Reducing Rates of Perioperative Deep Vein Thrombosis and Pulmonary Emboli in Hip and Knee Arthroplasty Patients: A Quality Improvement Project

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ABSTRACT

Objective: To decrease the rates of venous thromboembolism (VTE) associated with total knee arthroplasty (TKA) and total hip arthroplasty (THA), evaluate the effectiveness of the current practice of deep vein thrombosis (DVT) and pulmonary embolism (PE) prophylaxis, and improve patient care and recovery following surgery.

Methods: A multidisciplinary team of surgeons, intensivists, cardiologists, nurses, pharmacists, physical therapists, hospital quality and safety directors, and senior hospital administration was formed to study trends in care, review best practices, identify root causes of suboptimal performance, and implement improvements.

Results: DVT/PE rates associated with TKA/THA decreased nearly 60% over 2 years to a rate of 4.8 per 1000 discharges. Enoxaparin dosing has been sustained at 94% of patients, and 88% of patients experience early mobilization.

Conclusion: Multidisciplinary teams are capable of effecting sustained improvements in patient care and outcomes when paired with lean management practices and a commitment to quality improvement. Collective efforts towards education, removal of barriers to carry out best practices, and having physicians champion the prevention of DVT/PE led to a clinically significant and sustained improvement in patient outcomes.

Keywords: joint replacement; thrombosis; surgery; patient safety; prophylaxis.

Venous thromboembolism (VTE) in the form of deep vein thrombosis (DVT) and pulmonary embolism (PE) affects nearly 600,000 Americans annually, and is directly or indirectly responsible for at least 100,000 deaths per year.[1] VTE has historically been viewed as a complication of major surgery (ie, abdominal or thoracic operations that require general anesthesia lasting ≥ 30 minutes),[2,3] although it can occur outside of such settings. Risk factors for VTE include age, obesity, a history of VTE, cancer, bed rest of 5 or more days, major surgery, congestive heart failure, varicose veins, fracture (hip or leg), estrogen treatment, stroke, multiple trauma, childbirth, and myocardial infarction.[4] VTE is a disease with long-term complications that can affect patients for several years, and can lead to an avoidable death.[5] VTEs are of particular concern following total joint replacements.

The incidence of joint replacement procedures in the United States is high, with more than 1 million total hip and total knee replacement procedures performed each year. With the aging of the population, higher rates of diagnosis and treatment of advanced arthritis, and growing demand for improved mobility and quality of life, the annual procedure volumes are projected to increase considerably in the future, making joint replacements the most common elective surgical procedures in the coming decades.[6] The Centers for Medicare & Medicaid Services

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(CMS) are introducing new payment models that incorporate total cost of care with improved quality outcomes that must take into account complications of major surgical procedures.[7] Hospital-acquired perioperative DVT/PE rates are now publicly reported and may affect reimbursement rates from CMS for patients undergoing total hip arthroplasty (THA) or total knee arthroplasty (TKA).

Methods

Setting

OhioHealth Grant Medical Center (GMC), an American College of Surgeons verified Level 1 trauma center, was established in 1900 in downtown Columbus, Ohio, as the second member hospital of OhioHealth, a not-for-profit, faith-based health care system. The Bone and Joint Center at GMC performs approximately 1000 total joint procedures per year, with an overall orthopedic surgical case volume of approximately 6000 cases per year. In 2013 it was noted that the unadjusted DVT/PE rate of 11.3 per 1000 TKA/THA discharges was higher than the benchmark patient safety indicator of 4.51/1000 surgical patient discharges published by the Agency for Healthcare Research and Quality (AHRQ).

Intervention

In an effort to reduce DVT/PE rates for patients undergoing THA/TKA, a multidisciplinary quality improvement project was initiated. The purpose of this project was (1) to determine care opportunities within the surgical patient population to decrease the overall rates of DVT/PE, and (2) to determine if a multidisciplinary team could impact change. This initiative was led by 2 outcomes managers, a surgical outcomes manager and an orthopedic outcomes manager, due to the service line that these individuals supported. This multidisciplinary team's goal was to promote increased collaboration among all team members in order to provide higher quality care to our hip and knee patient population and improve patient outcomes.

