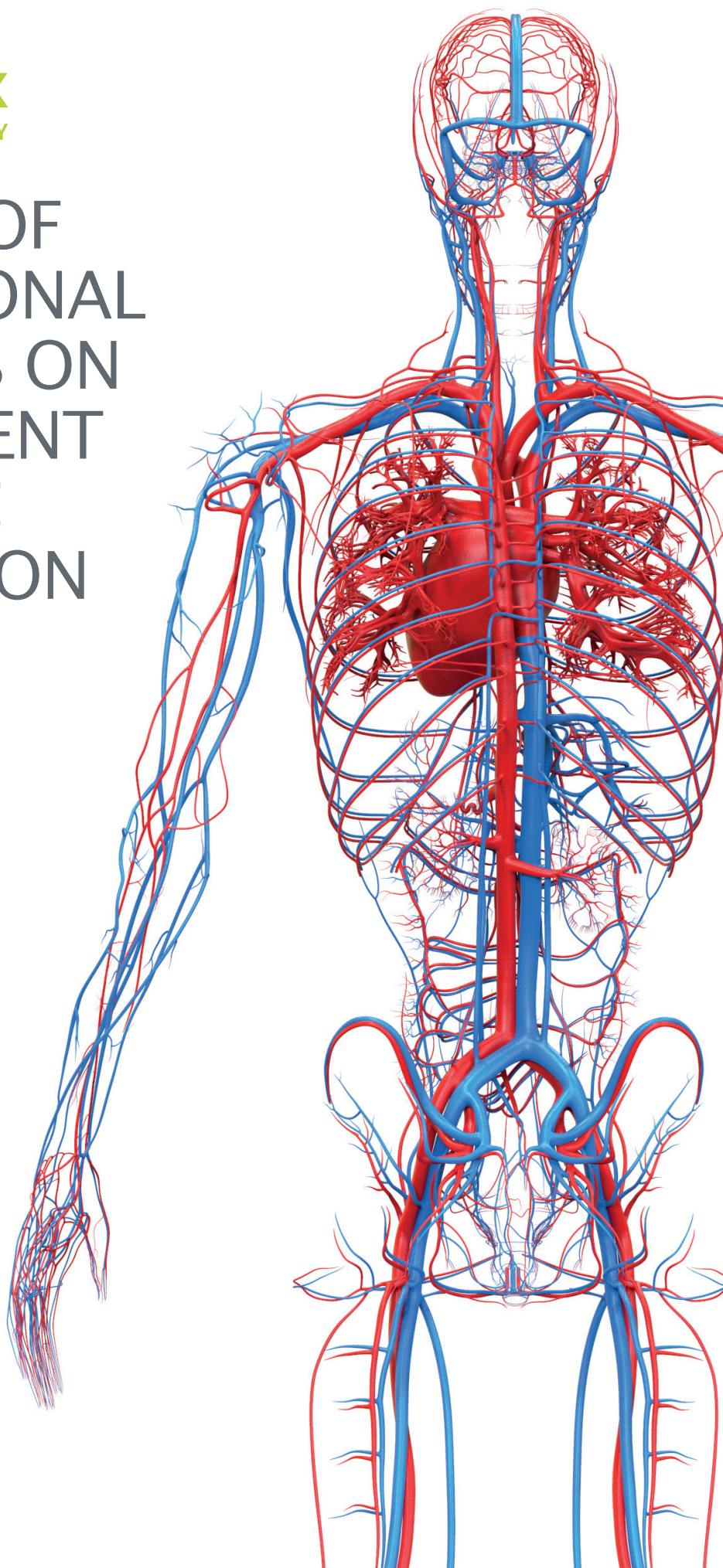


**VADO**<sup>®</sup> by OPED **plex**  
VASCULAR IMPULSE TECHNOLOGY

# SUMMARY OF INTERNATIONAL GUIDELINES ON INTERMITTENT PNEUMATIC COMPRESSION



Keeps you going.

