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Thromboembolism Prophylaxis in Hip Arthroplasty: Routine and High Risk Patients

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ABSTRACT

This study's purpose was to present the use of a risk stratification protocol in which "routine" risk patients receive a mobile compression device with aspirin and "high" risk patients receive warfarin for thromboprophylaxis after hip arthroplasty. 1859 hip arthroplasty patients were prospectively enrolled (1402 routine risk — 75.4%, 457 high risk — 24.6%). The cumulative rate of venous thromboembolism events was 0.5% in the routine versus 0.5% in the high-risk cohort within 6 weeks postoperatively ($P = 1.00$). Patients in the routine risk cohort had a lower rate of major bleeding (0.5% versus 2.0%, $P = 0.006$) and wound complications (0.2% versus 1.2%, $P = 0.01$). Use of our risk stratification protocol allowed the avoidance of more aggressive anticoagulation in 75% of patients while achieving a low overall incidence of symptomatic VTE.

Venous thromboembolic events (VTE), including deep vein thrombosis (DVT) and pulmonary embolism (PE), remain one of the most common complications following total hip arthroplasty (THA) [1]. Causes of VTE are multifactorial, with activation of the clotting cascade during intramedullary canal preparation, venous stasis with leg positioning, and the potential for endothelial injury all increasing the risk of a thrombotic event [2,3]. Following THA, reported rates of DVT and PE range from 4% to 15% and from 0.83% to 3%, respectively [2,4–6]; thus, there is general agreement between the American Academy of Orthopaedic Surgeons (AAOS) and the American College of Chest Physicians (ACCP) that some form of VTE prophylaxis be administered routinely following total hip arthroplasty [7]. However, in the past there has been a philosophical disconnect between the ACCP and the AAOS regarding the balance between efficacy and safety in recommending various forms of pharmacoprophylaxis [7,8]. Traditionally, ACCP recommendations were based largely on randomized controlled trials that used venographic DVT as an endpoint, the vast majority of which were asymptomatic. As the number of randomized controlled trials comparing thromboprophylactic regimens in the prevention of symptomatic events is limited, venographic screening was taken as a surrogate outcome measure [9,10]. This is best exemplified by their prior grade 1A recommendation against the use of aspirin (ASA; acetylsalicylic acid) for VTE prophylaxis and a recommended target international normalized ratio (INR) between 2.0 and 3.0 with the use of warfarin (versus a target INR between 1.8 and 2.2 preferred by the AAOS) [8].

In contrast, the AAOS has focused on the overall safety profile of pharmacoprophylactic regimens, raising concerns of postoperative bleeding, hematoma, infection, and potential reoperation with the use of more potent thromboprophylactic medications such as low molecular weight heparin [11–14]. Thus, patients at low risk of VTE postoperatively may unnecessarily receive excessive anticoagulation and risk further perioperative morbidity [8]. In 2007, the AAOS developed its first clinical practice guideline, focusing on prevention of symptomatic VTE events and limiting perioperative morbidity caused by anticoagulants. As part of this guideline, "risk stratification" for VTE events and/or bleeding was recommended, although this was noted to be difficult due to limited evidence elucidating specific risk factors that elevate VTE risk [8–10,15]. In 2011, the AAOS clinical practice guidelines were updated based on a systematic review of published studies on the prevention of symptomatic VTE following total joint arthroplasty [10]. However, of the ten recommendations provided, only one was "strong" and three were "moderate." Arguably the most telling recommendation stated, "the workgroup cannot recommend for or against a specific prophylactic regimen in these patients since current evidence is unclear about which strategy (or strategies) is or are optimal or suboptimal" [8,10]. Fortunately, the most recent ACCP clinical practice guideline demonstrated a clear philosophical shift, falling further in line with AAOS recommendations and focusing on the reduction of symptomatic

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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and fatal VTE events while limiting perioperative complications such as hematoma, bleeding, infection, and wound complications [16]. This shift is again best exemplified by the ACCP guidelines adding both aspirin and mechanical compression devices as adequate forms of thromboprophylaxis following THA.

