Reducing Postoperative Venous Thromboembolism Complications with a Standardized Risk-Stratified Prophylaxis Protocol and Mobilization Program

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BACKGROUND: Data revealed that our urban, academic, safety net medical center was a high outlier for postoperative venous thromboembolism (VTE). Our goal was to implement and determine the efficacy of a standardized intervention for reducing postoperative VTE complications.

STUDY DESIGN: We developed a strategy to decrease VTE complications, based on standardized electronic physician orders that specify early postoperative mobilization and mandatory VTE risk stratification for every patient, using the “Caprini” grading system. The derived scores dictate the nature and duration of VTE prophylaxis, including on an outpatient basis. Electronic reminders about appropriate VTE prophylaxis are automatically generated before and after operations, and on discharge. Both mechanical (pneumatic compression boots) and pharmacologic prophylaxis (unfractionated or low molecular weight heparin) are used, as indicated by risk level. We conducted a before-and-after trial, comparing National Surgical Quality Improvement Program (NSQIP) VTE outcomes (deep vein thromboses and pulmonary emboli) before and after implementing the standardized risk-stratified protocol combined with a postoperative mobilization program. Measured outcomes included NSQIP-reported raw and risk-adjusted VTE outcomes during 2 years before and after implementing the VTE prevention program.

RESULTS: The incidence of deep venous thromboses decreased by 84%, from 1.9% to 0.3% (p < 0.01), with implementation of VTE prevention efforts; the pulmonary emboli incidence fell by 55%, from 1.1% to 0.5% (p < 0.01). Risk-adjusted VTE outcomes steadily declined from an odds ratio of 3.41 to 0.94 (p < 0.05).

CONCLUSIONS: A patient care program, emphasizing early postoperative mobilization along with mandatory VTE risk stratification and commensurate electronic prophylaxis recommendations, significantly reduced the likelihood of VTE complications among our patients. (J Am Coll Surg 2014;218:1095–1104. © 2014 by the American College of Surgeons)

Postoperative venous thromboembolism (VTE) events, which include deep venous thromboses (DVT) and pulmonary emboli (PE), are a leading cause of morbidity and mortality. In the United States, the estimated annual incidence of VTE is 117 per 100,000. Among patients who undergo abdominal operations, symptomatic VTE occurs in 0.4% to 3.1%. Pulmonary emboli may cause sudden death and may independently reduce survival for up to 3 months after diagnosis. Those who live may develop pulmonary hypertension. Deep venous thromboses result in venous hypertension, which can lead to debilitating swelling and chronic pain. Other commonly encountered risk factors include older age, cancer, trauma, obesity,
Extended VTE prophylaxis, including after discharge.\textsuperscript{10,11} Maximum benefit, certain high risk patients may require reduce VTE complications. After reviewing the relevant thromboembolism prevention program Development of a standardized venous thromboembolism prevention program

METHODS

Development of a standardized venous thromboembolism prevention program

A VTE prevention team met to consider strategies to reduce VTE complications. After reviewing the relevant literature, the consensus was to use the Caprini risk stratification method for all general surgery and vascular surgery patients at our institution. Among the several available VTE prophylaxis programs, we selected the Caprini system because it is adaptable to individual patients’ risk factors, less likely to underestimate the hazards of VTE, and is well validated. We developed a scoring system and integrated it into the electronic inpatient medical record (Sunrise Acute Care, Allscripts). The system uses a check-box format so that each risk factor is explicitly listed and may be selected with a simple click (Fig. 1). The risk score is automatically calculated based on the selected factors, and the patient is placed into 1 of 5 risk categories (lowest, low, moderate, high, or highest risk). Our electronic order system is customized to require that a Caprini score be calculated for every patient at the time of operation and/or admission within general surgery and vascular surgery standardized order sets. If the surgery team does not calculate the Caprini score and act on the electronic recommendations, the orders cannot be completed. Therefore, we made an effort to ensure that each patient would be scored according to the Caprini model.

