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Methods of DVT Prophylaxis after Total Knee Arthroplasty

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Abstract

Postoperative deep-vein thrombosis (DVT), venous thromboembolism (VTE), and pulmonary embolism are few of the most serious complications following total joint arthroplasty. Identification of risk factors and initiation of prophylactic measures are the most important measures to prevent the occurrence of DVT. Several protocols and guidelines are published for DVT prophylaxis in TKA, leaving the surgeon still perplexed. Pharmacological and mechanical prophylaxis methods are used to reduce the risk of postoperative symptomatic deep-vein thrombosis and pulmonary embolism. The use of pharmacological methods is based on a fine balance between their efficacy and the adverse effects associated with them. Each of these agents has their own advantages and disadvantages. Several newer agents are getting approved by FDA for the same. Hence, the choice should be carefully made based on the patient characteristics and risk stratification, and the onset of side effects has to be carefully monitored.

Keywords: DVT, thrombosis, prophylaxis, embolism, postoperative, TKA, joint replacement

1. Introduction

The importance of DVT prophylaxis is well understood from the high incidence of DVT in patients undergoing total knee arthroplasty (TKA). Studies have shown that without any mechanical or pharmacologic prophylaxis, asymptomatic DVT develops in 40–60% of the patients undergoing total hip and knee arthroplasties. Hence, there is a general consensus that these patients require regular prophylaxis even beyond discharge [1]. Venous thrombosis, including deep-vein thrombosis, occurs at an annual incidence of about 1 per 1000 adults and is higher in men than that in women in older age. DVT incidence varies according to

the race and ethnicity. Asians have a very low incidence of deep-vein thrombosis due to the preferred vegetarian diet, low prevalence of obesity, hyperlipidemia, and Factor V Leiden mutation. Several meta-analysis studies have shown similar results of low DVT incidence in Asians [2]. Operating surgeon has to minimize the risk of occurrence of this complication and its associated morbidity and mortality. Surgeon’s choice of VTE prophylaxis should be based on a balance between safety and efficacy of a particular anticoagulant, with risk stratification of VTE or bleeding. Virchow’s triad of events – stasis, vascular endothelial injury, and hypercoagulability, increases the risk of deep-vein thrombosis (DVT). Patients who fulfill two of the three criteria are considered to be high-risk group. Most of the patients undergoing TKA are considered to be at high risk for DVT for the high incidence of endothelial injury during the surgery and the relative stasis during the postoperative period. Well’s criteria help us to stratify risk in these patients (Figure 1).

Clinical Parameter	
Active cancer (treatment ongoing, or within 6 months or palliative)	+1
Paralysis or recent plaster immobilization of lower extremities	+1
Recently bedridden for more than 3 days or major surgery less than 4 weeks prior	+1
Localized tenderness along the distribution of the deep venous system	+1
Entire leg swelling	+1
Calf swelling more than 3 cm compared with asymptomatic leg	+1
Pitting edema (greater than asymptomatic leg)	+1
Previous DVT documented	+1
Collateral superficial veins (nonvaricose)	+1
Alternative diagnosis (as likely or greater than that of DVT)	-2

Pretest probability score calculated from the Wells DVT score can be stratified in either 2 or 3 risk groups. In the 3 risk group, patients with a score of 0 or less are considered low risk, 1-2 are moderate risk, and 3 or greater are high risk. In the 2 risk group, patients are stratified as DVT unlikely (Wells score < 2) or DVT likely (Wells score =2). See Table 2 below.

Figure 1. Well’s criteria for DVT risk stratification.

Patients without prior clinical suspicion also can develop DVT and fatal pulmonary embolism. Hence, it is therefore important to take appropriate preoperative screening and preventive measures for all these patients and to determine which of them warrant additional prophylaxis. Worldwide accepted guidelines on DVT prophylaxis have been produced by the American College of Chest Physicians (ACCP), American Academy of Orthopedic Surgeons (AAOS), and the National Institute for Health and Clinical Excellence (NICE). But the priority consideration is to diagnose the patients with high risk of developing DVT.