# The 0.4 Second Impulse as a Key Advantage

VADOpnex is a medical device for intermittent pneumatic compression (IPC) therapy. With the special feature of intermittent impulse compression (IIC), VADOpnex generates a rapid pressure impulse on the foot's venous plexus, unlike the typical IPC devices with slow inflation. With VADOpnex, this impulse takes less than 0.4 seconds. This simulates the physiological effect of walking and enhances the venous return. Furthermore, the impulsive emptying of the venous plexus and subsequently the deep leg veins cause a turbulent flow within the veins and shear forces at the venous endothelium. Depending on the strength of these shear forces acting, two vasoactive hormones are released<sup>1</sup>:

- ✓ **Nitric oxide (NO), or endothelium-derived relaxing factor (EDRF)<sup>1</sup>**
- ✓ **Prostacyclin, or prostaglandin I<sub>2</sub> (PGI<sub>2</sub>), a derivative of arachidonic acid<sup>1,2</sup>**

Their release – especially of NO – makes IIC special, as NO and PGI<sub>2</sub> enhance the effect of pneumatic compression, increases microcirculation and improve thrombosis prophylaxis.<sup>1</sup>

The IIC's antithrombotic effect is based on 4 mechanisms:

- ✓ **IIC simulates the effect of physical exercise, accelerates venous return, creates turbulences in the pockets of venous valves, and thus prevents stasis.<sup>1</sup>**
- ✓ **The tissue hormones NO and prostacyclin, which are produced only during IIC, inhibit platelet aggregation and thus initiation of thrombus.<sup>1,3-5</sup>**
- ✓ **NO prevents monocyte adhesion.<sup>6,7</sup>**
- ✓ **NO increases fibrinolysis.<sup>8</sup>**

## **About the Guidelines**

The following text summarizes recommendations for IPC/IIC in venous thromboembolism (VTE) prophylaxis in various medical scenarios based on the four international guidelines:

- G1 Prevention and treatment of venous thromboembolism – International consensus Statement (Guidelines according to scientific evidence)**
- G2 European Guidelines on perioperative venous thromboembolism prophylaxis**
- G3 Asian Venous Thromboembolism Guidelines: Updated Recommendations for the Prevention of Venous Thromboembolism**
- G4 Antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines**

The guidelines refer to the following subjects:

- 1. General Surgery**
- 2. Orthopaedics and Traumatology**
- 3. Bariatric Surgery**
- 4. Intensive Care Unit**
- 5. Cancer and thoracic surgery**
- 6. After Stroke/in Neurosurgery**
- 7. In Obstetrics/Gynecology/Urology**
- 8. In Surgery in Elderly/Recommendations in general**
- 9. Evidence based recommendation of IIC/VADOpnex application by OPED GmbH**

## 1. IPC for venous thromboembolism prophylaxis in general surgery

Continuous mechanical thromboprophylaxis in terms of graduated elastic compression (GEC) and intermittent pneumatic compression can be used as an alternative approach in patients with moderate risk or risk for active bleeding. In high-risk patients or in patients with multiple risk factors, pharmaceutical methods should be combined with GEC and/or IPC.

- "An alternative method, especially in patients at risk for or with active bleeding, is GEC with IPC used continuously until the patient is fully ambulant (level of evidence: high)." <sup>G1 p.123</sup>
- "Any one of the three [Low molecular weight heparin (LMWH), fondaparinux or low dose unfractionated heparin (LDUH); author's note] may be combined with mechanical methods (GEC and/or IPC), particularly in the presence of multiple risk factors (level of evidence: high)." <sup>G1 p.123</sup>
- "GEC is contraindicated in patients with PAOD [peripheral arterial occlusive disease; author's note] because of anecdotal reports gangrene." <sup>G1 p.123</sup>

## 2. IPC for venous thromboembolism prophylaxis in orthopaedics and traumatology

IPC combined with GEC is effective in reducing proximal deep vein thrombosis (DVT) in patients undergoing total major orthopaedic surgery – like hip or knee replacement/ arthroscopy (THR/THA, TKR/TKA) or hip fracture surgery (HFS) – with less bleeding and swelling. This combination is considered as an equivalent alternative to low molecular weight heparin for surgeons or anaesthetists concerned about bleeding. Early mobilization and mechanical prophylaxis are highly recommended.

