

Developing a neurosurgery venous thromboembolism (VTE) guideline – achieving national consensus in New Zealand, a systematic approach.

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Abstract

Patients undergoing neurosurgical operations are at risk of venous thromboembolism (VTE), which includes deep vein thrombosis (DVT) and pulmonary embolism (PE). This risk requires assessment alongside the risk of bleeding, and these two complications inform decision making around the use of pharmacological VTE prophylaxis. Whilst mechanical devices such as intermittent pneumatic compression devices (IPCDs) are widely utilised from prior to surgery until the patient is mobile postoperatively, the decision to initiate chemoprophylaxis is more complex, due to the risk of post-operative haemorrhage in this high-risk population. Furthermore, the diagnosis of VTE makes treatment decisions more difficult, due to the potential for increased bleeding with therapeutic anticoagulation in this population. Preventative measures for VTE in the neurosurgical population vary significantly worldwide, nationally in New Zealand and within neurosurgery departments, however prevention is fundamental as treatment of VTE has increased risks for patients, is costly and causes longer hospital stays. Prevention really is better than cure. A team approach, integrating nurses and doctors is fundamental in the prevention, diagnosis and treatment of VTE. This article reviews the journey to a VTE National consensus guideline in New Zealand.

Key words: Neurosurgery, Venous Thromboembolism, Pulmonary Embolism, Deep Vein Thrombosis, Bleeding risk

Introduction

Virchow's triad was described in 1856, to define the three factors that contribute to PEs and DVTs. These include stasis of blood, hypercoagulability of blood and vessel wall injury (Kushner et al, 2022). In neurosurgery, the risk of VTE must be considered alongside the risk of haemorrhage, in the context of individual circumstances. A guideline is a tool to guide clinicians in the care and management of patients, rather than a rigid policy. A guide-

line can be adapted to the unique situation of each individual patient and informs, rather than dictating clinical practice. Reviewing and consolidating the applicable evidence led to the development of a national VTE guideline in New Zealand.

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VTE Risk Factors

Fundamentally, the VTE risk factors outlined in Table 1, determine whom chemoprophylaxis

is should be started for. Risk factors have been thoroughly explored in the European guidelines on perioperative venous thrombo-

Table 1 - Risk Factors (Most common risk factors in red)

Article	Number of patients, type of study	Risk factors
Parmontree et al, 2022	350 neurosurgical patients, single centre	Lack of postoperative ambulation Non-Asian ethnicity Septic shock complication
Buchanan et al, 2019	89,450 non emergent craniotomies, national readmission database assessing predictors for readmission due to VTE	Advancing age Increasing length of stay Steroid use Transfer to institutional care facility
Rinaldo et al, 2020	1622 patients, craniotomy for tumour resection, single centre	Advancing age Motor deficit Postoperative intracranial haemorrhage Prolonged intubation or reintubation were independently associated with increased VTE
Faraoni et al, 2018	European guidelines on perioperative venous thromboembolism prophylaxis: Neurosurgery	Malignancy Length of procedure Reduced mobility
Heim et al, 2024	European guidelines on perioperative venous thromboembolism prophylaxis: first update	For cranial surgery: Advancing age Motor deficit Malignant tumour Long duration of surgery Increased length of hospital stay History of VTE Obesity Meningioma Low Karnofsky score of <80 For spinal surgery: Advancing age History of VTE Presence of malignancy Immobility Diabetes Elevated pre-operative D-dimer levels Major intraoperative bleeding Long or extensive interventions involving cervical or thoracic levels Spinal trauma Spinal tumour
Anderson et al, 2019	American Society of Haematology 2019 guidelines for management of VTE	Reduced mobility
Rolston et al, 2014	Retrospective data analysis from American College of Surgeons NSQIP database	Active cancer Advancing age Long duration of surgery Delayed ambulation Increased length of hospital stay Motor deficit, specifically paresis Inherited thrombophilia

