REVIEW ARTICLE

Updates on Prophylaxis for Deep Venous Thrombosis and Venous Thromboembolism

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ABSTRACT

Purpose To concisely present recommendations and guidelines for venous thromboembolism (VTE) treatment and prevention for common subgroups of surgical patients as a comprehensive reference for clinical surgical practice.

Methods Thorough literature review, including the consensus guidelines and recommendations of various professional surgical societies, was evaluated and conglomerated to provide a comprehensive reference for practicing surgeons. Common surgical patient subgroups were investigated for differing recommendations. Recommendations, guidelines, and resources were tabulated into user-friendly formats for easy reference purposes.

Results Substantial updates have been made to the recommendations for VTE prevention and treatment. The American College of Chest Physicians (ACCP) have updated their VTE recommendations. The Eastern Association for the Surgery of Trauma has also released updated recommendations regarding VTE management. The Society of American Gastrointestinal and Endoscopic Surgeons has recalled their own specific recommendations for VTE treatment and prophylaxis in support of tenth edition of the ACCP guidelines on the subject.

Conclusions VTE affects up to 25% of hospitalized patients, with up to 30% of those experiencing complications. Risk stratification is important in choosing therapy for prevention and management of VTE. Management of VTE depends on precipitating factors

and future risk of VTE progression versus bleeding. Low-molecular-weight heparin is the preferred anticoagulant for initial treatment of VTE. The tenth edition of ACCP VTE guidelines provides comprehensive management recommendations.

Introduction:

Venous thromboembolism (VTE), which includes deep venous thrombosis (DVT) and pulmonary embolism (PE) occurs in up to 25% of those hospitalized, a population vulnerable to the elements of Virchow's Triad (stasis, hypercoagulability, and endothelial injury).[1] Although guidelines are in place to mitigate this, any ambiguity can lead to significant morbidity and mortality, particularly because 50% of all DVTs are asymptomatic, with approximately 30% having additional complications.[2]

In some instances, a DVT is self-limited, and resolves when the instigating disease process has been treated. However, in more than 1/3 of patients it can lead to a PE, which can in turn precipitate death in up to 34% of patients.[3] If the embolus in the lung fails to completely dissolve, chronic pulmonary hypertension may eventually occur, causing chronic shortness of breath and varying degrees of heart failure.

The Surgeon General's First Call to Action to Prevent Deep Vein Thrombosis and Pulmonary Embolism came in 2008 and estimated 350,000 to 600,000 Americans each year are afflicted by thromboembolic disease, with at least 100,000 attributable deaths.[3] This is estimated to be the number one cause of preventable death in hospitalized patients. To combat this risk, the Surgical Care Improvement Project encouraged chemoprophylaxis administration within 24 hours of an operation. The Joint Commission also supports this ideology, recommending all surgical patients receive anticoagulation, which is congruent with measures adopted by the Centers for Medicare and Medicaid Services in 2009.[4]

Despite these initiatives and mandates, VTE prophylaxis is underutilized in the United States. A 2009 analysis revealed that only 34% of high-risk patients receive appropriate prophylaxis.[5] Further studies revealed that only 58.5% of surgical patients received VTE prophylaxis.[4] The reasons delineated for recommendation nonadherence included fear of anticoagulant-associated bleeding, lack of VTE awareness, generalization of recommendations rather than patient subset specific guidelines, and difficulty of reinforcing protocols because of effort involved in individual risk assessment.

This is particularly significant, because these patients face complex medical issues that challenge the way in which they live their lives. Symptomatic patients with a PE have a higher risk of recurrent VTE than those with symptomatic VTE alone. There is a higher recurrence rate of VTE in men than women (20% vs 6%, relative risk 3.6).[2,6] Chronic venous insufficiency (CVI) may develop after DVT. CVI is also known as post-thrombotic syndrome (PTS), which

can occur months to years following a thrombotic event in up to 30% of patients. CVI results from a thrombus injuring or destroying one or more of the venous valves in deep veins of the leg, resulting in leg pain and edema with prolonged standing, accompanied by mild to extensive varicose veins, skin breakdown, ulceration, and eventually skin pigmentation changes. These patients may also develop chronic venous stasis ulcers, which can be complex to manage.[6-8] The need for lifestyle-altering vigilance is often required to avoid and manage the potential impact of other risk factors, ranging from routine activity such as lengthy travel, to significant events like surgery and trauma.