2. Risk factors

The risk factors for the development of DVT can be modifiable or nonmodifiable factors.

Modifiable factors include

- **Obesity:** it is defined as BMI above 30. Obesity leads to a two- to threefold higher risk of venous thrombosis in men and women. The obese have a further increase in thrombosis risk when they are exposed to other thrombosis risk factors, such as exogenous contraceptive or postmenopausal hormones.
- **Homocysteine levels:** elevated homocysteine has been consistently reported as a risk factor for venous thrombosis and levels can be reduced with B vitamin supplementation.

Nonmodifiable risk factors include the genetic factors which cause thrombophilic disorders. Protein C, protein S, and antithrombin deficiencies, Factor V Leiden mutation, and increased level of factor V, VII, VIII, IX, XI and von Willebrand factor are a few of the conditions that add up the risk of DVT.

Triggering factors are incidental situations which put patients into high risk of developing DVT, which cannot be avoided but can be tided over.

- **Hospitalization**—either due to immobility, infection, surgery.
- **Surgery/trauma.**
- **Immobility**—due to stasis of blood flow as in cases of plaster casts, bed rest, and paresis of legs due to neurological conditions.
- **Cancer**—increased risk due to cancer cells activating coagulation and tumors compressing veins causing hemostasis.
- **Travel**—duration of any form of travel more than 4 h increases the risk by about twofold for several weeks after travel [3].

3. Evaluation

Apart from the history and the classic clinical symptoms and examination findings of pain, tenderness, and swelling of the leg, different techniques are employed to detect even small thrombi in the venous system.

Ultrasound Doppler: it is the most common test used for diagnosing deep-vein thrombosis. It is quick, noninvasive, cheap and patient-friendly.

D-dimer test: the level of D dimer will be elevated in the presence of a blood thrombus.

Venography: this test is indicated if ultrasound does not provide a clear diagnosis. It is an invasive technique whereby a radio-opaque dye is injected into a vein, and then, a radiograph is taken of the leg. The entire pathway of the vein can be identified from the X-ray, and any obstruction somewhere indicates a thrombus.

Impedance plethysmography: changes in venous filling are produced by inflating and deflating the thigh cuff, and electrodes sense the change in blood volume by electrical impedance in the calf veins. A delay indicates that an occlusive thrombus is present in the popliteal or more proximal veins. But this modality is not useful in detecting more proximal DVTs.

Ventilation–Perfusion Scan (V/Q scan): a lung V/Q scan uses a ventilation (V) scan to measure air flow in the lungs and a perfusion (Q) scan to assess the blood flow in the lungs. This will detect even an occult event of pulmonary embolism.

Pulmonary CT angiography: currently, the most commonly used first-choice imaging examination in patients with suspected PE is pulmonary CT angiography [4]. This recommendation is based on high sensitivity and specificity for PE and other clinically important conditions that mimic PE.

But the point of interest is to prevent the occurrence of DVT rather than its detection. All these modalities are used to detect even a minute thrombus occurring in the system. Apart from the identification of high-risk patients, it would be better to screen all these patients for DVT preoperatively. So many studies have been done in this regard in different population using preoperative Doppler screening studies. According to the Scottish Arthroplasty Registry, the incidence of clinically significant VTE within 3 months of TKA is 1.79%, whereas that of fatal PE is 0.15% [5] and the asymptomatic DVT rates are much higher. Therefore, thromboprophylaxis use has been recommended for all patients undergoing TJA in Western population. Many other regional studies have shown that the incidence of DVT in patients undergoing TKA is so less to warrant a regular preoperative Doppler screening. However, it is said that a better modality to detect thrombi would be venography, which is not an appealing invasive procedure.

Numerous guidelines and recommendations suggest the use of various methods of thromboprophylaxis and methods to reduce the risk of development of modifiable factors. Pharmacological and mechanical prophylaxis methods are used, either in isolation or in combination, to reduce the risk of postoperative VTE.