embolism prophylaxis (Heim et al, 2024). The most common reported risk factors for both cranial and spinal surgery include advancing age, immobility, motor deficit, increased length of hospital stay, long duration of surgery >8 hours and presence of malignancy (Anderson et al, 2019; Buchanan et al, 2019, Faraoni et al, 2018; Heim, et al 2024; Parmontree et al, 2022; Rinaldo et al, 2021; Rolston et al, 2014). Other cranial and spinal risk factors are history of VTE and obesity, BMI >30. Cranial surgery risk factors also specifically include presence of meningioma and a low Karnofsky performance status score of <80 (Heim et al, 2024). Spinal surgery risk factors include major intraoperative bleeding, extensive interventions involving cervical or thoracic levels, spinal trauma, spinal tumours, diabetes and elevated pre-operative D-dimer levels (Heim et al, 2024). Other considerations include direct release of pro-coagulants such as tissue factor from brain tissue, increased inflammation, dehydration and prolonged length of ICU stay (Faraoni et al, 2018; Parmontree et al, 2022; Byrne et al, 2022; Yepes-Nuñez et al, 2020; Hotoleanu, 2020; Lieber et al, 2016; Peng et al, 2023).

Steroid use is an associated risk factor that commonly appears with malignancy. Steroid or immunoglobulin administration result in a pro-coagulant state, increasing the tendency towards clot formation. The inflammation that warranted steroid use also causes haemostatic changes and inhibits fibrinolytic activity in tissues and blood vessels, increasing the risk of clot formation (Buchanan et al, 2019; Lieber et al, 2016). Additionally, obesity and immobility are not uncommonly associated and present in the same patient, causing raised intra-abdominal pressure, a chronic low-grade inflammatory state, impaired fibrinolysis, and

higher levels of fibrinogen, von Willebrand factor and factor VIII. This leads to a pro-thrombotic state and elevated risk of VTE (Hotoleanu; 2020).

Multidisciplinary Approach

A team approach including physiotherapists, occupational therapists, nurses, and doctors, is fundamental to preventing and diagnosing VTE (Kushner et al, 2022). The gold standard for post-operative care for all neurosurgical patients is to ensure early mobilisation and prevent dehydration (Faraoni et al, 2018; NICE, 2018). In VTE prevention, the role of the nurse, physiotherapist and occupational therapist is central to optimising mobility and actively delivering mechanical and chemical prophylaxis. The role of the nurse and doctor is vital for preventing dehydration and recognising symptoms of VTE to inform diagnosis and prompt treatment. Including different specialities, predominantly neurosurgeons and haematologists, can further inform decision making and ensure high standards of practice through a guideline.

Mechanical Prophylaxis

Three CLOTS trials inform practices around mechanical VTE prophylaxis by demonstrating superiority of IPCDs. In CLOTS trial 1, n = 2518, skin breakdown, necrosis, ulcers and blisters occurred in 5% of the compression stockings cohort, compared to 1% in non-stockings cohort. DVT rates were similar in both groups, 10% versus 10.5% (CLOTS trial collaboration, 2009). CLOTS trial 2 showed DVT rates were higher with knee length stockings compared with thigh length stockings, however the trial was prematurely stopped due to patient harm through skin breakdown (CLOTS trial collaboration, 2010). CLOTS trial

3, n = 2876, compared the DVT rate in patients with IPCDs, 8.5% and without IPCDs, 12.1%, with a risk reduction rate of 3.6%. In this instance, skin breakdown with IPCDs was 3%, in this instance compared to 1% in the non-IPCD group. There was a 2% falls risk in both groups, though notably 1% had stockings and IPCDs and 3% had stockings and no IPCDs (CLOTS trial collaboration, 2013).

IPCDs are considered superior to graduated compression stockings and should be applied for up to 18 hours, when sitting in a chair or bed and removed for ambulating (Faraoni et al, 2018; NICE, 2018; Anderson et al, 2019). Skin complications such as ulcers, skin breaks and necrosis, are four times more likely with graduated compression stockings than IPCDs (Wang et al, 2021). It is also more difficult to remove compression stockings for skin

inspection; hence identification of damage can be delayed. However, in clinical practice anti-embolism stockings continue to be used in some areas due to inconsistent compliance with IPCDS. Nonadherence may be related to patient intolerance or discomfort, agitation, increased falls risk or failure to reapply once removed. This has not been explored in the literature. Furthermore, IPCDS have to be connected to a plug so difficulty removing them for mobilising can be a problem.

