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The Effect of a Provider-Enhanced Clinical Decision Support Tool for Guiding Venous Thromboembolism Pharmacoprophylaxis in “Low-Risk” Patients

Michael J. MaCauley, MD,

Department of Medicine, Penn State College of Medicine, Hershey, PA, 17033;
mmacauley@hmc.psu.edu

John W. Showalter, MD, MSIS,

Department of Medicine, University of Mississippi, Jackson, MS, 39216; JShowalter@umc.edu

Michael J. Beck, MD, and

Departments of Medicine and Pediatrics, Penn State College of Medicine, Hershey, PA, 17033;
mbeck@hmc.psu.edu

Cynthia H. Chuang, MD, MSc

Division of General Internal Medicine, Penn State College of Medicine, Hershey, PA, 17033;
cchuang@hmc.psu.edu

Abstract

Background—Computer-based tools to assess venous thromboembolism (VTE) risk have been shown to increase VTE pharmacoprophylaxis rates and decrease VTE incidence in high-risk hospitalized patients. However, VTE risk may be underestimated using computer-based tools alone. We tested the effect of a provider-enhanced clinical decision support (CDS) tool on VTE pharmacoprophylaxis and VTE incidence in patients who would have been deemed “low-risk” using a computer-based risk assessment tool alone.

Methods—The study sample was adult patients hospitalized during a 13-month period who were determined to be “low-risk” for VTE with a computer-based risk assessment tool. The provider-enhanced CDS tool was implemented 4 months into the study period that required providers to stratify patients as high, moderate, or low-risk for VTE. We compared rates of VTE pharmacoprophylaxis and VTE incidence before and after implementation of the provider-enhanced CDS tool.

Results—There were 1,322 patients in the 4-month pre-implementation period and 3,347 patients in the 9-month post-implementation period who were deemed “low-risk” for VTE based on a computer-based risk assessment tool. Using the provider-enhanced CDS tool, providers stratified 31% of these computer-assigned “low-risk” patients as moderate-risk and 7% as high-risk for VTE. The rate of VTE pharmacoprophylaxis increased (27% to 34%, $p<0.01$). VTE rate decreased from 0.98% to 0.42% after implementation of the provider-enhanced CDS tool ($p<0.02$).

Corresponding Author: Michael J. MaCauley, 500 University Drive, Hershey, PA 17033, P: (717) 579-1394; F: (717) 531-7726; mmacauley@hmc.psu.edu.

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Conclusions—Patients identified as “low-risk” for VTE solely by computer-based algorithms may include patients that providers determine to be at risk for VTE. Provider-enhanced CDS tools may outperform computer-based VTE risk stratification algorithms.

Keywords

VTE Prophylaxis; Decision support tools; thromboprophylaxis; computer-based tools

INTRODUCTION

Venous thromboembolism (VTE), which includes deep vein thrombosis (DVT) and pulmonary embolism (PE), contribute significantly to the morbidity and mortality of hospitalized patients and represent a tremendous economic burden to the health care system.¹ VTE was the primary or secondary diagnosis in over 1% of hospital discharges between 1998 and 2004 at a direct cost of approximately \$10,000–14,000 per event.² It is estimated that more than half of VTE events are related to a recent prior hospitalization.¹ When utilized appropriately in hospitalized patients, appropriate prophylaxis can reduce the risk of VTE by up to 63%.^{3–7} The ENDORSE study reported in 2006 that the majority of both medical and surgical inpatients were at risk for the development of VTE, but more than half of medical and almost one-third of surgical patients did not receive guideline appropriate prophylaxis.⁴ Since VTE prophylaxis remains underutilized,^{8–9} there is need to identify clinical support tools to overcome barriers to its use.

In 2008, the American College of Chest Physicians updated guidelines for the prevention, diagnosis, and treatment for VTE, which calls for hospitals to implement strategies for improving prophylaxis in order to reduce the incidence of VTE.¹ These guidelines recommend using varied and layered strategies for risk assessment and providing VTE prophylaxis, including clinical decision support (CDS) tools.¹ Computer-based CDS tools have been shown to increase VTE pharmacoprophylaxis rates and decrease VTE incidence in hospitalized patients that are recognized as high-risk.¹⁰ The strength of computer-based CDS tools is they can automatically determine VTE risk based on factors that can be identified from an electronic medical record (EMR), such as previously documented ICD-9 codes, laboratory results, and patient demographic data. However, these tools are dependent on, and thereby limited by, the quality of electronically available clinical data to accurately identify patients as high-risk. These tools then prompt the health care provider to consider prophylaxis. However, the electronic clinical data needed to accurately determine a patient's VTE risk may not be fully captured in an electronic medical record (e.g., remote cancer or VTE diagnosis, immobility). These limitations of computer-based CDS tools create the potential for underestimating VTE risk, possibly resulting in under-prophylaxis of at-risk patients misclassified as “low-risk.”