Thus, orthopedic surgeons now have greater flexibility regarding the use of different VTE prophylaxis regimens, yet controversy remains regarding which is optimal. Furthermore, shorter inpatient hospitalizations and earlier discharge require a VTE prophylaxis regimen that is simple, effective, easy to monitor, and has high patient compliance. For example, achieving a target INR range with the use of warfarin both at the time of discharge and throughout their postoperative course is known to be difficult [17,18]. With this in mind, early mobilization and pneumatic compression devices have been used with greater frequency following total joint arthroplasty [19,20]. Portable, intermittent pneumatic compression devices have been shown to increase the velocity of venous blood flow in the lower extremities and increase local and systemic fibrinolysis, with reports from multiple institutions showing their effectiveness in VTE prevention [19–27]. At our institution, a risk stratification protocol has been implemented in patients undergoing hip arthroplasty in which patients deemed "routine" risk receive a mobile pneumatic compression device in conjunction with aspirin, while patients deemed "high" risk are placed on warfarin for thromboprophylaxis. The purpose of this prospective study was to present our experience with the use of this risk stratification protocol and treatment method. Our hypothesis was that use of this risk stratification protocol and thromboprophylactic regimen would be an effective form of VTE prophylaxis following hip arthroplasty.

Patients and Methods

This was a prospective, institutional review board approved study of patients undergoing primary THA, revision THA, and surface replacement arthroplasty (SRA) at a single institution. All patients provided informed consent prior to their inclusion. Inclusion criteria for this study were patients greater than 18 years of age undergoing a unilateral hip arthroplasty procedure. Patients were excluded if they had a positive lower extremity DVT on preoperative ultrasound examination or were currently being treated for a recent DVT (as these patients would either have their surgery canceled or be treated with a low-molecular weight heparin bridge postoperatively), a history of PE (these patients would receive a low-molecular weight heparin bridge postoperatively), were on chronic warfarin therapy, and were scheduled for multiples surgeries (within 3 months) in close proximity to one another. In addition, any patient determined to be at high risk for wound complications based upon their health history (i.e. poor nutritional status, de-conditioned status, multiple previous incisions around the hip, previous radiation therapy around the hip) were excluded as determined by the treating surgeon.

Once enrolled in the study, patients were stratified to receive either "routine" or "high" risk anticoagulation therapy. Currently, there is no validated approach to stratify patients undergoing total joint arthroplasty according to their risk of PE [7]. For this reason patients were stratified based upon the standard clinical protocol at our institution. Patients were considered "high" risk if they met any of the following criteria (Table 1): 70 years of age or older, a history of a DVT (but, negative preoperative ultrasound examination; if positive, they were excluded from this study), active cancer, hypercoagulable state (Protein C or Protein S deficiency, Factor V Leiden, etc.), multiple medical comorbidities (2 of the following 3 conditions: heart disease, lung disease, diabetes), body mass index (BMI) ≥ 40 kg/m^2, family history of DVT or PE, or prolonged immobility (i.e. limited weight bearing) based on the surgeon's discretion. If none of these criteria were met, the patient was stratified to the "routine" risk anticoagulation regimen. After two years of patient enrollment (April 2010 to April 2012), a mid-term analysis was performed to determine the effectiveness of our risk stratification criteria, and to determine whether criteria for inclusion in the routine risk cohort could be expanded. Due to the low rates of VTE seen in both the routine and high-risk cohorts, indications for use of mobile pneumatic compression devices (MCDs) with aspirin were expanded as age ≥ 70 years, multiple medical comorbidities, and body mass index ≥ 40 kg/m^2 were no longer considered inclusion criteria for the high-risk cohort. This expansion of criteria was also influenced by the effectiveness of exclusion criteria for the use of MCDs previously reported by Colwell et al: history of venous thromboembolism, coagulation disorder, active cancer, or major surgery in the past three months [19]. Thus, redefining the high risk criteria cohort was based on encouraging preliminary results at our institution and prior published exclusion criteria for the use of MCDs following hip arthroplasty.

Table 1
Criteria to Determine "High" Risk Patients.

Age ≥ 70 years
History of DVT with Negative Preoperative Ultrasound Examination
Active Cancer
Hypercoagulable States (Protein C, Protein S, Factor V Leiden, etc.)
Multiple Medical Comorbidities (2 of the Following 3 Conditions: Heart disease, Lung disease, Diabetes)
Morbid Obesity (BMI ≥ 40 kg/m^2)
Family History of Deep Vein Thrombosis or PE
Immobility (i.e. Limited Weight Bearing) — Surgeon's Discretion

