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Thromboembolic Complications and Prophylaxis Patterns in Colorectal Surgery

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Abstract

IMPORTANCE—Venous thromboembolism (VTE) is an important complication of colorectal surgery, but its incidence is unclear in the era of VTE prophylaxis.

OBJECTIVE—To describe the incidence of and risk factors associated with thromboembolic complications and contemporary VTE prophylaxis patterns following colorectal surgery.

DESIGN, SETTING, AND PARTICIPANTS—Prospective data from the Washington State Surgical Care and Outcomes Assessment Program (SCOAP) linked to a statewide hospital discharge database. At 52 Washington State SCOAP hospitals, participants included consecutive patients undergoing colorectal surgery between January 1, 2006, and December 31, 2011.

MAIN OUTCOMES AND MEASURES—Venous thromboembolism complications in-hospital and up to 90 days after surgery.

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RESULTS—Among 16 120 patients (mean age, 61.4 years; 54.5% female), the use of perioperative and in-hospital VTE chemoprophylaxis increased significantly from 31.6% to 86.4% and from 59.6% to 91.4%, respectively, by 2011 ($P < .001$ for trend for both). Overall, 10.6% (1399 of 13 230) were discharged on a chemoprophylaxis regimen. The incidence of VTE was 2.2% (360 of 16 120). Patients undergoing abdominal operations had higher rates of 90-day VTE compared with patients having pelvic operations (2.5% [246 of 9702] vs 1.8% [114 of 6413], $P = .001$). Those having an operation for cancer had a similar incidence of 90-day VTE compared with those having an operation for nonmalignant processes (2.1% [128 of 6213] vs 2.3% [232 of 9902], $P = .24$). On adjusted analysis, older age, nonelective surgery, history of VTE, and operations for inflammatory disease were associated with increased risk of 90-day VTE ($P < .05$ for all). There was no significant decrease in VTE over time.

CONCLUSIONS AND RELEVANCE—Venous thromboembolism rates are low and largely unchanged despite increases in perioperative and postoperative prophylaxis. These data should be considered in developing future guidelines.

Venous thromboembolism (VTE) prevention in hospitalized patients has been promoted as a patient safety priority by a multitude of agencies.[1] Despite the fact that colorectal surgery is one of the most commonly performed procedures, the American College of Chest Physicians' revised evidence-based guidelines regarding strategies to reduce VTE among hospitalized surgical patients do not offer comprehensive recommendations for patients undergoing colorectal surgery.[2,3] General strategies recommended in the American College of Chest Physicians' guidelines regarding abdominal surgery, as well as the American Society of Clinical Oncology's guidelines for VTE prevention in cancer,[4] may be extrapolated and applied to patients with colorectal cancer. However, these patients represent a diverse population with an array of patient-related and procedure-associated factors that place them at particularly high risk of VTE. Colorectal surgery is often performed for inflammatory disease or malignancy, which are known risk factors for VTE.[5–8] In addition, lithotomy positioning, prolonged operative times, and pelvic dissection are procedure-specific risk factors associated with VTE.[9] In the absence of appropriate prophylaxis, rates of radiologically and clinically diagnosed VTE, including deep vein thrombosis (DVT) and pulmonary embolism, have been as high as 40% and 5%, respectively, following colorectal surgery.[9] Among patients undergoing colorectal procedures who receive guideline-recommended chemoprophylaxis, VTE rates are as high as 9.4%.[10] Furthermore, VTE risk peaks approximately 3 weeks after surgery and remains increased up to 12 weeks following surgery[11] when most patients have already left the hospital. These data have been the impetus for exploring potential benefits of extended prophylaxis regimens.[12,13]

Therefore, there is interest in determining ways to reduce the VTE rate in patients undergoing colorectal surgery by better characterizing specific risk factors and defining preventive strategies to lower overall VTE risk in this complex patient population.[5,14–17] Unfortunately, some contemporary studies are limited by short follow-up[17] or few patients.[5,14,16] A 2011 study[15] by our group examined 4195 patients undergoing elective colorectal resection and identified a 1.4% VTE rate, with 56.5% (2369 of 4195) receiving perioperative pharmacologic prophylaxis. The use of prophylaxis was associated with lower

VTE rates (1.1% [26 of 2369] vs 1.8% [33 of 1826], $P = .04$). However, questions remain regarding the optimal timing (ie, perioperative, in-hospital, or after discharge), patient selection, and effect of VTE prophylaxis on the general population at risk.

