticoagulant protocols versus anticoagulant protocols only in adult inpatients. Detailed study characteristics are provided in Table 2.

The health technology assessment noted a high strength of evidence supporting vitamin K antagonists in lowering the risk of proximal deep vein thrombosis compared with mechanical devices; which includes elastic compression stockings as well as pneumatic devices.

Two systematic reviews and four non-randomized studies indicated that combined use of pneumatic compression devices and anticoagulation (distinct in each study) are superior to their respective anticoagulant alone at lowering pulmonary embolisms, deep vein thrombosis, or venous thromboembolisms.

This contrasts with two other randomized controlled trials which indicated that their respective pharmacological interventions were associated with a reduced risk of venous
thromboembolism\textsuperscript{8} or deep vein thrombosis\textsuperscript{10} compared with intermittent pneumatic compression devices.

One systematic review\textsuperscript{3} indicated that the addition of anticoagulant to pneumatic compression devices increased the risk of bleeding when compared to the device alone. Another systematic review\textsuperscript{4} indicated that the risk of major bleeding was similar between anticoagulants and devices. Two systematic reviews\textsuperscript{5,7} and two randomized controlled trials\textsuperscript{9,10} indicated that pneumatic compression devices were associated with a lower risk of bleeding events compared with anticoagulation.

Two economic evaluations\textsuperscript{20-21} were identified regarding the cost-effectiveness of SCDs with or without anticoagulant protocols versus anticoagulant protocols. One study\textsuperscript{20} revealed that savings could be gained if a single best practice replaced the observed variations in types of prophylaxis utilised. The other study\textsuperscript{21} noted that SCDs were less effective and more expensive than unfractionated heparin therapy for one month following a specialty oncology surgery. Detailed study characteristics are provided in Table 2.

Two evidence-based guidelines were identified regarding the use of sequential/pneumatic compression devices. One guideline (presented in two separate volumes\textsuperscript{22-23}) was published by the National Institute for Health and Care Excellence in the United Kingdom. It addresses the correct use of venous thromboembolism prophylaxis while balancing risks, including the suitability of intermittent pneumatic compression in various inpatient clinical cases. The other guideline from the American College of Chest Physicians\textsuperscript{24} addresses venous thromboembolism prevention in non-orthopedic surgical patients by stratifying risk groups. The use of intermittent pneumatic compression devices is discussed for patients at a variety of risk levels for venous thromboembolism and major bleeding complications.\textsuperscript{24}

Table 2: Summary of Included Studies

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Study Characteristics: Intervention; Comparator</th>
<th>Outcomes</th>
<th>Results</th>
<th>Author Conclusions</th>
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<tbody>
<tr>
<td><strong>Health Technology Assessments</strong></td>
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| Balk, 2017\textsuperscript{1} | N = NA  
Mechanical devices (includes pneumatic and elastic); 
VKA | Proximal DVT risk | VKA have lower proximal DVT risk than mechanical devices | “VKA has lower proximal DVT risk than mechanical devices [high strength of evidence].”\textsuperscript{1} |
| **Systematic Reviews and Meta-analyses** |
| Khan, 2017\textsuperscript{2} | N = NA  
Sequential PCDs; 
Ultra-fractioned heparin, oral anticoagulant therapy | Complications of DVT | NA | “In the case of intracerebral hemorrhage, sequential PCDs should be placed initially, followed by the administration of ultra-fractioned heparin on the next day, and then oral anticoagulant therapy.” |
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</table>
| Kakkos, 2016$^3$ | N = 9,137  
Combined intermittent PCDs and anticoagulation;  
Single modalities | Incidence of PE  
Incidence of DVT  
Risk of bleeding | Combined devices and anticoagulation, compared with anticoagulation alone, decrease the incidence of symptomatic PE.  
Adding anticoagulation to devices, increased the risk of bleeding compared to devices alone. | "The results of the current review agree with current guideline recommendations, which support the use of combined modalities in hospitalised patients (limited to those with trauma or undergoing surgery) at risk of developing VTE$^3" |
| Park, 2016$^4$ | N = 8,622  
Intermittent PCD;  
UFH, LMWH, or controls. | Incidence of DVT  
Incidence of major bleeding | Devices were associated with a reduced incidence of DVT (not statistically significant).  
The treatment groups showed a similar risk of major bleeding for critically ill patients. | "In critically ill patients, the efficacy of mechanical thromboprophylaxis in reducing the risk of DVT is not as robust as those of pharmacological thromboprophylaxis.$^4" |
| Pavon, 2016$^5$ | N = 2,633 from RCTs,  
1,724 from observational studies  
Intermittent PCD; anticoagulants | Mortality  
VTE  
Symptomatic or asymptomatic DVT  
Major bleeding  
Ease of use  
Adherence | "Intermittent [PCDs] were comparable to anticoagulation for major clinical outcomes […] Limited data suggest that concurrent use of anticoagulation with [intermittent PCDs] may lower VTE risk compared with anticoagulation alone, and that [intermittent PCDs] compared with anticoagulation may lower major bleeding risk.$^5" | "[Intermittent PCDs] are appropriate for VTE thromboprophylaxis when used in accordance with current clinical guidelines.$^5" |
| Poultsides, 2012$^6$ | N = 99,441 patients (373 deaths)  
Potent anticoagulation combined with regional anaesthesia and/or PCDs, anticoagulants combined with regional anaesthesia and/or | Post-operative mortality  
Cause of death | Cardiopulmonary, PE and bleeding were common causes of death.  
The thromboprophylaxis regimen did not significantly affect the proportion of deaths | "Our study demonstrated that the routine use of [potent anticoagulation] does not reduce the overall mortality or the proportion of deaths due to PE$^6" |