All patients in both the routine and high-risk cohorts received mobile pneumatic compression devices (Active Care + SFT; Medical Compression Systems, Or Akiva, Israel) [20,28,25] applied to the contralateral lower extremity prior to the operative procedure, and to the operative extremity postoperatively in the operating room. The MCD applies intermittent, sequential pressure to the patient's legs in a systematic pattern. This increases the peak venous blood flow velocity to reduce the risk of clot formation. Disposable sleeves fit over the patient's calves in a form-fitting fashion and are secured with hooks and loop fasteners. The sleeves are then connected to the 1.65-lb pump and battery pack with plastic hoses. The pump can function for up to 6 hours on battery power, and can be recharged via an electrical outlet. The device provides a maximum pressure during inflation of 50 mm Hg and uses 8 seconds of compression followed by 36 to 56 seconds of decompression. The protocol for "routine" risk anticoagulation therapy consisted of use of MCDs for 23 hours a day for 10 days (including the inpatient stay), along with enteric-coated aspirin (325 mg twice daily) started the evening of surgery for 6 weeks postoperatively.

Patients in the "high" risk cohort also received MCDs, but only for the duration of their inpatient hospital stay. Warfarin therapy was initiated the night before surgery to expedite achievement of the target international normalized ratio (INR) postoperatively, and adjusted for a target INR between 1.8 and 2.2 for four weeks postoperatively in adherence with national guidelines [9,29]. The INR was monitored by the Barnes-Jewish Anticoagulation Service or by the patient's extended care facility if applicable. INR levels were checked two times a week to have their warfarin doses adjusted accordingly, but the frequency of INR checks varied based on the presence of a sub-therapeutic or supra-therapeutic INR level. In addition, high-risk patients wore thigh high compression stockings on both lower extremities for 6 weeks postoperatively.

All patients in both cohorts were mobilized on postoperative day 0. Rehabilitation protocols were identical between the two cohorts focusing on early mobilization, range of motion, and strengthening exercises. The primary outcome measures were the incidence of DVT and PE in both groups. Patients were monitored throughout their inpatient stay and following discharge for any clinical signs of symptoms of VTE. All patients were called or seen for clinical follow-up at two weeks postoperatively and assessed for any clinical symptoms of DVT or PE including increased swelling or tenderness to palpation in the lower extremity, chest pain, or shortness of breath. All patients were also assessed with a clinical examination at between 4 and 6 weeks postoperatively.

Patients with clinical symptoms of DVT underwent duplex ultrasonography, while patients with clinical suspicion of a PE received a spiral computed tomography scan of the lungs. Routine screening was not performed in the absence of clinical symptoms. Any postoperative wound, bleeding, or medical complication and readmissions within 6 months after surgery were recorded. A major bleeding complication was considered the development of a hematoma or seroma diagnosed on clinical examination. The number of days of "drainage" from the wound including any signs of discharge (blood, serous fluid) seen at the time of incisional dressing changes was also recorded. Reasons for readmission were categorized into (a) planned lower extremity orthopedic procedure (i.e. elective contralateral total hip arthroplasty), (b) unplanned lower extremity orthopedic procedure (i.e. ankle fracture), (c) complication related to anticoagulation (i.e. prolonged wound drainage or supratherapeutic INR), (d) planned unrelated procedure (i.e. hand or shoulder surgery) and (e) an unrelated medical concern (i.e. pneumonia, asthma exacerbation). Lastly, patient satisfaction with their thromboprophylaxis protocol was recorded at 2 weeks and at 4–6 weeks postoperatively using the following scoring system: 1 = very satisfied, 2 = satisfied, 3 = neutral, 4 = dissatisfied, 5 = very dissatisfied.

Statistical Analysis

Chi-square and Fisher's exact tests were used to assess group differences in categorical variables and independent t-tests were used to compare continuous variables. A P value of <0.05 was considered statistically significant. All statistical analyses were performed using IBM SPSS software version 22 (IBM Corp., Armonk, NY, USA).

