Deep venous thrombosis (DVT) and pulmonary embolism (PE), collectively known as venous thromboembolism (VTE), are leading causes of morbidity and mortality in the United States. The incidence of VTE is estimated to be 100–120 per 100,000 population (~0.1%), and VTE accounts for over 200,000 deaths annually in the United States. In addition to the obvious public health burden, an estimated $15.5 billion is spent annually on diagnosing and treating VTE, placing a significant strain on the U.S. health care system.

Over 12 million people in the United States are at risk of VTE due to hospitalization for major surgery or medical illness. In fact, the majority of hospitalized patients have at least one factor that may put them at risk for a hospital-acquired VTE. Without appropriate prophylaxis, the rate of hospital-acquired DVT ranges from 10% to 40% in the medical and general surgery population and increases to 40% to 60% for orthopedic surgery patients. Furthermore, hospital-acquired VTE is associated with increased hospitalization and increased mortality.

Purpose. The effectiveness of a program to improve adherence to best-practice guidelines for venous thromboembolism (VTE) risk assessment and prevention in a community hospital setting was evaluated.

Summary. Variation in the use of best-practice guidelines for VTE risk assessment and prevention with regard to the frequency of VTE risk assessment and the risk score assigned, as well as the communication of the risk of VTE and the need for prophylaxis to treating physicians, was found. To improve adherence to established guidelines, the responsibilities of a nurse case manager were expanded to serve as a single point of contact who was accountable for identifying high-risk patients and advocating for appropriate pharmacologic prophylaxis in the absence of contraindications. To facilitate the role of the nurse case manager, an automated VTE-risk-assessment tool was developed to reliably identify high-risk patients in real time. This intervention was evaluated from January 1 to June 30, 2010. Before the intervention, contraindications to anticoagulation were reported for 19.1% of high-risk patients not receiving prophylaxis and pharmacologic prophylaxis was ordered for 47.9% of high-risk patients without contraindications. During the course of the intervention, contraindications to anticoagulation were reported for 36.2% of high-risk patients not receiving prophylaxis and pharmacologic prophylaxis was ordered for 64.9% of high-risk patients without contraindications.

Conclusion. The appointment of a nurse case manager trained in anticoagulation and the development of an automated VTE-risk-assessment tool to identify patients at high risk of VTE were associated with improved adherence to best-practice guidelines for VTE risk assessment and prevention.

Index terms: Anticoagulants; Compliance; Contraindications; Hospitals; Nurses; Protocols; Quality assurance; Risk management; Venous thromboembolism

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costs: $10,000 per DVT and $20,000 per PE. Although hospital-acquired VTE will never be completely eradicated, efforts to reduce these events can have a dramatic effect on hospital costs and patient care.

**Background**

There are established guidelines describing evidence-supported best practices for preventing, diagnosing, treating, and managing VTE, such as those published by the Agency for Healthcare Research and Quality (AHRQ) and the American College of Chest Physicians. According to most guidelines, appropriate prophylaxis (i.e., appropriate duration, dosage, and modality) is considered to be the most effective strategy for preventing VTE. AHRQ ranked appropriate VTE prophylaxis as the most important safety practice with the greatest impact on patient care.

The literature also supports the use of the practices outlined in the guidelines and their beneficial impact on VTE outcomes. Despite the wealth of evidence supporting the use of VTE guidelines, they are not universally followed. Several studies have shown that the rates of appropriate pharmacologic prophylaxis range from 34% to 40% in medical patients and 32% to 59% in surgical patients. Factors that may limit adherence to VTE prevention guidelines include a decreased awareness of VTE risk factors and the frequency of VTE, clinician belief that VTE is not a problem in his or her practice, clinician reluctance to use pharmaceutical prophylaxis due to concerns regarding bleeding complications, and insufficient clinician knowledge about recommended standards for VTE prevention.

**Problem**

Even when best-practice guidelines are implemented, their application may be inconsistent. At our community hospital, we found variations in the frequency of VTE risk assessment and in the risk score assigned, depending on the individual performing the review. Inhouse surveys also found significant variability in how the risk of VTE and the need for prophylaxis are communicated to treating physicians between facilities and even among units within the same facility. We assembled a study team, which included a physician, a pharmacist, and a nurse, to perform a chart review to examine patterns of pharmacologic prophylaxis at our hospital. Among 106 randomly selected patients with a VTE risk documented between May 1 and June 30, 2009, 82 patients (77.4%) were identified as being high risk for VTE. Seventy-three high risk patients had no contraindication to prophylaxis; 35 of these patients (47.9%) received pharmacologic prophylaxis. Of the 47 high-risk patients without prophylaxis, 9 (19.1%) had contraindications to pharmacologic prophylaxis documented in the medical chart.