4. DVT prophylaxis guidelines

ACCP 2012 guidelines recommend thromboprophylaxis for patients undergoing TJA for a minimum of 10–14 days. They prefer agents like low molecular weight heparin (LMWH), vitamin K antagonist, aspirin, fondaparinux, apixaban, dabigatran, or rivaroxaban. Regular Doppler screening during postoperative period is not recommended. But, prophylaxis is advocated as it is recognized that asymptomatic DVT can produce a fatal PE [6] (Figure 2).

Current ACCP Clinical Practice Guidelines for Prevention of VTE After Total Joint Arthroplasty	
Recommendation	Grade
In patients undergoing THA/TKA, one of the following agents should be used for a minimum of 10-14 days rather than no antithrombotic prophylaxis:	
LMWH	1B
Fondaparinux	1B
Apixaban	1B
Dabigatran	1B
Rivaroxaban	1B
Low-dose unfractionated heparin	1B
Adjusted-dose vitamin K antagonist	1B
Aspirin	1C
IPC/D	1B
For patients undergoing major orthopedic surgery (THA, TKA, hip fracture) and receiving LMWH as VTE prophylaxis, the agent should be started either ≥ 12 h preop or ≥ 12 h postop rather than ≤ 4 h preop or ≤ 4 h postop.	
In patients undergoing THA/TKA, regardless of the use of IPC/D or length of treatment, LMWH should be used in preference to the following alternative agents:	
Fondaparinux	2B
Apixaban	2B
Dabigatran	2B
Rivaroxaban	2B
Low-dose unfractionated heparin	2B
Adjusted-dose vitamin K antagonist	2C
Aspirin	2C
In patients undergoing major orthopedic surgery, VTE prophylaxis should be extended in the outpatient period for up to 35 days from the day of surgery rather than for only 10-14 days.	2B
In patients undergoing major orthopedic surgery, dual prophylaxis with an antithrombotic agent and an IPC/D during the hospital stay is recommended.	2C
In patients undergoing major orthopedic surgery with an increased risk of bleeding, an IPC/D or no prophylaxis is recommended over pharmacological treatment.	2C
In patients undergoing major orthopedic surgery and who decline or are uncooperative with injections or an IPC/D, apixaban or dabigatran should be used (alternatively rivaroxaban or adjusted-dose vitamin K antagonist if apixaban or dabigatran are unavailable) rather than alternative forms of prophylaxis.	1B
In patients undergoing major orthopedic surgery, it is not recommended to use an inferior vena cava filter for primary prevention over no VTE prophylaxis in patients with an increased bleeding risk or contraindications to both pharmacologic and mechanical VTE prophylaxis.	2C
Following major orthopedic surgery, asymptomatic patients do not need Doppler (or duplex) ultrasound screening before hospital discharge.	1B

Abbreviations: ACCP, American College of Chest Physicians; IPC/D, intermittent pneumatic compression device; LMWH, low-molecular-weight heparin; postop, postoperatively; preop, preoperatively; THA, total hip arthroplasty; TKA, total knee arthroplasty; VTE, venous thromboembolism. Data from Falck-Ytter et al⁵ and Lieberman and Penzabak.^{6f}

Figure 2. Highlights of the recent ACCP guidelines for thromboprophylaxis.

The AAOS 2011 guidelines suggest pharmacologic agents and/or mechanical device for the prevention of VTE following joint replacement surgery. They did not recommend any specific agent or duration of thromboprophylaxis. Both guidelines support combined methods of chemoprophylaxis with mechanical device. Also, they discourage the regular Doppler screening for DVT postoperatively [7] (Figure 3).

4.1. Methods of thromboprophylaxis

Thromboprophylaxis methods can be broadly divided into three—pharmacological, mechanical, and multimodal measures. Pharmacological measures include early active mobilization, intermittent pneumatic compression device (IPCD), compression stockings, and active ankle pumps. Anticoagulants often used are unfractionated and low molecular weight heparins, vitamin K antagonists, and selective factor Xa inhibitor (e.g., fondaparinux).