Our objective was to use a large, statewide cohort of patients undergoing colorectal surgery to determine if VTE incidence has changed with evolving prophylaxis patterns. We also aimed to characterize patient, procedural, and postoperative factors associated with VTE up to 90 days after surgery.

Methods

The Comparative Effectiveness Research Translation Network (CERTAIN) provided analytic support to the Surgical Care and Outcomes Assessment Program (SCOAP).[18] The SCOAP is a coordinated quality improvement program of the Foundation for Health Care Quality. The CERTAIN is a program of the University of Washington, the academic research and development partner of the SCOAP.

This prospectively gathered cohort included all adult (≥18 years) patients who underwent colorectal surgery between January 1, 2006, and December 31, 2011, at 52 Washington State SCOAP hospitals (eTable 1 in the Supplement). The SCOAP draws medical record data by trained, audited abstractors using standardized definitions available via a secure website (http://www.SCOAP.org). The clinical records from SCOAP index cases were linked to Washington State Comprehensive Hospital Abstract Reporting System records to identify patients who were rehospitalized after a SCOAP index admission. The Comprehensive Hospital Abstract Reporting System data set is derived from all public and private hospitals in Washington State, excluding Veterans Affairs and US military hospitals, and contains demographic variables, admission and discharge administrative details, payer status, and *International Classification of Diseases, Ninth Revision* procedure and diagnosis codes. The Comprehensive Hospital Abstract Reporting System data set is linked to the Washington State vital records registry to determine vital status. The Madigan Army Medical Center Human Subject Review Committee and Washington State Department of Social and Health Services Institutional Review Board approved this study.

The SCOAP records were used to obtain sociodemographic characteristics, clinical comorbidities, and operative details. The Charlson Comorbidity Index for each patient was calculated.[19] The primary operative indication was obtained from clinical records and classified as diverticulitis, malignancy (colon cancer, rectal cancer, colon mass, or polyps), inflammatory disease (Crohn disease or ulcerative colitis), or other. Operation types were dichotomized into abdominal procedures (right hemicolectomy, left hemicolectomy, total abdominal colectomy, and colostomy takedown) and pelvic procedures (low anterior resection, abdominal perineal resection, and perineal proctectomy). Surgical approach was specified by the manner initiated as open or minimally invasive (including laparoscopic, laparoscopic converted to open, laparoscopic or hand-assisted, robotic, or robotic converted to open). Operative time was measured from incision to the final wound closure and was obtained from perioperative logs. Venous thromboembolism pharmacologic prophylaxis administration is recorded in the SCOAP from directed medical record review. Venous

thromboembolism prophylaxis is defined as perioperative, in-hospital, or discharge VTE prophylaxis. Perioperative prophylaxis is defined based on the Surgical Care Improvement Project's guidelines, namely, receipt of appropriate pharmacologic VTE prophylaxis within 24 hours before or after surgery.[20] In-hospital prophylaxis consisted of continued prophylaxis use throughout the index hospitalization; discharge prophylaxis was continued after hospital discharge. Inclusion or exclusion of specific pharmacologic agents was identical to our group's prior definitions.[15] Acceptable agents included unfractionated heparin, low-molecular-weight heparins, and synthetic factor Xa inhibitors.[15]