We hypothesized that a provider-enhanced CDS tool may identify patients as being at-risk (moderate and high-risk) for VTE that a computer-based CDS tool (that does not incorporate provider input) would consider to be “low-risk.” We further hypothesized that more accurate identification of at-risk patients would lead to increased rates of prophylaxis in these at-risk patients and hence decrease the 30-day incidence of VTE.

METHODS

This study was conducted at the Penn State Hershey Medical Center and was approved by the Institutional Review Board of the Penn State College of Medicine (Protocol ID #34141EP). Among medical and surgical patients who would have been deemed “low-risk”

by a computer-based tool alone, we compared the rates of pharmacoprophylaxis and VTE before and after implementation of a provider-enhanced CDS tool.

Provider-Enhanced CDS Tool

In March 2009 our institution implemented a provider-enhanced CDS tool for VTE risk stratification and prophylaxis. This provider-enhanced CDS tool is a series of 2 screens that were inserted into the electronic admission order process. All patients admitted to our medical center are required to have admission orders entered electronically—this is typically completed by a resident physician or physician extender, and less commonly, an attending physician. The first screen (Figure 1) of the provider-enhanced CDS tool requires the provider to stratify each patient as high, moderate, or low-risk for VTE—which we will call the provider-assigned VTE risk score. The provider determines the provider-assigned VTE risk score using a point-based VTE risk assessment that is displayed on the same screen, which guides the provider to assign points for well-recognized VTE risk factors.^{11–13} Relative and absolute contraindications to pharmacologic prophylaxis are also provided (not shown). The provider must then enter their provider-assigned VTE risk score based on whether the patient is assessed to be at low risk (0–1 point), moderate risk (2–4 points), or high risk (>4 points) for developing VTE. Occasionally admission orders are permitted to be initiated when a patient is expected, but has not yet arrived or been evaluated by the primary admitting team—in those situations the provider can defer the VTE risk assessment until the patient's arrival. Clinical situations where this scenario can arise are during admissions for elective procedures where the patient will undergo spinal, cranial, or peripheral nerve surgery. After the admission orders are completed, the provider will see the second screen (Figure 2) if their provider-assigned VTE risk score is either moderate or high, but appropriate VTE prophylaxis was not ordered. This reminder alert requires the provider to order VTE pharmacoprophylaxis or indicate that VTE pharmacoprophylaxis is contraindicated. Providers will not receive the reminder alert for patients stratified as low-risk for VTE.

Study Sample

Our study sample was drawn from all adult patients admitted to the Penn State Hershey Medical Center from December 1, 2008 through December 31, 2009. This 13 month time period represents a 4 month pre-implementation cohort (December 1, 2008 through February 28, 2009) and a 9 month post-implementation cohort (March 1, 2009 through December 31, 2009), with the provider-enhanced CDS tool implementation occurring on March 1, 2009. Our tool was derived from previously described risk assessment tools.¹² In order to analyze the outcomes among patients that a computer-based VTE risk assessment tool would deem to be “low-risk,” we restricted our analytic sample to patients who were deemed “low-risk” using a computer-based risk tool, as has been described in previously by Kucher and colleagues.¹⁰ All clinical data required to determine VTE risk using their computer-based VTE risk assessment algorithm was available in our EMR (age, prior VTE, surgical duration if applicable, active cancer, obesity, and congestive heart failure), with the exception of genetic test results and use of hormone replacement therapy.

Definition of Outcome Variables

We assessed VTE pharmacoprophylaxis, 30-day VTE incidence, and in-hospital bleeding complications as the main study outcomes. Pharmacoprophylaxis was determined from the medications administered to the patient as documented in the EMR. Patients were defined as receiving pharmacoprophylaxis if they received prophylactic doses of unfractionated heparin, low molecular weight heparin, or fondaparinux; use of mechanical prophylaxis was not studied. Thirty-day VTE incidence was determined by whether any VTE occurred during the index hospitalization, subsequent outpatient/ED visit, or subsequent admission

within 30-days after the initial hospitalization, using ICD-9 codes within our hospital system.

Statistical Analysis

Using t-tests and chi-square tests, we compared the pre- and post-implementation cohorts in terms of age, sex, race/ethnicity, and computer-derived VTE risk score. Since the study cohort was limited to patients who would have been deemed “low-risk” for VTE using a computer-based tool alone, all the computer-derived VTE risk scores were either 0 or 1. Among the patients in the post-implementation cohort, we describe the provider-assigned VTE risk scores. Using the chi-square test, we then compared the pre-implementation and post-implementation cohorts on pharmacoprophylaxis rates, 30-day VTE incidence. All statistical analysis was performed using SAS 9.1 (Cary, N.C.).