The use of multidisciplinary in-hospital teams limits adverse events, improves outcomes, and adds to patient and employee satisfaction. Acting like components of a machine, multidisciplinary in-hospital teams include staff from different levels of the treatment pyramid (eg, staff including nurses' aides, surgical technicians, nurses, anesthesiologists, attending physicians, and others). Their teamwork counters the silo effect by enhancing communication between the different levels of health care workers, thus reducing adverse events.[8]

In August 2014, a multidisciplinary team of surgeons, intensivists, cardiologists, nurses, pharmacists, physical therapists, hospital quality and safety directors, and senior hospital administration was formed at GMC. The outcomes managers were tasked as the team leads to review the hospital's rate of DVT/PE, reported as AHRQ's Patient Safety Indicator (PSI) 12.[9] The goals of this multidisciplinary quality improvement project were to decrease the rates of DVT/PE, evaluate the effectiveness of the current practice of DVT/PE prophylaxis, and improve patient care for patients undergoing THA/TKA. The team performed monthly case reviews to identify trends in care. Based on these reviews, several opportunities for improvement were identified, including (1) poor clinician understanding of the risk of DVT/PE; (2) lack of standardized use of mechanical prophylaxis in the operating room; (3) inconsistent use and under-dosing of enoxaparin; (4) delayed initiation of enoxaparin; (5) minimized exclusions for VTE prophylaxis utilizing trauma exclusions; and (6) delayed early mobilization.

The quality improvement committee reviewed evidence-based best practices, including American College of Chest Physicians recommendations[10] and guidelines previously implemented at OhioHealth Grant Medical Center Trauma Center. This Level 1 trauma center had well-defined guidelines for DVT/PE prevention (**Figure 1**) and corresponding DVT/PE rates that were lower than Trauma Quality Improvement Program benchmarks. The collection and reporting of this data was deemed exempt from Institutional Review Board review at OhioHealth GMC.

From August through November 2014, the quality improvement team reviewed DVT/PE data on a monthly basis and issued evidence-based recommendations designed to address the identified areas of improvement, including screening for DVT/PE when clinically indicated, but not routine screening; maximum utilization of mechanical prophylaxis prior to induction of anesthesia; standardization of chemical prophylaxis postoperatively, including the use of enoxaparin over aspirin alone and dosing of enoxaparin according to the patient's body

DVT Prophylaxis

1. Patients with risk factors for DVT ** should receive enoxaparin 30 mg SQ every 12 hours as early as possible and maintained throughout hospitalization.
   Patients who have very low risk for DVT require only early ambulation.*
2. Patients with BMI > 40kg/m^2 will receive enoxaparin 40mg SQ every 12 hours.
3. Patients with CrCl < 30 will receive enoxaparin 30mg SQ once daily. Patients in acute renal failure or with CrCl < 10 will receive heparin 5000 units SQ every 8 hours in lieu of enoxaparin.
4. Contraindications to the use of chemical DVT prophylaxis include all of the following:
   a. Active hemorrhage from any site
   b. Unstable intracerebral hemorrhage
   c. Around the time of insertion or removal of epidural catheters
   d. Uncorrected coagulopathy
5. In patients with traumatic brain injury:
   a. SCDs should be placed immediately
   b. Chemical DVT prophylaxis will be initiated 24 hours after a stable CT of the head, and 48 hours after admission, in non-operative TBI patients without an ICP monitor
   c. In patients status post craniotomy or craniectomy or with surgical drains or monitors, the decision for chemical DVT prophylaxis will be made in conjunction with the neurosurgery service.
   d. In the event the patient has a decline in neurological exam or worsening of a CT head, chemical DVT prophylaxis will be held immediately.
6. In patients with spinal cord injury:
   a. SCDs should be placed immediately
   b. Chemical DVT prophylaxis should be started within 24 hours of admission
   c. Chemical DVT prophylaxis should be held on the day of spine surgery and resumed 24 hours after surgery
7. In patients with Grade II-V solid organ injury:
   a. SCDs should be placed immediately
   b. Chemical DVT prophylaxis should be initiated after two stable serial hemoglobin checks

*Patients with isolated facial or upper extremity trauma, under age 60, BMI < 25, who are fully ambulatory.

** SEE CHART BELOW

Each Risk Factor: 1 point	Each Risk Factor: 2 Points	Each Risk Factor: 3 Points	Each Risk Factor: 5 points
○ Age 41-60 years ○ Minor surgery planned ○ History of major surgery (<1mo) ○ Varicose veins ○ Inflammatory bowel disease ○ Currently swollen legs ○ BMI > 25 ○ Acute MI ○ CHF (<1mo) ○ Sepsis (<1mo) ○ Serious lung disease, pneumonia (<1mo) ○ COPD ○ Medical patient on bedrest ○ *Oral contraceptive use* ○ *Pregnancy/postpartum* ○ *Unexplained recurrent spontaneous abortion (>3)*	○ Age 60-74 years ○ Arthroscopic surgery ○ Malignancy (past or present) ○ Major Surgery (> 45 min) ○ Laparoscopic surgery (> 45 min) ○ Bedrest (> 72hr) ○ Immobilizing cast (<1mo) ○ Central venous access	○ Age > 75 years ○ History of DVT/PE ○ Family history of thrombosis ○ Factor V Leiden ○ Prothrombin 20210A ○ Elevated serum homocysteine ○ Lupus anticoagulant ○ Anticardiolipin antibody ○ Heparin induced thrombocytopenia ○ Other congenital/acquired thrombophilia	○ Elective major lower extremity arthroplasty ○ Hip, pelvis or leg fracture (<1mo) ○ Stroke (<1mo) ○ Multiple trauma (<1mo) ○ Acute spinal cord injury (<1mo)