The study team also reviewed discharge records between May 1 and October 31, 2009, to examine VTE-related outcomes at our hospital. Among 5775 discharge records (excluding 100 cases of patients who had VTE at admission), 27 patients (0.47%) were identified as having a hospital-acquired VTE. Of these patients, 17 had a hospital-acquired DVT, 7 had a hospital-acquired PE, and 3 suffered both a hospital-acquired DVT and PE. Of 2404 patients receiving pharmacologic prophylaxis, 11 (0.46%) experienced prophylaxis-related bleeding.

**Analysis and resolution**

A VTE intervention program, consisting of two components, was designed to improve adherence to best-practice guidelines. First, we appointed a nurse case manager to the inpatient setting, who served as a single point of contact and was accountable for VTE risk assessment and prevention. Second, to facilitate the role of the nurse case manager, we developed an automated risk-assessment tool to reliably identify high-risk patients in real time.

The VTE intervention was conducted at Sutter General Hospital, a 326-bed, specialty, not-for-profit, community medical center in Sacramento, California. The hospital provides general acute medical and surgical care as well as advanced cancer, orthopedics, spine, neurology, and neurosurgery services. The hospital’s institutional review board approved this study on January 20, 2009.

A registered nurse specially trained in anticoagulation management was designated as a part-time inpatient nurse case manager and was assigned to the hospital Monday through Friday from December 7, 2009, through June 30, 2010. The nurse case manager’s activities to support the intervention were in addition to her usual role in the outpatient anticoagulation program. The time spent on tasks related to the risk assessment was estimated to be about 25% of total work time.

The nurse case manager served as a single point of contact for nurses, physicians, pharmacists, and patients with respect to VTE risk assessment and prevention. In this regard, the nurse case manager had the following key responsibilities: (1) identify patients at high risk for VTE who were not receiving pharmacologic prophylaxis, (2) encourage documentation of contraindications to pharmacologic prophylaxis, and (3) in the absence of contraindication, advocate for appropriate pharmacologic prophylaxis.

**Development of an automated risk-assessment tool.** To support the role of the nurse case manager, the study team developed an automated decision-support tool to allow for real-time identification of patients at high risk for VTE. This tool was derived from an existing proprietary clinical-decision-support tool, Core Measure Manager (CMM),
developed at Sutter Medical Center Sacrament to support Medicare Core Measure compliance track-

ing for heart failure, pneumonia, and myocardial infarction.18 CMM compiles relevant data from separate systems into one database, including admitting, discharge, and transfer; laboratory, pharmacy, and radiology systems, allowing for a broad picture of a patient’s status. An interface was added for dictated documents, which facilitated keyword searches of free-text reports, including medical history and physical examinations, consultation notes, and operative reports. The VTE-risk-assessment algorithm (Figure 1), used these data to identify VTE risk factors in each patient for whom a total risk score was calculated. Patients with a risk score of $\geq 3$ were deemed to have a high risk of VTE. The nurse case manager then reviewed and scored each chart for patients on the CMM-generated risk report. The nurse case manager administered, discharge, and transfer: systems for heart failure, pneumonia, and myocardial infarction. CMM, Medicare Core Measures; VTE, venous thromboembolism.

![Figure 1. Point-based venous thromboembolism (VTE)-risk-assessment tool used to power the risk-assessment algorithm. GU = genitourinary, DVT = deep venous thromboembolism, PE = pulmonary embolism.](https://academic.oup.com/ajhp/article-abstract/68/22/2184/5129319)

**Part A: Clinical Setting of Patient**

<table>
<thead>
<tr>
<th>1 Point</th>
<th>2 Points</th>
<th>3 Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor surgery</td>
<td>Bedrest &gt; 72 hrs</td>
<td>Major surgery &gt; 45 minutes (neurosurgical, abdominal, thoracic, GU, pelvic, vascular, lower extremity - except total hip/total knee replacement)</td>
</tr>
<tr>
<td>Pregnancy or &lt; 2 months post-partum</td>
<td>Immobilizing plaster cast</td>
<td>Stroke, paralysis, or spinal cord trauma</td>
</tr>
<tr>
<td>Central venous catheter</td>
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<td></td>
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</tbody>
</table>