- "FIT [foot impulse technology alternative wording of IIC; authors note] combined with GEC is effective in reducing the incidence of proximal DVT in patients having THR or TKR ... with less bleeding and swelling." <sup>G1 p.147</sup>
- "IPC and FIT offer an alternative for patients with contraindications to chemical prophylaxis" <sup>G1 p.147</sup>
- "IPC or FIT combined with GEC stockings are an equivalent alternative to LMWH (level of evidence: high) for those surgeons or anaesthetists concerned about bleeding either in all or in certain patients" <sup>G1 p.148</sup>
- "LMWH combined with IPC is more effective than LMWH prophylactic modality used alone and should be considered in all cases (level of evidence: high)." <sup>G1 p.150</sup>
- "If the bleeding risk and thrombosis risk are both high, mechanical prophylaxis using IPC is recommended." <sup>G3 p.15</sup>
- "Mechanical prophylaxis in the form of sequential mechanical compression to the lower limbs is highly recommended." <sup>G3 p.15</sup>
- "In patients undergoing THA or TKA, we recommend use of one of the following for a minimum of 10 to 14 days rather than no antithrombotic prophylaxis: low-molecular-weight heparin (LMWH), fondaparinux, apixaban, dabigatran, rivaroxaban, low-dose unfractionated heparin (LDUH), adjusted-dose VKA [vitamin K antagonists; author's note], aspirin (all Grade 1B), or an intermittent pneumatic compression device (IPCD) (Grade 1C)." <sup>G4 p.135</sup>
- "In patients undergoing HFS, we recommend use of one of the following rather than no antithrombotic prophylaxis for a minimum of 10 to 14 days: [...], or an IPCD (Grade 1C)." <sup>G4 p.135</sup>
- "In patients undergoing major orthopaedic [sic] surgery and increased risk of bleeding, we suggest using an IPCD or no prophylaxis rather than pharmacologic treatment (Grade 2C)." <sup>G4 p.145</sup>

## 3. IPC for venous thromboembolism prophylaxis in Bariatric Surgery

Mechanical prophylaxis, such as IPC, is recommended for all bariatric surgical patients. Especially for obese patients with a high risk of VTE, a combination of anticoagulants and IPC is recommended during and after bariatric procedures.

- "Patients undergoing bariatric surgical procedures should receive LMWH (higher dosage) alone or in combination with GEC and I (level of evidence: moderate)." <sup>G1 p.123</sup>
- "We [ESA VTE Guidelines Task Force; author's note] recommend using anti coagulants and IPC together for obese patients with a high risk of VTE (age >55 years, BMI>55 kg.m-2, history of VTE, venous disease, sleep apnoea, hypercoagulability and pulmonary hypertension) during and after bariatric procedures (Grade 1C)." <sup>G2 p.77</sup>
- "Mechanical prophylaxis (e.g., IPC) is recommended for all bariatric surgical patients." <sup>G3 p.15</sup>

#### 4. IPC for venous thromboembolism prophylaxis in Intensive Care Unit

IPC or pharmacological prophylaxis with LMWH subcutaneously is suggested.

- "We [ESA VTE Guidelines Task Force; author's note] recommend an institution-wide protocol for the prevention of VTE that includes the use of mechanical thromboprophylaxis, that is IPC (Grade 1B)." <sup>G2 p.79</sup>
- "We suggest no prophylaxis or the use of IPC in patients with a platelet count less than 50 x10<sup>9</sup> l<sup>-1</sup> and a high-risk of bleeding (Grade 2C)." <sup>G2 p.79</sup>
- "Consider using IPC or pharmacological prophylaxis with SC [subcutaneous; author's note] LMWH." <sup>G3 p.15</sup>

#### 5. IPC for venous thromboembolism prophylaxis in cancer and thoracic surgery

Mechanical thromboprophylaxis in terms of IPC should be considered in low-risk patients or patients with risk of bleeding. IPC is further recommended in addition to pharmacological prophylaxis in high-risk patients.