TOTAL SCORE: ________

TOTAL SCORE	*Incidence of DVT*	*Risk Level*	*Regimen*
0-1	<10%	Low	No specific measures
2	10-20%	Moderate	IPC or LDUH, LWMH
3-4	20-40%	High	IPC + LDUH, LWMH
5+	40-80%, 1-5% mortality	Highest	LDUH, LWMH + IPC, or warfarin

IPC=intermittent compression device; LDUH=low dose unfractionated heparin; LMWH=low molecular weight heparin

Sources: Pannucci CJ, et al. Validation of the Caprini Risk Assessment Model in Plastic and Reconstructive Surgery Patients. *J Am Coll Surg*, 2011;212(1):105-112.

Jacobson BF et al. The use of VTE prophylaxis in relation to patient risk profiling (TUNE-IN) Wave 2 study. *SAMJ*. 2014;104(12):880-884.

Figure 1. OhioHealth Grant Medical Center Trauma Center guidelines for deep vein thrombosis/pulmonary embolism prevention.

mass index; emphasis on early mobility; and utilization of data to drive performance.

To determine the cumulative effectiveness of the guidelines in a specific orthopedic population, we compared DVT/PE rates in patients undergoing THA/TKA, the use of chemical prophylaxis, and adherence to early mobilization after surgery between the pre-implementation (July 2013-July 2014) period and post-implementation

Table 1. **Demographic and Clinical Characteristics of Patients Undergoing Total Hip or Total Knee Arthroplasty**

	Pre-intervention Period 1 July 2013-July 2014			Post-intervention Period 2 Dec. 2014-Dec. 2015			Post-intervention Period 3 Jan. 2016-Jan. 2017		
Characteristic	**Overall (n = 886)**	**DVT (n = 10)**	**No DVT (n = 876)**	**Overall (n = 984)**	**DVT (n =7)**	**No DVT (n = 977)**	**Overall (n = 1041)**	**DVT (n = 5)**	**No DVT (n = 1036)**
Gender, n (%)									
Male	363 (41)	3 (30)	360 (41)	403 (41)	2 (29)	401 (41)	427 (41)	2 (40)	425 (41)
Female	523 (59)	7 (70)	516 (59)	581 (59)	5 (70)	576 (59)	614 (59)	3 (60)	611 (59)
Age, mean	61.3	61.0	61.3	60.8	63.7	60.8	61.2	56.8	61.2
Mean length of stay, days	2.8	4.1	2.8	2.8	5.9	2.7	2.9	5.4	2.9
Surgery type									
TKA, n (%)	611 (69)	9 (90)	602 (69)	630 (64)	6 (86)	624 (64)	687 (66)	5 (100)	609 (59)
THA, n (%)	275 (31)	1 (10)	274 (31)	354 (36)	1 (14)	353 (36)	354 (34)	0 (0)	427 (41)

DVT, deep vein thrombosis; THA, total hip arthroplasty; TKA, total knee arthroplasty.

period (December 2014-December 2015). In order to assess continued compliance with best practices, DVT/PE rates were also calculated for a sustainment period (January 2016-January 2017).

Analysis

Descriptive statistics for continuous variables were reported as mean, standard deviations (SD), median, and range, and for dichotomous or categorical variables as frequencies and percentages. Efficacy of the revised guidelines was assessed in relationship to national and hospital benchmarks due to the small sample size of this study, as there was insufficient power for statistical analysis of DVT/PE rates.

Results

During the pre-implementation period, 886 THA/TKA procedures were performed. The number of surgeries increased slightly during the post-implementation period, with 984 THA/TKA procedures performed post-implementation and 1041 THA/TKA procedures performed during the sustainment period. Demographic and clinical characteristics of patients during the pre- and post-implementation periods are shown in **Table 1**.

