

Anticoagulation in orthopaedic surgery or trauma outside of THA, TKA, and hip fracture : a clinical review

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of THA, TKA, and Hip fracture: a Clinical Review

Kevin Andrew Kelch
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2010

Dedication

To my wife, Kali:

Thank-you for all that you have done for me and for all you have put up with for the last 2 and a half years of PA school. You have been extremely supportive and understanding. I love you.

To my parents:

Thank you for all the support over the years. You have been the best parents anyone could ask for. You have given up so much for me and I appreciate it. I love you both.

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INTRODUCTION

Thromboembolic disease is a common complication in orthopaedic surgery, a complication which can even become fatal. Thromboembolic disease often starts as the formation of a venous thrombus located in either the deep or superficial veins, often occurring first in the distal extremities. These thrombi can become dislodged from their location on the venous walls or valves and travel more proximal into the larger veins and even into the heart. Once into the heart, the lungs are the next victim, and can cause severe pulmonary emboli, resulting in pulmonary failure and death.

Over the years, extensive research has been done on the rates of venous thromboembolism after total hip arthroplasty (THA), total knee arthroplasty (TKA), and hip fracture surgery (HF). Studies have shown that the rates of deep vein thrombosis (DVT), proximal DVT, and pulmonary embolism (PE) in these patients are 40 to 60%, 10 to 30%, and 0.9 to 28% respectively (Geerts, et al., 2004). For this reason, both mechanical and pharmacologic methods of anticoagulation are universal for these types of surgeries. Guidelines and protocols have been set and widely accepted in the medical community. Other orthopedic traumas and surgeries have not been as extensively studied. These other traumas and surgeries include but are not limited to ACL reconstruction, tibial plateau fracture, ankle fractures, and ruptured Achilles tendons. Over the past few years, many studies have started to come out regarding these areas but no real consensus has been made on the use of anticoagulation therapy. It is unknown whether pharmacologic methods decrease the risk of venous thromboembolism; and if so, to what extent? If pharmacologic anticoagulation is helpful, do the benefits outweigh the risks and costs of their use? Anticoagulation therapy can cause harmful side effects, mostly

excessive bleeding due to its effects on the coagulation cascade. Anticoagulation can also be very expensive.

With no specific guidelines for these surgeries outside of THA, TKA, and HF, all the recent studies on this topic need to be collaborated, so that health care providers can provide the best possible care for patients suffering from such injuries.

METHODS

A search was performed using MEDLINE and Pubmed to find English-language studies of venous thromboembolism incidence and prophylaxis following trauma and surgeries to the lower and upper extremity. Medical subject headings included combinations of DVT, pulmonary embolism, anticoagulation, thromboembolism, venous thromboembolism, venous thrombosis, foot, ankle, leg, calcaneous, lower extremity, tibia, femur, fracture, knee, arthroscopy, ACL, Achilles tendon, prophylaxis, upper extremity, labrum, rotator cuff, clavicle, humerus, radius, ulna, Colles' fracture, hand, shoulder, wrist, elbow, SI joint, spine, cervical, lumbar, thoracic, sacrum, PICC lines, risk factors, and complications. I took the most recent articles that qualified in each category to be included in the research. No articles were to be included that were prior to 1989. Inclusion criteria required prospective observational studies involving anticoagulation prophylaxis by any means or with no prophylaxis. Studies were required to perform post-operative screening for thromboembolism by either ultrasound or contrast venography. Retrospective studies were considered, for use of comparison to prospective studies. Exclusion criteria consisted of non-English or not meeting inclusion criteria.

VENOUS THROMBOSIS MECHANISM

Venous thrombosis occurs when a thrombus, or clot, is formed in the veins of a patient. Problems arise when the thrombus grows so large that it blocks the vessel or when the thrombus breaks off. A thrombus that breaks off can travel with the blood towards the heart. If the thrombus does not get broken down by the body's natural fibrinolytics, it will ultimately make it to the heart and then into the lungs, causing a pulmonary embolism. There are three important keys to the pathophysiology of thrombus formation, making up what is known as Virchow's triad. Virchow's triad consists of venous stasis, endothelial injury to the vessel wall, and hypercoagulability (Kumar, Abbas, Fausto, & Mitchell, 2007).

Venous stasis means that the blood is pooling or not traveling through the venous system. The veins are a low pressure system that depends on skeletal muscle contraction to force blood back to the heart. This is especially true in the lower extremity, where the veins are constantly fighting against gravity. Patients who are immobile are not using the leg muscles necessary to push venous blood. Instead, the blood just sits there in one area for an extended time. When blood pools in an area, it causes more platelets to come into contact with the endothelial lining of the vessel wall. This can create injury to these endothelial cells, leading to the creation of clots. In order to prevent venous stasis, mechanical prophylaxis is commonly used. Mechanical prophylaxis is often carried out by using pressure cuffs on the legs. The cuffs can push the blood through the veins, much like a muscle contraction would (Kumar, Abbas, Fausto, & Mitchell, 2007).

The endothelial cells lining the inside of the veins can also promote blood flow by preventing clot formation. The endothelial wall is naturally resistant to platelets and coagulation factors. These endothelial cells also have molecules similar to heparin that inactivate

coagulation factors. These cells also make tissue plasminogen factor (t-PA) which promotes the breakdown of fibrin. Any injury to the endothelial lining inside the vessel will expose the extracellular matrix (ECM) within the vessel wall. The ECM is thrombogenic and platelets easily adhere to it. Within the ECM is collagen, which contains von Willebrand factor, a cofactor that causes platelet adherence. After adhering to the ECM, the platelet is then activated and it recruits more platelets. These platelets create the primary hemostatic plug and tissue factor is released at the site of injury. Tissue factor works with factor VII to begin the extrinsic pathway of the coagulation cascade that results in the formation of thrombin. Thrombin changes fibrinogen to fibrin which creates the secondary hemostatic plug. Thrombin also recruits more platelets causing the clot to grow larger and larger (Kumar, Abbas, Fausto, & Mitchell, 2007).

Hypercoagulability is the state in which the blood is more prone to clotting. This can be due an increase in platelet count or an increase in clotting factors. Pregnant patients and patients on oral contraceptive pills have increased estrogen levels which increase the hepatic synthesis of clotting factors and also decrease the synthesis of an anticoagulant called antithrombin III. Other anticoagulants that exist are protein C and protein S. Anticoagulants are important in regulating clot formation and keeping it under control. With insufficient levels of anticoagulants, there is no control mechanism and the clot will not be broken down and can continue to grow, resulting in vein occlusion. An increase in blood viscosity can also cause a hypercoagulable state due to the high concentration of formed elements in the blood in relation to the water in the blood plasma. With less plasma, the platelets will be in contact with the endothelial lining more and can cause wall injury. Other hypercoagulable states are smoking, obesity, heart failure, cancer, and age (Kumar, Abbas, Fausto, & Mitchell, 2007).

Placement of inferior vena cava (IVC) filters has been used to prevent an embolus from traveling from the lower extremity to the heart. Despite the filter being in place, the PE rate with IVC filters is often 2-5% (Nazzal, et al., 2010). Pulmonary emboli after IVC filter placement can be due to several different factors. PE due to filter placement can be due to air emboli or access-site thrombosis. PE after placement can be due to the filter design, filter malfunction or fracture, or gonadal vein thrombosis. There are several different types of filters in use, and not all are created equally. Some filters can allow smaller thrombi to pass through the filter. Others have a large surface area that comes in contact with the venous wall, increasing the odds of blood stagnation, recirculation, and thrombus formation. Filters can break, sending foreign body emboli to the heart and lungs. Since IVC filters are often placed infrarenally, thrombosis of the gonadal veins, which join the abdominal aorta superior to the renal veins, can be the source of embolism (Nazzal, et al., 2010).

SIGNS AND SYMPTOMS

Classically, DVT causes increased pain and leg swelling due to the reduced blood flow in the venous system. Unfortunately, it isn't always so simple to diagnose. DVTs are often asymptomatic, especially smaller thrombi. Even if symptoms such as pain and swelling are present, it can be difficult to differentiate the symptoms of DVT from the symptoms of a trauma or surgery. The Homan's sign has been classically used clinically to determine if a DVT is present. With this test, the patient with a DVT will feel a burning pain in the calf when the calf is squeezed during passive ankle dorsiflexion. The Homan's sign, however, is unreliable and non-specific. It has been found to have a sensitivity anywhere between 8-56% and a specificity that is often less than 50% (Urbano, 2001).

The main complication with DVT is the potential to become a pulmonary embolism (PE). If the DVT becomes dislodged, it can travel through the venous system to the heart. While traveling through the venous system, it can continue to recruit platelets, allowing the thrombus to grow larger. Once in the heart, the thrombus is then sent to the lungs where it can become lodged in the arteries of the lung, preventing gas exchange with the alveoli. The smallest thrombi can travel into the tiny capillaries where gas exchange occurs. These patients are usually asymptomatic. Larger thrombi, however, will block the larger arteries, thus preventing blood flow to all the capillary beds distal to the blockage. The more capillary beds involved, the greater the chance of having symptoms. As the amount of gas exchange at the alveoli decreases, the patient becomes short of breath and can get pleuritic chest pain. The shortness of breath brings on tachycardia and tachypnea. If the shortness of breath is severe enough, organs will not receive enough oxygen and death can occur (Goldman & Ausiello, 2008, p. 689).