Table 1 Bleeding Risk Factors

Age>65
Age>75
Previous bleeding
Cancer
Metastatic cancer
Renal failure
Thrombocytopenia
Previous stroke
Diabetes
Anemia
Antiplatelet therapy
Poor anticoagulant control
Comorbidity and reduced functional capacity
Recent surgery
Frequent falls
Alcohol abuse
NSAIDS

Categorizations of Bleeding Risk

	Estimated Absolute Risk of Major Bleeding		
	Low 0 Risk Factors	Moderate 1 Risk Factor	High ≥2 Risk Factors
Anticoagulation 0-3 months			
Baseline risk %	0.6	1.2	4.8
Increased risk %	1.6	2	8
Total risk %	1.6	3.2	12.8
Anticoagulation > 3 months			
Baseline risk %/year	0.3	0.6	≥2.5
Increased risk %/year	0.5	1	≥4
Total risk %/year	0.8	1.6	≥6.5

List of bleeding risk factors. Risk of major bleeding as stratified by bleed risk category and duration of anticoagulation.

BLEEDING RISK

The International Medical Prevention Registry on Venous Thromboembolism investigators developed a scoring system to calculate the risk of bleeding in medical patients, depicted in Table 1.6 Scores ≥ 7.0 were associated with a 7.9% risk of any bleeding and a 4.1% risk of major bleeding.6 If the risk of bleeding is greater than the risk of VTE, then chemical prophylaxis should be avoided.

The tenth edition of the American College of Chest Physicians (ACCP) guidelines includes a consideration of the bleeding risk in patients with thromboembolic disease requiring anticoagulation. In general, for those with high bleeding risk, 3 months of anticoagulative therapy was recommended over more prolonged treatment. Major bleeding was characterized with an annual risk of ≥6.5%. Table 1 includes the risk factors for these bleeding categories, with data from the ninth Edition of the Antithrombotic Guidelines incorporated. [6, 10-11]

CHOICE OF ANTICOAGULANT

Table 2 summarizes ACCP recommendations for both initial and long-term treatment of patients with varying contributing factors. Patients with a malignant process should undergo anticoagulation with low molecular weight heparin (LMWH), as it has been shown to be more effective when compared to Vitamin K Antagonists (VKA) in this population, including against recurrent thromboembolic processes. It is also easier to titrate doses, and a non-oral medication may be better tolerated in patients who may be prone to nausea and vomiting. Those without a malignant process can typically tolerate an oral VKA well, barring other factors detailed here.

In those who cannot tolerate parenteral medications, rivaroxaban and apixaban were recommended. This is largely because these medications can be dosed without the requirement of a parenteral bridging medication.

Organ damage should also play a role in anticoagulant decision making. In patients with hepatic insufficiency, LMWH is preferred in the setting of elevated international normalized ratio (INR). Novel oral anticoagulants (NOAC) are contraindicated in this population. VKA can be challenging to dose as the INR may not be truly reflective of anticoagulation. In contrast, those with renal insufficiency should undergo anticoagulation with VKA, as other anticoagulants can yield further renal damage.

Dabigatran has been shown to have more frequent instances of coronary artery events, and should be avoided in these patients. It has also been associated with dyspepsia, which should be a consideration for patient adherence. Dabigatran, rivaroxaban, and edoxaban have also been implicated in a higher number of instances of gastrointestinal bleeding than VKAs.

LMWH is the agent of preference for pregnant patients, as other agents have the potential to cross the placenta. Additionally, LMWH is the agent of choice for those patients with epidurals in place. LMWH should be held for 24 hours after the epidural has started, and discontinued 10-12

hours prior to catheter removal. Chemoprophylaxis can be re-initiated 24 hours after catheter removal.

Of course, other factors such as cost, route of administration, insurance coverage, and drug level monitoring should all be assessed when choosing the appropriate anticoagulant agent for a specific patient.