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Results

The incidence of VTE events within 6 weeks postoperatively was identical before and after expansion of our inclusion criteria for both the routine and high-risk cohorts. Prior to expansion of our inclusion criteria (from April 2010 to April 2012), a total of 874 patients were enrolled with 311 stratified to the high-risk cohort. After expansion of our inclusion criteria, a total of 985 patients were enrolled with 146 stratified to the high-risk cohort. The overall VTE incidence was 0.5% both before and after expansion of our inclusion criteria. Therefore, the decision was made to include all participants of this study in a single statistical analysis. From April of 2010 to October of 2014, a total of 1859 hip arthroplasty patients were prospectively enrolled (1402 routine risk — 75.4%, 457 high risk — 24.6%). Four hundred and sixty-four hip arthroplasty patients were excluded based on the aforementioned criteria during this period. In the routine risk cohort, there were 1178 primary THAs, 107 revision THAs, and 117 SRAs, while in the high-risk cohort there were 371 primary THAs, 77 revision THAs, and 9 SRAs. As expected, based on stratification criteria, patients in the routine risk cohort were younger than participants in the high-risk cohort (55.5 ± 12.0 versus 65.1 ± 12.1 years, $P < 0.0001$). In addition, there were significantly more men in the routine risk cohort versus the high-risk cohort (50.8% vs. 41.7%, $P = 0.001$; Table 2).

91.6% of routine and 85.1% of high risk patients were available for clinical follow-up between 4 and 6 weeks postoperatively. There were no significant differences for the incidence of VTE between the routine and high-risk cohorts. The rate of VTE was low in both cohorts, with a total of only 9 VTE events documented within 6 weeks postoperatively, all occurring in patients undergoing primary THA. The cumulative rate of VTE events was 0.5% in the routine risk cohort versus 0.5% in the high-risk cohort within 6 weeks postoperatively ($P = 1.00$), and 0.7% in the routine risk and 1.3% in the high-risk cohort within 6 months postoperatively ($P = 0.25$; Table 3).

The rate of major bleeding complications within 6 weeks postoperatively was significantly lower among patients in the routine risk cohort (0.5%) versus the high-risk cohort (2.0%; $P = 0.006$). In addition, the incidence of wound complications at 2 weeks postoperatively was significantly lower in the routine risk cohort versus the high-risk cohort (0.2% versus 1.2%, $P = 0.01$) as was incisional drainage lasting greater than 7 days (4.7% versus 11.1%, $P < 0.0001$). In addition, incisional drainage lasting greater than 3 days was significantly lower in the routine risk cohort (15.9% versus 25.2%, $P < 0.001$).

One thousand two hundred fifteen patients in the routine risk cohort (86.7% follow-up) and 398 patients in the high-risk cohort (87.1% follow-up) were analyzed regarding their six-month postoperative readmission history. During the first 6 months postoperatively, 121 patients in the routine risk cohort (10.0%) and 56 patients in the high-risk cohort (14.1%, $P = 0.02$) were readmitted to the hospital, with several patients having multiple readmissions. A total of 145 readmissions occurred in the routine cohort versus 67 in the high-risk cohort (Table 4). Of note, no participants with a confirmed DVT were readmitted to the hospital for treatment, but all 4 participants with a

Table 2
Preoperative Demographics of the Routine and High-Risk Patient Cohorts. Data Is Presented as Absolute Number with Percentage in Parentheses or Mean ± Standard Deviation.

	Routine (n = 1402)	High (n = 457)	*P* Value
Operative Side			0.90
Right	750 (53.5%)	243 (53.2%)	
Left	652 (46.5%)	214 (46.8%)	
Operative Procedure			<**0.0001**
THA	1285 (91.7%)	448 (98.0%)	
SRA	117 (8.3%)	9 (2.0%)	
Revision Status			<**0.0001**
Primary	1295 (92.4%)	380 (83.2%)	
Revision	107 (7.6%)	77 (16.8%)	
Age at Surgery (years)	55.49 ± 11.97	65.13 ± 12.16	<**0.0001**
Body Mass Index (kg/m^2)	29.28 ± 5.5	30.68 ± 6.8	<**0.0001**
Gender			**0.001**
Female	690 (49.2%)	267 (58.4%)	
Male	712 (50.8%)	190 (41.6%)	

Table 3
Rates of VTE Events and Bleeding Complications in the Routine and High-Risk Cohorts. Data Is Presented as the Absolute Number and the Percentage of Respondents in Parentheses. "n" Refers to the Number of Patients for Which Data Was Available for Each Outcome Measure.