Many orthopedic patients have DVT, but it is unknown how many of these DVT will have any clinical significance (Geerts, et al., 2008). There is no way to tell what the outcomes of a DVT will be. Most are broken down by the body's natural thrombolytics. Unfortunately, not all do. It is important that we get an understanding of which conditions make a patient more susceptible to a DVT or a PE.

SCREENING METHODS

There are a several different methods available to screen patients for DVT. Each method comes with risks and benefits that must be weighed when considering a specific screening method. Despite multiple options for determining the presence of a DVT, few tests are routinely used due to their ease of use, low cost, and relatively high sensitivity and specificity.

A less commonly used screening test is impedance plethysmography. With impedance plethysmography, blood volume changes are assessed by measuring the blood's electrical impedance. Continuous uniform blood flow will have no change in the electrical impedance, whereas disrupted blood flow will result in impedance changes. The advantages of impedance plethysmography are the relative ease of use and minimal user error. It, however, can miss a proximal DVT, especially one that is nonocclusive or has adequate collateral blood supply (Ciccone, Reid, & Pellegrini, 1999).

More commonly used screening methods are venous duplex ultrasound (DUS) and contrast venography. DUS is the most widely used imaging technique due to its high accuracy, availability, noninvasiveness, and lower cost. The downfall of DUS is that it tends to be user dependent and it is not as sensitive as venography, especially for small and nonocclusive DVT. The decreased sensitivity for small DVT may not be a problem, as these smaller DVT often have a much smaller clinical significance (Geerts, et al., 2004).

Contrast venography, however, is the gold standard when it comes to DVT detection due to its high sensitivity. Using fluoroscopy and IV dye, venography allows for a detailed image of the veins. Venography, however, has its limitations. It has limited availability, requires contrast medium in which some patients are allergic, exposes patients to harmful radiation, and has high financial costs (Geerts, et al., 2004).

The D-Dimer test is a blood test that measures the levels of fibrin D-Dimer in the body. Fibrin D-Dimer is a product of cross-linked fibrin, which is increased in patients with VTE. It is highly sensitive (96%) but has a very poor specificity (41%) (Perrier, et al., 1997). False-positives can be due to various conditions such as cancer, inflammation, infection, or necrosis (Bounameaux, Perrier, & Righini, 2010).

There are a few different imaging techniques for the determining the diagnosis of pulmonary embolism. The gold standard in diagnosing PE is pulmonary angiography. This technique is not widely used due to its cost, invasiveness, and availability. The two most commonly used imaging techniques are computed tomography pulmonary angiography (CTPA) and ventilation and perfusion (V/Q) scan. CTPA is the modality of choice due to its increased sensitivity and specificity when compared to conventional planar ventilation and perfusion (V/Q) scans. With advancements in both CTPA and V/Q scans, these two imaging techniques are much more comparable than before. A study by Reinartz, et al, (2004), found that the 4-slice CTPA, V/Q SPECT, and planar V/Q had a positive predictive value of 92.8%, 94.0%, and 80.7% respectively for PE. The 4-slice CT had an 86% sensitivity and a 98% specificity, while the V/Q SPECT had a 97% sensitivity and a 91% specificity. The planar V/Q scan had only a 76% sensitivity and an 85% specificity.

CTPA and V/Q SPECT each has its own advantages and limitations that might help in determining the modality of choice. CTPA is much more widely available, may have a higher specificity, is useful in finding alternative diagnosis, and is more accurate in patients with severe COPD. It, however, has a much higher radiation dose than V/Q scan and poses the risk of allergies to contrast dye as well as contrast dye induced nephropathy. V/Q SPECT may have a higher sensitivity, does not use contrast dye, and has a much lower radiation dose, making it

much safer during pregnancy. It, however, is not as widely available, and is not good for determining alternative diagnosis (Leblanc & Paul, 2010).

RISK STRATIFICATION

Several methods have been proposed to allow clinicians a quick and easy way of establishing which patients should receive thromboprophylaxis and the type of prophylaxis needed. CHEST (Geerts, et al., 2008) explains two different approaches for risk stratification. The first approach involves individually prescribing prophylaxis based upon the patient's risk factors and the type of surgery or injury. The other approach is a group-specific approach for all patients that are getting a specific surgery or have an injury. For example, all patients who are getting a TKA will receive a certain prophylaxis. The first approach is a more patient specific which seems to be the better option. The problem is that there is not much data on which risk factor or combination of risk factors is worse for the patient. The second approach is less complicated, but does not treat each patient individually. A 17 year old male will not have the same risk of venous thromboembolism (VTE) as a 65 year old female receiving the same surgery. However, CHEST supports the second approach at this time, stating that individualized approaches have not been extensively tested like group approaches and individualized approaches are complex and cumbersome for clinicians.

Regardless of the approach used in determining prophylaxis, knowing the risk factors for VTE is important. The risk factors in Table 1 have been suggested by various groups, clinicians, and studies (Geerts, et al., 2008; Race & Collier, 2007; SIGN, 2002).

TABLE 1: VTE RISK FACTORS	
Acute medical illness	Anesthesia
Cancer and Cancer therapy	Central venous catheterization
Contraceptives containing estrogen	Erythropoiesis-stimulating agents
Hormone replacement therapy	Immobility
Increasing age	Inherited or acquired thrombophilia
Inflammatory bowel disease	Myeloproliferative disorders
Nephrotic syndrome	Obesity
Paroxysmal nocturnal hemoglobinuria	Pregnancy and acute post-partum
Previous VTE (DVT and PE)	Prolonged travel
Surgery	Trauma
Varicose Veins	Venous compression (tumor, hematoma, etc.)

PROPHYLAXIS METHODS

One of the key methods for VTE prevention is early mobilization and ambulation. By ambulating, blood does not pool in the veins and VTE rates can be reduced. Ambulation alone is often not enough to completely prevent VTE and unfortunately, not all patients can ambulate after hospital admission or post-operatively. Many times, other means of thromboprophylaxis are needed. There are both mechanical and pharmacological methods of thromboprophylaxis that can be used. Mechanical methods include the use of graduated compression stockings (GCS), intermittent pneumatic compression (IPC), and venous foot pumps (VFP). These mechanical methods serve to increase blood flow in the venous system, preventing the pooling of venous blood. Mechanical methods are extremely useful in patients with increased bleeding risks that contraindicate pharmacologic methods. These methods, however, have not been as widely studied and compliance by the patient is often poor (Geerts, et al., 2008).

Aspirin is a form of pharmacologic thromboprophylaxis that can have anticoagulation effects by preventing platelets from aggregating and forming clots. Aspirin use is not recommended by the American College of Chest Physicians because they believe other forms of thromboprophylaxis are more effective. Some studies have even shown aspirin to be ineffective in the prevention of VTE (Powers, et al., 1989; Westrich & Sculco, 1996), but these studies were done on total hip and knee replacements and not for other orthopedic surgeries and traumas.

Other forms of pharmacologic thromboprophylaxis are widely used and accepted. These drugs include low-dose unfractionated heparin (LDUF), low-molecular-weight heparin (LMWH), and vitamin K antagonists (VKA), fondaparinux and other coagulation factor antagonists. These drugs have been extensively studied and their effects on DVT are well known. These drugs do come with their downfalls. By preventing the formation of blood clots,

they predispose patients to an increased risk for bleeding. Since many of these drugs are eliminated by the kidney, patients with renal impairment should be closely monitored if using these drugs (Geerts, et al., 2008). Studies have shown that the use of antithrombotic drugs can increase the risk of a rare, serious complication of spinal bleeding when used in patients receiving neuraxial anesthesia. For this reason it is recommended that the use of anticoagulants in this patient population be used with caution (Geerts, et al., 2008).

PROPHYLAXIS USE AMONG CLINICIANS

To fully understand the complexity of the issue, it is important to find out what the use of VTE prophylaxis is among healthcare professionals. Several studies and questionnaires have been completed, trying to better understand their prophylaxis tendencies.

In a survey by Wolf & DiGiovanni (2004) of 508 surgeons on outpatient foot and ankle surgery, the use of preoperative, intraoperative, and postoperative prophylaxis was determined. The survey found that 67% had reported that they never use preoperative prophylaxis, with 29% saying they occasionally use it. The biggest reason for the occasional use was in patients with a previous history of VTE. Only 15% of surgeons used intraoperative prophylaxis, mostly via stockings and leg pumps. Postoperative prophylaxis was always performed by 44% of the surgeons. The remaining 56% of the surgeons claimed they did not routinely use prophylaxis but the majority did report using it for certain risk factors such as history of VTE, trauma, and obesity. When asked about immediately admitted patients that needed foot and ankle surgery, 59% used prophylaxis with half of those only for patients with risk factors. Common risk factors were similar to outpatient surgery with history of VTE being the most common.

In a study done in Italy (Ageno, Dentali, & Imberti, 2004a), 200 orthopaedic departments were surveyed regarding the use of prophylaxis in patients undergoing knee arthroscopy. Most surgeons (84%) believed that prophylaxis should be used. Of these surgeons, 83% prescribe anti-coagulants to all patients, while 17% did it based of risk factors. LMWH was the most commonly used prophylactic drug (97.3%). Fifty-nine percent prescribed the drugs for more than 10 days while only 21.8% prescribed until full weight bearing was achieved.