Table 2 Factors That May Influence Which Anticoagulant Is Chosen for Initial and Long-Term Treatment of VTE

Factor	Preferred Anticoagulant	Qualifying Remarks
Cancer	LMWH	More so if: just diagnosed, extensive VTE, metastatic cancer, very symptomatic; vomiting; on cancer chemotherapy.
Parenteral therapy to be avoided	Rivaroxaban; apixaban	VKA, dabigatran, and edoxaban require initial parenteral therapy.
Once daily oral therapy preferred	Rivaroxaban; edoxaban; VKA	
Liver disease and coagulopathy	LMWH	NOACs contraindicated if INR raised because of liver disease; VKA difficult to control and INR may not reflect antithrombotic effect.
Renal disease and creatinine clearance <30 mL/min	VKA	NOACs and LMWH contraindicated with severe renal impairment. Dosing of NOACs with levels of renal impairment differ with the NOAC and among jurisdictions.
Coronary artery disease	VKA, rivaroxaban, apixaban, edoxaban	Coronary artery events appear to occur more often with dabigatran than with VKA. This has not been seen with the other NOACs, and they have demonstrated efficacy for coronary artery disease. Antiplatelet therapy should be avoided if possible in patients on anticoagulants because of increased bleeding.
Dyspepsia or history of GI bleeding	VKA, apixaban	Dabigatran increased dyspepsia. Dabigatran, rivaroxaban, and edoxaban may be associated with more GI bleeding than VKA.
Poor compliance	VKA	INR monitoring can help to detect problems. However, some patients may be more compliant with a NOAC because it is less complex.
Thrombolytic therapy use	UFH infusion	Greater experience with its use in patients treated with thrombolytic therapy
Reversal agent needed	VKA, UFH	
Pregnancy or pregnancy risk	LMWH	Potential for other agents to cross the placenta
Cost, coverage, licensing	Varies among regions and with individual circumstances	

INR = International Normalized Ratio; NOAC = non-vitamin K oral coagulant. See Table 1 legend for expansion of other abbreviations.

CAPRINI SCORE AND INDIVIDUALIZED RISK ASSESSMENT

A standardized approach to addressing DVT prophylaxis is by assessing a patient's Caprini Score. This metric incorporates physical symptoms, history, and attributes as well as comorbid factors to align a patient into one of four risk category stratifications guiding anticoagulant use.[12–14] A score of 0 equates to Very Low risk, while 1-2 correlates to Low risk. Caprini

Scores greater than 2 are deemed moderate risk, and scores greater than 5 are high risk for VTE.[14] The Caprini score uses risk factors for VTE to assign points, resulting in a score with which the surgeon can weigh the risk of bleeding against the risk of VTE to determine what prophylaxis is appropriate for an individual patient. There is a direct correlation between an increased risk score and the development of clinically relevant VTE over a wide variety of surgical subspecialties.[13] The Caprini score "avoids blanket prophylaxis with anticoagulants since those with low scores have a risk of thrombosis that is lower than the bleeding risks with anticoagulation."[6] In a practical translation, a Caprini score greater than 8 increases the risk of VTE about 20-fold, whereas scores of 7 to 8 are at a 5- to 10-fold increase when compared with low-risk patients across surgical subspecialties.[15-16] Table 3 outlines the factors used to tabulate the Caprini Score, as well as the protocol recommended for each risk grouping.

Those who fall into the Very Low category simply require mechanical prophylaxis via early and frequent ambulation, while those in the Low group should have more substantial mechanical prophylaxis in the form of sequential compression devices (SCDs). At the Moderate level, patients should have chemoprophylaxis with or without the addition of SCDs. Those who are found to be High risk are recommended to have both chemoprophylaxis and SCDs.

ACCP TENTH EDITION RECOMMENDATIONS AND GUIDELINE UPDATES

Two significant principles in the management of VTE are avoiding clot extension and recurrence of DVT in order to reduce the risk of PE and the occurrence of PTS. The current school of thought recommends treatment with NOACs rather than VKA in patients whose VTE disease process is not present in the setting of malignancy. For those with VTE in the setting of malignancy, LMWH remains this anticoagulant of choice. However, as previously detailed, there may be extenuating factors to consider on a case-by-case basis that makes one agent preferable over another.