Three evidence based international guidelines, outlined in Table 2, provide guidance on VTE prophylaxis. They specify the chemoprophylaxis agent low molecular weight heparin (LMWH), which is most commonly enoxaparin sodium. The European guideline has been updated in 2024, by Heim et al.

Table 2 – International Guidelines for VTE Prophylaxis in Neurosurgery

	European (Heim et al, 2024)	European (Faraoni et al, 2018)	American (Anderson et al, 2019)	NICE UK guidelines (2018)
Cranial	IPCDs LMWH from 24 – 72 hours Non-traumatic intracerebral haemorrhage (ICH), 48 – 96 hours once no blood expansion has been es-	IPCDs LMWH after 24 hours Early mobilisation	IPCDs If high VTE risk/ reduced mobility, LMWH as soon as risk of bleed- ing is reduced	IPCDs LMWH from 24 – 48 hours for 7 – 30 days, or until mobilising, or until discharge
Spinal	Spinal cord injury, chemoprophylaxis within 48 hours following trauma or surgery 3 to 6 months of chemoprophylaxis after cord injury with neurological deficit,	LMWH after 24 hours If additional VTE risk factors are present, commence as soon as risk of bleed-		LMWH after 24 – 48 hours for elective surgery
TBI (Traumatic brain injury)	LMWH 24 hours post injury if no surgical intervention and no progression of intracranial haemorrhage on CT scan at 24 hours Early LMWH within 48 hours post injury If urgent surgical interventions performed, delay chemoprophylaxis on a case-by-case basis, balancing risks of haemorrhage and VTE Recommend against routine			

Chemoprophylaxis

In an audit, registered with the audit department, of neurosurgical patients at a hospital in New Zealand, clinical records were identified and matched with data from our Pyxis Med Station. All records were examined between June 2023 – June 2024, $n = 1184$ and the background rate of VTE was 1.35%, $n = 16$. VTE occurred in patients with a range of conditions, with subarachnoid haemorrhage constituting the highest proportion, $n = 3$. Of the 16 VTE occurrences, 9 had a PE, 3 had a DVT, and 1 had a PE and a DVT. 141 patients, or 11.9% were documented to have been commenced on prophylactic enoxaparin, and the rate of bleeding was 0%. Of the patients on treatment dose enoxaparin for their PE or DVT, only one patient with a melanoma metastasis developed an intracerebral haemorrhage (ICH) 12 hours after their first therapeutic enoxaparin injection for PE. This was 5 weeks after surgery in their peripheral hospital and they required further surgery due to the ICH.

Therapeutic anticoagulation potentially increases the risk of bleeding for post-operative neurosurgery patients but there is limited evidence for this, as recent neurosurgery is typically an exclusion criterion for anticoagulation studies (de Melo Junior et al, 2020). A systematic review did report bleeding rates with VTE treatment with the mean ICH after commencing anticoagulant at 6.8 days and the rate was 7.96% between 0-30 days after starting anticoagulant treatment, 11.61% between 0-10 days and 9.15% between 10-30 days (Gibbon et al, 2025). This is a lot higher than prophylaxis rates as outlined in the table below of less than 2%. It is important to high-

light that most of these papers demonstrate a rate of less than 1% with prophylactic treatment; of which is similar to the rate of risk of bleeding post operatively (Shani, 2020). This demonstrates prevention really is better than cure. However, this review did not specify types of anticoagulation and suggests a mixed approach. Rigorous VTE prophylaxis strategies are beneficial, to avoid VTE and potentially reduce post-operative bleeding by avoiding therapeutic anticoagulation. In New Zealand some neurosurgeons were concerned about the bleeding risk from prophylactic enoxaparin, and this was a barrier to starting it, hence it was necessary to determine the bleeding risk. The research on bleeding rates from chemoprophylaxis is summarised in Table 3, all of which showed no significant rates of haemorrhage. There was one retrospective study ($n=1622$) of patients with craniotomy for brain tumour that did document one case of progression of a clinically significant postoperative haemorrhage, 24 hours after receiving prophylactic LMWH, but this was not statistically significant (Rinaldo et al, 2021).