- "If the risk of bleeding is to be considered high, we [ESA VTE Guidelines Task Force; author's note] suggest the use of mechanical prophylaxis using IPC (Grade 2C) [in patients undergoing coronary artery bypass graft and bioprosthetic aortic valve implantation surgery; author's note]. The presence of one or more risk factors [...] should place the cardiac population at high risk for VTE. In this context, we suggest the use of pharmacologic prophylaxis as soon as satisfactory haemostasis has been achieved, in addition to IPC (Grade 2C)." <sup>G2 p.79</sup>
- "In low-risk patients, we [ESA VTE Guidelines Task Force; author's note] suggest the use of mechanical prophylaxis using IPC (Grade 2C). In high-risk patients, we suggest the use of pharmacological prophylaxis in addition to IPC (Grade 2B)." <sup>G2 p.80</sup>
- "Mechanical prevention using IPC or GCS should be considered instead of LMWH in patients with high bleeding risk." <sup>G3 p.15</sup>
- "For thoracic surgery patients at moderate risk for VTE who are not at high risk for perioperative bleeding, we suggest LDUH (Grade 2B), LMWH (Grade 2B), or mechanical prophylaxis with optimally applied IPC (Grade 2C) over no prophylaxis. [...] For thoracic surgery patients at high risk for VTE who are not at high risk for perioperative bleeding, we suggest LDUH (Grade 1B) or LMWH (Grade 1B) over no prophylaxis. In addition, we suggest that mechanical prophylaxis with elastic stockings or IPC should be added to pharmacologic prophylaxis (Grade 2C). [...] For thoracic surgery patients who are at high risk for major bleeding, we suggest use of mechanical prophylaxis, preferably with optimally applied IPC, over no prophylaxis until the risk of bleeding diminishes and pharmacologic prophylaxis may be initiated (Grade 2C)." <sup>G4 p.125</sup>

#### 6. IPC for venous thromboembolism prophylaxis after Stroke/ in Neurosurgery

IPC is recommended in all patients, with or without GEC stockings. For stroke patients, where the bleeding risk outweighs the benefit of pharmacological prophylaxis, IPC combined with GEC is recommended. IPC is recommended for haemorrhagic stroke patients, while ischemic stroke patients can use IPC or LMWH subcutaneously.

- "Recommendations for prophylaxis in this group [patients after neurosurgery; author's note] consist of the use of IPC in all patients with or without GEC stockings (level of evidence: high). Addition of LMWH is associated with an increase of efficacy (level of evidence: high)." <sup>G1 p.167</sup>
- "In patients with suspected or proven haemorrhagic [sic] stroke and in those with ischemic stroke in whom the risks of prophylactic anticoagulant therapy are perceived to outweigh the benefits, IPC combined with GEC is recommended (level of evidence: moderate)." <sup>G1 p.175</sup>
- "We suggest thromboprophylaxis with IPC (Grade 2C) [in patients with non-traumatic intra cranial haemorrhage; author's note]. We recommend the application of IPC on admission, used continuously (except when the patient is actually walking) and monitored frequently to optimize compliance (Grade 1C)." <sup>G2 p.80</sup>
- "For patients undergoing spinal surgery with additional risk factors (limited mobility, active cancer, complex surgical procedure), we [ESA VTE Guidelines Task Force; author's note] recommend starting mechanical thromboprophylaxis with IPC preoperatively (Grade 1C), and we suggest the addition of LMWH postoperatively when the risk of bleeding is presumed to be decreased (Grade 2C)." <sup>G2 p.80</sup>
- "VTE prophylaxis options for ischemic stroke patients are IPC use or pharmacological regimens with SC LMWH. IPC is recommended for haemorrhagic [sic] stroke patients." <sup>G3 p.15</sup>
- "In patients with acute ischemic stroke and restricted mobility, we suggest prophylactic-dose SC UFH [unfractionated heparin; author's note] or LMWH or intermittent pneumatic compression devices over no prophylaxis (Grade 2B). [...] In patients with acute primary intracerebral haemorrhage [sic] and restricted mobility, we [American College of Chest Physicians Antithrombotic Therapy and Prevention of Thrombosis Panel; author's note] suggest prophylactic-dose SC heparin (UFH or LMWH) started between days 2 and 4 or intermittent pneumatic compression devices over no prophylaxis (Grade 2C)." <sup>G4 p.335</sup>

## 7. IPC for venous thromboembolism prophylaxis in Obstetrics/Gynaecology/Urology

In high-risk patients, pharmaceutical prophylaxis or IPC is recommended throughout the hospital stay. Mechanical thromboprophylaxis should be considered in patients with high bleeding risk.