The same group (Ageno, Dentali, & Imberti, 2004b) also did a study in Italy on the use of prophylaxis for lower extremity fractures. Once again, 200 orthopedic departments were

selected. The survey showed that 94.5% said they prescribe antithrombotic drugs, with 93.1% of them prescribing to all patients. LMWH was once again the most common drug prescribed (96.8%). Fifty-five percent prescribed until the patient was full weight bearing while 40.7% prescribed for more than 10 days. Ninety-one percent of surgeons used prophylaxis in patients put in plaster casts, with only 25.8% of them using it only for patients with risk factors.

Redfern & Burks (2009) performed a study at a conference in which the audience, representing 41 U.S. states and 11 different countries were asked to take part in a survey. Of the 134 responses, 69% claimed they use no DVT prophylaxis or only compression boots after a simple knee arthroscopy. Aspirin use was performed by 29% of the audience and 1% each for LMWH and warfarin use. For knee surgery on the ACL or PCL, 56% of the 130 respondents use no prophylaxis or only compression boots. Aspirin use accounted for 40% of the audience. LMWH was 3% and warfarin consisted of only 1%.

In a retrospective study done on thromboembolic complications of arthroscopic shoulder surgery, 33.9% of the surgeons that returned the questionnaire used antithrombotic prophylaxis. The most commonly used drugs were sodium enoxaparin and nadroparin (Randelli, et al., 2010). Since this study was more about the complications of arthroscopic shoulder surgery, no further details about the use of prophylaxis was given. With the rates of VTE in the upper extremity so low, it is interesting that almost 34% still used prophylaxis in this study.

Without guidelines, there is no uniformity across the medical world. From the results of the surveys, it can be concluded that there are widely differing opinions out there regarding prophylaxis. In today's world of defensive medicine, you can believe that until proper guidelines are set in place, surgeries that do not require prophylaxis will continue to be treated with anticoagulants. Other examples of defensive medicine can be seen with the overuse of

antibiotics or ordering unnecessary diagnostic tests instead of relying on a good history and physical.

GUIDELINES

With the differing opinion of so many practitioners regarding thromboprophylaxis in orthopedic patients, a couple health care groups have put forth their guidelines towards thromboprophylaxis. The main problem with these guidelines is that they are centered on major surgery, i.e. TKA, THA, and hip fracture surgery. When looking through the guidelines set forth, there many pages written on these major surgeries and only a few sentences written on the other ones.

The American College of Chest Physicians (CHEST) publishes their guidelines for the prevention of venous thromboembolism. In 2008, they released their 8th edition. In it, they break down each area of surgery and provide recommendations for prophylaxis (Geerts, et al., 2008). They clearly state that patients undergoing elective hip and knee replacement or hip fracture surgery should receive routine thromboprophylaxis, including the specific drugs that should be used and when they should be given. This is not the case for other surgeries. For knee arthroscopy, their recommendation is to not use routine thromboprophylaxis and to only use it in cases where additional thromboembolic risk factors are present. These patients should be given LMWH. Patients undergoing spine surgery should not receive routine prophylaxis, but patients with additional risk factors should receive either post-operative LDUH, post-operative LMWH, or optimal use of perioperative IPC. For patients with isolated lower extremity injuries distal to the knee, they suggest that routine thromboprophylaxis not be used. All major trauma patients should receive routine thromboprophylaxis of LMWH. Inferior vena cava (IVC) filter should not be used. Major trauma is not defined. There are no recommendations given for upper extremity injuries or surgeries.

Another set of guidelines set forth by The Scottish Intercollegiate Guidelines Network (SIGN, 2002) only gives recommendations for TKA, THA, HF surgery, KA, and orthopaedic trauma. They do not recommend routine prophylaxis for knee arthroscopy, saying that at this time it is unjustified. As for orthopaedic trauma cases, there are three recommendations based upon the level of trauma involved. For patients with spinal cord injury, major lower extremity, or multiple traumas, prophylaxis with LMWH “can be considered, unless contraindicated.” Patients with contraindications should use mechanical prophylaxis. Aspirin should be used for 35 days and started upon admission for patients who have contraindications for LMWH and are unable to use mechanical prophylaxis (i.e. placed in plaster splints/casts) (SIGN, 2002).

UPPER EXTREMITY

Deep vein thrombosis in the upper extremity is not a very common occurrence. In fact it makes up about 4-10% of all incidences of DVT (Bernardi, Pesavento, & Prandoni, 2006; Garofalo, et al., 2010). The estimated incidence is about 0.003% in the general population but this may be inaccurate since many upper extremity DVTs are asymptomatic (Bernardi, et al., 2006). However, the incidence of DVT following upper extremity injuries and surgeries is unknown. Very few studies have been done in regards to the upper extremity since the occurrence of symptomatic DVT is so rare.

Most cases of DVT in the upper extremity are due the presence of significant risk factors. The largest risk factor for DVT in the upper extremity is the presence of a PICC line or peripherally inserted central venous catheter. According to Garofalo, et al, nearly 50% of upper extremity DVT cases are due to PICC lines. Another source reports a 12-17% incidence of VTE in patients with central venous catheters with some studies showing as much as a 56% incidence in these patients (Paauw, et al., 2008). Most other cases of upper extremity DVT occur in the presence of malignancy, pregnancy, congenital thrombophilia, coagulation deficiencies, diabetes mellitus, smoking, and intense sports activities (Garofalo, et al., 2010). Additionally, the presence of various gene mutations can contribute to upper extremity DVT. The prevalence of the factor V leiden gene mutation is about 3-7% but accounts for about 20% of all patients with VTE. Factor 2 (prothrombin) mutations occur in about 1-3% of the general population and account for about 6% of all VTE cases. Deficiencies in antithrombin, protein C, or protein S are prevalent in less than 1% of the general population, and account for 5-7% of all VTE (Prosciak & Stawicki, 2008).

SHOULDER ARTHROSCOPY

No reliable data has been found on the incidence of DVT after shoulder arthroscopy and no reliable studies have been performed to determine the effects of anticoagulation therapy on the incidence of DVT after shoulder arthroscopy. There is, however, a retrospective survey and a few documented case reports regarding shoulder arthroscopy patients that formed a VTE. Most of the cases presented identified a contributable risk factor or factors.

Randelli, et al (2010), performed a retrospective survey asking surgeons in Italy about complications from arthroscopic shoulder surgery. Fifty-nine surgeons responded, totaling to 9385 arthroscopic surgeries. Out of the 9385 arthroscopic surgeries, only five DVT and one PE were identified. Of the 59 surgeons, 20 (33.9%) routinely used thromboprophylaxis. Enoxaparin and Nadroparin were the most commonly used drugs. It is unknown what risk factors, if any, were found in these patients. Even though this study was retrospective and it only accounted for symptomatic thromboembolic events, the occurrence (0.6/1000) was very rare.

Garafalo, et al (2010) wrote a case report on two patients that formed a VTE after arthroscopy without the presence of any known significant risk factors. The first patient was a 21-year-old, non smoker that underwent arthroscopy for chronic shoulder instability. After the 45 minute long procedure, the shoulder was immobilized for 4 weeks, only allowing active use of the wrist and elbow a couple times a day. At 3 weeks, the patient had a symptomatic DVT and PE. The patient had no identifiable risk factors for DVT, but the patient did have a history of recurrent shoulder dislocations and subluxations. The other patient was a 54-year-old, non-smoking male who underwent arthroscopic rotator cuff repair. After the 50 minute procedure, the shoulder was immobilized for 4 weeks, with active wrist, elbow, and shoulder movement

allowed several times per day. At 3 weeks, the patient had a symptomatic DVT. This patient also had no known significant risk factors for DVT.

Other cases involved patients with significant risk factors for DVT. Burkhart (1990) wrote the first known published case of DVT following arthroscopic shoulder surgery. This was a 32-year-old male having surgery for shoulder instability. At postoperative day 3, the patient presented with a symptomatic DVT. A chest radiograph followed by needle biopsy revealed Hodgkin's lymphoma that was compressing the innominate vein.

Polzhofer, et al (2003) wrote a case report on a 48-year-old obese male with diabetes and a known enchondroma that underwent an arthroscopic acromioplasty. After reviewing the risk factors, post-operative administration of Mono-Embolex once per day was given. At day seven, the patient presented with a symptomatic pulmonary embolism.

Another report was a 2009 case by Hariri, et al (2009) on a 25-year-old rugby player and skier. He had a history of tobacco use but no other known risk factors. After the 150 minute long procedure for shoulder instability, the shoulder was immobilized for 6 weeks, preventing external rotation. On day 10, the patient presented with a symptomatic pulmonary embolism. With smoking as the only known preoperative risk factor, the patient still developed a VTE when combined with an extended surgery time.