	Routine (n = 1402)	High (n = 457)	*P* Value
DVT or PE within 6 weeks	n = 1284	n = 389	1.000
No	1277 (99.5%)	387 (99.5%)	
Yes	7 (0.5%)	2 (0.5%)	
DVT	5 (0.4%)	0 (0.0%)	0.21
PE	2 (0.2%)	2 (0.5%)	
DVT or PE at 6 months	n = 1215	n = 398	0.25
No	1207 (99.3%)	393 (98.7%)	
Yes	8 (0.7%)	5 (1.3%)	
Major Bleeding Complications within 6 weeks	n = 1282	n = 391	**0.006**
No	1275 (99.5%)	383 (98.0%)	
Yes	7 (0.5%)	8 (2.0%)	
Wound Problems at 2 weeks	n = 1324	n = 419	**0.01***
No	1322 (99.8%)	414 (98.8%)	
Yes	2 (0.2%)	5 (1.2%)	
Days of Drainage	n = 1325	n = 416	<**0.0001**
0–3	1114 (84.1%)	311 (74.8%)	
4–7	149 (11.2%)	59 (14.2%)	
>7	62 (4.7%)	46 (11.1%)	

Table 4
Reasons for Readmission in the Routine and High-Risk Cohorts. "n" Refers to the Number of Patients for Which Data Was Available.

	Routine (n = 1215)	High (n = 398)	*P* Value
Number of Patients Readmitted	121 (10.0%)	56 (14.1%)	**0.02**
Reasons for Readmission			**Total**
Total Number of Readmissions	145	67	212
Planned Lower Extremity Orthopedic Procedure	69	24	93
Unplanned Lower Extremity Orthopedic Procedure	10	5	15
Complication Related to Anticoagulation Therapy	4	5	9
Planned Unrelated Procedure	4	2	6
Unrelated Medical Concern	58	31	89

confirmed pulmonary embolism were readmitted. Four readmissions in the routine cohort (2.8% of all readmissions in routine cohort) were related to anticoagulation therapy versus 5 readmissions in the high-risk cohort (7.5%, $P = 0.23$). There were no participant deaths during the time course of this study.

Patients in the routine risk cohort had superior patient satisfaction scores at 2 weeks (1.60 ± 0.64 versus 1.78 ± 0.69, $P < 0.0001$) and 4–6 weeks postoperatively (1.55 ± 0.61 versus 1.66 ± 0.63) versus the high-risk cohort.

Discussion

As the number of total hip arthroplasties performed in the United States is projected to increase 174% by the year 2030 [30], optimization of perioperative care continues to be paramount. Furthermore, as the occurrence of "avoidable" complications following THA will increasingly be scrutinized with evolving healthcare legislation, the selection of an effective thromboprophylaxis protocol is even more critical. The inability of the AAOS and AACP to recommend the optimal method of thromboprophylaxis based on the current available evidence demonstrates prophylaxis for VTE to be a continued area of debate [1,8,31]. While more potent chemical prophylactics are known to be effective in preventing VTE, they have also been shown to increase the risk of potential hematoma, wound complications, and infection [11,13,32,33]. Mobile compression devices with aspirin are an attractive alternative for prophylaxis against VTE events as they do not require laboratory monitoring, minimally impact postoperative hemostasis, and thus potentially avoid the increased risk of bleeding complications with more potent chemical prophylactics. This study prospectively evaluated a risk stratification protocol with the use of mobile pneumatic compression devices in conjunction with aspirin in "routine" risk patients versus the use of warfarin for thromboprophylaxis in "high" risk patients. Our findings demonstrate a risk stratification protocol with the use of MCDs with aspirin in routine risk patients and warfarin in high-risk patients to be effective in the prevention of VTE events, while also enabling the avoidance of more aggressive anticoagulation in approximately 75% of patients.

This study has several limitations that must be recognized prior to interpretation of our results. First, given the low incidence of VTE events following hip arthroplasty, large cohort sizes are required to demonstrate statistical significance or superiority between the two regimens. In addition and by design, the present study was not a randomized controlled trial. However, the purpose of this study was not to prove superiority of one prophylaxis regimen, but rather to analyze the effectiveness of a risk stratification protocol implemented at our institution. Our study found both the routine and high risk regimens to be effective in preventing VTE events, but we noted a higher incidence of bleeding and wound complications in the high risk cohort. Furthermore, other relevant issues regarding cost-effectiveness, ease of use, and patient compliance of each regimen were not collected, although patient satisfaction with the thromboprophylactic regimen was improved in the routine risk cohort. In addition, based on our institution's risk stratification protocol and this study, we are unable to comment on which preoperative factors truly increase a patient's risk of VTE following hip arthroplasty. Limited evidence is present that elucidates specific risk factors that elevate VTE risk following total joint arthroplasty, and thus future studies may be directed at refining our risk stratification criteria. Lastly, during this prospective study, our indications for the inclusion of patients in the high-risk cohort did change, as our prior criteria for age, multiple medical comorbidities, and body mass index were removed. However, the incidence of VTE events in both the routine and high risk cohorts was identical both before and after our change in risk stratification criteria, thus limiting this change's impact on our reported results. Furthermore, our refined criteria fell further in line with prior reports by Colwell et al who assessed the effectiveness of mobile compression devices following total joint arthroplasty [19,20].