4.1.1. Mechanical methods

The most recent amendments to the AAOS, ACCP, and Surgical Care Improvement Project (SCIP) clinical practice guidelines for VTE prophylaxis after total joint arthroplasty now include mechanical compression devices as modalities for VTE prophylaxis. Mechanical compressive devices increase the local blood flow in the lower extremities, decrease the concentration of the

Table 1

Current AAOS Clinical Practice Guidelines for Prevention of VTE After Total Joint Arthroplasty		
No.	Recommendation	Grade
1	Recommendation against routine postoperative duplex ultrasonography screening.	Strong
2	Assessing risk of VTE by determining previous VTE events should be considered.	Weak
3	Panel recommends that patients be assessed for known bleeding disorder like hemophilia and for the presence of active liver disease, which further increases risk for bleeding and bleeding-associated complications.	Inconclusive
4	Panel suggests discontinuation of antiplatelet agents (eg, aspirin, clopidogrel) before undergoing elective THA/TKA.	Moderate
5	Panel suggests use of pharmacological agents and/or mechanical compressive devices for VTE prevention in patients undergoing elective THA/TKA.	Moderate
	Panel cannot recommend for or against a specific prophylactic regimen in TKA/THA patients.	Inconclusive
	In the absence of reliable evidence regarding the duration of prophylactic strategies, it is the opinion of the panel that patients and physicians discuss the duration of prophylaxis.	Consensus
6	In the absence of reliable evidence, it is the opinion of the panel that patients undergoing THA/TKA, who have also had a previous VTE, receive pharmacologic prophylaxis and use mechanical compressive devices.	Consensus
7	In the absence of reliable evidence, it is the opinion of the panel that patients undergoing THA/TKA, who also have a known bleeding disorder and/or active liver disease, use mechanical compressive devices for prevention VTE.	Consensus
8	In the absence of reliable evidence, it is the opinion of the panel that patients undergo early mobilization following elective THA/TKA.	Consensus
9	The use of neuraxial (eg, intrathecal, epidural, spinal) anesthesia for patients undergoing elective THA/TKA is recommended to help limit blood loss, although evidence suggests that neuraxial anesthesia does not affect the occurrence of VTE.	Moderate
10	Panel cannot recommend for or against the use of inferior vena cava filters because current evidence does not provide clear guidance about whether inferior vena cava filters prevent embolus in patients undergoing elective THA/TKA who also have a chemoprophylaxis and/or known residual VTE.	Inconclusive

Abbreviations: AAOS, American Academy of Orthopaedic Surgeons; THA, total hip arthroplasty; TKA, total knee arthroplasty; VTE, venous thromboembolism.
Data from Lieberman and Pensak,⁸⁹ Mont and Jacobs,⁹⁰ and Lieberman.⁹¹

Figure 3. Highlights of the recent AAOS guidelines for thromboprophylaxis.

activated coagulation factors, and promote lymphatic drainage in adjacent tissues. It avoids the side effects of the anticoagulant drugs such as wound drainage, hematoma, and gastrointestinal and intracranial bleeding and also enhances the effects of anticoagulant.

Early mobilization: it has shown that early mobilization reduces the incidence of DVT in patients undergoing TJA [8]. Patients are encouraged to be mobilized as soon as feasible. These act by increasing the velocity of venous blood flow and preventing stasis as well as decreasing the coagulability of blood by stimulating fibrinolysis. Early mobilization is the simplest, cheapest, and easiest method to prevent DVT after any surgery. The more you mobilize the patient on the first postoperative day, much lesser is the DVT incidence. The incidence reduces by a third in those who mobilize more than 1 m on the first postoperative day, and it reaches zero in those who mobilize more than 5 m [9]. Physical methods can be combined with pharmacological methods also for better control.

Intermittent pneumatic compression device (IPCD): inflatable garments are wrapped around the legs, which are intermittently inflated by a pneumatic pump enhancing venous return. Two meta-analyses found that rates of DVT after total knee arthroplasty were much lower with intermittent pneumatic compression devices or LMWH (17–29%) than with aspirin or warfarin (45–53%) [10].