**Part B: Risk Factors Associated with Patient**

<table>
<thead>
<tr>
<th>1 Point</th>
<th>2 Points</th>
<th>3 Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 41–60</td>
<td>Age 61–70</td>
<td>History of DVT/PE in the past</td>
</tr>
<tr>
<td>Hx of major surgery within 12 months</td>
<td>Malignancy</td>
<td>Inherited or acquired hypercoagulable state</td>
</tr>
<tr>
<td>Myocardial infarction, heart failure, pneumonia, or sepsis</td>
<td>Varicose veins</td>
<td></td>
</tr>
<tr>
<td>Varicose veins</td>
<td>Inflammatory bowel disease</td>
<td>Obesity</td>
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<tr>
<td>Inflammatory bowel disease</td>
<td>Obesity</td>
<td></td>
</tr>
<tr>
<td>Obesity</td>
<td>Current birth control pills/hormone replacement therapy</td>
<td></td>
</tr>
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**Example Calculation**

Part A: ________ Points + Part B: ________ Points = _________ Total VTE Risk Score
receiving pharmacologic prophylaxis were added to the CMM VTE risk report for follow-up with the nurse case manager.

Outcomes analyses. The charts of inpatients age 18 years or older who were discharged between January 1 and June 30, 2010, were reviewed for hospital-acquired VTE and bleeding events. The month of December was excluded from analysis because the program was still in development and not fully operational. Acute care rehabilitation, skilled-nursing facility, and labor and delivery inpatients were excluded from this analysis.

Hospital-acquired VTE was defined as a DVT or PE that occurred during hospitalization or within 30 days of discharge and that was not present on hospital admission. Hospital-acquired VTE was identified by International Classification of Diseases, 9th edition, discharge diagnosis codes for DVT or PE, (415.11, 415.19, 451.11, 451.19, 451.2, 451.81, 453.40–453.42, 453.8, 453.9, 639.6, 671.30, 671.31, 671.33, 671.40, 671.42, 671.44, 671.50–671.54, 673.20–673.24) which were confirmed to be hospital acquired per chart review. All non-VTE discharges were compared with all discharges with VTE present on hospital admission (also confirmed by chart review) from January 1 through July 31, 2010, to determine if a patient was readmitted within 30 days due to VTE. Hospital-acquired prophylaxis-related bleeding was defined as bleeding that occurred during the hospital stay; these events were excluded. Contraindications to pharmacologic prophylaxis included one or more of the following: evidence of active bleeding or a high risk of bleeding, history of heparin-induced thrombocytopenia, and a platelet count of <100,000/mm³.

Patients whose VTE risk was categorized as low or moderate received usual care per nurse or physician discretion. For example, low-risk or moderate-risk patients might have received mechanical prophylaxis, such as knee-high compression stockings or other knee-high sequential compression devices when in bed. Mechanical prophylaxis is not documented electronically at our hospital; therefore, these data were not captured in this study.

Descriptive statistics were used for all study variables.

Results

During the six-month intervention period, data for 6000 acute-care discharges were captured. Seventy-seven patients (1.3%) had VTE on admission and were excluded from further analysis. Of the remaining 5923 patients, 4131 (69.7%) were identified by the automated risk-assessment tool as high risk for VTE (Figure 2). Among high-risk patients, 2018 (48.9%) had orders for pharmacologic prophylaxis at the time of the assessment, but 1787 (43.2%) had no active orders for prophylaxis and were added to the VTE risk report for follow-up. Contraindications to anticoagulation were identified for 407 (36.2%) of 1124 high-risk patients not receiving pharmacologic prophylaxis. The overall rate of pharmacologic prophylaxis for high-risk patients was 64.9% (2681 of 4131 high-risk patients).

Among the 5923 discharge records evaluated, 15 hospital-acquired VTEs were identified (0.25%). Five patients experienced a hospital-acquired DVT, 7 patients had a hospital-acquired PE, and 3 patients had both a hospital-acquired DVT and PE. Among the 2681 patients with orders for pharmacologic prophylaxis, 10 patients (0.37%) experienced prophylaxis-related bleeding events.

Discussion

In this study, the nurse case manager served as a single point of contact for hospital staff and patients and augmented the consistency of care for VTE risk assessment and prevention. With the aid of an automated risk-assessment tool, the nurse case manager could reliably assess VTE risk in real time and advocate for appropriate pharmacologic prophylaxis. All patients admitted to the hospital during the intervention period were assigned a VTE risk score. Moreover, scores were automatically updated daily to capture any patients whose VTE risk may have changed during hospitalization. Before the intervention, the majority of patients in our chart review received at least one VTE risk score; however, we noted some interrater variability in the risk scores calculated. Interrater variability is a common issue with manual risk assessments that can be mitigated by the use of an automated risk-assessment tool.