In addition, we created standardized VTE prophylaxis regimens and linked them to the Caprini risk categories. The prophylaxis regimens provide the recommended mechanical and pharmacologic prophylaxis along with a suggested duration (Table 1), which is automatically displayed. The duration of chemoprophylaxis may require extended regimens continued on an outpatient basis. For example, patients whose Caprini scores place them in the high risk category (scores 5 to 8) are advised to receive 7 to 10 days of chemoprophylaxis, both of which typically require outpatient treatment. The electronic order system is designed to require that all patients receive standardized prophylaxis regimens. When the discharge orders are recorded, the recommended VTE prophylaxis is automatically displayed for patients who require an extended course.

Our electronic order system requires selection of a prophylaxis regimen. Nevertheless, a surgeon may still decline VTE prophylaxis, when it is contrary to his or her judgment, by choosing the “opt out” selection in the order sets. This prompts an automatic drop-down menu that indicates reasons for not prescribing VTE chemoprophylaxis. The selections include active bleeding, risk of hemorrhage outweighing risk of VTE, surgeon preference, heparin allergy or contraindication, or other reason (supported by an explanation in the medical record). As a result, the order set even documents the reason.

Abbreviations and Acronyms

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DVT & deep venous thrombosis \\
O/E & observed to expected ratio \\
OR & odds ratio \\
PE & pulmonary embolism \\
VTE & venous thromboembolism \\
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for not using prophylactic anticoagulation. Although the ultimate decision for each patient receiving VTE prophylaxis is made by the surgeons, the electronic reminders are designed to encourage adherence to a standardized prevention strategy. The electronic system was implemented and became fully operational in February 2011.

We combined the requirement for Caprini risk stratification and commensurate prophylaxis with a standardized postoperative mobilization program. We created specific standardized mobilization instructions and included them in order sets used for all general surgery and vascular surgery patients. The nursing orders require that each patient be out of bed at least 3 times daily, beginning on the day of the operation. When possible, based on the physical capacity of the patient and specifics of the operation, early ambulation is encouraged. Nurse educators and surgeons met with unit nurses, including those from the ICU, to review baseline outcomes data and to establish expectations for mobilization. Attending surgeons and housestaff were also educated about VTE outcomes data and prevention principles. The mobilization program was implemented in August 2010.

Audits of practice
During deliberations about the risk-stratified program, we reviewed preintervention VTE prophylaxis practices of our surgeons. After introduction of the program, we tracked compliance with the new VTE prevention guidelines by
recording the percentage of general and vascular surgery patients for whom the prescribed prophylaxis regimen was consistent with the risk-stratified recommended prophylaxis. To be considered in compliance, both the nature and duration of VTE prophylaxis must have matched the recommended regimen for the patient’s risk score. Compliance was measured based on prescribing information for both inpatient and outpatient prophylaxis. Actual compliance at home could not be confirmed. A retrospective review of patient records was performed for the period from February 2013 to August 2013.

In order to understand baseline care of postoperative patients at our institution before development of the VTE prevention program, we had audited mobilization practices in the spring of 2010. All patients who had undergone elective open abdominal or pelvic operations were visited at 8:00 AM, 1:00 PM, and 6:00 PM on the day of surgery and during the 2 subsequent days. Nurses were unaware of these audits. Trained clinical staff recorded whether each patient was in bed, sitting in a chair, or walking at the time of the visit. We defined optimal practice as patients being out of bed, either sitting in a chair or walking. Auditors were independent of both the ordering surgeons and the responsible nursing staff, and included a quality improvement nurse, residents, and medical students. The audits were observational only and were not intended to directly alter patient management. The mobilization program was fully implemented in August 2010, and further audits were performed between 8 and 14 weeks after implementation.