"therapy to replace the heparin after a week in high-risk patients"$^2$
<table>
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<tr>
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<tr>
<td>PCDs, multimodal prophylaxis; Anticoagulants, and others</td>
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<td>due to PE. Groups that relied on anticoagulation were associated with higher fatal bleeding (not statistically significant).</td>
<td></td>
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<tr>
<td>Collen, 2008&lt;sup&gt;7&lt;/sup&gt;</td>
<td>N = 7,779 Mechanical VTE prevention; Pharmacologic prevention</td>
<td>Rates of VTE Rates of bleeding</td>
<td>LMWH and intermittent compression devices are effective in reducing the rate of DVT. Rates of intracranial hemorrhage and minor bleeding were generally higher in groups that included heparins.</td>
<td>“In a mixed neurosurgical population, LMWH and [intermittent compression devices] are both effective in the prevention of VTE”&lt;sup&gt;7&lt;/sup&gt;</td>
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<td>Nagata, 2015&lt;sup&gt;8&lt;/sup&gt;</td>
<td>N = 30 Intermittent PCD; Enoxaparin</td>
<td>Incidence of VTE Incidence of PE Incidence of DVT</td>
<td>Five VTEs occurred in the device group and one in the enoxaparin group. Three PE in the device group, but none in the enoxaparin group.</td>
<td>The study was terminated at the interim analysis. “Enoxaparin might have lowered the risk of VTE among surgical patients with gynecologic malignancy.”&lt;sup&gt;8&lt;/sup&gt;</td>
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<td>Hardwick, 2011&lt;sup&gt;9&lt;/sup&gt;</td>
<td>N = 395 MCD with or without ASA; LMWH</td>
<td>Bleeding and VTE events over three months Hours of device use</td>
<td>All major bleeding events occurred in the LMWH group. VTE occurrence was similar in both groups. The device group used devices 83% of possible usable time.</td>
<td>“Findings of significantly less major bleeding in the [device] group than the LMWH group supported our hypothesis with no significant difference in VTE.”&lt;sup&gt;9&lt;/sup&gt;</td>
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<td>Chin, 2009&lt;sup&gt;10&lt;/sup&gt;</td>
<td>N = 440 Intermittent PCD; PE LMWH, and others.</td>
<td>DVT prevalence Major bleeding occurrences</td>
<td>DVT prevalence was 8% and 6% in the device and LMWH groups, respectively. The LMWH group received more blood transfusions and two had major bleeding complications.</td>
<td>“[Intermittent PCDs are] the preferred method of thromboprophylaxis for TKA in Asian patients.”&lt;sup&gt;10&lt;/sup&gt;</td>
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<td><strong>Non-Randomized Studies</strong></td>
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|**Jiang, 2017**<sup>11</sup> |  N = 754  
Simultaneous: mechanical and pharmacological; 
Sequential: mechanical then rivaroxaban | Incidence of proximal and distal DVT 
Wound drainage volume | DVT incidence was no different between the groups at five weeks. | “The use of the mechanical compression method alone during the early-postoperative 48 hours, then followed by rivaroxaban then until the 5th week had the same antithrombotic effects and reduced the postoperative wound drainage volume as compared with simultaneous combined modalities.”<sup>11</sup> |
|**Kwak, 2017**<sup>12</sup> |  N = 379  
Intermittent PCD with ASA; 
ASA | Incidence of symptomatic VTE | Three patients in the device group and six in the ASA-only group experienced a symptomatic VTE. No device-associated complications were detected. | “The results of this study suggest that intermittent PCD might be an effective and safe method for the prevention of postoperative VTE.”<sup>12</sup> |
|**Liu, 2017**<sup>13</sup> |  N = 120  
Intermittent PCD with rivaroxaban; 
Rivaroxaban | Incidence of DVT | DVT incidence was lower in the device with rivaroxaban group compared with the rivaroxaban-alone group. | “Compared with the use of rivaroxaban alone, [intermittent PCDs] combined with anticoagulants can significantly reduce the incidence rate of distal DVT and intermuscular DVT in the early postoperative period after TKA.”<sup>13</sup> |
|**Parry, 2017**<sup>14</sup> |  N = 313  
Intermittent PCD with LMWH; 
LMWH | Symptomatic VTE events | The device group saw a rate of 1.5% for symptomatic VTE, compared with 6.8% in the LMWH-only group. | “The addition of [intermittent PCDs] in patients undergoing esophagectomy for cancer was associated with a reduction in symptomatic VTEs.”<sup>14</sup> |
|**Odeh, 2016**<sup>15</sup> |  N = 2,611  
Risk-stratified protocol: sequential PCD with | Incidence of VTE 
Cost-effectiveness | VTE prevention was equivalent between the protocols. | “The use of [sequential PCDs + ASA] in a risk-stratified [total joint arthroplasty] population...”<sup>15</sup> |
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<tr>
<td>ASA, or targeted anticoagulants; Aggressive VTE anticoagulation protocol</td>
<td>The use of the device and ASA was associated with a reduction in costs compared with the anticoagulation within the risk-stratified protocol group.</td>
<td>is a safe and cost-effective method of VTE prophylaxis.</td>
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Nam, 2015<sup>16</sup>  
N = 96 patients (192 TKA)  
MCDs with ASA; Warfarin  
Incidence of VTE  
One symptomatic VTE in the warfarin group  
"In appropriately selected patients, MCDs with ASA shows promise in VTE prevention following simultaneous bilateral TKA."<sup>16</sup>

