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Nomograms to predict risk of in-hospital and post-discharge venous thromboembolism after abdominal and thoracic surgery: an American College of Surgeons National Surgical Quality Improvement Program analysis

Dhruvil R. Shah, MD,[a] Hui Wang, BS, MS,[b] Richard J. Bold, MD,[a] Xiaowei Yang, PhD,[c] Steve R. Martinez, MD, MAS,[a] Anthony D. Yang, MD,[a] Vijay P. Khatri, MbChB,[a] David H. Wisner, MD,[d] and Robert J. Canter, MD, MAS[a,]*

[a] *Division of Surgical Oncology, Department of Surgery, University of California Davis Comprehensive Cancer Center, Sacramento, California*
[b] *Department of Statistics, University of California at Davis, Davis, California*
[c] *Division of Biostatistics, Department of Public Health Sciences, University of California Davis, Davis, California*
[d] *Division of Trauma and Emergency Surgery, Department of Surgery, University of California Davis, Sacramento, California*

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ABSTRACT

Background: Postoperative venous thromboembolism (VTE) is increasingly viewed as a quality of care metric, although risk-adjusted incident rates of postoperative VTE and VTE after hospital discharge (VTEDC) are not available. We sought to characterize the predictors of VTE and VTEDC to develop nomograms to estimate individual risk of VTE and VTEDC.

Methods: Using the American College of Surgeons National Surgical Quality Improvement Program database, we identified 471,867 patients who underwent inpatient abdominal or thoracic operations between 2005 and 2010. We excluded primary vascular and spine operations. We built logistic regression models using stepwise model selection and constructed nomograms for VTE and VTEDC with statistically significant covariates.

Results: The overall, unadjusted, 30-d incidence of VTE and VTEDC was 1.5% and 0.5%, respectively. Annual incidence rates remained unchanged over the study period. On multivariate analysis, age, body mass index, presence of preoperative infection, operation for cancer, procedure type (spleen highest), multivisceral resection, and non-bariatric laparoscopic surgery were significant predictors for VTE and VTEDC. Other significant predictors for VTE, but not VTEDC, included a history of chronic obstructive pulmonary disease, disseminated cancer, and emergent operation. We constructed and validated nomograms by bootstrapping. The concordance indices for VTE and VTEDC were 0.77 and 0.67, respectively.

Conclusions: Substantial variation exists in the incidence of VTE and VTEDC, depending on patient and procedural factors. We constructed nomograms to predict individual risk of 30-d VTE and VTEDC. These may allow more targeted quality improvement interventions to reduce VTE and VTEDC in high-risk general and thoracic surgery patients.

* *Corresponding author*. Division of Surgical Oncology, Department of Surgery, Suite 3010, UC Davis Comprehensive Cancer Center, 4501 X Street, Sacramento, CA 95817. Tel.: +1 916 734 7044; fax: +1 916 703 5267.
E-mail address: Robert.canter@ucdmc.ucdavis.edu (R.J. Canter).

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1. Introduction

Venous thromboembolism (VTE) is a quality of care metric and represents one of the core measures evaluated by the Joint Commission on Accreditation of Healthcare Organizations, renamed The Joint Commission (TJC). The 2008 American College of Chest Physicians (ACCP) outlined risk stratification schemes for VTE prophylaxis among general surgical patients undergoing surgical intervention. Although these guidelines stratify patients into broad categories of low, intermediate, and high risk [1], this generic risk stratification scheme incompletely accounts for variation in individual risk factors. Consequently, there is a wide range in the incidence of VTE within risk categories (e.g., 15%–40% within the ACCP moderate-risk group) [1]. This lack of individualized patient assessment of the risk of postoperative VTE undermines the generalizability of interventions aimed at reducing or eliminating these events.