Because the risk of operation-related VTE is increased in the first 12 postoperative weeks and is evident 4 to 12 months after surgery for conditions such as cancer,[11] the primary outcomes were 90-day new VTE diagnosis or VTE-related intervention. Readmissions for VTE were defined as any VTE-related hospital admission within 90 days of discharge from the index hospitalization. At index and subsequent hospitalizations, VTE diagnosis or VTE-related interventions were defined as documented new use of therapeutic anticoagulation for presumed or confirmed DVT or pulmonary embolism (from the SCOAP) or specific *International Classification of Diseases, Ninth Revision* codes related to VTE diagnosis or treatment, as previously described (eTable 2 in the Supplement).[15] To capture potential fatal pulmonary embolisms that were not preceded by symptomatic VTE, a composite adverse event (CAE) was defined as any new VTE or death up to 90 days.

Patient characteristics were summarized using frequency distributions for categorical variables and using means, medians, and SDs for continuous variables stratified by the presence of 90-day VTE events. To evaluate selective prophylaxis use, we described differences in patients who did and did not receive VTE prophylaxis. Yearly trends are reported using linear regression tests. In the subgroup with diverticulitis, malignant neoplasm, or inflammatory disease, logistic regression was used to evaluate the crude and adjusted associations with VTE events and CAEs of the characteristics identified as statistically significant ($P < .05$) on univariate evaluation or deemed clinically important based on existing evidence, with clustering accounted for at the hospital level. All analyses were conducted using statistical software (STATA, version 13; Stata-Corp LP).

Results

VTE Incidence

Between January 1, 2006, and December 31, 2011, a total of 16 120 consecutive patients (mean [SD] age, 61.4 [15.7] years; 54.5% female) underwent colorectal surgery at 52 Washington State SCOAP hospitals. The incidence of 90-day VTE complications was 2.2% (360 of 16 115). Sixty-one percent (218 of 360) of VTE complications occurred during the index hospitalization. Although the unadjusted 90-day VTE rate increased during this interval from 1.2% in 2006 to 3.0% in 2011 ($P < .01$ for trend), there were no significant differences in VTE rate after adjusting for patient and operative variables ($P = .09$). In addition, the overall CAE rate (ie, VTE or 90-day mortality) was 5.0% (range, 3.1%–5.8%; $P = .02$ for trend). However, there was no increase in events over time after adjustment ($P = .07$).

Patient demographics, operative details, and outcomes stratified by occurrence of VTE are listed in Table 1. Patients developing VTE were more often male, were older, had a higher Charlson Comorbidity Index and American Society of Anesthesiologists class, more frequently had a history of VTE, and had a greater likelihood of undergoing nonelective, open abdominal surgery. Patients who developed VTE after discharge more commonly had a history of VTE or were receiving therapeutic anticoagulation before surgery ($P < .001$ for both). Abdominal operations had higher rates of in-hospital (1.6% vs 1.0%) and 90-day (2.5% vs 1.8%) VTE compared with pelvic operations ($P = .001$ for both). Operations for malignant neoplasms had a significantly lower incidence of inhospital VTE compared with operations for nonmalignant processes (1.1% vs 1.5%, $P = .05$) but no difference in 90-day VTE incidence (2.1% vs 2.3%, $P = .24$).

VTE Prophylaxis

By 2011, VTE chemoprophylaxis had increased in the perioperative setting (from 31.6% [323 of 1021] to 86.4% [3007 of 3480]), in-hospital postoperative setting (from 59.6% [603 of 1012] to 91.4% [3223 of 3527]), and postdischarge setting (from 8.6% [68 of 790] to 11.7% [411 of 3527]) ($P < .001$ for trend for all) (Figure). Patients receiving in-hospital chemoprophylaxis were more frequently obese (body mass index [calculated as weight in kilograms divided by height in meters squared] ≥30), had a higher overall American Society of Anesthesiologists class, had a greater likelihood of undergoing pelvic surgery and operations for malignant neoplasm or inflammatory disease, and more often had a history of VTE ($P < .001$ for all). Similarly, patients discharged on an extended prophylaxis regimen were more often obese, had a higher overall American Society of Anesthesiologists class, more often had a history of VTE, and had a greater likelihood of having an underlying malignant neoplasm ($P < .001$ for all). Patients developing postdischarge VTE were less frequently placed on postoperative in-hospital prophylaxis (87.0% [114 of 131] vs 94.6% [194 of 205], $P = .01$) and discharge prophylaxis (52.0% [51 of 98] vs 65.7% [111 of 169], $P = .03$). Other differences among the 3 groups of patients were nominal, or the group sizes were underpowered to detect differences.