Foot impulse devices (or foot pumps): it increases venous outflow and reduces stasis in immobilized patients. It artificially compresses the venous plexus around the sole, mimicking normal walking and reducing stasis in immobilized patients.

4.1.2. Chemoprophylaxis

Aspirin: it is an inhibitor of the cyclooxygenase enzyme system. It is the most simple and commonly used drug for thromboprophylaxis. It is very cheap, patient compliant and with least side effects. Aspirin inhibits COX1 more than COX2. COX1 is chiefly expressed on platelets, which helps in platelet aggregation. Meta-analysis showed that aspirin was effective in reducing the rate of DVT to 30.6% from 48.5% [11]. Conflicting literature exists with regard to the efficiency of aspirin in preventing DVT. Aspirin is inferior to warfarin or LMWH in terms of preventing symptomatic PE or proximal DVT [8]. Also, the rate of complications is very low with the use of aspirin. Pulmonary embolism prevention (PEP) trial [12] which concluded that low-dose aspirin, when taken for 35 days, would result in seven times less symptomatic DVT cases, but three bleeding cases and two nonfatal myocardial infarction per 1000 patients. Studies have shown up to 0.13% developing hematoma and bleeding with warfarin in comparison to 0% with aspirin [13]. Studies have been done comparing the incidence of VTE, PE, proximal DVT, and distal DVT in multimodal prophylaxis methods with aspirin and warfarin. They have showed lower incidence of all types of thromboses with aspirin group [14].

Warfarin: warfarin is a vitamin K antagonist. It has been used extensively for DVT prophylaxis since decades. It was the first oral anticoagulant. However, the usage is restricted by the bleeding risk, potential drug interaction, and requirement for constant monitoring (INR). Warfarin inhibits the maturation of vitamin k-dependent coagulation factors in the coagulation cascade. Multitude

of studies has been carried out comparing the efficacy of warfarin and LMWH. Majority of them showed LMWH was a more effective agent to prevent DVT formation ($P < 0.05$), but no difference to warfarin in preventing symptomatic events including PE [15]. Though regular INR monitoring is needed with warfarin, it significantly reduced the incidence of DVT when compared to aspirin but less effective than LMWH [11].

Low molecular weight heparins (LMWHs): another widely used drug is low molecular weight heparin (LMWH). LMWHs are fragments of heparin produced by chemical or enzymatic depolymerization. LMWH has the highest efficacy in terms of preventing VTE. Few available ones are enoxaparin, dalteparin, and tinzaparin. Among these three, only two (enoxaparin and dalteparin) are indicated in major orthopedic surgery [16]. The ACCP recommends the use of LMWH in preference to other agents [17]. With the use of LMWH, the rate of fatal PE is reduced to 0.04% (from 0.16%), but the rate of clinically significant bleeding increased from 1.67% to 2.22% [18]. Its advantages are predictability, dose-dependent plasma levels, no need for regular monitoring, a long half-life and less bleeding for a given antithrombotic effect, low risk of immune-mediated thrombocytopenia, and heparin-induced osteoporosis.

Novel oral anticoagulants: since 2000, newer oral anticoagulants were introduced, collectively known as novel oral anticoagulants. They inhibit specific steps in the coagulation pathway. New oral anticoagulants include two classes of drugs—direct thrombin inhibitors and factor Xa inhibitors. Factor Xa inhibitors are mainly rivaroxaban and apixaban. They act by binding to the active site of factor Xa, thus inhibiting the interaction with its substrate. Dabigatran is the first FDA-approved direct thrombin inhibitor. Another DTI—Ximelagatran—was introduced but had to be withdrawn from market in 2006 as the FDA-denied approval (**Figure 4**).

The advantages of these agents are rapid onset of action, predictable anticoagulant response, no need for monitoring, wider therapeutic index, fewer drug–drug and drug–food interactions, reduced or comparable rates of thrombosis, bleeding, and other adverse events, and being orally administered, it is convenient and compliant. Many studies have come up with conflicting conclusion regarding these molecules.