RESULTS

During the study period, there were 17,666 adult patients admitted to our hospital. Of these patients, 4,669 (26.4%) were defined as low-risk using the computer-based risk assessment algorithm alone and thus included in our analysis (Table 1). This included 1,322 patients in the 4 month pre-implementation cohort and 3,347 patients in the 9 month post-implementation cohort. There were no significant differences with regard to age, race, or computer-derived VTE risk point score in the two cohorts. There were a statistically significant greater proportion of women in the pre-implementation cohort.

The effect of the provider-enhanced CDS tool is summarized in Figure 3. Of the 3,347 patients in the post-implementation cohort, 1,593 (48%) had a provider-assigned VTE risk score of low-risk, 1,034 (31%) were moderate-risk, and 239 (7%) were high-risk. Thus, 38% of patients were classified as having higher risk for VTE than the computer-based assessment. Provider risk assessment was deferred or missing in the remaining 481 (14%) patients. Of the patients in the pre-implementation cohort, 27% received pharmacoprophylaxis, compared with 34% in the post-implementation cohort using the provider-enhanced CDS, representing a 26% increase in VTE prophylaxis ($p<0.0001$). Specifically, 68% of the high-risk patients, 56% of the moderate-risk, and 22% of the low-risk patient received VTE prophylaxis. We observed 13 confirmed VTEs in the 4 month pre-implementation cohort (0.98% incidence rate) and 14 confirmed VTEs (0.42% incidence rate) in the 9 month post-implementation cohort ($p<0.02$), representing a 57% relative risk reduction.

DISCUSSION

We hypothesized that computer-based VTE risk assessment tools alone may underestimate VTE risk, because an EMR may not contain comprehensive elements of a patient’s medical history needed to accurately determine VTE risk. In our study, we found that 38% of these presumed “low-risk” patients were actually deemed moderate or high-risk for VTE using the provider-enhanced clinical decision support tool. As a result of VTE risk assignment with provider interaction, there was a 26% increase in VTE prophylaxis and a 57% relative risk reduction in 30-day VTE incidence, translating to a NNT (number needed to treat) of 178.

At our 501-bed tertiary-care hospital, we estimate 4,200 patients per year would be deemed “low-risk” for VTE by a computer-based stratification program. Extrapolating our study findings, our provider-enhanced CDS would predict approximately 2,000 of these patients to be either moderate- or high-risk for VTE. If the provider-enhanced CDS tool truly results in a 57% risk reduction in VTE as we observed in our study, this would reduce VTE incidence in this group from 19.6 to 8.4 cases per year. These data suggest that a provider-enhanced

CDS tool could reduce VTE in hospitalized patients. The tool was implemented across specialties and used a point-based, individualized VTE risk assessment with provider interpretation because all risk factors are not readily identified by our EMR.

There are limitations to this study. First, there is an assumption that our provider-enhanced CDS tool provides greater accuracy in assigning VTE risk than previously described computer-based tools. However, our provider-enhanced CDS likely still underestimates VTE risk. Other studies suggest that a range of 5–45% of hospitalized patients are truly low-risk, which would suggest that our tool is still not sensitive enough to classify all at-risk patients appropriately.^{14, 15, 16} (Bergmann 2010 pg736, Cohen 2008 pg387)). This is consistent with other studies that have found “at-risk” patients are often misclassified as low-risk when using a point-based VTE risk assessment tool.¹⁵ Additionally, we mostly relied on housestaff to use the VTE risk assessment tool, and previous work has suggested reliability of such a tool is limited when used by medical residents early in their training.¹⁶ Thirdly, only the post-hospital VTE events which were identified and documented in our hospital system were able to be captured. It is possible that events occurred outside our system and were not included; however we do not expect that the likelihood of this occurring would have differed before and after the provider-enhanced CDS implementation. We observed a statistically significant drop in VTE event rate in the setting of a modest increase in prophylaxis rate; thus we could not rule out a type 2 error leading to these findings. Due to limitations in the data, we were not able to determine whether the effect of the CDS tool differed among medical or surgical patients. We were not able to exclude patients with a contraindication to VTE prophylaxis since it was not documented electronically in the pre-implementation cohort. However, since there was little difference in the pre and post-implementation cohorts there should be an equal proportion of people with contraindications to prophylaxis in each group. Lastly, we were unable to accurately determine the occurrence of bleeding complications that may have occurred as a result of increased VTE prophylaxis in this study.