Bongiovanni (2009) reported in 2009 about 3 different patients with hereditary thrombophilias that developed VTE. The first case involved a 30-year-old male, tae kwon do athlete who had surgery for a SLAP lesion as well as an intraarticular partial tear of the supraspinatus tendon. The surgery lasted 80 minutes. Four days later, the patient presented with a symptomatic DVT in the basilic and humeral veins. The second patient was a 54-year-old female

with a full-thickness L-shaped rotator cuff tear. The 90 minute procedure involved repair of the rotator cuff as well as resection of the distal end of the clavicle. After 10 days, the patient developed a symptomatic DVT in the popliteal vein of the left leg. The third patient was a 66-year-old male with repair of a rotator cuff tear. Six days after the 80 minute procedure, the patient developed a symptomatic occlusion of the humeral, cephalic, and basilic veins.

SHOULDER ARTHROPLASTY

Only one prospective study could be found on the incidence of DVT in shoulder arthroplasty. Willis, et al (2009) performed a study on 100 patients receiving a total shoulder replacement or a hemiarthroplasty. Patients that were on anticoagulation medicines, had active thromboembolic disease, or those that declined consent were all excluded from the study. In all, 73 total shoulder replacements and 27 hemiarthroplasties were involved in the study. Females made up 56% of the patients and the mean age was 67. The most common indication for surgery was osteoarthritis.

All the procedures consisted of a standard deltopectoral approach with the patient in a semi-reclined, beach chair position. Interscalene block regional anesthesia was performed in all patients. No perioperative thromboprophylaxis was given, including pneumatic compression devices, compression stockings, or medications. Post-operatively, all patients received an enteric coated 325 mg aspirin twice per day, pneumatic compression foot pumps, and performed early ambulation. Color duplex ultrasonography was performed on all patients on day 2 and in only 50 randomly selected patients at 12 weeks due to cost restraints. No screening was done prior to surgery.

The incidence of DVT in this study was 13%. Ten DVTs were found at day 2 and an additional 3 patients were found to have DVT at 12 weeks, all confirmed with color duplex ultrasonography. Overall, 6 of the DVTs were found in the operative limb while 7 of the DVTs were found in the lower extremity. Five of the upper extremity DVTs extended into the subclavian and internal jugular veins. Pulmonary embolism (PE) occurred in three patients, with one being fatal. Two of the PEs were documented by CT in symptomatic patients. The third patient had what was most likely a PE after doing a valsalva maneuver while using the bathroom approximately 7 weeks post-operatively, which ended fatally. According to the patient's wife, the man became pale, dyspneic, diaphoretic, and unresponsive. The family declined autopsy, so the diagnosis was never confirmed. The patient had his surgery due to a 4-part proximal humerus fracture. His day two doppler ultrasound did not show any clots.

The authors of the study concluded they could not find any significant risk factors due to a small sample size. However, they did find that increased age, prolonged operative time, and previous DVT tended to increase the incidence of DVT in this study.

The study was performed in a manner that the authors could compare their results to the results of studies done at their institution for total hip arthroplasty (THA) and total knee arthroplasty (TKA). At their institution, the incidence of DVT in this study was not significantly different than the 10.3% incidence in THA patients. The 27.0% incidence of DVT with TKA was significantly higher than that of shoulder arthroplasty, however.

The authors recognized that there were some downfalls to their study. During the surgery, the axillary vein could be traumatized or kinked when the arm was moved around throughout the surgery. Also the position of the patient in a gravity dependent position for an extended period of

time could have significantly increased the chances of DVT, especially without the use of any pneumatic pumps during surgery. Finally, preoperative screening was not performed, so it cannot be determined if any clots preexisted that all of the clots resulted from the surgery.

KNEE ARTHROSCOPY

Knee arthroscopy (KA) is a minimally invasive procedure in which small incisions are made in the anterior knee, one incision for the arthroscope or camera, and the others for the surgical instruments used to cut, cauterize, tease, etc. It is commonly used for meniscectomy, synovectomy, and cruciate ligament repair. The advantage, and reason for its increased popularity is that compared to open surgery, the recovery time and complications are drastically decreased. In fact, it is most often performed as an outpatient procedure in which the patient can usually go home that day. One complication that is decreased with KA is DVT. It is suggested that the risk of VTE is very low, especially compared to the risks associated with knee arthroplasty (Geerts, et al., 2008, p. 409).

Until recently, there were not many studies done on the risk of VTE in patients undergoing knee arthroscopy. Over the last few years more and more studies are being done in the area. These studies show a wide variety in VTE outcomes as very few studies were carried out in the same manner. Some studies were control studies with a low molecular weight heparin (LMWH) used in one group and placebo for the other as thromboprophylaxis. Many other studies had all the patients either receiving medical prophylaxis or none at all. Not all of the studies had the same VTE screening protocols. With the variety in study protocols, it made it difficult to compare data from each study.

There are a couple sets of anticoagulation guidelines that have been put in place regarding knee arthroscopy. CHEST guidelines state that routine prophylaxis should not be given and that prophylaxis should only be used when additional thromboembolic risk factors are present (Geerts, et al., 2008, p. 410). The Scottish Intercollegiate Guidelines Network states that

“there is insufficient evidence to justify routine prophylaxis in patients undergoing knee arthroscopy” (SIGN, 2002, p. 20).

Delis, et al (2001) studied 102 patients receiving knee arthroscopy. Patients in this study were excluded if they also had ACL injury or if an emergency knee arthroscopy was performed. The following risk factors were investigated: age >65 years old, tourniquet time >30 minutes, BMI >30, past DVT, chronic venous insufficiency, and hormone replacement therapy. No patients received medical prophylaxis in this study, but the patients did receive physiotherapy and mobilized weight bearing. All patients underwent duplex ultrasonography (DUS) four days prior to the procedure and weekly for a month afterward, and then once a month for an average of 118 days postoperative.

The authors confirmed unilateral DVT with ultrasound in 8 patients (7.8%) who underwent KA, all confined to the calf. One DVT did progress proximally into the middle 1/3 of the popliteal vein. Half of the DVTs were completely asymptomatic. The other four patients had calf tenderness, 1 of which had a positive Homan's sign, but none with measurable calf swelling. DVTs were located in five of the 21 patients with at least two risk factors (, which was a significant number based off of a 95% confidence interval. Of the eight patients with DVT, two had no risk factors and one had one risk factor. Having a past DVT was the only risk factor associated with the development of DVT (95% CI) and was calculated to have a relative risk of 8.167. All seven patients with a distal calf DVT were put on aspirin (ASA) and elastic compression stockings and the patient with the proximal popliteal DVT was put on heparin and warfarin. The problem with this study, however, is that the patients underwent treatment after a DVT was diagnosed. We do not know what the outcome would have been if these eight DVT would have gone untreated, especially the four that were asymptomatic. In a follow up of about

118 days, four of the clots had complete resorption while the other four had partial resorption. It does not state which category the proximal DVT fell under.

Demers, et al (1998) studied patients receiving knee arthroscopy without the use of prophylaxis. In their study, patients were excluded if they were under age 18, were pregnant, had a previous DVT or PE, or if they were allergic to contrast medium. All patients received a baseline venography before surgery and then had a subsequent venography at one week post-operatively. After the surgery, patients were instructed not to bear weight on the operative leg for 24-48 hours, followed with weight bearing as tolerated. Of the 184 patients in the trial, 33 (17.9%) developed a venographically proven DVT. Nine of these were located proximally. One patient was found to have an asymptomatic PE after screening for another study. Twenty of the 33 patients with DVT were symptomatic, while 25 patients without DVT complained of DVT like symptoms. This confirms that clinical symptoms have a low sensitivity and a low specificity. Risk factors were included in the analysis and the only risk factor found to have significance was tourniquet time greater than 60 minutes. Tourniquet time over 60 minutes had a 46.7% incidence of DVT and 15.4% incidence for time less than 60 minutes.

Hoppener, et al (2006) performed a prospective study in the Netherlands on 335 patients with knee arthroscopy that received no venous thromboprophylaxis. The exclusion criterion for this study was current anticoagulant use, unwilling to consent or follow up, other causes or immobility, or a previous intraarticular reconstructive procedure of the knee. Patients were evaluated at two weeks clinically and with bilateral compression ultrasonography. Nineteen of the 335 patients (5.7%) were found to have a DVT at the two week mark. Only two of these 19 were found to be symptomatic. Three clots were located proximally in the leg (0.9%), eight in the calf veins and eight were confined to the muscle veins only. All 16 patients with calf or

muscle vein thrombus at two weeks underwent a repeat ultrasound a week later. None of these thrombi showed progression and therefore none were treated. All 16 of these patients were asymptomatic for an additional eight weeks of follow up. No risk factors were found to pose a significant risk of developing a DVT. In fact, there were even five patients in the study that had a previous DVT and four patients with a previous PE, and none of these patients developed a DVT or PE in this study.