**Outcomes measures**

We used NSQIP data from our institution to determine the impact of the standardized VTE risk stratified prophylaxis protocol and mobilization program. (Trained NSQIP surgical clinical reviewers collect clinical data rather than exclusively administrative data. This includes 30-day surveillance of patients to capture events that occur after hospital discharge.) The NSQIP defines DVT as a new diagnosis of venous thrombosis, confirmed by imaging study or autopsy, which is treated with anticoagulation or placement of vena cava filter. Criteria are also satisfied if the patient refuses treatment. A PE is defined as a new diagnosis of a new blood clot in a pulmonary artery, which is confirmed by imaging or autopsy. All patients who underwent an operation on the general and vascular surgery services at our institution during the specified time periods, and who were accrued to the NSQIP database, including those admitted to an ICU or to a non-ICU, were captured in our analysis. The absolute incidences of DVT and PE during the first 30 postoperative days, as defined by NSQIP, were compared between 1-year time periods before and after implementation of the programs. Comparisons were made by using the chi-square test, with statistical significance set at \( p < 0.05 \). SigmaStat statistical software (Systat) was used for all analyses. Additionally, we queried the NSQIP database

<table>
<thead>
<tr>
<th>Caprini score</th>
<th>Risk category</th>
<th>Recommended prophylaxis</th>
<th>Recommended duration of chemoprophylaxis</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Lowest</td>
<td>Early frequent ambulation only, OR At discretion of surgical team: Compression boots OR Low dose heparin OR Low molecular weight heparin</td>
<td>During hospitalization</td>
</tr>
<tr>
<td>1—2</td>
<td>Low</td>
<td>Compression boots OR Low dose heparin OR Low molecular weight heparin (Choose 1 item)</td>
<td>During hospitalization</td>
</tr>
<tr>
<td>3—4</td>
<td>Moderate</td>
<td>Compression boots AND Low dose heparin OR Low molecular weight heparin (Choose 1 medication)</td>
<td>During hospitalization</td>
</tr>
<tr>
<td>5—8</td>
<td>High</td>
<td>Compression boots AND Low dose heparin OR Low molecular weight heparin (Choose 1 medication)</td>
<td>7—10 days total</td>
</tr>
<tr>
<td>&gt;9</td>
<td>Highest</td>
<td>Compression boots AND Low dose heparin OR Low molecular weight heparin (Choose 1 medication)</td>
<td>30 days total</td>
</tr>
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for the same outcomes during the same time periods at comparable institutions, which we considered to be academic medical centers with more than 500 beds. We also compared our risk-adjusted VTE outcomes, which NSQIP reports as observed/expected ratios (O/E) for periods before calendar year (CY) 2010, and as odds ratios (OR) for CY 2010 and later. The O/E and OR values are considered to be statistically comparable for large sample sizes. A risk-adjusted ratio of 1.0 indicates that the number of observed events is equal to the number of events that would be expected based on the risk profile of the patients. Ratios exceeding 1.0 indicate a higher number of adverse events than would be expected; ratios less than 1.0 suggest fewer adverse events than expected. Risk-adjusted data in the NSQIP database account for patient comorbidities and severities of illness, which limit the effects that variation in patients’ disease characteristics between the 2 study periods may have had on the measured outcomes. This study was approved by the Institutional Review Board of the Boston University School of Medicine.

RESULTS
Preintervention practice
Before development of our standardized program, no VTE prevention guidelines were formally used. Our surgeons generally acknowledged the American College of Chest Physicians guidelines, but no structured system existed and no individualized risk stratification was performed. Pneumatic compression boots and subcutaneous heparin were frequently used, even in combination, but outpatient VTE chemoprophylaxis was rarely, if ever, used. There were no electronic reminders about VTE prophylaxis, and no surgeons used the Caprini system to guide decisions.

Preintervention analysis of practice revealed that patients generally remained in bed more than desired. Mobilization orders were often absent or vague; for example, orders might have simply stated “ambulate” without specifying a frequency. Nurses were not required to document details about ambulation.

Impact on practice
There was an excellent level of adherence to recommended prophylaxis regimens after implementation of the electronic risk-stratification and prophylaxis program. During the audit period, we observed 100% adherence to recommended prophylaxis regimens among patients stratified to low risk and moderate risk groups (n = 749). Among patients stratified to the high-risk category (n = 99), 89% received appropriate pharmacologic prophylaxis and duration. Ten percent of patients did not receive the recommended prophylaxis, based on surgeon discretion. One percent had a contraindication to pharmacologic prophylaxis. Adherence to the recommended prophylaxis and duration was 77% for patients in the highest risk category (n = 13), with 23% of patients having contraindications to pharmacologic prophylaxis. No patients received inappropriate or inadequate prophylaxis without a documented reason, by virtue of the electronic system. Documented reasons for choosing an alternative regimen included ambulatory operations, history of heparin-induced thrombocytopenia, early termination due to low platelet count, outpatient warfarin therapy, and administration of clopidogrel. Only the patient discharged on clopidogrel instead of the recommended prophylaxis developed a VTE complication.