Adverse Events

There was no difference in transfusion rates between patients who received perioperative prophylaxis and those who did not (14.0% [807 of 5760] vs 13.0% [176 of 1359], $P = .31$). Patients receiving in-hospital chemoprophylaxis more frequently received a postoperative blood transfusion (14.4% [961 of 6653] vs 10.8% [73 of 674], $P = .01$). However, there was no difference in reoperation rates for bleeding ($P = .78$). When stratified by a hemoglobin level of less than 7 g/dL, 21 of 59 patients (35.6%) received a transfusion, with no difference between those who did (19 of 50 [38.0%]) and did not (2 of 9 [22.2%]) receive perioperative prophylaxis ($P = .36$) (to convert hemoglobin level to grams per liter, multiply by 10.0).

In the patient subgroup with diverticulitis, inflammatory disease, or malignant neoplasm, 90-day VTE and CAEs were associated with male sex, older age, history of VTE, and non-elective surgery after adjustment for patient and operative characteristics, as well as changes in chemoprophylaxis practice over time ($P < .05$ for all) (Table 2 and Table 3). Operations

performed for inflammatory bowel disease were associated with increased 90-day VTE risk (odds ratio, 1.79; 95% CI, 1.06–3.02; *P* = .03).

Discussion

One of our primary goals was to evaluate VTE incidence in light of changes in chemoprophylaxis use. Unlike previous studies, we wanted to look in more depth at the timing of administration, its potential effect on VTE, and risk factors for VTE in colorectal surgery. We found that the overall incidence of 90-day VTE among more than 16 000 patients undergoing colorectal operations across 52 hospitals in Washington State was 2.2%. Despite the steady increase in chemoprophylaxis use in the perioperative and in-hospital settings to 86.4% and 91.4%, respectively, the annual VTE incidence remained low and largely unchanged (Figure). Although chemoprophylaxis use following discharge has also increased over this period, the percentage of patients discharged home on a chemoprophylaxis regimen was considerably less than perioperative and inhospital use and appears to be selectively prescribed by health care professionals.

Ideally, we would have had better data to base recommendations regarding which patients with colorectal surgery would benefit most from perioperative and extended postdischarge chemoprophylaxis. Unfortunately, most hospitalized patients have at least 1 risk factor for VTE, and up to 40% will have 3 or more.[2] Therefore, determining the appropriate patients to receive prophylaxis based on risk factors alone is problematic. As a result, there has been a trend toward providing perioperative and in-hospital postoperative chemoprophylaxis. Despite overwhelming perioperative and in-hospital postoperative chemoprophylaxis use, VTE rates remain approximately 1% to 3% annually, with 60.6% of VTE events occurring during the index hospitalization. Unfortunately, this study cannot explain why VTE rates remain unchanged. One possibility is that the national focus on VTE prevention as a quality measure and reimbursement driver[20] may result in increased surveillance and closer monitoring of patients receiving prophylaxis.[5] Therefore, the increased VTE incidence may reflect increased identification of clinically silent VTE. Our adjusted trends analysis supports this possibility because the apparent rise in VTE incidence is minimized when adjusting for high levels of risk factors. Some studies,[21–23] particularly in the trauma literature, have documented increased frequency of asymptomatic VTE when routine screening protocols are used. Furthermore, original investigations on which current guidelines are based included active surveillance, and all showed higher VTE rates than the present study.[10,24,25] While information on individual health care professional or hospital practices regarding surveillance testing for VTE is unavailable in the current data set, most reported VTE is asymptomatic.[26] Conversely, it may be that high-risk patients are appropriately identified and prescribed risk-appropriate prophylaxis. In this scenario, VTE rates would presumably be higher without chemoprophylaxis. In fact, VTE rates are lower than many reported outcomes with active surveillance programs in place.[18] Unfortunately, despite receiving best-practice prophylaxis, patients continue to develop VTE both in-hospital and after discharge at a nonnegligible rate, suggesting that not all VTE is preventable. This hypothesis has been proposed in another colorectal surgery series, which reported that 92.0% (23 of 25) of patients who developed VTE had received risk-appropriate VTE prophylaxis.[5]