- *“Moderate-risk patients: LDUH (5000 IU, 12 h), LMWH (initiated and dosed according to labelling) or IPC are recommended (level of evidence: high). LMWH, is the preferred method because it has the advantage of once daily injection and is less likely to cause HIT [heparin induced thrombocytopenia; author’s note]. IPC is the method of choice in patients with a high risk of bleeding (level of evidence: high). High-risk patients: LMWH (initiated and dosed according to labelling) (level of evidence: high), fondaparinux (level of evidence: low), LDUH (5000 IU 8 h) (level of evidence: high) or IPC (throughout hospital stay) (level of evidence: moderate) are recommended. LMWH or LDUH combined with IPC or GEC stockings provide optimal prophylaxis (level of evidence: moderate).”* <sup>G1 p.134</sup>
- *“Woman with gynaecological cancers have a high risk of VTE, perioperative thromboprophylaxis with LMWH is recommended. In patients with high bleeding risk, mechanical thromboprophylaxis should be considered.”* <sup>G3 p.15</sup>

## 8. IPC for venous thromboembolism prophylaxis in Surgery in Elderly/Recommendations in general:

Multi-faceted interventions, including pneumatic compression devices, are recommended for VTE prophylaxis in elderly and frail patients. Especially in patients with increased risk of bleeding IPC is recommended. Combined modalities (mechanical/ and pharmacological prophylaxis) should be considered in all high-risk surgical patients.

- *“Combined modalities (IPC and pharmacological prophylaxis) should be considered in all high-risk surgical patients (level of evidence: high).”* <sup>G1 p.187</sup>
- *“In patients with inherited bleeding disorders undergoing major surgery, we suggest mechanical thromboprophylaxis, (Grade 2C), especially in factor VII deficiency (Grade 1C).”* <sup>G2 p.81</sup>
- *“We recommend multi-faceted interventions for VTE prophylaxis in elderly and frail patients, including pneumatic compression devices, LMWH [and/or direct oral anticoagulants (DOACs) after knee or hip replacement] (Grade 1C).”* <sup>G2 p.78</sup>
- *“We suggest the use of specific mechanical measures (IPC devices) in patients with an increased bleeding risk (Grade 2C) [For patients undergoing a low-risk procedure with additional risk factors; author’s note].”* <sup>G2 p.78</sup>
- *“We suggest no prophylaxis or the use of IPC in patients with a platelet count less than 50 x10<sup>9</sup> l<sup>-1</sup> and a high-risk of bleeding (Grade 2C).”* <sup>G2 p.79</sup>
- *“In patients with contra-indications to pharmacological thromboprophylaxis, we recommend the use of mechanical prophylaxis with IPC or GCS (Grade 1B) and suggest the use of IPC over GCS (Grade 2B).”* <sup>G2 p.82</sup>
- *“For acutely ill hospitalized medical patients at increased risk of thrombosis who are bleeding or at high risk for major bleeding, we suggest the optimal use of mechanical thromboprophylaxis with graduated compression stockings (GCS) (Grade 2C) or intermittent pneumatic compression (IPC) (Grade 2C), rather than no mechanical thromboprophylaxis.”* <sup>G4 p.105</sup>

# Evidence based Recommendations of IIC/ VADOPlex Application by OPED GmbH

## Duration of VADOPlex application

For thrombosis prophylaxis, VADOPlex should be applied daily between 6 to 18 h depending on the degree of mobilization and the use of further prophylactic measures.<sup>G4</sup>

## No graduated compression stockings

The additional use of GCS reduces peak blood flow velocity and therefore the effect of IIC.<sup>9</sup> Hence, the sole use of IIC (VADOPlex) does not reduce the efficiency of DVT prophylaxis but enhances patient compliance.<sup>10</sup>

## Recommended patient age

Young patients aged 14 and over can use VADOPlex. It is critical to ensure that the pad is positioned correctly. The attending physician decides at what age the VADOPlex is used.

## Risk stratification

With a comprehensive risk assessment, the most appropriate thrombosis prophylaxis can be selected without undue burden on the patient.<sup>11</sup> Thus, IIC can be an alternative for chemical thromboprophylaxis in low-risk patients.