Michot et al (2002) did a controlled study on patients receiving knee arthroscopy in which 66 patients received dalteparin and 64 patients received no prophylaxis. The patients receiving treatment were given one dose 1-2 hours prior to the procedure and then again 6 hours postoperatively for up to 30 days. Patients that had local anesthesia only, did not have a tourniquet used in their procedure, while patients with general or regional anesthesia did. Patients were allowed to choose the anesthesia type. This study, however, excluded many patients that had risk factors for DVT or bleeding such as a history of DVT/PE, antithrombin 3 or protein s or c deficiency, ongoing treatment with steroids, anticoagulants or long term NSAIDs, hypersensitivity to heparin, or recent history of GI or cranial bleed. All patients underwent a history and physical followed by bilateral compression ultrasonography at postoperative days 12 and 31. Unilateral DVT developed in 10 of the 64 patients (15.6%) in the control group and in one of the 66 patients (1.5%) in the treatment group, which was significantly lower ($P= 0.004$). All cases of DVT were located in distal leg: five in the axial calf and nine in the calf muscle branch. There was no correlation to anesthesia type or to tourniquet use. One patient in the treatment group did have a PE. Symptoms of diffuse calf tenderness were noted in two patients and nine had localized pressure pain. It was not documented if the patient with the PE had a symptomatic DVT. At day 12, eight DVTs were diagnosed, with two more diagnosed at day 30.

Patients with confirmed DVT were treated with oral anticoagulation for 3 months. The main problem with this study was that it excluded patients with certain risk factors, so many risk factors cannot be assessed. Also, patients that were diagnosed with DVT were given treatment, so we do not know if any of the DVTs would have amounted to anything clinically significant.

Marlovits, et al (2007) did a study on arthroscopic anterior cruciate ligament (ACL) reconstruction. All 140 patients in this study were treated with enoxaparin once daily starting 12-18 hours preoperatively and lasting for three to eight days in the hospital. After discharge, patients were then randomized to a self-administration of enoxaparin or placebo for an additional 20 days. Venography was performed at hospital discharge and at the end of the 23-28 day study. No patients had a confirmed DVT at discharge. At the end of the study, two of 72 patients in the treatment group had a confirmed DVT (2.8%), both being proximal but asymptomatic. In the placebo group, 28 of 68 patients had confirmed DVT (41.2%) with only 3 being symptomatic and 18 being in the proximal region. The authors found this to be a significant difference when comparing incidence of VTE in treatment versus control groups ($P < 0.001$). Complications were limited in this study. There were no patients with a PE and only 13 minor bleeding complications after 513 self injections of enoxaparin (2.5%) were reported. The study states that age >30 years and immobilization before surgery were significant risk factors for DVT. However, there were limitations of the study. The study was done at a teaching hospital and the length of surgery was over 2 hours in 50% of the surgeries. The long surgery times for all the patients in this study must be considered when analyzing the data. It is also unknown if any of the patients followed instructions on post operative mobilization and weight bearing or if the patients were compliant with administration of enoxaparin. Since the study was aimed at in-hospital prophylaxis vs.

extended period prophylaxis, the authors recommended that extended period prophylaxis be used.

Schippinger, et al (1998) did a prospective study in Sweden on 101 patients undergoing knee arthroscopy for conditions other than ligament repair, cartilage transfer, or any involving bone drilling. All patients had preoperative duplex ultrasound to both legs and ventilation/perfusion scans performed. Patients were not included in the study if they had present or previous DVT or PE, had malignancy, were pregnant, or allergic to contrast media. All patients received 5000 units of Dalteparin once daily at least 12 hours prior to surgery until the patient was discharged. Patients were on average discharged on post-operative day two. Tourniquets were placed during surgery but only used when visualization decreased. Patients received postoperative stockings to be worn for 14 days and mobilization was begun that night on patients with general anesthesia and the next day for patients under regional anesthesia. All patients followed up at 5 weeks with duplex ultrasonography and ventilation/perfusion scans. If ultrasonography raised any doubt about the presence of DVT, venography was performed. Of the 101 patients, 12 had a thromboembolic event. Of these patients, eight developed a DVT with half being asymptomatic. Nine patients had a PE with only one of these being symptomatic. Five of the DVT patients went on to develop a PE and were included in the nine with PE. The only statistically significant risk factor was the presence of varicose veins. Nine of the 45 patients with varicose veins presented with a DVT and/or PE (20%). No association was found with the type of anesthesia.

Various limitations exist in the Schippinger study. Although this study used heparin, it was only used it for an average of 3 days. It would have been beneficial to see the patients on heparin longer, especially if they were willing to fund the use of ventilation/perfusion scans for

all patients. This is the only study found that scanned for PE in every patient post-operatively. Other studies only scanned patients if they were symptomatic. If that was the case, only one patient would have been found to have a PE. It would be interesting to know if these findings are similar to other studies if ventilation/perfusion scans were performed on all patients in every study.

Stringer, et al (1989) did a study on patients receiving various types of surgeries to the knee. The study included 48 patients with knee arthroscopy, 151 with open meniscectomy, and 58 miscellaneous surgeries including patellectomy, arthrotomy or removal of loose bodies, arthrodesis, or synovectomy. These patients were given no venous thromboprophylaxis and ascending venography was performed seven to ten days postoperatively. Two of the 48 patients (4.2%) undergoing knee arthroscopy were found to have a calf DVT and no patients had a proximal DVT or PE. Of the 151 patients undergoing open meniscectomy, 37 (24.5%) were found to have a calf DVT with three of these patients (2%) also having a proximal DVT. No patients had a PE. Forty-five patients had an arthrotomy and 11 of these patients (24%) had a calf DVT with only one (2.2%) also extending in the popliteal or femoral region; however, no patients had a PE. Four of the six patients receiving an arthodesis had a distal calf DVT with two also having a proximal DVT. One of these patients also had a non-fatal PE. Two of the four patients with a patellectomy had a calf DVT and one of these patients also had a non-fatal PE. One of the three synovectomy patients had a calf DVT but there were no proximal DVT or PE in this group. All proximal DVTs were treated heparin and warfarin for three months. Major calf DVT (DVTs greater than 5 cm) were treated with an unspecified anticoagulation therapy while minor calf DVTs were treated with elastic compression stockings only. The study does not state if or how many of the patients had symptomatic vs. asymptomatic DVTs. It should also be noted that it

was physician preference on the type of exsanguinations (esmarch or elevation) was to be used during surgery. The number of surgeries that used each method was given but no data was given comparing the incidence of DVT regarding the method of exsanguination. It is mentioned that the only significant risk factors for DVT during the study were age and length of surgery.

TABLE 2. KNEE ARTHROSCOPY: NO ANTICOAGULATION PROPHYLAXIS				
Author	Sample #	Confirmed DVT	%	Method of Confirmation
Delis, et al	102	8	7.8	Color duplex ultrasonography
Demers, et al	184	33	17.9	Venography
Hoppener, et al	335	19	5.7	Compression ultrasonography
Marlovits, et al	68	28	41.2	Venography
Michot, et al	64	10	15.6	Color duplex ultrasonography
Stringer, et al	48	2	4.2	Venography
Total	801	100	12.48	

TABLE 3. KNEE ARTHROSCOPY: ANTICOAGULATION PROPHYLAXIS					
Author	Sample size	Confirmed DVT	%	Method of confirmation	Anticoagulation type
Marlovits, et al	72	2	2.8	Venography	Enoxaparin 40 mg x23-28 days
Michot et al	66	1	1.5	Color duplex ultrasonography	Dalteparin x 10 days
Schippinger et al	101	8	7.9	Color duplex ultrasonography	Dalteparin x 3 days (average)
Total	239	11	4.6		

Dahl et al (2000) studied 1355 patients from 1989 to 1998 that underwent knee arthroscopy (KA) and received no medical prophylaxis. Patients with symptoms of DVT were screened with Venous Doppler Ultrasound (DUS) and then venography if DUS was negative. The study found 8 of the 1355 pts (0.6%) had a clinical DVT after KA. Of these, seven were located in the calf only and the other was located in the popliteal vein. All DVT had developed within 1-6 days. Keep in mind that only the patients with clinically suspected DVT were screened with ultrasound and venography. Since many DVT are asymptomatic, it is unknown how many patients actually had a DVT. An advantage of knee arthroscopy though, is that the post-surgical sequelae, including pain and swelling are less severe than in TKA, making the symptoms of DVT much more recognizable. This study does not indicate if the patients had physical therapy or if the patients were mobilizing the lower extremity. However, the only patient demographics given were age and gender. The ages of the patients with DVT ranged from 32-65 and there were 3 times as many men with DVT.

Jaureguito, et al (1999) performed a retrospective study on 2050 patients and a prospective study on 239 patients receiving knee arthroscopy. The patients were grouped into two groups. Group one patients had intraarticular arthroscopic surgery without ligamentous involvement. This included partial meniscectomy, loose body removal, or chondroplasty. Group two included those with ligament involvement, meniscus repair, or tibial osteotomy. The retrospective study involved reviewing patient charts from all patients from January 1993 to December 1994. The review found 5 patients (0.24%) with a clinically suspected DVT confirmed by ultrasound. Four of the five patients with confirmed DVT were classified into group two with a total DVT incidence of 0.5% in group two.

In Jaureguito's (1999) prospective study, patients taking anticoagulation therapy or with a history of DVT or PE were eliminated. Patients over 45 years old were prescribed 325 mg aspirin for three weeks after surgery. Patients underwent preoperative duplex ultrasonography followed by repeat ultrasonography at 5 to 10 days after surgery. The study found seven DVT for an incidence of 2.9%. Five of these were asymptomatic and occurred within one to eight days postoperatively. Two other patients developed symptomatic DVT within 70 and 119 days. All DVTs were confirmed by color duplex ultrasonography. Two of the original five DVT occurred in patients in group one and three in group two. Two DVT were located proximally. No PE were identified. The study found no significant risk factors, but the authors noted that patients in group two with DVT tended to have a longer tourniquet time. Based on the cost-benefit analysis, the authors did not support the use of duplex ultrasonography for screening patients undergoing intraarticular knee arthroscopic surgery.