Before introduction of a standardized early postoperative mobilization program, nursing practice audits revealed that only 19.6% of patients were out of bed at the time of the visit (n = 250). In contrast, postintervention audits 8 to 14 weeks after implementation of the program revealed a significant difference in practice, with 69.1% of patients out of bed (n = 250, p < 0.001).

Impact of risk-stratified prevention and mobilization on incidence of venous thromboembolism complications
During calendar year 2009, before implementation of the risk-stratified prophylaxis and mobilization program, the incidence of DVT at our institution was 1.9% of 1,569 patients (Fig. 2). The incidence of DVT fell by 84% to 0.3% of 1,323 patients, by the reporting period of July 2011 to June 2012, after implementation of VTE prevention efforts in 2010 and 2011 (p < 0.01). The average incidence of DVT at comparable NSQIP hospitals (academic medical centers with more than 500 beds) during the same time periods are presented in Figure 2 for purposes of comparison, and remained steady at 0.8%.

The incidence of PE at our institution decreased by 55%, from 1.1% of 1,569 patients before the prevention program to 0.5% of 1,323 patients (Fig. 3, p < 0.01). The same outcomes at comparable NSQIP hospitals are demonstrated in Figure 3, and remained 0.4% over time.

In terms of risk-adjusted NSQIP data, our O/E for VTE was 3.41 before implementation of the program (n = 1,569, 95% confidence interval [CI] 2.40 to 4.70), and steadily decreased to an OR of 0.94 (n = 1,323, 95% CI 0.56 to 1.58, p < 0.05) after risk-stratified prophylaxis was introduced (Fig. 4).

DISCUSSION
More than 20 years since Joseph Caprini introduced a VTE risk score, and despite guidelines from multiple
sources for VTE prophylaxis regimens, PE and DVT remain significant problems among hospitalized patients in the United States. Data show that high-risk patients tend to receive insufficient prophylaxis; low-risk patients may be overtreated. It has been suggested that the solution to this problem is standardized risk assessment and commensurate prophylaxis.

We were distressed to discover that our hospital was a high outlier for NSQIP-defined VTE events, but we regarded this as an opportunity to improve care. By adopting mandatory VTE risk calculation and associated risk-stratified prophylaxis for every patient, along with standardized early postoperative mobilization, we demonstrated excellent adherence to prophylaxis guidelines and a dramatic reduction in postoperative VTE events among our patients. Although the Caprini scoring system has been well validated in terms of its predictive value for VTE, to our knowledge this is the first study to demonstrate a reduction in VTE events based on its standardized and required use in conjunction with a formal mobilization program.

We have demonstrated that the incidence of VTE events was reduced after the introduction of a postoperative mobilization program and a mandatory risk stratification system with corresponding risk-based prophylaxis guidelines, including recommendations for extended chemoprophylaxis. Our data (Figs. 2 to 4) indicate that the incidence of VTE events began to decline before the official introductions of the programs, although they still remained greater than expected. Our faculty had deliberated and planned these new programs for quite a while, likely influencing changes in practice before formal implementation of the programs. Once the programs were operational, we observed a continued reduction in adverse VTE events.