Discussing Consensus

To illustrate the differing VTE prevention practices amongst individual neurosurgical units around Australasia, some hospitals were using surgeon preference, one was using a tick box tool, and another was using a traffic light coded system. One hospital started all neurosurgical patients on prophylactic enoxaparin on day 1 post operatively. Simplification and education were key factors to developing a tool or guideline that would work nationally throughout New Zealand. New Zealand has the advantage of a small population of 5.2 million people, and only 5 regional neurosurgical units with 24 neurosurgeons nationwide, 7

Table 3 - Summary of studies

	Study Type/ Patients	Timeframe/ Condition	Outcome
Wagar et al, 2024	Prospective database review 1551 patients	Administered day 1 and 2 Skull base	18 intracranial haematomas, 0.8%; Chemoprophylaxis did not significantly increase the risk of intracranial haematoma, $p > 0.99$. Initiating day 1 versus day 2 resulted in similar rates of haematoma.
Briggs et al, 2022	Retrospective review 1087 patients	Administered within 72 hours Brain tumours	Initiating chemoprophylaxis with subcutaneous enoxaparin sodium 40mg once daily, within 72 hours of surgery is safe, while reducing the risk of developing lower extremity
Spano et al, 2020	Systematic review of randomised controlled trial (RCT), prospective observational studies, retrospective reviews and systematic reviews	Administered within 24 – 72 hours TBI with ICH	Early initiation of chemoprophylaxis at 24 – 72 hours is associated with reduced VTE incidence and no increase in intracranial haemorrhage, with a stable interval CT prior to initiating, in 14 out of 17 studies.
Lu et al, 2020	Systematic review/meta-analysis 5036 patients, 11 studies	Administered before versus after 72 hours TBI with ICH	Chemoprophylaxis initiated before 72 hours compared with after 72 hours – no statistically significant difference in incidence of haemorrhage progression but VTE incidence significantly less if initiated before 72
Paciaroni et al, 2021	Systematic review/meta-analysis including RCT 4609 patients	Administered after 72 hours ICH	Reduction in VTE but no increase in rate of haematoma. Chemoprophylaxis is safe in acute ICH.
Yepes - Nuñez et al, 2020	Systematic review of RCTs and non-randomised controlled studies 10 studies	General neurosurgery	No effect of chemoprophylaxis on mortality. No increase in incidence of major bleeding in 7 RCTs, compared with non-pharmacologic VTE prophylaxis (relative risk, 1.57; 95% confidence interval, 0.70 – 3.50)
Shani, 2020	Systematic review of RCTs and observational studies 2811 patients	Administered from 12 hours to day 5-6 General neurosurgery	Incidence of post operative bleeding and haematoma on chemoprophylaxis was 0.4-1.8%, which is within the limits of usual post operative bleeding.
Ellenbogen et al, 2021	Systematic review/meta-analysis of RCTs and retrospective trials	Spinal surgery	Spinal epidural haematomas and significant bleeding are rare, and incidence is similar with or without chemoprophylaxis. Significant decrease in post op DVTs with chemoprophylaxis
Rinaldo et al, 2021	Retrospective study 1622 patients	Mean initiation at 4.6 days, standard deviation 3.8 Brain tumours	192 patients received LMWH chemoprophylaxis, 11.8%; 30 instances of clinically significant postoperative haemorrhage occurred, 1.9%; Only 1 haemorrhage occurred after initiation of LMWH chemoprophylaxis, 0.1%.

nursing educators and 7 clinical nurse specialists who all work collaboratively with one another. A national meeting was arranged to discuss this issue.