If nonselective perioperative and in-hospital prophylaxis is not successful in reducing rates of in-hospital VTE over time, are we placing patients at undue risk without significant benefit? Surgeons may withhold perioperative chemoprophylaxis owing to concerns about major bleeding.[17] These concerns are not without merit given a series citing a major bleeding rate of 11.5% with administration of prophylaxis.[26] In the prior study[15] by our group, patients receiving perioperative prophylaxis had lower rates of blood transfusion. In the present study, we found no difference in transfusion rates between those receiving and not receiving perioperative prophylaxis. While patients receiving postoperative in-hospital chemoprophylaxis received blood transfusion more frequently (14.4% [961 of 6653] vs 10.8% [73 of 674], $P = .01$), transfusion indications vary by health care professional and institution. There were no differences between patients who did and did not receive perioperative prophylaxis when stratifying by all-cause transfusions or by transfusions in patients with a hemoglobin level of less than 7 g/dL. Furthermore, there was no difference in reoperations for bleeding. This potential risk highlights factors that should be weighed when considering perioperative and extended-use prophylaxis, including the number needed to treat to provide a relative benefit, potential higher economic costs, and patient quality-of-life considerations that are outside of the scope of this analysis.

The American College of Chest Physicians' guidelines recommend using risk models to identify patients at particularly high risk of VTE to mitigate the complexity involved in decision making.[27] However, current recommendations for patients undergoing colorectal surgery are primarily derived from a dated Cochrane review[28] that included heterogeneous patient populations, and only 3 of 19 included trials were specific to colorectal surgery.[10,24,25] Therefore, which risk factors are independently associated with VTE in colorectal surgery remains undetermined. Malignancy represents an accepted risk factor associated with higher VTE rates,[8] but the data are not universally indicative.[7] Other patient-related and procedure-oriented risk factors such as open surgery, emergency operations, obesity, American Society of Anesthesiologists class, and bleeding disorders have been associated with VTE in some series[5,14,16,29–31] but not in others.[32,33] Furthermore, recent data suggest that patients with inflammatory bowel disease may represent an underrecognized group associated with particularly high risk of VTE complications.[6,7]

Contrary to prior evidence,[9] we found that VTE rates were higher among patients undergoing abdominal surgery compared with those undergoing pelvic dissection. This finding is likely attributable to the fact that patients undergoing abdominal surgery were commonly older, more often had a prior VTE, and more frequently underwent nonelective surgery for a malignant condition or inflammatory disease ($P < .05$ for all). Furthermore, patients undergoing abdominal surgery were less likely to receive preoperative and in-hospital chemoprophylaxis compared with those undergoing pelvic surgery ($P < .001$ for both). After adjusting for these factors, no difference in VTE incidence ($P = .77$) or CAEs ($P = .19$) was seen. Likewise, malignancy was associated with lower VTE rates compared with inflammatory disease (1.1% vs 1.8% for in-hospital VTE and 2.1% vs 2.6% for overall 90-day VTE rates) ($P < .001$ for both). Non-malignant conditions were more frequently treated as emergency cases with open procedures and were less likely to have received

chemoprophylaxis in all perioperative settings compared with malignant conditions ($P < .001$ for all). Furthermore, inflammatory bowel disease operations were associated with increased risk of 90-day VTE. Although patients with traditional high-risk features such as pelvic surgery and a malignant condition tend to receive appropriate perioperative prophylaxis, these findings suggest that we may be underestimating the overall risk among patients undergoing abdominal surgery, as well as the risk associated with inflammatory disease.