The risk of VTE conferred by some operations persists after discharge, and up to one-third of VTE events after cancer operations may be diagnosed after the index admission. Several randomized controlled trials have demonstrated excellent risk reduction by extending the course of VTE prophylaxis on an outpatient basis. Despite this evidence, adherence to extended prophylaxis regimens in actual practice has been poor. In the experience at our medical center, extended regimens of prophylaxis were rarely used before introduction of the mandatory risk stratification and electronic reminder system. The reminders have particularly increased awareness among our
surgeons about the recommendation for extended prophylaxis in high-risk patients. Indeed, audits show that majority of high-risk patients at our institution now routinely receive extended duration prophylaxis. This may account for much of the dramatic reduction that we observed in the overall incidence of DVT and PE at 30 days. Our decision to construct the risk-stratified regimens with extended courses of prophylaxis was based on the collected literature on Caprini scores and the commensurate risk for VTE at each level. In particular, a report by Bahl and colleagues demonstrated the greatest likelihood of VTE in patients with scores greater than 5. Furthermore, there was a significant increase in the likelihood of VTE between scores of 7 and 8 (2.58% incidence) and scores of 9 or higher (6.51% incidence). Therefore, we chose to recommend extended duration chemoprophylaxis of 7 to 10 days for patients with scores 5 to 8, and a more extended 30-day duration for those with scores of 9 or greater. The risk of VTE in patients with scores less than 5 is quite low (less than 1%) so that the cost and risk of extended prophylaxis does not seem to be justified in those groups.

The concept of electronic reminders has been shown to increase use of VTE prophylaxis and to decrease the incidence of VTE events. In a study by Kucher and associates, patients randomized to an intervention group in which physicians were shown an automatically generated electronic reminder of VTE prophylaxis recommendations were nearly twice as likely to receive pharmacologic prophylaxis, when compared with the group for which no electronic reminders were generated. Importantly, the incidence of DVT and PE was reduced by 41% in the intervention group. We used this strategy to increase adherence to VTE prophylaxis among our surgeons and demonstrated similar success. This lends support to the strategy of electronic reminders that are tailored to individual risk factors.

Early frequent mobilization has been suggested as a strategy to prevent VTE, based largely on the fact that immobilized patients are at particular risk for VTE. However, there are no randomized controlled trials to prove the benefit of postoperative mobilization. Despite the lack of evidence, VTE prevention guidelines emphasize early mobilization as a key component of prophylaxis and as the only necessary prophylactic measure in lowest risk patients. We embraced the idea of standardized, early, frequent postoperative mobilization as a mechanism of VTE prevention, and as an element of excellent patient care, to decrease the likelihood of postoperative respiratory complications. We are not able to determine the extent to which mobilization may...
have reduced our incidence of VTE relative to the benefits of mandatory risk calculation and risk-based prophylaxis. Nevertheless, our incidence of VTE had decreased with institution of the mobilization program alone while the risk-stratified VTE program was being designed. Ultimately, our aim was not to demonstrate the superior efficacy of a solitary intervention, but rather to support the concept that standardization of practices can improve patient outcomes. In reality, the 2 practices—mobilization and risk-based prophylaxis—may be synergistic.

We perceived little resistance to the program among our surgeons, which is reflected in the high compliance rates with prophylaxis regimens. We found that surgeons appreciated the simplicity of the program, including the electronic automation, as an easy and thoughtful way to individualize VTE prophylaxis based on risk. Although the risk-stratification element was required, the specific prophylaxis regimens were not mandated, and an “opt out” choice was provided, along with documented reasons for declining the therapy. Therefore, surgeons maintain autonomy and gain awareness of VTE hazards by virtue of the risk-assessment and electronic reminders.

There are several methodologic limitations of this study. We present a before-after analysis, comparing our NSQIP-reported VTE outcomes before implementation of our standardized prevention protocol to subsequent outcomes. Therefore, we have not conducted a randomized trial of the described interventions. Because the basis of our work was a quality improvement effort founded on standardization, we believed it necessary to implement the program for all of our general and vascular surgery patients at the same time. Furthermore, the usage of NSQIP data allowed us to present risk-adjusted data for our entire study population during the periods before and after intervention. Admittedly, NSQIP has some inherent limitations, such as capturing only a representative sampling of patients rather than including all patients. Nevertheless, its statistical methods are well validated and accepted by surgery audiences. The risk-adjusted outcomes account for patient comorbidities, limiting the impact of possible variability in patient disease between the study periods, and show a definite improvement in VTE events.