Additionally, the use of graduated compression stockings is no longer regularly suggested for PTS prevention, and IVC filters should not be placed for those patients who can tolerate anticoagulation. Those who have an unprovoked PE should be considered for anticoagulation without endpoint, and thrombolytics should be avoided in those with PE who are anticoagulated in the setting of normotension without acute decompensation. All ACCP tenth edition updates are Grade 1 or 2 guidelines, however, none are based on Grade A evidence. These updates are summarized in Table 4.[17]

Table 3. Caprini Score

1 Point	2 Points	3 Points	5 Points
Age 41-60	Age 61-74	Age ≥ 75	Stroke < 1 month
Swollen Legs	Arthroscopic Surgery	History of DVT/PE	Elective major lower extremity arthroplasty
Varicose Veins	History or Current Malignancy	Positive Factor V Leiden	Hip/Pelvis/Leg fracture < 1 month
Obesity	Laparoscopic surgery > 45 mins	Elevated serum homocysteine	Acute Spinal Cord Injury/Paralysis < 1 month
Minor Surgery	Bedrest > 72 hours	Heparin-Induced Thrombocytopenia	Multiple Trauma < 1 month
Sepsis < 1 month	Immobilizing plaster cast < 1 month	Elevated anticardiolipin antibodies	
Serious pulmonary disease including pneumonia < 1 month	Central Venous Access	Family history of thrombosis	
Oral Contraceptives or Hormone Replacement Therapy	Major Surgery > 45 mins	Positive prothrombin 20210A	
Pregnancy or Postpartum < 1 month		Positive Lupus anticoagulant	
History of unexplained stillborn infant, ≥3 recurrent/spontaneous abortions, premature birth with toxemia or growth restricted infant		Other congenital or acquired thrombophilia	
Acute Myocardial Infarction Congestive Heart Failure < 1 month			
Medical patient current on bedrest			
History of inflammatory bowel disease			
History of prior major surgery < 1 month			
Abnormal pulmonary function/COPD			
Other risk factors			

Interpretation

Surgical Risk Category	Score	~VTE risk without prophylaxis	Prophylaxis
Very Low	0	<0.5%	Early ambulation
Low	1 -2	1.5%	SCDs
Moderate	3 - 4	3.0%	1 of the following ± SCDs: • 5000 units Heparin SQ TID • Enoxaparin/Lovenox ○ 40 mg SQ, wt < 150 kg, CrCl >30 mL/min ○ 30 mg SQ, wt < 150 kg, CrCl 10-29 mL/min ○ 30 mg SQ BID, wt > 150 kg, CrCl >30 mL/min
High	≥5	6.0%	1 of the following + SCDs: • 5000 units Heparin SQ TID • Enoxaparin/Lovenox ○ 40 mg SQ, wt < 150 kg, CrCl >30 mL/min ○ 30 mg SQ, wt < 150 kg, CrCl 10-29 mL/min

Breakdown of Caprini Score contributors and point system. Outline of interpretation of Caprini Score Risk Categories and their associated recommendations.