Both the routine risk and high-risk prophylaxis regimens were effective in the prevention of VTE following hip arthroplasty. Only 9 total events were noted in 1673 total patients when combining both cohorts, thus demonstrating the efficacy of both regimens. Warfarin is currently the most commonly prescribed oral anticoagulant medication for both orthopedic and non-orthopedic indications [34,35] and is efficacious in the prevention of both DVT and PE [9,36,37]. However, several disadvantages are present with the use of warfarin including its relatively narrow therapeutic window and difficult dosing due to its sensitive pharmacokinetics [38,39]. Furthermore, as length of stay following hip arthroplasty continues to decrease, there may be increased difficulty in gauging a patient's responsiveness to warfarin and obtaining a therapeutic INR prior to discharge and during their postoperative course [17,18]. Recently, Aynardi et al reported that 80% of patients were "subtherapeutic" at the time of discharge following total joint arthroplasty when prescribed warfarin [18]. Thus, a VTE prophylaxis regimen that is simple, effective, and requires little monitoring would prove beneficial. Aspirin for chemical thromboprophylaxis requires no monitoring, has demonstrated efficacy in the prevention of VTE events and has received a Grade IB recommendation for its use according to the most recent ACCP guidelines [16]. In addition, mobile compression devices have been introduced following unilateral joint arthroplasty with reports demonstrating VTE rates similar to those of patients receiving chemical thromboprophylaxis [19,21]. This study confirms that the use of MCDs with aspirin in routine risk patients is non-inferior in VTE prevention versus the use of warfarin therapy in high-risk patients.

However, the use of MCDs with aspirin did demonstrate some advantages with regard to limiting bleeding complications, wound drainage, and anticoagulation related readmissions following hip arthroplasty. One major concern with the use of warfarin is the potential increase in bleeding and wound complications. The relationship between postoperative wound complications and subsequent infection is well recognized [14,40]. McDougall et al performed a retrospective case–control study comparing the outcomes of patients on warfarin following primary total hip arthroplasty (THA) versus patients receiving aspirin. Patients on warfarin had increased rates of hematoma (28% versus 4%), deep joint infection (9% versus 2.2%), and superficial infection (13.5% versus 2.2%) with 11% of patients having a supra-therapeutic INR at the time of readmission [13]. Given that the two cohorts were intentionally stratified into routine and high-risk cohorts, we cannot comment on the direct impact of each anticoagulation regimen on the rate of readmission, but this study corroborates prior studies demonstrating a high risk of wound complications with the use of warfarin following total joint arthroplasty [13,14,17,40].

Lastly, patients in the routine risk cohort had superior satisfaction with their thromboprophylaxis protocol when surveyed at 2 weeks and at 4–6 weeks postoperatively versus patients in the high-risk cohort. As patient satisfaction continues to be a key determinant of quality of care and an important component of pay-for-performance metrics, use of a thromboprophylaxis protocol that is easy to administer with

good compliance is essential. Furthermore, Mostafavi et al have performed a Markov cost-effectiveness analysis of aspirin versus warfarin following total joint arthroplasty and found aspirin to cost less and save more quality-adjusted life-years versus warfarin in all age groups [41]. Thus, the frequent monitoring required and potential increased risk of readmissions with the use of warfarin may become a greater concern as the number of total joint arthroplasties performed continues to grow.

In conclusion, this study demonstrates that use of our risk stratification protocol allowed the avoidance of more aggressive anticoagulation in 75% of patients while achieving a low overall incidence of symptomatic VTE. As noted earlier, although the AAOS has previously recommended the use of risk stratification for VTE events and/or bleeding, this has been shown to be difficult due to limited evidence elucidating specific risk factors for VTE. Our risk stratification protocol may serve as a potential starting point for future studies and guidelines that attempt to avoid the use of more aggressive anticoagulation following hip arthroplasty. Future directions will focus on elucidating specific risk factors that increase the probability of VTE to determine which patients truly require more potent chemical thromboprophylaxis.

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