Because of changes in the way NSQIP reports risk-adjusted outcomes, data are presented as O/E ratios for
periods before calendar year 2010 and as odds ratios for calendar year 2010 and later. As a result, we compare O/E ratios for the periods before our VTE prevention program to ORs for the later intervals. However, O/E and OR are considered to be statistically comparable for large sample sizes. We have received formal NSQIP assurance that the interchangeability of these data for large groups offers a valid comparison. The dramatic reduction of absolute and risk-adjusted VTE events provides convincing evidence that an actual benefit was achieved among our patients.

Health systems that have higher use of imaging studies have a higher likelihood of diagnosing VTE complications. Such a surveillance bias could theoretically influence the results of our study if use of VTE diagnostic imaging changed during the study period. Although we did not track testing patterns, we have no reason to believe that our institutional imaging practices changed substantively.

CONCLUSIONS
In conclusion, our patient care program emphasizing early postoperative mobilization, mandatory VTE risk stratification, and commensurate electronic prophylaxis recommendations, significantly reduced the likelihood of VTE complications among our patients. Risk-based prophylaxis for VTE provides a distinct benefit to patients, and standardization of care ensures that best-practice guidelines are followed to the greatest extent possible. We are encouraged by the success in reducing these devastating events among our patients by implementing such a strategy, and we are optimistic that postoperative complications may be diminished by adherence to risk-stratified and standardized patient care standards.

Author Contributions
Study conception and design: Cassidy, Rosenkranz, McAneny
Acquisition of data: Cassidy, Rosenkranz, McAneny
Analysis and interpretation of data: Cassidy, Rosenkranz, McAneny
Drafting of manuscript: Cassidy, McAneny
Critical revision: Cassidy, McAneny

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REFERENCES

Invited Commentary

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Cassidy and colleagues should be commended for their work to develop a standardized protocol to reduce postoperative venous thromboembolism (VTE). Although surveillance bias complicates the interpretation and comparison of VTE rates between hospitals (increased hospital VTE event rates are associated with increasing hospital imaging use rates), few organizations would likely argue that they can’t improve in the implementation of postoperative VTE reduction strategies. It is heartening to see that an organization can experience such an impressive reduction in VTE rates in a relatively short period of time.

Cassidy and colleagues present us with a program that includes mandatory risk stratification (in the form of an electronic system that provides guidance on prophylaxis selection and provides reminders at key times during hospitalization) and early mobilization. In addition, the electronic guidance included recommendations for postdischarge prophylaxis for certain groups of high risk patients.

As we seek to reduce VTE events in our own organizations, our challenge is to determine which particular interventions have the most impact and therefore, are worthy of time and resource investment. Fully implementing the VTE reduction program proposed by Cassidy and associates would require a fair institutional commitment, both in information technology and process improvement resources. It would be helpful to know which particular aspects of the program were most impactful. Could the reduction in VTE events have been driven exclusively by the electronic risk stratification module? Was much benefit attributable to mobilization? Or, was providing postdischarge prophylaxis for high risk patients really the key intervention? The authors stated that it was not their intent to demonstrate the superiority of a particular intervention, but rather to support the concept that standardization of practices can improve patient outcomes. This is understandable, but it makes it more difficult for us to make judgments about focused interventions. In addition, it is not clear how chemoprophylaxis practices actually changed as a result of the intervention. It would be helpful to have data about rates and other aspects of VTE chemoprophylaxis practices pre-, peri- and postintervention, especially because most of the reduction in the VTE risk-adjusted ratio actually came before any of the interventions were formally launched. The authors suspected that this is because surgeons were already starting to implement certain aspects of the program before the formal launch, but we don’t have the data on practices to validate this hypothesis.

Certainly, few would argue that we shouldn’t work to improve decision-making about prophylaxis, improve the consistency of prophylaxis administration when ordered, and improve postoperative mobilization in a safe manner. With time and further study, it should become clearer whether these are synergistic practices, as the authors suggest, or whether certain high-impact interventions drive the bulk of improvement. Cassidy and colleagues have done great work to develop and implement a VTE reduction strategy, and they have seen a remarkable improvement in outcomes. We should applaud their success as we continue the work to refine our understanding of the impact of VTE reduction strategies.

REFERENCE