Table 4

Summary of Recommendations	
Recommendation	*Grade*
Choice of Long-term Agent	
Proximal DVT or PE → long-term (3 months) anticoagulation > nothing	1B
Long-term (first 3 months) anticoagulation for leg DVT or PE and no cancer → dabigatran, rivaroxaban, apixaban, or edoxaban over VKA	2B
Leg DVT or PE and no cancer, not treated with dabigatran, rivaroxaban, apixaban, or edoxaban → VKA > LMWH	2C
Long-term (first 3 months) anticoagulation for leg DVT or PE and cancer → LMWH > VKA*, dabigatran, rivaroxaban**, apixaban**, edoxaban****	2B* 2C**
Leg DVT or PE requiring extended therapy: no need to change anticoagulant after the first 3 months	2C
Duration of Anticoagulant Therapy	
Proximal leg DVT or PE provoked by surgery → 3 months anticoagulation > shorter periods, longer time-limited period (6, 12, or 24 months), or extended therapy without endpoint	1B
Proximal leg DVT or PE provoked by a nonsurgical transient risk factor → 3 months anticoagulation > treatment of a shorter period* or longer time-limited period (6, 12, or 24 months)*. 3 months anticoagulation > extended therapy if there is a low, moderate**, or high bleeding risk***	1B* 2B**
Isolated provoked distal leg DVT of the leg → 3 months anticoagulation > treatment of a shorter period, longer time-limited period (6, 12, or 24 months)*, or extended therapy***	1B* 2C**
Unprovoked DVT of the leg or PE → anticoagulation for 3+ months > treatment of a shorter duration or longer time-limited period (6, 12, or 24 months)	1B
First unprovoked proximal leg DVT or PE in patient with: • **Low or moderate bleeding risk → extended anticoagulation without endpoint > 3 months of therapy**** • **High bleeding risk → 3 months anticoagulation > extended therapy without endpoint***	1B* 2B**
Second unprovoked VTE in patient with Low*, Moderate, or High** bleeding risk → extended anticoagulation without endpoint > 3 months of therapy**	1B* 2B**
Active cancer and leg DVT or PE with or without* high bleeding risk → extended anticoagulation without endpoint > 3 months of therapy**	1B* 2B**
Aspirin for Extended VTE Treatment	
In patients with an unprovoked proximal DVT or PE who are stopping anticoagulant therapy and do not have a contraindication to aspirin, we suggest aspirin over no aspirin to prevent recurrent VTE	2B
Anticoagulation for Isolated Distal DVT	
Acute isolated distal leg DVT: • **Without severe symptoms or risk factors for extension → serial imaging of deep veins for 2 weeks > anticoagulation** • **With severe symptoms or risk factors for extension → anticoagulation > serial imaging of the deep veins**	2C
Acute isolated distal leg DVT managed with anticoagulation → use same anticoagulation as for acute proximal DVT	1B
Acute isolated distal leg DVT managed with serial imaging: • **No anticoagulation if thrombus does not extend*** • **Anticoagulation if thrombus extends but remains confined to distal veins**** • **Anticoagulation if thrombus extends into the proximal veins***	1B* 2C**
Catheter-Directed Thrombolysis for Acute DVT of the Leg	
Acute proximal leg DVT → anticoagulation alone > CDT	2C
Role of Inferior Vena Cava Filter in Addition to Anticoagulation for Acute DVT or PE	
Acute DVT or PE treated with anticoagulants → no inferior vena cava filter	1B
Compression Stocking to Prevent PTS	

Acute leg DVT → no routine compression stockings use to prevent PTS	2B
Whether to Anticoagulate Subsegmental PE	
Subsegmental PE without proximal leg DVT with • **Low risk for recurrent VTE → clinical surveillance > anticoagulation** • **High risk for recurrent VTE → anticoagulation > clinical surveillance**	2C
Treatment of Acute PE Out of the Hospital	
Low-risk PE and adequate home resources → outpatient treatment or early discharge > standard discharge on treatment day 5	2B
Systemic Thrombolytic Therapy for PE	
Acute PE in setting of hypotension without high bleeding risk → systemically administered thrombolytics > no thrombolytics	2B
Acute PE in setting of normotension → no systemically administered thrombolytics	1B
Acute PE with deterioration status post anticoagulant administration in setting of normotension with low bleeding risk → systemically administered thrombolytics > no thrombolytics	2C
Catheter-Based Thrombus Removal for the Initial Treatment of PE	
Acute PE treated with thrombolytics → systemic thrombolytic therapy via peripheral vein > CDT	2C
Acute PE in setting of hypotension with high bleeding risk, failed systemic thrombolysis, or shock with threat of imminent mortality prior to systemic thrombolysis becoming therapeutic (within hours) and appropriate expertise/resources available → catheter-assisted thrombus removal > no catheter-assisted thrombus removal	2C
Pulmonary Thromboendarterectomy for the Treatment of Chronic Thromboembolic Pulmonary Hypertension	
Select chronic thromboembolic pulmonary hypertension under care of thromboendarterectomy team → pulmonary thromboendarterectomy > no pulmonary thromboendarterectomy	2C
Thrombolytic Therapy in Patients with Upper Extremity DVT	
Acute upper extremity DVT involving axillary or more proximal veins → anticoagulant therapy alone > thrombolysis	2C
Acute upper extremity DVT status post thrombolysis → same intensity and duration of anticoagulation treatment as those who do not undergo thrombolysis	1B
Management of Recurrent VTE on Anticoagulant Therapy	
Recurrent VTE on therapeutic VKA treatment or compliant dabigatran, rivaroxaban, apixaban, or edoxaban use → at least temporary switch to LMWH	2C
Recurrent VTE on long-term compliant LMWH → increase LMWH dose ~ ¼ - ⅓	2C