During the intervention, the rates among high-risk patients of documented contraindications to anticoagulation (407 [36.2%] of 1224 patients) and orders for pharmacologic prophylaxis (2681 [64.9%] of 4131 patients) were higher than those found during the preintervention period (9 [19.1%] of 47 patients had documented contraindications, and 35 [47.9%] of 73 patients had orders for prophylaxis). However, the preintervention values were derived from a chart review of a small number of patients and should be interpreted with caution.

A subset of patients (n = 227) who were added to the risk report during the intervention period were classified as having documented contraindications and orders for prophylaxis. This subset likely represents patients who were receiving prophylaxis but developed a contraindication during therapy, at which time anticoagulation was discontinued. Alternatively, these patients may have had an initial contraindication but were later cleared to receive pharmacologic prophylaxis.

During the intervention period, 326 high-risk patients were not added to the risk report. This was due to the fact that the risk report was run daily Monday through Friday; thus, patients who were admitted...
and discharged over the weekend would not have been assessed in this study. After evaluating the medical records of these patients, we ascertained that they did not have orders for pharmacologic prophylaxis; however, we do not know if they had contraindications to anticoagulation. Furthermore, 717 additional high-risk patients who were added to the risk report did not receive pharmacologic prophylaxis despite the absence of documented contraindications. Several factors may have contributed to this. For example, the nurse case manager was available to follow up on high-risk patients on a part-time basis, and although patients may have been admitted during this time, the patients may have been discharged before the nurse case manager had the opportunity to intervene. Furthermore, the treating physician may have disregarded the nurse case manager’s recommendation for pharmacologic prophylaxis (e.g., withholding prophylaxis, ordering mechanical prophylaxis instead). Unfortunately, data on mechanical prophylaxis were not captured in this study, because orders for mechanical prophylaxis were not documented electronically.

The rates for hospital-acquired VTE (0.25%) and prophylaxis-related bleeding events (0.37%) were low during our study period relative to the preintervention period (0.47% and 0.46%, respectively). Notably, the percentage of patients who had VTE on admission was also relatively lower during the intervention period (1.3%) compared with the preintervention period (1.7%); however, the magnitude of change was greater for hospital-acquired VTEs compared with VTE that was present on admission. Although we are encouraged by our findings, a direct comparison of rates of hospital-acquired VTE and rates of prophylaxis-related bleeding events among patients during the preintervention and intervention periods is not appropriate, as our study was not designed to make such comparisons. Moreover, there is insufficient statistical power in our study to detect significant differences between these low rates. It is possible that the rates of hospital-acquired VTE were underestimated both before and during the intervention if patients experienced a VTE within 30 days after discharge but were admitted to a different hospital.

To the best of our knowledge, our study is the first to show that an ac-
countable, single point of contact was associated with improved adherence to best-practice guidelines for VTE risk assessment and prevention. There are several advantages to having an accountable individual managing inpatient VTE care. This person can directly communicate with the physician about high-risk patients; follow up when prophylaxis is not ordered; provide documentation of contraindication to prevent prophylaxis that can be harmful to a patient, particularly with respect to bleeds; and act as a resource for physicians, nurses, and patients with respect to VTE education.

In contrast to previous studies, ours was conducted in a community hospital without the resources of a large, academic medical center. In fact, only a few studies have addressed VTE prevention in a community hospital setting. Nevertheless, our study is the first to implement an automated system to facilitate a streamlined approach to VTE risk assessment and prevention in a community hospital with improved adherence to best-practice guidelines.

This study had several limitations, including a short duration of follow-up and a single-site study design. In addition, the nurse case manager was part-time and provided coverage only on weekdays. Communication between the nurse case manager and the treating physicians was primarily a written note left in the patients’ charts, and there was little follow-up if a physician did not act on the recommendation. Furthermore, this intervention was designed as a process-improvement initiative; therefore, it is unknown if the intervention had any effect on patient outcomes.

Our hospital study site and a second hospital within our network are preparing to replace the manual VTE risk assessment, as performed daily by nurses, with the automated risk-assessment tool. At these hospitals, VTE risk assessment will be allocated to the pharmacy department, which will print the risk report daily and follow up with physicians as needed. A third hospital in our network has also requested implementation of the automated VTE risk-assessment tool.

Conclusion

The appointment of a nurse case manager trained in anticoagulation and the development of an automated VTE-risk-assessment tool to identify patients at high risk of VTE were associated with improved adherence to best-practice guidelines for VTE risk assessment and prevention.

References