This study is not included in the comparative data for knee arthroscopy because all the patients over age 45 were given aspirin and no data was given for the incidence of DVT in this

population versus the incidence in the under 45 age group who did not receive aspirin. The authors mentioned that there was no significance found between the over 45 age group and the less than 45 age group. With increasing age as a risk factor, you would expect more patients in the over 45 group to develop a DVT. Since this was not the case, this may have been due to the use of aspirin. Therefore, the use of aspirin following KA is something that should potentially be studied in this age group. Also, screening was performed at days 5-10 days postoperatively, which may be too early and is a factor that prohibits the inclusion of this study in the comparative analysis.

LOWER EXTREMITY FRACTURE

Any type of fracture that affects the lower limb can have serious effects on the ankle and muscular pump that is involved in venous return. Lower extremity fractures are commonly splinted, casted, or immobilized, thus increasing the chances to develop VTE. Even minor surgeries involving the foot can have these effects if the patient is immobilized or not actively using that limb. In addition to this, many lower extremity fractures are surgically fixed, which also increases the risk of VTE.

CHEST (Geerts, et al., 2008) guidelines for the foot and ankle suggest that routine thromboprophylaxis not be used. They state that it doesn't significantly decrease the chances of significant DVT and it is not cost effective. The guidelines do not mention risk factors.

Abelseth et al (1996) did an interesting study in which they included only patients with femoral shaft, tibial shaft, tibial plateau, and tibial pilon fractures that were surgically fixed. No patients were put in casts or splints and early mobilization was required. Patients were excluded from the study if they had a history of PE or DVT, contraindication to anticoagulation therapy, fractures requiring traction postoperatively or where mobilization was not possible, associated hip or pelvic fractures, admission to an ICU, head or spine injury, or contraindication for contrast media. There were 102 patients included in the study, which consisted of 20 femoral shaft fractures, 28 tibial plateau fractures, 54 tibial shaft fractures, and eight tibial pilon/plafond fractures. These patients were given no prophylaxis and were checked for DVT with venography around the ninth post-operative day. DVT was confirmed in 29 (28.4%) patients: eight of 20 femoral shafts (40%), 12 of 28 tibial plateaus (43%), 12 of 54 tibial shafts (22%), one of eight tibial plafonds (12.5%). Proximal DVT were located in four patients and the rest were distal DVT. All DVT were asymptomatic. Clinical evidence of PE was believed to occur in 4 patients.

Pulmonary angiograms were done on two of these patients, with both having negative results. The other two patients had V/Q scans with one being positive and the other being inconclusive. The authors did not state why two patients had angiogram, while the other two had V/Q scan.

The authors found three risk factors that had a high significant association with rates of DVT. These factors were age greater than 60, operating room (OR) time >105 min, and time from injury to operation greater than 27 hours. Patients with at least one of these three risk factors were labeled as high risk patients by the authors. Patients considered high risk had a DVT incidence of 47.2% (25 of 53). None of the patients had all three risk factors. The other patients had an incidence of only 8.5%.

Sems, et al (2009) performed a study on 136 patients with lower extremity fractures requiring surgical fixation. All patients in the study were treated within 24 hours with external fixation spanning either the ankle or the knee joint. Patients were kept in the external fixator until the surgeon was ready to proceed with internal fixation. On average the patients were in the external fixators for 17.9 days. All patients were treated daily with either 40 mg of enoxaparin or 5000 units of dalteparin. Sometime within one to three days of planned internal fixation, the patients were screened for DVT with duplex ultrasonography.

In all, 143 external fixators were placed on the 136 patients. There were 84 knee spanning fixators and 59 ankle spanning fixators. The following made up the patient population.

Diaphyseal femur fracture- 4	Distal femur fracture- 10
Proximal tibial/tibial plateau fracture- 62	Diaphyseal tibial fracture- 4
Distal tibial/pilon fracture-44	Ankle fracture-5
Calcaneous fracture- 8	Knee dislocation- 10
Talar fracture/dislocation- 4	

Only three patients (2.2%) were found to have a DVT confirmed by duplex ultrasonography. All three DVT were in limbs that had an external fixation crossing the knee joint. Two of the three involved an open fracture. None of the patients had any significant risk factors outside of the trauma already present, but each of the three did have injuries to multiple limbs. None of the patients with injuries to only one limb developed a DVT. The first DVT occurred in a 36-year-old male with a tibial pilon and talus fracture on one leg and a supracondylar and intracondylar femur fracture in the DVT affected leg. This patient had an occlusive popliteal DVT after 4 days. Before internal fixation, the patient received an IVC filter and no further complications arose. The second DVT occurred in a 45-year-old male with a tibial plateau fracture. A nonocclusive DVT was found in the tibial vein. This patient too received an IVC filter before internal fixation. The last DVT occurred in a 49-year-old male with a tibial plateau fracture from a motorcycle crash. This patient had a popliteal DVT and eventually died due to the injuries from the crash. No bleeding problems occurred but 2 patients were taken off of LMWH after their platelet counts dropped below 100×10^9 .

Lapidus, et al (2007) performed a prospective study on 197 patients being surgically treated for unimalleolar, bimalleolar, or trimalleolar ankle fractures. Patients had to be 18-75 years of age and had an ankle fracture within 72 hours of surgery. Patients were excluded if they if they were currently on anticoagulation therapy or platelet inhibitors, had a known allergy to contrast, known kidney disorder, nephrectomy or kidney transplant, recent VTE, previous surgery within one month, known malignancy, current bleeding disorder, pregnancy, and multiple traumas. The mean age of the population was 48 and females made up 54% of the patients. After surgery, patients were placed in a plaster cast or an orthosis for an average of 44 days. All patients were placed on 5000 units of Dalteparin once daily for the first week, starting

on the first evening after surgery. Patients were then either given 5000 units of Dalteparin daily or placebo until the plaster cast was removed. This was a double blinded study, with 101 patients in the treatment group and 96 patients in the control group.

Mandatory follow up took place at two and six weeks. Casts were removed and venography was performed. Color duplex ultrasonography had to be used in a few patients in which venography failed. CT scan or scintigraphy was used if PE was suspected.

The incidence of DVT in the treatment group was 21/101 (21%) and it was 27/96 (28%) in the control group. The authors found no significant difference between the two groups. Four in the treatment group had a proximal DVT (4%) and three in the control group had a proximal DVT (3%). Most of the DVT were asymptomatic and no patients had a confirmed PE.

Patil et al (2007) did a study on 100 patients with an ankle fracture. These patients were treated with a below knee plaster cast and received no medical pharmacologic prophylaxis. Of the 100 patients, 72 were allowed full weight bearing, 9 partial weight bearing, and 19 no weight bearing. Asymptomatic DVT were found in 5 (5%) patients through the use of DUS. No patients were symptomatic. Distal DVT were found in 3 patients and proximal DVT in the other 2. After diagnosis of DVT, 4 of the patients received treatment of warfarin and dalteparin. The other patient did not receive any treatment. No patients showed any progression of their DVT on follow-up. This study was beneficial in that it only included ankle fractures. Many studies have mixed together an assortment of lower extremity injuries, making it hard to make any injury specific conclusions. Additionally fifteen patients were already on low dose (75 mg daily) aspirin for cardiovascular or cerebrovascular problems, and the authors did not mention if this had any impact on the results of the study.

TABLE 4. LOWER EXTREMITY FRACTURE: NO ANTICOAGULATION PROPHYLAXIS				
Author	Sample #	Confirmed DVT	%	Method of Confirmation
Abelseth, et al	102	29	28.4	Venography
Lapidus, et al	96	27	28	Venography
Patil, et al	100	5	5	DUS
Total	298	61	20.47	

TABLE 5. LOWER EXTREMITY FRACTURE: ANTICOAGULATION PROPHYLAXIS					
Author	Sample size	Confirmed DVT	%	Method of confirmation	Anticoagulation type
Lapidus, et al	101	21	21	Venography	Dalteparin
Sems, et al	136	3	2.2	DUS	Enoxaparin or dalteparin
Total	237	24	10.13		

ACHILLES TENDON RUPTURE

Achilles tendon rupture is an injury that requires a high force and is often associated with athletics. Surgery to repair the Achilles tendon often requires post-operative immobilization in a boot for an extended period of time, thus decreasing the mobilization of that extremity. There is no mention of Achilles tendon injuries in the guidelines for thromboprophylaxis.

Lapidus, et al (2007) performed a double blinded prospective study comparing the effects of dalteparin versus placebo in patients with surgically corrected Achilles tendon ruptures. From 1997-2001, they authors claimed that at their clinic, the incidence of symptomatic DVT after surgically treated Achilles tendon ruptures was 7.6%. The group wanted to find out if the use of LMWH would reduce the chance of acquiring a DVT in the six week postoperative immobilization after surgery.