While most patients received preoperative and inhospital chemoprophylaxis, extended chemoprophylaxis administration was far more selective. The postoperative VTE risk peaks approximately 3 weeks after surgery and does not return to baseline for 12 weeks.[11] Therefore, one might propose that patients with certain high-risk features should be provided extended prophylaxis. For example, although a malignant condition was not found to be independently associated with increased risk of 90-day VTE in our series, it has in others.[16] Furthermore, VTE prophylaxis in patients with cancer undergoing abdominal or pelvic surgery in both the perioperative and extended settings beyond the initial hospitalization reduces overall VTE and VTE-related complications.[34,35] Approximately 40% of patients in the present study had an underlying malignancy, although only 12.8% (665 of 5191) received extended chemoprophylaxis following discharge despite current recommendations supporting extended prophylaxis in this cohort.[2–4] This may represent an opportunity for quality improvement. However, only 2.1% (128 of 6216) of patients with a malignant condition developed VTE, and sample size calculations ($\alpha = .05$ with 0.9 power) suggest that a trial of approximately 5600 patients is necessary to elucidate the effectiveness of extended prophylaxis in reducing the risk from 2.1% to 1.0%. Furthermore, it becomes difficult to argue for more prophylaxis in the discharge setting with the currently available data given similar VTE rates despite increased use of preoperative and in-hospital prophylaxis.

We acknowledge certain limitations to this study. First, while clinical data quality in the SCOAP during the index hospitalization is robust, documentation of VTE after discharge depended on hospitalization at another hospital and proper coding and will miss outpatient VTE. Linkage to the state's vital statistics allowed us to capture patients who were seen with fatal VTE, although most VTE-related deaths are presumed and not confirmed by autopsy. Second, the SCOAP does not include compliance with VTE prophylaxis after discharge or dosage and length of treatment. Furthermore, specific reasons regarding why anticoagulation was withheld were not available in this database. Third, despite the large cohort, the low VTE rate in any subgroup of patients makes our conclusions vulnerable to type II error. Despite these limitations, this is the largest multi-institutional, statewide database study to date evaluating the effect of evolving prophylaxis patterns on VTE rates.

Conclusions

Venous thromboembolism remains an infrequent but important complication, and rates are largely unchanged despite increasing chemoprophylaxis use. Although most patients receive perioperative and in-hospital VTE chemoprophylaxis, extended prophylaxis rates lag behind. With almost 40% of VTE events occurring after discharge, this may represent an

area for quality improvement implementation. However, it must be carefully balanced against the potential for increased complications and higher costs at no additional benefit. These findings should influence future studies looking specifically at extended prophylaxis and prophylaxis guidelines.

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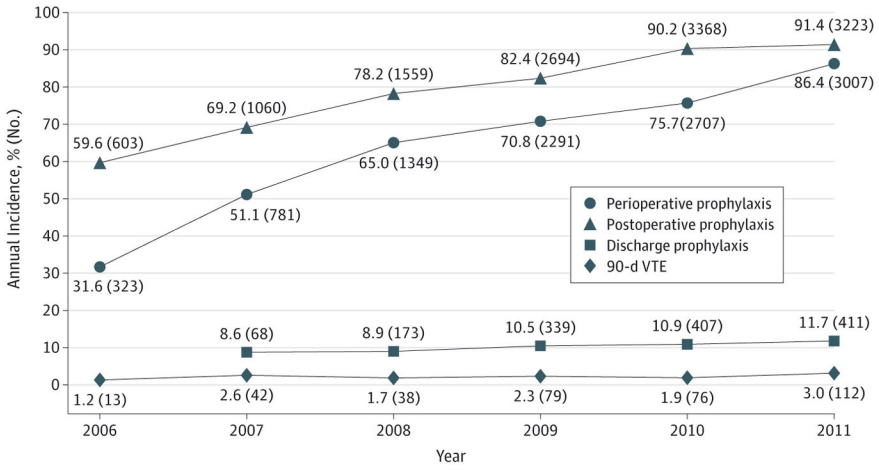