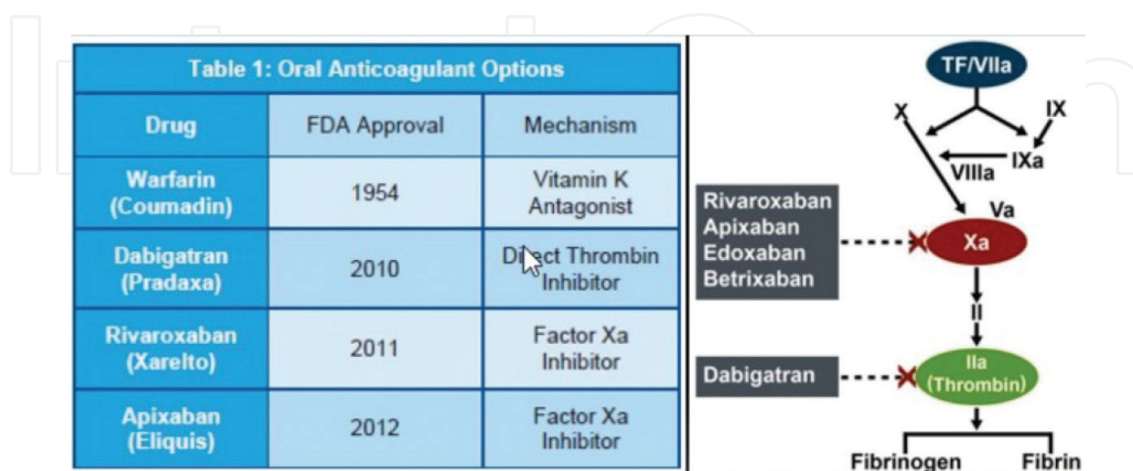


Figure 4. The new oral anticoagulants and their mode of action.

Rivaroxaban: these US FDA-approved drugs were launched after four phase III trials. Studies showed that these groups of drugs showed to be more effective than LMWH in reducing overall VTE incidence and mortality rate in TKA patients with no additional risk of bleeding [19, 20]. But most of the large-scale studies have shown increased risk of bleeding with rivaroxaban when compared to LMWH even though statistically not significant. Apart from the drug reactions and risk of bleeding, these have drug interactions with NSAIDs which the treating surgeon has to be aware of (Figure 5).

Apixaban: it is another class of DTI with similar mechanism of action as of dabigatran. It exerts minimal impact on PT, INR, and aPTT. American College of Cardiology (ACC) and American Heart Association (AHA) in 2011 released a focused update recommendation on dabigatran vs. warfarin comparison which stressed its use as an alternative to warfarin in patients with increased risk of developing deep vein thrombosis.

Dabigatran: it is a direct thrombin inhibitor which cleaves both free and fibrin-bound thrombin. FDA investigated the rates of GI bleed and intracranial hemorrhages with dabigatran and warfarin and initially concluded that they both showed similar results. But a similar trial in Europe (RE-ALIGN trial) was stopped as the dabigatran users showed higher incidence of strokes, heart attacks, and thrombosis on prosthetic heart valves. Hence, it is not advised in patients with renal/hepatic impairment or prior history of GI bleeds or recent ulcers.

Creatine Clearance (mL/min)	>50	50-30	29-15	<15 or HD
Atrial fibrillation	20 mg po daily	15 mg po daily		Avoid use
Postoperative thromboprophylaxis	10 mg po daily Knee: 12-14 days Hip: 35 days	10 mg po daily, use with caution	Avoid use	Avoid use
Treatment of PE/VTE	15 mg twice daily x21 days, then 20 mg po daily	Use with caution	Avoid use	Avoid use
Secondary Prophaxis for PE/VTE	20 mg po daily	Use with caution	Avoid use	Avoid use

Figure 5. Figure showing the characteristics of rivaroxaban.