Summary of ACCP CHEST 10 guideline recommendations

INFERIOR VENA CAVA FILTERS

Inferior vena cava (IVC) filters have been shown to lower the risk of fatal PE in patients with a DVT who are unable to be anticoagulated and in those who failed therapy (for example, PE despite adequate anticoagulation). When the bleeding risk resolves, a conventional course of anticoagulation is still recommended. In most instances, IVC filters should not be used in patients without a DVT or PE as a prophylactic measure alone, regardless of the risk factors, including trauma, surgery, or even cancer.[18] Per ACCP tenth edition guidelines, IVC filters should not be placed in those patients who can tolerate anticoagulation.

VENOUS THROMBOEMBOLISM PREVENTION IN SPECIFIC PATIENT POPULATIONS

General

The grouping of general surgery procedures is largely inclusive of abdomino-pelvic

operations. These procedures tend to range form low to high Caprini score, with ~ 1% baseline bleeding risk. The baseline thrombotic risk increases in the setting of malignancy to 3.7%, which those without a cancerous disease process have a baseline thrombotic risk of approximately 0.5 – 1.6%. Factors that alter the baseline risk in this patient population include age, malignancy, type of procedure, and length of operative time. Data analysis of patients undergoing colon resection showed no significant difference for bleeding events nor thrombotic events when comparing patients who received pre- and post-operative chemoprophylaxis with only post-operative chemoprophylaxis. This suggests no clear recommendation for the timing of chemoprophylaxis in those such cases.[19]

The information presented to follow reflects the most recent version of the ACCP's guidelines on VTE prevention for specific surgical specialties. It is intended as a concise summary of the rationale and final recommendations taking into account the unique characteristics of each patient population.

Table 5. Risk by Surgery Type

Type of Surgery	*Caprini Score*	*Baseline Thrombosis Risk*	*Baseline Bleeding Risk*
General / Abdomino-Pelvic	Low – High	0.5 – 1.6%; up to 3.7% with cancer	1%
Bariatric	Low – High	1.9 – 5.4%; less extensive procedures as low as 0.5%	<1%
Noncardiac Vascular	Low – High	Open abdomen: up to 10% Peripheral artery surgery: 1.8 – 9% Venous ablation: < 1% Lower extremity amputation: 2 – 15%; higher for above knee amputation	0.3 – 1.8%
Plastic / Reconstructive	Low-High	0.5 – 1.8%	0.5 – 1.8%
Cardiac	Moderate – High	Up to 1%	5%
Noncardiac Thoracic	Moderate – High	0.18 – 7.4%; pneumonectomy, esophagectomy highest	1%
Neurosurgery	Moderate – High	Pooled: 16 – 29%; highest for craniotomy Spinal: 0 – 15%; benign and cervical spine less	Pooled: 1 – 1.5% Spinal: < 0.5%
Major Trauma	Moderate – High	Most severe injuries: 58% No prophylaxis: 8.7% Mechanical prophylaxis only: 3.7%	3.4 – 4.7%

Caprini categorization, VTE risk, and bleeding risk stratified by type of surgery

Minimally Invasive Surgery

In 2017, the Society of American Gastrointestinal Endoscopic Surgeons published a statement in support of the updated VTE guidelines from the ACCP rather than updating their previously published VTE prophylaxis recommendations for various procedures. This endorsement takes into consideration the use of the Caprini model for VTE risk stratification, as well as the general recognition of the ACCP guidelines as

thorough, comprehensive, and easy to implement.[20]