There are a range of practices nationwide for VTE prevention, including variable strategies within hospitals. All units were using IPCDs, with most using stockings in addition to IPCDs. Most centres used enoxaparin as their chemoprophylaxis agent of choice, and the remainder use unfractionated heparin (UFH) injections.

Questions for discussion at the national neurosurgery meeting, after presenting the above findings, are outlined in Table 4.

Table 4 – Questions for Consensus

- Can it be agreed to start IPCDs on admission or day of surgery and removed once mobilising frequently to the toilet independently, with a stick or walking frame?
- Can it be agreed to consider chemical VTE prophylaxis at 24 – 48 hours post operatively, with satisfactory post-operative imaging?
- Can it be agreed to consider chemical prophylaxis at 72 hours post moderate to severe traumatic brain injury, with satisfactory interval imaging?
- Can it be agreed to start prophylactic enoxaparin or unfractionated heparin?
- Can we agree on when to stop prophylactic enoxaparin or unfractionated heparin?
- Can we utilise a guideline to manage our approach and guide decision making, by assessing risk factors?
- Should the consultant decide on commencing prophylactic enoxaparin or can a registrar make the decision?

The outcome of the meeting was that national consensus was reached with the following criteria. The word 'consider' was intentionally utilised to use to allow for individualisation of the guideline based on clinical experience. Agreeing on a guideline to guide practice rather than a fixed policy was also key to achieving consensus. New Zealand is the first country in the world to reach consensus on VTE prophylaxis practice in neurosurgery (see appendix 1).

Conclusion

VTE prevention is important to prevent the need for therapeutic anticoagulation, although the risk of bleeding can often delay this. There are a variety of VTE prevention practices that exist in neurosurgery, and it is necessary to ensure that considering this is a priority of all members of the team. The risk factors for cranial and spinal surgery include active cancer, previous VTE, patients who are immobile or have a motor deficit, prolonged surgery >8 hours, multiple major surgeries, BMI >30 with the addition of multitrauma for patients with TBI.

Nurses are fundamental to the prevention of VTE through early mobilisation, prevention of dehydration and the management of mechanical and chemical prophylaxis as well as coordinating a multidisciplinary approach. The risk of pressure injury exists with stockings but SCDs need to be in place for 18 hours a day as per manufacturer. This can be difficult to manage with patients mobilising and risks weighed up for agitated patients or in high risk of falls patients, further research is needed and a solution for this should be explored. A

guideline ensures structure, ensuring all staff understand the importance of VTE prevention whilst allowing for consideration of individual decision making. VTE prevention should be at the forefront of decision making for all members of the multidisciplinary team to prevent a need for treatment of VTE as prevention really is better than cure.

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Appendix 1 - National Consensus Neurosurgery VTE Prophylaxis Guideline New Zealand**Principles for Guideline**

Consider each patient individually, encompassing their unique risk factors and circumstances

Early mobilisation is key

Prevent dehydration

Intermittent pneumatic compression devices for 18 hours per day when in bed/chair

Consider risk of harm for patients with high falls risk and agitation. Can be stopped on discharge or when mobilising frequently around the ward. Compression stockings are not required.

Risk Factors for Consideration for Cranial and Spinal Patients

Patients with one or more risk factor should be considered for chemoprophylaxis

Active Cancer

Previous VTE

Patients who are immobile or have a motor deficit

Prolonged surgery >8 hours

Multiple major surgeries

BMI >30

Risk Factors for Consideration for Traumatic Brain Injuries Patients (TBI)

Patients with one or more risk factor should be considered for chemoprophylaxis

Active Cancer

Previous VTE

Patients who are immobile or have a motor deficit

Prolonged surgery >8 hours

Multiple major surgeries

BMI >30

Multitrauma

Management

Consider prophylactic enoxaparin for cranial or spinal surgery patients at 24 – 48 hours post operatively

Consider prophylactic enoxaparin for traumatic brain injury patients at 24 – 72 hours post operatively or post injury, if not requiring surgery.

Stop prophylactic enoxaparin for 12 hours prior to drain removal or further surgery

Prophylactic enoxaparin can continue for 7 days, until discharge or for 30 days in the context of malignancy

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