Colwell, 2014<sup>17</sup>  
N = 3,060  
MCD with or without ASA; Anticoagulants  
Symptomatic VTE events  
Symptomatic VTE rates in the MCD group were similar to the anticoagulant group, except for the knee arthroplasty subgroup where rivaroxaban was favoured by 0.06%.  
"Use of the MCD with or without ASA for patients undergoing arthroplasty of a lower-extremity joint provides a noninferior risk for the development of venous thromboembolism compared with current pharmacological protocols."<sup>17</sup>

Reish, 2012<sup>18</sup>  
N = 105  
Risk stratified: PCD; Risk stratified: UFH, LMWH  
DVT  
Bleeding  
No clinically detected DVT.  
"[...] this treatment algorithm for thromboembolism prevention results in a low rate of bleeding and thrombosis."<sup>18</sup>

Deleyannis, 2011<sup>19</sup>  
N = 114 patients  
Intermittent PCD; Anticoagulants  
Guideline applications  
Twenty two patients utilised intermittent PCD only. Of those receiving anticoagulants, 13.2% received the recommended frequency.  
"No consistent chemoprophylaxis protocol was followed. Chemoprophylaxis was not associated with an increased risk of bleeding."<sup>19</sup>

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<th>Economic Evaluations</th>
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| Kirkpatrick, 2013<sup>20</sup>  
N = NA  
SCD; LMWH, UFH  
Mortality  
Morbidity  
Cost for each treatment algorithm  
"Outcomes were identical and value-based analysis suggested a savings opportunity of nearly $4 million if a single [best practice]  
"There were substantial variations in the type of DVT prophylaxis used by the hospitals with no difference in outcomes. A single [best practice]
<table>
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<th>Author Conclusions</th>
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<tr>
<td>Teoh, 2011&lt;sup&gt;21&lt;/sup&gt;</td>
<td>N = NA SCD; No treatment, inpatient UFH, inpatient LMWH, UFH for one month, LMWH for one month.</td>
<td>Savings opportunity</td>
<td>practice] was adopted.&lt;sup&gt;20&lt;/sup&gt;</td>
<td>increased value and resulted in savings of $1.5 million, with a savings opportunity of nearly $4 million.&lt;sup&gt;20&lt;/sup&gt;</td>
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</table>

ASA = acetylsalicylic acid; DVT = deep vein thrombosis; LMWH = low-molecular-weight heparin; MCD = mobile compression device; NA = not available; PCD = pneumatic compression device; PE = pulmonary embolism; RCT = randomized controlled trial; SCD = sequential compression device; TKA = total knee arthroplasty; UFH = unfractionated heparin; VKA = vitamin K antagonists; VTE = venous thromboembolism.

### References Summarized

#### Health Technology Assessments


#### Systematic Reviews and Meta-analyses


Sequential Compression Devices


Randomized Controlled Trials


Non-Randomized Studies


Economic Evaluations


Guidelines and Recommendations


*NOTE: Information throughout the guideline*


*NOTE: See abstract of reference #22. Information throughout the guideline and includes incremental cost-effectiveness comparisons on pages 136 and 214.*
Appendix — Further Information

Previous CADTH Reports


Systematic Reviews and Meta-Analyses

Alternative/Unspecified Population


Type of Intermittent Pneumatic Compression Device Not Specified


Randomized Controlled Trials

Alternative Population – Home Setting


Alternative Comparator


Non-Randomized Studies

Alternative/Unspecified Comparator


Economic Evaluations - Alternative/Unspecified Intervention


Clinical Practice Guidelines - Unspecified Methods


Additional References

Registered Trial Protocol


PubMed: PM27488380