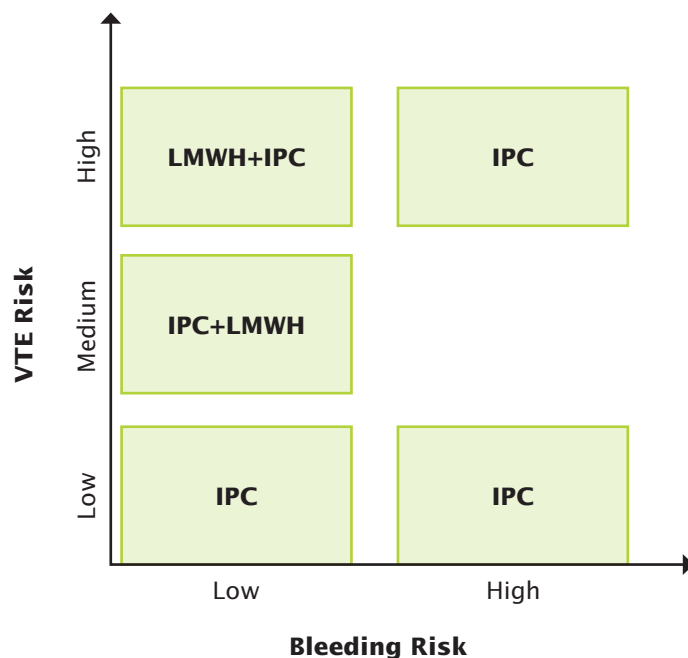


Fig. 1: Graphical summary of thrombosis prophylactic measures depending on VTE risk and bleeding risk according to evidence-based clinical practice guideline on Antithrombotic Therapy and Prevention of Thrombosis (9th ed.) by American College of Chest physicians<sup>G4</sup>

## Guidelines

### **G1. PREVENTION AND TREATMENT OF VENOUS THROMBOEMBOLISM International Consensus Statement**

Nicolaides, A. N., Fareed, J., Kakkar, A. K., Comerota, A. J., Goldhaber, S. Z., Hull, R., Myers, K., Samama, M., & Fletcher, J. (2013). Prevention and treatment of venous thromboembolism. *International Angiology: A Journal of the International Union of Angiology*, 32(2).

### **G2. European Guidelines on perioperative venous thromboembolism prophylaxis**

Afshari, A., Ageno, W., Ahmed, A., Duranteau, J., Faraoni, D., Kozek-Langenecker, S., Llau, J., Nizard, J., Solca, M., Stensballe, J., Thienpont, E., Tsiroidis, E., Venclauskas, L., & Samama, C. M. (2018). European Guidelines on perioperative venous thromboembolism prophylaxis: Executive summary: Executive summary. *European Journal of Anaesthesiology*, 35(2), 77–83. <https://doi.org/10.1097/EJA.0000000000000729>

### **G3. Asian venous thromboembolism guidelines: updated recommendations for the prevention of venous thromboembolism**

Liew, N. C., Alemany, G. V., Angchaisuksiri, P., Bang, S. M., Choi, G., Silva, D. A. de, Hong, J. M., Lee, L., Li, Y. J., Rajamoney, G. N., Suviraj, J., Tan, T. C., Tse, E., Teo, L. T., Visperas, J., Wong, R. S., & Lee, L. H. (2017). Asian venous thromboembolism guidelines: Updated recommendations for the prevention of venous thromboembolism. *International Angiology : A Journal of the International Union of Angiology*, 36(1), 1–20. <https://doi.org/10.23736/S0392-9590.16.03765-2>

### **G4. Antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians ACCP. Evidence-Based Clinical Practice Guidelines**

Guyatt, G. H., Akl, E. A., Crowther, M., Gutterman, D. D., & Schünemann, H. J. (2012). Executive summary: Antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. *CHEST*, 141(2 Suppl), 7S-47S. <https://doi.org/10.1378/chest.1412S3>