Bariatric

By nature, bariatric patients are at higher risk for VTE secondary to obesity and associated comorbidities. The Caprini classification for these procedures tends to fall in the low to high range, with 1.9 to 5.4% risk of thrombosis; less extensive procedures have risk as low as 0.5%. The risk of bleeding in these cases is typically <1%. The American Society of Bariatric and Metabolic Surgeons recommends mechanical prophylaxis and early ambulation for this subgroup of patients, and leaves the decision for chemoprophylaxis to each independent surgeon. If chemoprophylaxis is ordered, there is some evidence for LMWH as a preferred agent.[21]

A 2013 survey of practice patterns among 385 bariatric surgeons revealed the majority agreed on what qualifies a patient as high risk and use VTE chemoprophylaxis preoperatively. VTE screening and duration of therapy, however, varied widely among practitioners. Most of the surgeons surveyed routinely performed bariatric surgery laparoscopically (98.7%).[22]

Risk factors thought to qualify a patient as high risk for VTE included history of DVT, known hypercoagulable status, severe immobility, body mass index exceeding 55 kg/ m2, and PaO2 less than 60 mm Hg. More than half of the surgeons routinely performed preoperative DVT screening (56%), either by clinical examination alone (33.1%) or routine ultrasound (20.9%). Preoperative VTE prophylaxis was used by 92.4% of respondents, with 48.0% using unfractionated heparin, 33.4% using enoxaparin sodium (Lovenox), 2.6% using fondaparinux, and 8.3% using another agent. Retrievable IVC filters have also been used in the past with this patient population, and 28.1% continue to routinely use them preoperatively.[22]

Sequential compression devices were used by most of the respondents, both intraoperatively and postoperatively (96.3% and 91.6%, respectively). Postoperative chemical prophylaxis was also used routinely (97%), starting on postoperative day 0 in most (70%). Lovenox was the most commonly used agent (49.5%), followed by heparin (33%), other agents (9.1%), and fondaparinux (5.4%). Chemical prophylaxis was discontinued at discharge in most cases (48.5%). If continued after discharge (as with 43.8% of respondents), the most common duration of therapy was 2 to 4 weeks (40.1%) with Lovenox (39.7%). If a retrievable IVC filter was used, it was most commonly removed 30 to 90 days postoperatively (55.2%).35 The wide range of practice patterns among bariatric surgeons reflects the need for validated studies regarding this subset of patients.

Vascular

Vascular procedures have a variable risk of generating thrombotic disease processes; a major open abdominal vascular intervention can carry a thrombogenic risk of up to 10%, whereas a lower extremity amputation has a risk of 2 to 15% (higher in above the knee amputations), peripheral arterial procedures 1.8 to 9%, venous ablation < 1%. In general, vascular operations have a bleeding

risk of 0.3 to 1.8%. These interventions typically fall in the low to high Caprini category. Interestingly, it has been shown that while endovascular aneurysm repair has a lower incidence of VTE when compared to open interventions, however DVT incidence status post endovascular approach was found to be 5.3% regardless of chemoprophylaxis.[23]

When considering chemoprophylaxis for amputations, it is important to consider the level at which the limb will be severed, as the amount of tissue loss has varying functionality and mobility that impacts its associated recovery process. This can lend to the decision for preoperative chemoprophylaxis. Those who do develop VTE status post amputation have higher morbidity and mortality, as well as a longer rehabilitation course. [24-25]

Neurosurgery

VTE risk for patients undergoing neurosurgery is higher than the general population, falling in the Moderate to High Caprini category. In the unstratified population of neurosurgery patients, the risk of VTE is 16% to 29%, with craniotomy being among the highest risk procedures. These patients have a bleeding risk of 1% to 1.5%. When stratified by injury type, those who sustain spinal cord injuries have a risk for developing a VTE of 0% to 15%, with benign processes at less risk. The risk of bleeding for these patients is <0.5%. The increased risk for VTE exists for at least a year status post inciting injury, the highest risk being within the first three months.[26-28] VTE chemoprophylaxis can certainly be justified in this acute phase after injury, if no contraindication to administration exists. If bleeding risk or other contraindications do prevent pharmaceutical prophylaxis, mechanical prophylaxis is reasonable.[29-31] For those undergoing elective neurosurgery, the use of postoperative VTE chemoprophylaxis is supported.[32]