Pre-implementation, 10 patients out of 886 patients who underwent TKA/THA surgeries were diagnosed with DVT/PE. This rate (11.3 per 1000 TKA/THA discharges) was more than 25% higher than the overall hospital rate (8.98 per 1000 surgical discharges) and 150% higher than the national benchmark (4.51). Post-implementation, 7 patients out of 984 who underwent THA/TKA surgeries were diagnosed with DVT/PE. This new rate (7.1 per 1000 TKA/THA discharges) was in line with the overall hospital rate (7.64 per 1000 surgical discharges), although both the overall hospital and TKA/THA rates remained above the national benchmark (4.51 per 1000 surgical discharges). However, the DVT/PE rate reduction has continued to decline, with 5 patients out of 1041 who underwent THA/TKA surgeries being diagnosed with DVT/PE (a rate of 4.8 per 1000 TKA/THA discharges) for the sustainment (third) period, bringing the current rate in line with the national benchmark. The change in DVT/PE rates over time is shown in **Figure 2**.

Prior to this quality improvement project, there were no standardized guidelines for enoxaparin dosing for patients undergoing TKA/THA, and enoxaparin dosing occurred for only 15% of TKA/THA patients (**Table 2**). Following implementation of the quality improvement

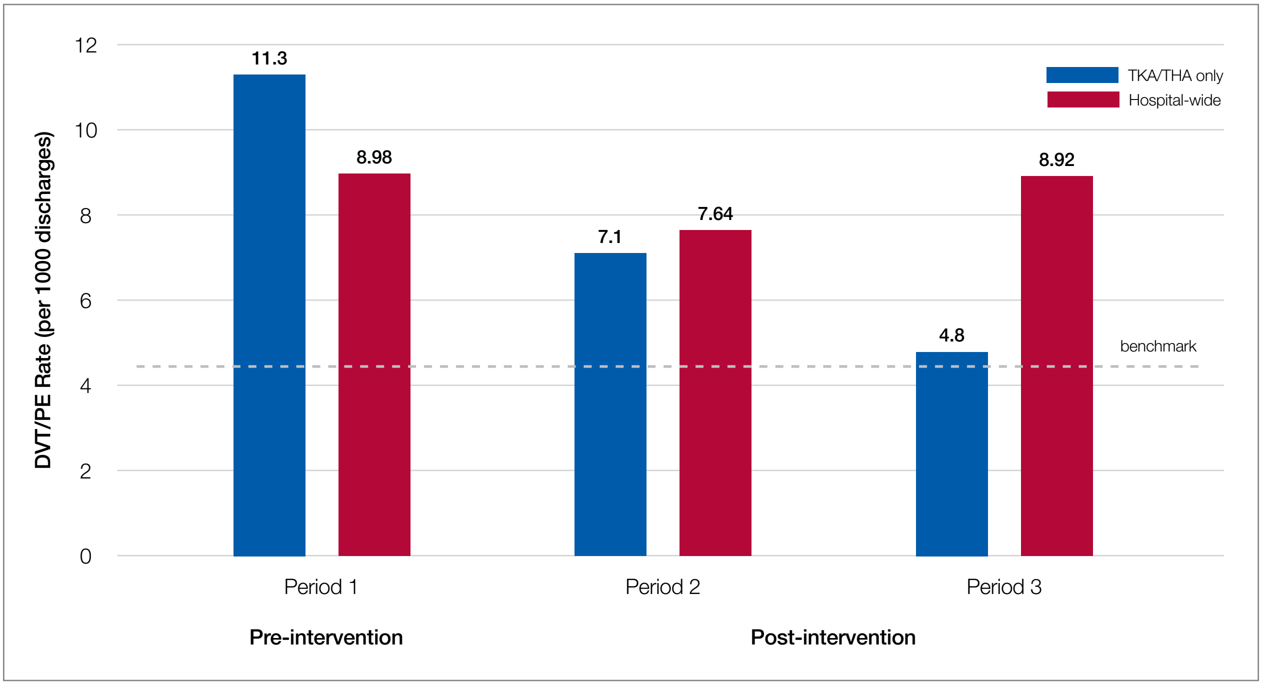

Figure 2. Change in deep vein thrombosis/pulmonary embolism rates from pre-implementation period through sustainment period.

committee recommendations for chemical prophylaxis, the rate of use of enoxaparin in TKA/THA patients increased to 66%; enoxaparin dosing increased further, with 94% of TKA/THA patients receiving enoxaparin during the sustainment (third) period.

Orthopedic best practice for out of bed day of surgery with physical therapy increased from 84% (745 patients mobilized/886 THA/TKA patients) pre-implementation to 88% (868 patients mobilized/984 THA/TKA patients) post-implementation. Early mobilization efforts remained increased through the sustainment period (917 patients mobilized/1041 THA/TKA patients; 88%).