## References

- [1] Gardner, A. M. C., & Fox, R. H. (2001). *The venous system in health and disease* (3. ed., rev). Biomedical and health research: Vol. 28. IOS Press.
- [2] Stitham, J., Midgett, C., Martin, K. A., & Hwa, J. (2011). Prostacyclin: An inflammatory paradox. *Frontiers in Pharmacology*, 2, 24. <https://doi.org/10.3389/fphar.2011.00024>
- [3] Riddell, D. R., & Owen, J. S. (1999). Nitric oxide and platelet aggregation. *Vitamins and Hormones*, 57, 25–48. [https://doi.org/10.1016/s0083-6729\(08\)60639-1](https://doi.org/10.1016/s0083-6729(08)60639-1)
- [4] Gryglewski, R. J. (1980). Prostaglandins, platelets, and atherosclerosis. *CRC Critical Reviews in Biochemistry*, 7(4), 291–338. <https://doi.org/10.3109/10409238009105464>
- [5] Moncada, S., & Vane, J. R. (1979). The role of prostacyclin in vascular tissue. *Federation Proceedings*, 38(1), 66–71. <https://eurekamaq.com/research/029/415/029415157.php>
- [6] Cockrell, A., Laroux, F. S., Jourd'heuil, D., Kawachi, S., Gray, L., van der Heyde, H., & Grisham, M. B. (1999). Role of inducible nitric oxide synthase in leukocyte extravasation in vivo. *Biochemical and Biophysical Research Communications*, 257(3), 684–686. <https://doi.org/10.1006/bbrc.1999.0484>
- [7] Pirahanchi, Y., Marsidi, J. L., & Brown, K. N. (2023). StatPearls: Physiology, Endothelial Derived Relaxation Factor.
- [8] Schini-Kerth, V. B. (1999). Vascular biosynthesis of nitric oxide: Effect on hemostasis and fibrinolysis. *Transfusion Clinique Et Biologique : Journal De La Societe Francaise De Transfusion Sanguine*, 6(6), 355–363. [https://doi.org/10.1016/s1246-7820\(00\)88980-6](https://doi.org/10.1016/s1246-7820(00)88980-6)
- [9] Warwick, D. J., Pandit, H., Shewale, S., & Sulkin, T. (2002). Venous impulse foot pumps: Should graduated compression stockings be used? *The Journal of Arthroplasty*, 17(4), 446–448. <https://doi.org/10.1054/arth.2002.31248>
- [10] Pitto, R. P., & Young, S. (2008). Foot pumps without graduated compression stockings for prevention of deep-vein thrombosis in total joint replacement: Efficacy, safety and patient compliance. A comparative, prospective clinical trial. *International Orthopaedics*, 32(3), 331–336. <https://doi.org/10.1007/s00264-007-0326-9>
- [11] Gill, S. K., Pearce, A. R., Everington, T., & Rossiter, N. D. (2020). Mechanical prophylaxis, early mobilisation and risk stratification: As effective as drugs for low risk patients undergoing primary joint replacement. Results in 13,384 patients. *The Surgeon : Journal of the Royal Colleges of Surgeons of Edinburgh and Ireland*, 18(4), 219–225. <https://doi.org/10.1016/j.surge.2019.11.002>

## Abbreviations

<b>DVT</b>	Deep Vein Thrombosis
<b>EDRF</b>	Endothelium-Derived Relaxing Factor
<b>FIT</b>	Foot Impulse Technology
<b>GEC</b>	Graduated Compression Stockings
<b>HFS</b>	Hip Fracture Surgery
<b>IIC</b>	Intermittent Impulse Compression
<b>IPC</b>	Intermittent Pneumatic Compression
<b>IPCD</b>	Intermittent Pneumatic Compression Device
<b>LDUH</b>	Low-Dose Unfractionated Heparin
<b>LMWH</b>	Low Molecular Weight Heparin
<b>NO</b>	Nitric Oxide
<b>PAOD</b>	Peripheral Arterial Occlusive Disease
<b>PGI2</b>	Prostaglandin I2
<b>SC</b>	Subcutaneous
<b>THA/THR</b>	Total Hip Arthroscopy/Total Hip Replacement
<b>TKA/TKR</b>	Total Knee Arthroscopy/Total Knee Replacement
<b>UFH</b>	Unfractionated Heparin
<b>VKA</b>	Vitamin K Antagonists
<b>VTE</b>	Venous Thromboembolism