Future research should identify how to best combine computer-based algorithms and provider assessment. In our post-implementation period, only 13% of all admissions would have been identified as low risk if the computer-based algorithm was used in conjunction with our provider-enhanced CDS tool.

In summary, patients identified as “low-risk” for VTE solely by computer-based algorithms may include patients that providers determine to be at-risk for VTE and warrant VTE prophylaxis. While our study suggests a provider-enhanced CDS tool that involves clinician-guided risk assessment may outperform computer-based VTE risk stratification algorithms, we are still likely under-identifying patients at risk for VTE. Therefore, process improvement should continue to develop and evaluate tools that are user-friendly and effective at improving VTE outcomes.

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VTE Risk Score

VTE Risk Score

☒ 0 to 1 point - Low Risk

☐ 2 to 4 points - Moderate Risk

☐ Greater than 4 points - High Risk

☐ Spinal surgery - Risk Assess at 72 hours

☐ Cranial or Peripheral Nerve surgery - Risk Assess at 72 hours

☐ Primary service will assess on patient's arrival

Each Risk Factor Represents 1 Point

- Age 40 - 60 years (> 65 for orthopaedics)
- History of prior major surgery within 1 month
- Varicose veins
- History of inflammatory bowel disease
- Swollen legs (current)
- Acute myocardial infarction (< 1 month ago)
- Leg plaster cast or brace
- Arthroscopic surgery (> 60 minutes duration)
- History of unexplained stillborn infant, recurrent spontaneous abortion (>= 3), premature birth with toxemia
- Laparoscopic surgery < 2 hours
- Obesity (BMI > 30)
- Low energy foot/ankle trauma with immobilization within 1 month
- Smoker
- Inability to ambulate
- Estrogens or estrogen receptor modulators
- Pregnancy or postpartum (< 1 month)

Each Risk Factor Represents 2 Points

- Age 61 - 74 years
- Major surgery (> 60 minutes)
- Sepsis or severe infection
- Acute/chronic, diastolic/systolic heart failure
- Chronic or acute lung disease
- Active Rheumatologic Disease
- Active Inflammatory bowel disease
- Nephrotic range proteinuria

Each Risk Factor Represents 3 Points

- Age over 75 years
- History of venous thromboembolism (4 points for orthopaedics)
- Confirmed Antiphospholipid Syndrome
- "High Risk" thrombophilic state (4 points for orthopaedics)
- Metastatic or active cancer (4 points for orthopaedics)
- High energy foot/ankle trauma with immobilization within 1 month

Each Risk Factor Represents 4 Points

- Major surgery lasting 3 or more hours
- Elective major hip/knee arthroplasty
- Hip, pelvis or leg fracture (< 1 month)
- Ischemic stroke with immobility
- Multiple trauma (< 1 month)
- Acute spinal cord injury | PARALYSIS (< 1 month)
- S/P combined Anterior/Posterior Spinal Procedure
- Brain tumor (benign or malignant)

Orthopaedics should consider only pink items when doing risk assessment. Other services should consider ALL items.

Figure 1.
VTE Risk CDS Tool. Display presents well recognized VTE risk factors for review. This assessment is automatically prompted after admission orders are placed.

Discern:

VTE HIGH RISK

Your patient has been documented as being Medium or High Risk for a DVT/PE and does not have a prophylactic medication ordered. Please select one of the medications below or the contraindication to pharmacoprophylaxis.

Add Order for:

- ☐ enoxaparin -> 30 mg, injection, subQ, q12h
- ☐ dalteparin -> 2500 unit, injection, subQ, q12h
- ☐ heparin -> 5000 unit, injection, subQ, q12h
- ☐ VTE Prophylaxis Contraindicated

OK

Figure 2.
Provider prompt to order VTE prophylaxis based on risk assessment.

Figure 3.
Effect of Provider-Enhanced CDS Tool on Risk Evaluation, Prophylaxis, and VTE Incidence in "Low-Risk" Patients, n=4669.

Table 1

Patient Characteristics in the pre and post-implementation cohorts, n=4,655.

	Pre- Implementation N=1,328	Post- Implementation N=3,327	P-value
Age—mean (SD)	40.5 (13.4)	40.1 (13.9)	0.40
Female—no. (%)	770 (58%)	1831 (54%)	0.03
Race—no. (%)			
White	1122 (85%)	2785 (83%)	0.47
Black	104 (8%)	283 (8%)	
Hispanic	72 (5%)	199 (6%)	
Other	24 (2%)	80 (2%)	
Computer-derived VTE Risk Score¹			
0	622 (47%)	1562 (47%)	0.81
1	700 (53%)	1785 (53%)	