Major Trauma

The risk of DVT in trauma patients can vary from 5% to 63%, and is influenced by risk factors, prophylaxis modality, and methods of detection.[33-34] Coagulopathy in trauma patients is multifactorial, with contributions from elements such as the consumption of clotting factors, acidosis, hypothermia, dilutional changes secondary to resuscitation, blood product administration, immobility, and shock, as well as the systemic activation of anticoagulant and fibrinolytic pathways associated with shock.[35] Greenfield and colleagues developed a validated risk assessment profile (RAP) to identify the factors associated with an increased incidence of DVT.[36-37] In this study, patients with an RAP score of 5 or more were 3 times more likely to develop VTE than patients with an RAP score less than 5**.** Table 6 depicts the RAP score developed by Greenfield and colleagues.

These patients generally fall into a Caprini category of Moderate to High, with the most severe injuries having a thrombotic risk as high as 58%. Without prophylaxis, this population as a whole has a VTE risk of 8.7%; VTE risk falls to 3.7% risk if mechanical prophylaxis is initiated. The risk of bleeding is 3.4% to 4.7%

The Eastern Association for the Surgery of Trauma (EAST) has developed evidence based guidelines for VTE prophylaxis, last published in 2002, with pediatric guidelines last updated in 2017. The pediatric guidelines remain conditional recommendations, as insufficient data is available to make stronger statements regarding protocol. A summary of these recommendations can be found in Table 7. [38]

Table 6. RAP in Trauma Patients

Underlying Condition	*Points*	*Iatrogenic Factors*	*Points*	*Injury-Related Factor*	*Points*	*Age*	*Points*
Obesity	2	Femoral Venous Line	2	Chest AIS > 2	2	40-59	2
Malignancy	2	Transfusion > 4 units	2	Head AIS > 2	2	60-74	3
Abnormal Coagulation	2	Operation > 2 hours	2	Spinal Fractures	2	≥ 75	4
VTE History	3	Major Venous Repair	3	Glasgow Coma Scale < 8	3		
				Severe Lower Extremity Fracture	3		
				Pelvic Fracture	4		
				Spinal Cord Injury	4		

Risk Assessment Profile point system

Table 7. Adult Trauma

Prophylaxis	*Recommendation*	*Level*
LDH	Little evidence of benefit in trauma patients	II
	Individual decisions supported	III
LMWH	Recommended in spinal cord injury, pelvic fracture, complex lower extremity fracture	II
	Indicated for ISS > 9	III
A-V Foot Pump	Acceptable substitute if unable to wear IPCD	III
IPCDs	Some benefit shown in TBI studies	III
IVC filters	Considered for very high-risk patients in whom anticoagulation is contraindicated	III
Pediatric Trauma		
Conditional Recommendations		
Chemoprophylaxis considered for children > 15 years with low bleeding risk, or children < 15 years if post-pubertal and ISS > 25		
Chemoprophylaxis not routinely recommended for children < 15 years if pre-pubertal even if ISS > 25		
Mechanical prophylaxis considered alone or with chemoprophylaxis for children > 15 years, or children < 15 years if post-pubertal and ISS > 25		
Ultrasound VTE surveillance not recommended compared with daily physical exam		

EAST Trauma guideline updates for VTE prophylaxis in the setting of adult and pediatric traumas

Other Subspecialty Surgeries

The plastic and reconstructive surgery population has a Low to High Caprini categorization, with a 0.5% to 1.8% risk of both VTE and bleeding.[39-41]

Non-cardiac thoracic surgeries have a Caprini designation of Moderate to High, with a VTE risk of 0.18% to 7.4%. Esophagectomy and pneumonectomy have the highest risk. Bleeding risk is approximately 1% with these procedures.[42-45]

Cardiac procedures also carry a Moderate to High Caprini level. They have a risk of VTE of up to 1%, and a bleeding risk of 5%. [42, 46-48]

SUMMARY

The development of VTE remains a high risk in hospitalized surgical patients, leading to complications in up to 30%. The stratification of patient risk factors and subsequent utilization of a validated prophylaxis and treatment regimen is, therefore, of utmost importance. Familiarity with the current guidelines and recommendations ultimately results in decreased morbidity, mortality, and health care costs.

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