4.1.3. Multimodal methods

Combining mechanical and pharmacological prophylaxis enables greater reduction of the risk of DVT. It also reduces the dosage of anticoagulants and thus the risk of bleeding, and achieves the same or even better thromboprophylaxis than monotherapy. Classifying patients into low or high risk of developing VTE is advocated. Low-risk patients received aspirin and intermittent calf compression, whereas high-risk patients received LMWH or warfarin and intermittent calf compression. All patients have to be mobilized within 24 h of surgery.

Few studies have advocated less potent pharmacological agents for low-risk patients and more potent agents for high-risk patients as the results showed negligible incidence of DVT, PE, and wound hematoma in both the groups [21]. Few recent studies show superior effects for aspirin in multimodal thromboprophylaxis when compared to warfarin [13, 14, 22].

4.1.4. Concerns with thromboprophylaxis

The risks associated with thromboprophylaxis are mainly hemorrhage, wound hematoma, persisting wound drainage, failure of wound healing, risk of infection, and blood loss requiring transfusion. One of the main drawbacks of initiating thromboprophylaxis is the high incidence of major bleeding, reaching up to 4–7.9% [23]. More potent the prophylactic agent, more the incidence. Oral agents hence have lower bleeding rates [15]. A study on 290 patients post-TJA using 10-day course of inj. enoxaparin 30 mg twice daily showed high incidence of 3–5% of readmission, re-exploration, and prolonged hospitalization for wound drainage and bleeding [24]. There were increased rates of return to the operating room for wound complications, wound drainage for more than 7 days, and incidence of symptomatic DVT in 3.8% patients and nonfatal PE in 1.3% patients. Parvizi et al. reviewed 78 septic failure cases that underwent revision and showed a direct correlation between excessive anticoagulation and development of periprosthetic infection [25]. The occurrence of such complications after elective TJA due to the use of prophylactic agents is heartbreaking to most surgeons.

Also, timing of initiation of the prophylaxis is also debated. Two schools of thought are initiation of LMWH 12 h preoperative and 12 h postoperative. Earlier initiation of prophylaxis has shown greater efficacy in preventing DVT but also causes a higher incidence of bleeding. The decision about which agent and when to initiate chemoprophylaxis should be based on the balanced efficacy-bleeding ratio of the prophylactic agents [26].

There is still no consensus on the duration of the use of prophylaxis too. The recently released new AAOS guidelines do not provide a specific duration for prophylaxis [27]. Earlier ACCP guidelines advocated a minimum of 10 days of prophylaxis, with extended prophylaxis up to 35 days. AAOS advised different duration for different agents: LMWH/fondaparinux for 7–12 days and aspirin/warfarin for 6 weeks. Extended prophylaxis with only LMWH was effective post THA, but not TKA [28].

5. Current trend

Ideal DVT prophylaxis method still remains an enigma. The choice is based on patient characteristics and surgeon's experience. Aspirin is recognized as a primary chemoprophylactic agent with the adaptation of the recent ACCP guidelines by the Surgical Care Improvement Project (SCIP). They strongly endorse risk stratification for VTE prophylaxis and opined that aspirin will become the mainstay of prevention of VTE for the majority of patients after TJA. Thus, we could optimize outcomes for our patients, by preventing the feared VTE while limiting bleeding complications that can occur with other aggressive anticoagulants [29]. Identifying and stratifying the patients at risk for DVT remains a challenge. As a general consensus, it is taken that patients post TJA can receive aspirin as thromboprophylaxis without much risk. But, those patients at very high risk may need more potent agents and careful monitoring [30].

Further research is needed to identify patients at major risk and probability of VTE and bleeding. The current clinical guidelines provide an orthopedic surgeon with more latitude, and choices of VTE prophylaxis without emphasis on aggressive chemical, and often unneeded prophylaxis. The key to determining the appropriate chemical prophylaxis for patients is to balance safety and efficacy while minimizing bleeding. Modern arthroplasty surgeons advocate early postoperative mobilization and use of mechanical prophylaxis in combination with chemoprophylaxis according to the risk stratification, which of course seems to be a reasonable safer approach.

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