CLINICAL RESEARCH STUDY

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# Electronic Alerts, Comparative Practitioner Metrics, and Education Improves Thromboprophylaxis and Reduces Thrombosis

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## ABSTRACT

**BACKGROUND:** Venous thromboembolism chemoprophylaxis remains underutilized in hospitalized medical patients at high risk for venous thromboembolism. We assessed the effect of a health care quality-improvement initiative comprised of a targeted electronic alert, comparative practitioner metrics, and practitioner-specific continuing medical education on the rate of appropriate venous thromboembolism chemoprophylaxis provided to medical inpatients at high risk for venous thromboembolism.

**METHODS:** We performed a multicenter prospective observational cohort study in an urban Utah hospital system. All medical patients admitted to 1 of 2 participating hospitals from April 1, 2010 to December 31, 2012 were eligible. Patients were members of the "control" (April 1, 2010 to December 31, 2010), "intervention" (January 1, 2011 to December 31, 2011), or "subsequent year" (January 1, 2012 to December 31, 2012) group. The primary outcome was the rate of appropriate chemoprophylaxis among patients at high risk for venous thromboembolism. Secondary outcomes included rates of symptomatic venous thromboembolism, major bleeding, all-cause mortality, heparin-induced thrombocytopenia, physician satisfaction, and alert fatigue.

**RESULTS:** The rate of appropriate chemoprophylaxis among patients at high risk for venous thromboembolism increased (66.1% control period vs 81.0% intervention period vs 88.1% subsequent year; $P < .001$ for each comparison). A significant reduction of 90-day symptomatic venous thromboembolism accompanied the quality initiative (9.3% control period, 9.7% intervention period, 6.7% subsequent year; $P = .009$); 30-day venous thromboembolism rates also significantly decreased.

**CONCLUSIONS:** A multifaceted intervention was associated with increased appropriate venous thromboembolism chemoprophylaxis among medical inpatients at high risk for venous thromboembolism and reduced symptomatic venous thromboembolism. The effect of the intervention was sustained.

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**KEYWORDS:** Chemoprophylaxis medical patient; Prevention; Quality improvement; Venous thromboembolism

Without prophylaxis, up to 15% of hospitalized medical patients will develop venous thromboembolism (characterized as deep vein thrombosis or pulmonary embolism)[1-3] during hospitalization. Yet only about 40% of hospitalized medical patients at high risk for venous thromboembolism receive appropriate thromboprophylaxis, defined as chemoprophylaxis with low-molecular-weight heparin, unfractionated heparin, or fondaparinux.[4-6]

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Adoption of formalized venous thromboembolism risk assessment models has been recommended by guideline authors[7-12]; however, they have not been uniformly adopted.[13,14] Selective application of chemoprophylaxis avoids rare adverse events associated with chemoprophylaxis such as bleeding and heparin-induced thrombocytopenia,[15,16] that can be associated with substantial morbidity, mortality, and expense.[17,18] The importance of a reliable methodology to identify patients at high risk for hospital-associated venous thromboembolism and reduce that risk is highlighted by a recent Centers for Disease Control Hospital-Associated Venous Thromboembolism Reduction Challenge.[19]

Our primary objective was to report the rate of appropriate chemoprophylaxis among hospitalized medical patients at high risk for symptomatic venous thromboembolism following implementation of a multifaceted intervention including (a) targeted electronic alerts for high-risk patients, (b) comparative practitioner metrics, and (c) practitioner-specific continuing medical education. Appropriate venous thromboembolism prophylaxis rates were compared over a 3-year period. Secondarily we report 30- and 90-day rates of symptomatic venous thromboembolism, in-hospital major bleeding, in-hospital heparin-induced thrombocytopenia, in-hospital and 90-day all-cause mortality, practitioner response to electronic messaging, alert fatigue, and practitioner satisfaction with the intervention. We also evaluated outcomes in patients admitted to the medical service who were not at high risk for venous thromboembolism. These data are reported in the Appendix (online). The Intermountain Healthcare Institutional Review Board approved this study (Institutional Review Board #1019819).

## CLINICAL SIGNIFICANCE

- Targeted electronic alerts for high-risk patients, comparative practitioner metrics, and practitioner-specific continuing medical education increased appropriate thromboprophylaxis from 66.1% to 88.1%, and it was sustained.
- Ninety-day venous thromboembolism decreased significantly from 9.3% (control period) to 6.7% (subsequent year) among high-risk patients.
- No increase in major bleeding or heparin-induced thrombocytopenia was observed with improved chemoprophylaxis.
- Hospitalists' response to the alerts increased from 19.5% (Q1) to 28.1% (Q4; $P = .006$), refuting alert fatigue.

## METHODS

The multifaceted health care quality-improvement initiative, entitled the Venous Thromboembolism Reduction Initiative, was presented to all hospitalists of a multihospital urban health care hospitalist group at a Division meeting, and each hospitalist (100%) provided signed informed consent. The Venous Thromboembolism Reduction Initiative consisted of 4 components. First, an electronic venous thromboembolism risk assessment model[20,21] interrogated the electronic medical record daily and generated a venous thromboembolism risk score classifying each patient as being either high risk for venous thromboembolism (a venous thromboembolism risk score of $\geq 4$ as defined by Kucher et al[20]) or not (a venous thromboembolism risk score $<4$ as defined by Kucher et al[20]). Second, another electronic tool interrogated the medical administration record for appropriate chemoprophylaxis as recommended by the American College of Chest Physicians[15]; or therapeutic anticoagulation (**Appendix Table 1**, online). Third, an audit-and-feedback assessment of each hospitalist's venous thromboembolism prophylaxis rates was developed that generated a monthly report of each hospitalist's performance in comparison with their de-identified peers. Fourth, a proprietary targeted online continuing medical education activity was provided (see below).

The Venous Thromboembolism Reduction Initiative began on April 1, 2010 with the prospective collection of data during the control period of 9 months. Beginning January 1, 2011 (intervention period), if a patient was: (a) high risk for venous thromboembolism and (b) not receiving appropriate chemoprophylaxis, then an electronic venous thromboembolism risk alert was sent to the attending hospitalist's pager. An electronic interface with the hospitalist billing program identified the attending hospitalist of record for each patient every day. In the intervention period and subsequent year, an electronic medical record electronic message was sent, which permitted the hospitalist to interface with the electronic alert system to document any reasons that prophylaxis was being withheld (eg, active bleeding, hospice). By doing so, the daily alert would be turned off for 5 days, and the hospitalist would be credited with having appropriately dispensed venous thromboembolism prophylaxis. At the end of the 5 days, if chemoprophylaxis had not yet been ordered, the alert would be resent.

Each hospitalist was provided a monthly e-mail link to a secure Web site where individual chemoprophylaxis performance metrics were presented along with the performance of the hospitalist's de-identified peers. Coincident with this calculation, proprietary software (Twine Clinical Consulting, LLC, Park City, Utah and Medical Impact Ventures, LLC, Austin, Texas) identified the characteristics of those patients cared for by the hospitalist that did not receive appropriate chemoprophylaxis. For example, if a given hospitalist's rate of chemoprophylaxis was 85% overall but only 35% among patients with cancer, then that hospitalist was invited to complete the continuing medical education activity entitled "Mitigating thrombosis risk