Figure. Trends in the Use of Venous Thromboembolism Prophylaxis by Perioperative Setting and Annual Incidence of 90-Day VTE

Denominators vary for each group. VTE indicates venous thromboembolism.

Table 1

Patient and Clinical Characteristics Stratified by Occurrence of 90-Day Venous Thromboembolism (VTE)[a]

Variable	No VTE (n = 15 760)	90-d VTE (n = 360)	Total (N = 16 120)	*P* Value[b]
Demographics				
Age, mean (SD), y[c]	62.4 (15.8)	65.8 (14.6)	61.4 (15.7)	<.001
Female sex, No. (%)	8611 (54.7)	169 (46.9)	8780 (54.5)	.004
Charlson Comorbidity Index, No. (%)				<.001
0	10 881 (69.0)	205 (56.9)	11 086 (68.8)	
1	3435 (21.8)	98 (27.2)	3533 (21.9)	
2	1019 (6.5)	42 (11.7)	1061 (6.6)	
≥3	425 (2.7)	15 (4.2)	440 (2.7)	
BMI				
Mean (SD)	27.8 (6.8)	27.9 (6.4)	27.8 (6.8)	.25
≥30, No./total No. (%)	4488/14 937 (30.0)	104/331 (31.4)	4592/15 268 (30.1)	.59
Procedure priority, No. (%)	(n = 15 702)	(n = 359)	(n = 16 061)	<.001
Elective	12 221 (77.8)	193 (53.8)	12 414 (77.3)	
Nonelective	3481 (22.2)	166 (46.2)	3647 (22.7)	
Indication for surgery, No. (%)				<.001
Other	5213 (33.1)	152 (42.2)	5365 (33.3)	
Diverticulitis	3296 (20.9)	49 (13.6)	3345 (20.8)	
Malignant neoplasm	6088 (38.6)	128 (35.6)	6216 (38.6)	
Inflammatory disease	1163 (7.4)	31 (8.6)	1194 (7.4)	
Current cigarette smoker, No./total No. (%)	3077/15 721 (19.6)	61/359 (17.1)	3138/16 080 (19.6)	.23
Therapeutic anticoagulation 1 wk before surgery, No. (%)	1035 (6.6)	71 (19.7)	1106 (6.9)	<.001
History of VTE, No. (%)	584 (3.7)	75 (20.8)	659 (4.1)	<.001
Operative				
Minimally invasive approach, No. (%)	4925 (31.3)	57 (15.8)	4982 (30.9)	<.001
Operation type, No. (%)				.001
Abdominal	9460 (60.0)	246 (68.3)	9706 (60.2)	
Pelvic	6300 (40.0)	114 (31.7)	6414 (39.8)	
American Society of Anesthesiologists class, No. (%)	(n = 15 420)	(n = 350)	(n = 15 770)	<.001
1	884 (5.7)	7 (2.0)	891 (5.6)	
2	7768 (50.4)	85 (24.3)	7853 (49.8)	
3	5738 (37.2)	179 (51.1)	5917 (37.5)	
4	945 (6.1)	74 (21.1)	1019 (6.5)	
5	85 (0.6)	5 (1.4)	90 (0.6)	
Operative time, mean (SD), min	148 (76)	167 (95)	149 (76)	.01
DVT prophylaxis, No./total No. (%)				
Perioperative	10 220/14 598 (70.0)	238/319 (74.6)	10 458/14 917 (70.1)	.08