Patients were randomized into a treatment group or a control group. The treatment group received 5000 units of dalteparin subcutaneously once per day while the control group received injections of 9% sodium chloride. Patients were evaluated at three and six weeks post-operatively for clinical signs of DVT as well as with color duplex ultrasonography. All ultrasound confirmed DVT were then confirmed by venography. Patients were excluded if they were already on anticoagulation therapy or antiplatelet inhibitors, had a known allergy to contrast media, known renal disorder, pregnant, current bleeding disorder, recent surgery, known malignancy, other injuries, or recent thromboembolic event. At the end of the study, the treatment group consisted of 47 patients and 44 more patients were in the control group. Even though there were no significant differences in DVT risk factors for the two groups, the control group had more patients with risk factors than did the group receiving dalteparin.

The incidence of DVT in the treatment group was 16 of 47 patients (34%). The control group had 16 confirmed DVT out of 44 patients (36%). The P value comparing these groups is 0.8 and is therefore not significant. One patient on the dalteparin had a proximal DVT and 3 patients on placebo did. Of the confirmed DVT, 65% were diagnosed at the three week visit while the remaining 35% were diagnosed at the 6 week visit. No patient had a diagnosed PE. The authors stated that only 15 of the DVT were symptomatic but this number is not reliable as it is difficult to differentiate symptoms of a DVT from those of the surgery.

Even though the incidence of DVT was higher than expected in both groups, there was no significant difference found between the two groups. The incidence of DVT in the patients with risk factors was not given, as this would have been a good addition to the study. Only one patient had a bleeding complication from the dalteparin. This patient had a severe bloody nose after just 2 days of treatment and was subsequently withdrawn from the study.

Of the 180 patients that were not included in the study, mostly due to consent, 10 patients had a symptomatic DVT (5.6%). Two DVT were proximal, seven were distal, and one was in a muscle vein. DVTs in this group were mostly confirmed with venography. Most of the patients were not on anticoagulation therapy; however, four patients were placed on dalteparin and one of these patients developed a proximal DVT. No patients in this group were diagnosed with a pulmonary embolism.

Nilsson-Helander, et al (2009) performed a prospective randomized study of 100 patients, ages 24-63, with Achilles tendon ruptures. Of the 100 patients, 51 were treated surgically, while the other 49 were treated non-surgically. Exclusion criteria were diabetes, previous Achilles tendon rupture, other lower leg injuries, immune-suppressant therapy and neurovascular disease.

Seven patients received prophylactic dalteparin at 5000 U for 10 days due to risk factors. All patients received a below-knee plaster cast with the foot in equinus position for two weeks followed by an adjustable lower leg brace for six weeks. ROM training started when the brace was applied. Full weight bearing was started when the ankle was at the neutral position. Screening was performed at eight weeks with color duplex ultrasonography. These examinations were performed by any of six different experienced technicians and then reviewed by two blinded vascular physicians, each with more than 10 years experience.

Of the 51 surgical patients, a tourniquet was used in 26 patients. General, spinal, or local anesthesia was performed in four, 26, and 19 patients respectively. Five total patients were excluded due to compliance issues or re-rupture leaving 95 patients with 49 in the surgical group and 46 in the non-surgical group. Fourteen of the 49 surgical patients and 18 of the 46 non-surgical patients were found to have a DVT at eight weeks. There was no significant difference between the two groups ($P=0.217$). One of the seven patients that received prophylactic dalteparin was found to have a distal DVT. It is unclear what treatment group this occurred in but with only seven patients given prophylaxis, this data is insignificant. Of the 32 confirmed DVT, 22 were asymptomatic. Three patients also developed a PE, all from the non-surgical group.

This study was limited in that there was a small test number. Only 95 patients ended up being a part of the study and about half of them had different treatment plans. In addition, seven patients were treated with dalteparin while none of the other patients were. These seven patients should not have been even included in the study because this is not a large enough sample size to draw any conclusions from in regards to the effects of LMWH on this patient population. However, the study did use two independent vascular diagnostic physicians that were blinded to

the diagnosis as well as to each other's diagnosis. Two technicians often worked together while performing and interpreting the duplex ultrasonography.

Altogether, 32 of the 95 patients experienced a confirmed DVT for a rate of 33.68%. LMWH was used in seven patients with one having a confirmed DVT for a rate of 14.29%. The sample size for this is not large enough to draw any conclusions. Taking these seven patients out of the picture, that leaves 88 patients that were not medically prophylaxed. Of the 88, 31 patients had a confirmed DVT for a rate of 35.23%.

This study looked to compare surgical versus conservative treatment and the authors concluded that there is no significant difference between the two treatment types for preventing DVT. Without a significant population of patients with DVT prophylaxis, we cannot draw any conclusions regarding the effect of prophylaxis from this study alone.

TABLE 6. ACHILLES RUPTURE: NO ANTICOAGULATION PROPHYLAXIS				
Author	Sample #	Confirmed DVT	%	Method of Confirmation
Lapidus et al	44	16	36	Color duplex ultrasonography
Nilsson-Helander, et al	88	31	35	Color duplex ultrasonography
Total	132	47	35.61	

TABLE 7. ACHILLES RUPTURE: ANTICOAGULATION PROPHYLAXIS					
Author	Sample size	Confirmed DVT	%	Method of confirmation	Anticoagulation type
Lapidus et al	47	16	34	Color duplex ultrasonography	Dalteparin x 6 weeks
Nilsson-Helander, et al	7	1	14	Color duplex ultrasonography	Dalteparin x 10 days
Totals	54	17	31.48		

OTHER FOOT SURGERY

Radl et al (2003) did a study on patients being surgically treated for bunions, or hallux valgus, with the use of the Chevron bunionectomy. In this study, 100 patients underwent the procedure and were not given medical prophylaxis. They were, however, allowed to walk in hallux valgus shoe for six weeks and patients were encouraged to actively dorsiflex and plantarflex the ankle. The patients were also put on NSAIDs (diclofenac, 75 to 150 mg/day). Patients were checked at four weeks for DVT with venography. No patients had any clinical indication of DVT or PE in hospital stay. Dorsal foot swelling was found in eight patients, but no other signs of DVT were present. Venography showed four patients with distal DVT (4%) at four weeks post-operatively, two in which had swelling of the dorsum of the foot at time of venography. No significance was found in relation to weight, BMI, duration of surgery, nicotine use, use of hormone meds, prothrombin time, or activated partial thromboplastin time. There was, however, a significant association with age. The mean age for patients with DVT was 61.7 \pm 6.1 years and mean age for no DVT was 48.4 \pm 13.9 years. The study does not indicate if any treatment was given to patients after a confirmed DVT.

CONCLUSIONS

UPPER EXTREMITY

As noted by the study done by Randelli, et al (2010), the occurrence of symptomatic VTE following arthroscopic shoulder surgery is very rare (0.6 per 1000 patients). No other studies could be found regarding arthroscopic shoulder surgery and the incidence of venous thromboembolism. Several case studies have been published, indicating the possible risk factors that may predict venous thromboembolism. However, without statistically comparing the significant risk factor for DVT, it is difficult to determine causality of the DVT in the arthroscopic shoulder surgery cases.

Only one study has been performed on the incidence of VTE in patients undergoing shoulder arthroplasty. The authors found a 13% incidence of DVT, confirmed by color duplex ultrasound, in the 100 patient prospective study of patients prophylactically treated with 325mg aspirin per day. Six of the patients had upper extremity DVT, while the other seven had lower extremity DVT. No incidence of symptomatic DVT was given. The authors found a correlation of DVT in the study with patients with increased age, prolonged operative time, and prior DVT (Willis, et al., 2009).

In patients undergoing shoulder arthroscopy or shoulder arthroplasty, pharmacologic thromboprophylaxis is not warranted at this time. Only patients with more than one known risk factor associated with increased incidence of VTE should be considered for thromboprophylaxis. These risk factors include patients with PICC lines, increased age, smoking history, previous DVT, malignancy, decreased mobility, and prolonged surgery time. With only one study

performed on each procedure, and a low incidence VTE reported in the medical community, there is not enough data to recommend it for the general population.

KNEE ARTHROSCOPY

There were six prospective studies on knee arthroscopy that involved no pharmacologic prophylaxis that we included in our analysis. With these studies combined, there were 100 DVT confirmed by either duplex ultrasonography or venography for a total incidence of 12.45%. These studies included patients without significant risk factors for DVT. However, 50% of the patients in the study by Marlovitz, et al had a surgery time of over two hours, which is a significant risk factor for VTE. If the study by Marlovitz, et al is removed, the incidence of DVT drops to 9.82% (Delis, et al., 2001; Demers, et al., 1998; Hoppener, et al., 2006; Marlovits, et al., 2007; Michot, et al., 2002; Stringer, et al., 1989).

Only three prospective studies were found that included pharmacologic prophylaxis in patients undergoing knee arthroscopy. The incidence of duplex ultrasound or venographically proven DVT was 4.6% (Marlovits, et al., 2007; Michot, et al., 2002; Schippinger, et al., 1998).

Two retrospective studies showed an incidence of symptomatic DVT rate of 13 of 3045 (0.38%), all confirmed with duplex ultrasonography or venography (Dahl, et al., 2000; Jaureguito, et al., 1999). A prospective study that used aspirin in all patients over age 45 showed a DVT incidence of 2.9% in 239 patients (Jaureguito, et al., 1999). This study was not included in our comparative analysis because no data was given for aspirin use versus no aspirin use.