Discussion

An outcomes manager–led multidisciplinary team was assembled in response to higher than expected rates of DVT/PE, particularly in patients undergoing elective THA/TKA. The intent of the quality improvement project was to identify all areas where care could be improved. Through the implementation of evidence-based best practices, the DVT/PE rate in patients undergoing TKA/THA was reduced from 1.13% to 0.48%, bringing DVT/PE rates in line with the AHRQ benchmark (0.451%). This project was successful because all parties were willing to examine current practices, identify opportunities for improvement, and actively engage in a collaborative effort to improve patient outcomes. The data presented here demonstrate that when interprofessional process improvements are utilized, improved efficiency can be achieved.

It was noted that there was an "implementation gap" between knowing the risk factors for DVT/PE and executing the recommended measures.[11] While clinicians could articulate the risk of DVT/PE in their patient population, they underestimated the severity risk. As internists provided preoperative evaluation for many elective orthopedic patients, the quality improvement team focused education on the internists in regard to DVT/PE risk and prevention.

Based on recommendations from the American College of Physicians, the committee recommended the use of enoxaparin over the use of aspirin for DVT/PE prophylaxis.[11] While this project was not designed to examine the correlation between this practice change and the decrease in the DVT/PE rate, it can be concluded that presenting evidence to clinicians does change ordering behavior, as enoxaparin dosing increased to 94% of

Table 2. **Mode of Chemical Prophylaxis in Total Hip and Knee Arthroplasty Patients Over Time: Increased Use of Enoxaparin**

Period	Anticoagulant	Hip/Knee Replacement Cases	% of Total	Cases with DVT/PE	DVT/PE per 1000 Discharges
1	Aspirin only	687	78	1	1.5
	Enoxaparin only	98	11	2	20.4
	Enoxaparin and aspirin	37	4	7	189.2
	Neither	64	7	0	-
	Total	886		10	11.3
2	Aspirin only	240	24	0	-
	Enoxaparin only	537	55	1	1.9
	Enoxaparin and aspirin	106	11	0	-
	Neither	101	10	6	59.4
	Total	984		7	7.1
3	Aspirin only	40	4	0	-
	Enoxaparin only	791	76	0	-
	Enoxaparin and aspirin	186	18	0	-
	Neither	24	2	5	208.3
	Total	1041		5	4.8

DVT, deep vein thrombosis; PE, pulmonary embolism.

patients following guideline implementation, compared to 15% of patients prior to guideline implementation.

Furthermore, THA/TKA patients with a body mass index (BMI) greater than 40 were dosed with enoxaparin 40 mg twice daily, instead of 30 mg twice daily used in patients with a BMI less than 40.[12-14] Many clinicians were unaware of the option to increase the dose of enoxaparin. One orthopedic surgeon member on the quality improvement team became the champion for enoxaparin use in that population, and his leadership led to an increase in the use of guideline-based chemical prophylaxis. Bedside clinical pharmacists were instrumental in reviewing the enoxaparin orders and recommending increased dosing. Ongoing auditing of patient care helped to inform the team of compliance with VTE prophylaxis and understand barriers to the implementation of the standard work.

The root cause of poor compliance with the use of mechanical prophylaxis in the operating room was a knowledge gap regarding the importance of initiation prior to induction of anesthesia.[15] This was corrected with targeted education of staff. Also, several nurses pointed out that, while they were aware of the best practice, sequential compression devices were physically unavailable for patients in the preoperative and postoperative areas. This was corrected by working with the vendor and hospital supply chain to increase periodic automatic replenishment levels.

It is intuitive that a reduction in the DVT/PE rate will translate into costs savings for the health care system and the patient, although this study was not powered or designed to study actual costs of treating DVT/PE. Costs associated with treating a DVT/PE are variable, but have been estimated to range from $9805 to $14,722.[16] Taking these estimates and applying them to the current study, reducing the DVT/PE rate from 11.4 to 7.1 from pre-implementation to post-implementation, the total cost savings may be up to $4118 per TKA/THA discharge. Beyond cost considerations, the reduction of DVT/PE leads to improved patient outcomes and a reduction in morbidity and mortality.

Conclusion

Multidisciplinary teams are capable of effecting sustained improvements in patient care and outcomes when paired with lean management practices and a commitment to quality improvement. Collective efforts towards education, removal of barriers to carry out best practice, and having physicians champion the prevention of DVT/PE led to a clinically significant and sustained improvement in patient outcomes.

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