In addition, nearly half of all VTE events have been estimated to occur after hospitalization for the index surgical procedure [2]. Randomized controlled trials demonstrate a decreased incidence of VTE among patients receiving prolonged thromboprophylaxis after hospital discharge, but these trials involved narrow inclusion criteria and may not be applicable to diverse populations of general and thoracic surgery patients [3–5]. The 2008 ACCP guidelines recommend continuation of chemical VTE prophylaxis in selected high-risk general surgery patients after hospital discharge, but data to define which patients fall into this high-risk category are limited. Furthermore, even among these narrowly defined high-risk patients, the overall incidence of VTE after discharge (VTEDC) was $< 1\%$. [6–8] These results suggest that establishing guidelines for extended thromboprophylaxis even among high-risk patients undergoing major abdominal, pelvic, or cancer operations may be premature, especially when considering the narrow benefit–risk ratio and the associated costs of these therapies to the patient and the health care system.

Given the increasing tendency to view postoperative VTE and VTEDC as completely preventable patient outcomes (http://www.ahrq.gov/qual/patientsafetyix.htm), we sought to analyze the contribution of patient, procedural, and postoperative risk factors to the individual risk of developing VTE and VTEDC. We used this analysis to develop nomograms to estimate the 30-d risk of VTE and VTEDC for individual patients, hypothesizing that substantial variation exists in the incidence of VTE and VTEDC depending on specific patient, procedural, and postoperative factors.

2. Methods

We queried the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database to identify all patients who underwent inpatient, open abdominal and thoracic operations from 2005 to 2010 based on primary Current Procedural Terminology (CPT) codes. We excluded patients who were pregnant, who underwent primary vascular or spine operations, who had an operation performed 30 d before the primary operation, or who were admitted for fewer than 24 h. We elected to exclude primary vascular operations because routine practice typically includes the administration of pharmacologic doses of systemic heparin in the operating room. As a result, consensus vascular surgery guidelines recommend against the routine use of postoperative chemical thromboprophylaxis [9]. We excluded patients undergoing spine operations because of the routine practice of holding anticoagulants for prolonged periods of time to reduce the risk of epidural hematoma. By excluding these two subgroups of patients, our intent was to focus our analysis on patients who were likely to receive perioperative thromboprophylaxis consistent with Joint Commission guidelines. We also excluded patients undergoing pediatric, traumatic, transplant, or concurrent (an additional operative procedure performed by a different surgical team under the same anesthesia) operations, because NSQIP does not collect data on these cases. We included patients who underwent multiple simultaneous procedures by the same surgical team, because complete data were available for these patients.

Primary end points of our study were a first occurrence of VTE and an occurrence of VTEDC. Capture of these endpoints was limited to 30 d after the index operation, consistent with the data collection methods of NSQIP. We categorized VTE based on the presence of either a deep vein thrombosis (DVT) or a pulmonary embolism (PE). The NSQIP reporting guidelines for DVT and PE mandate confirmation of the complication by radiographic evaluation (duplex, venogram, and/or computed tomography scan) and treatment with therapeutic anticoagulation. (*ACS NSQIP User Guide*, www.acsnsqip.org). Studies have shown that NSQIP data are highly accurate and reproducible [10]. We defined VTEDC as any VTE that occurred after hospital discharge.

We evaluated potential predictor variables associated with our primary end points among the 135 variables that NSQIP collects. We selected 22 candidate preoperative and 10 candidate perioperative variables for univariate and multivariate analysis based on well-established predictors of VTE in the literature [7,8]. In selected cases, we grouped preoperative comorbidities into a single predictor variable when the prevalence of the individual comorbid condition was low and the composite variable was biologically plausible. For example, we grouped preoperative congestive heart failure within 30 d before surgery, myocardial infarction (within 6 mo before surgery), and angina (within 30 d before surgery) into a composite predictor variable ("preoperative cardiac risk factors"). Similarly, we grouped preoperative stroke, paraplegia, hemiplegia, quadriplegia, transient ischemic attack, and impaired sensorium into a single variable termed "preoperative central nervous system (CNS) risk factors." Preoperative acute renal failure or dialysis (within 2 wk before surgery) was combined into "preoperative renal failure/dialysis," and preoperative infection and systemic sepsis occurring before the operation were grouped into "preoperative infection." Because all patients underwent laparotomy, laparoscopy, thoracotomy, or thoracoscopy as an inclusion criterion for entry into the study cohort, most patients in the subgroup classified as preoperative infection harbored an intracavitary infection such as diverticulitis with abscess, appendicitis with abscess, or empyema. These composite