At this time, no pharmacologic prophylaxis is recommended for patients without the presence of major risk factors undergoing knee arthroscopy. Only patients with major risk factors should be considered for venous thromboprophylaxis. Major risk factors found to have a significant effect on the presence of venous thromboembolism in these studies are prolonged

surgery time, tourniquet time greater than 60 minutes, immobilization prior to surgery, and history of a previous DVT (Delis, et al., 2001; Demers, et al., 1998; Marlovits, et al., 2007; Stringer, et al., 1989).

LOWER EXTREMITY FRACTURE

Very few studies were found that looked at the incidence of DVT in patients with lower extremity fractures. These studies had a wide variety of fracture types, locations, and severities. The studies included fractures of the femoral shaft, proximal tibia, tibial shaft, and of the ankle joint. These studies showed an incidence of DVT anywhere from 5-28% for patients with no prophylaxis and 2-21% for patients with pharmacologic prophylaxis. Fractures more proximally located in the lower extremity had a higher incidence of DVT than fractures more distally located in the lower extremity. Abelseth found a 40% incidence in femoral shaft fractures while Patil found an incidence of 5% in patients with ankle fractures. When comparing the use of prophylactic anticoagulation, the only controlled study found no significant difference in the incidence of DVT in ankle fracture patients on Dabigatran versus placebo (Abelseth, et al., 1996; Lapidus, Ponzer, et al., 2007; Patil, et al., 2007; Sems, et al., 2009).

At this time, it is not recommended that medical prophylaxis be used for every patient with a lower extremity fracture. Patients with proximal lower extremity fractures, including femoral shaft fractures should be considered for medical prophylaxis, especially when risk factors are present. Risk factors that were identified in these studies were multiple lower extremity fractures, age greater than 60, operating room time >105 min, and time from injury to operation greater than 27 hours (Abelseth, et al., 1996; Sems, et al., 2009).

ACHILLES TENDON RUPTURE

Two studies were found that were included in our analysis. The incidence of DVT was much higher than expected. However, there was no significance found between those being prophylactically treated with a LMWH and those not treated (Lapidus, Rosfors, et al., 2007; Nilsson-Helander, et al., 2009). At this time, there is no statistical data to support the use of medical prophylaxis in patients with an Achilles tendon rupture that is either treated surgically or conservatively.

FOOT SURGERY

Only one study was performed on surgeries or injuries of the foot, distal to the ankle. This study involved 100 bunionectomies without medical prophylaxis and resulted in a DVT incidence of 4% (Radl, et al., 2003). At this time, medical prophylaxis for patients with foot injuries or surgeries distal to the ankle is not recommended.

Overall, we have found several studies on prophylaxis of thromboembolism in orthopaedic surgery outside of THA, TKA, and hip fracture. However, there is not any level one evidence nor convincing evidence of any level to support the use of prophylactic anticoagulation at this time. Many of the injuries or surgeries did not have enough data available to properly conclude that pharmacologic intervention is needed. Of those surgeries that did have more data available, the numbers were not significant to warrant pharmacologic prophylaxis.

The studies, however, have given suggestions on possible risk factors that may warrant consideration for possible pharmacologic anticoagulation. Risk factors that have been found to have increased risk of developing venous thromboembolism is the presence of a PICC line,

malignancy, prolonged surgery time, pregnancy, previous DVT or PE, thrombophilias, diabetes mellitus, age >65 years, and venous insufficiency.

It is important that health care providers look at each patient individually to determine if anticoagulation therapy is justified. At this time, the authors conclude that due to the cost and the risk of complications, pharmacologic thromboprophylaxis is not warranted for every patient undergoing orthopaedic surgery outside of THA, TKA, and hip fracture surgery. Prophylaxis should be only used after considering risk factors and after good clinical judgment has been applied for those at risk patients. Clinicians need to consider what their goal is for VTE prophylaxis. Is it to stop all DVT or just symptomatic DVTs or PEs or fatal PEs. Depending on their goals, this may determine their treatment guidelines.

More studies are needed in this area so health care providers can make the right decisions in regards to the health and safety of the patient. Future studies need to be aimed at multicenter randomized controlled studies to determine if the benefits outweigh the risks for pharmacologic prophylaxis. Studies should involve the use of LMWH versus no pharmacologic prophylaxis as well as the use of aspirin alone. The study by Abelseh et al (1996) indicated a need for more research on femoral shaft fractures. More research should also be done on knee arthroscopy with and without ligamentous repair, open reduction internal fixation (ORIF) and external fixation of lower extremity fractures, Achilles tendon repair, spine surgery, and shoulder arthroplasty. Studies should also be performed on these similar patients that are surgically versus non-surgically treated. Without surgery, patients are often immobilized longer and therefore may be at an increased risk for developing venous thromboembolism. Finally, it would be helpful if authors focus primarily on symptomatic DVT, symptomatic PE, and fatal PE as the outcomes in these patients are of clinical significance.

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TABLES

TABLE 1: VTE RISK FACTORS	
Acute medical illness	Anesthesia
Cancer and Cancer therapy	Central venous catheterization
Contraceptives containing estrogen	Erythropoiesis-stimulating agents
Hormone replacement therapy	Immobility
Increasing age	Inherited or acquired thrombophilia
Inflammatory bowel disease	Myeloproliferative disorders
Nephrotic syndrome	Obesity
Paroxysmal nocturnal hemoglobinuria	Pregnancy and acute post-partum
Previous VTE (DVT and PE)	Prolonged travel
Surgery	Trauma
Varicose Veins	Venous compression (tumor, hematoma, etc.)

TABLE 2. KNEE ARTHROSCOPY: NO ANTICOAGULATION PROPHYLAXIS				
Author	Sample #	Confirmed DVT	%	Method of Confirmation
Delis, et al	102	8	7.8	Color duplex ultrasonography
Demers, et al	184	33	17.9	Venography
Hoppener, et al	335	19	5.7	Compression ultrasonography
Marlovits, et al	68	28	41.2	Venography
Michot, et al	64	10	15.6	Color duplex ultrasonography
Stringer, et al	48	2	4.2	Venography
Total	801	100	12.48	

TABLE 3. KNEE ARTHROSCOPY: ANTICOAGULATION PROPHYLAXIS					
Author	Sample size	Confirmed DVT	%	Method of confirmation	Anticoagulation type
Marlovits, et al	72	2	2.8	Venography	Enoxaparin 40 mg x23-28 days
Michot et al	66	1	1.5	Color duplex ultrasonography	Dalteparin x 10 days
Schippinger et al	101	8	7.9	Color duplex ultrasonography	Dalteparin x 3 days (average)
Total	239	11	4.6		

TABLE 4. LOWER EXTREMITY FRACTURE: NO ANTICOAGULATION PROPHYLAXIS				
Author	Sample #	Confirmed DVT	%	Method of Confirmation
Abelseth, et al	102	29	28.4	Venography
Lapidus, et al	96	27	28	Venography
Patil, et al	100	5	5	DUS
Total	298	61	20.47	

TABLE 5. LOWER EXTREMITY FRACTURE: ANTICOAGULATION PROPHYLAXIS					
Author	Sample size	Confirmed DVT	%	Method of confirmation	Anticoagulation type
Lapidus, et al	101	21	21	Venography	Dalteparin
Sems, et al	136	3	2.2	DUS	Enoxaparin or dalteparin
Total	237	24	10.13		

TABLE 6. ACHILLES RUPTURE: NO ANTICOAGULATION PROPHYLAXIS				
Author	Sample #	Confirmed DVT	%	Method of Confirmation
Lapidus et al	44	16	36	Color duplex ultrasonography
Nilsson-Helander, et al	88	31	35	Color duplex ultrasonography
Total	132	47	35.61	

TABLE 7. ACHILLES RUPTURE: ANTICOAGULATION PROPHYLAXIS					
Author	Sample size	Confirmed DVT	%	Method of confirmation	Anticoagulation type
Lapidus et al	47	16	34	Color duplex ultrasonography	Dalteparin x 6 weeks
Nilsson-Helander, et al	7	1	14	Color duplex ultrasonography	Dalteparin x 10 days
Totals	54	17	31.48		

ABSTRACT

Objective: To better establish rates of DVT with and without pharmacologic prophylaxis in common orthopaedic procedures of the lower and upper extremities other than THA, TKA, and hip fracture. **Method:** A MEDLINE and Pubmed search was performed for publications of DVT following upper and lower extremity trauma or surgery from 1989 to 2010. **Results:** Few prospective studies on the rates of VTE in minor orthopaedic surgery were found. Outside of knee arthroscopy, there was no significant difference between pharmacologically prophylaxed patients and those that were not. Knee arthroscopy patients with significant risk factors had higher rates of VTE when not given pharmacologic prophylaxis. **Conclusions:** In the general population, pharmacologic prophylaxis is not warranted for patients undergoing knee or shoulder arthroscopy, shoulder arthroplasty, surgical or non-surgical treatment of Achilles tendon rupture, and those with lower extremity fractures. Only patients with known major risk factors should be considered for pharmacologic VTE prophylaxis.