Variable	No VTE (n = 15 760)	90-d VTE (n = 360)	Total (N = 16 120)	*P* Value[b]
Postoperative	12 199/14 732 (82.8)	308/336 (91.7)	12 507/15 068 (83.0)	<.001
Discharge	1237/12 963 (9.5)	162/267 (60.7)	1399/13 230 (10.6)	<.001
Tumor stage, No. (%)[d]	(n = 5999)	(n = 148)	(n = 6147)	<.001
T0	2185 (36.4)	45 (30.4)	2230 (36.3)	
T1	815 (13.6)	13 (8.8)	828 (13.5)	
T2	2284 (38.1)	55 (37.2)	2339 (38.1)	
T3	678 (11.3)	35 (23.6)	713 (11.6)	
T4	37 (0.6)	0	37 (0.6)	
Outcomes				
Discharge disposition, No. (%)	(n = 15 738)		(n = 16 098)	<.001
Home	13 464 (85.6)	190 (52.8)	13 654 (84.8)	
Rehabilitation	210 (1.3)	16 (4.4)	226 (1.4)	
Skilled nursing facility	1415 (9.0)	88 (24.4)	1503 (9.3)	
Other	64 (0.4)	5 (1.4)	69 (0.4)	
Acute care	113 (0.7)	12 (3.3)	125 (0.8)	
Death	472 (3.0)	49 (13.6)	521 (3.2)	
Length of stay, mean (SD), d	7.7 (8.8)	16.4 (13.4)	7.9 (9.0)	<.001
VTE, No. (%)				
In-hospital	NA	218 (60.6)	218 (1.4)	NA
Any up to 90 d	NA	360 (100)	360 (2.2)	NA
Transfusion >24 h after surgery, No./total No. (%)	1069/7577 (14.1)	77/193 (39.9)	1146/7770 (14.7)	<.001
Reoperation for bleeding, No. (%)	52 (0.3)	0	52 (0.3)	.28
Composite adverse event, No. (%)[e]	453 (2.9)	360 (100)	813 (5.0)	<.001

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); DVT, deep venous thrombosis; NA, not applicable.

[a] The rate of missing data in this study was found to be low (<10%), and data were missing at random. Accordingly, patients with any missing data were not excluded, and the appropriate denominators have been provided for those variables.

[b] Comparison of the no VTE group vs 90-day VTE group using χ^2 test for heterogeneity unless otherwise indicated.

[c] Comparison using Wilcoxon rank sum test for continuous variables that were not normally attributed.

[d] Tumor stage only applies to those with indication of a malignant neoplasm.

[e] Venous thromboembolism or death up to 90 days.

Table 2

Unadjusted and Adjusted Risk Factors for 90-Day Venous Thromboembolism (VTE)

	Univariate Unadjusted Risk of 90-d VTE		Multivariable Adjusted Risk of 90-d VTE	
Variable	**OR (95% CI)**	***P* Value**	**OR (95% CI)**	***P* Value**
Demographics				
Age	1.02 (1.01–1.03)	<.01	1.02 (1.01–1.03)	.01
Male sex	1.36 (1.02–1.82)	.04	1.37 (1.02–1.83)	.04
Charlson Comorbidity Index				
0	1 [Reference]	NA	1 [Reference]	NA
1	1.51 (1.12–2.06)	.01	0.70 (0.43–1.12)	.14
2	2.19 (1.41–3.39)	<.01	0.58 (0.25–1.33)	.20
≥3	1.87 (1.12–3.14)	.02	0.63 (0.23–1.74)	.37
BMI ≥30	1.07 (0.85–1.34)	.58	1.37 (0.97–1.95)	.08
Nonelective procedure	3.02 (2.23–4.10)	<.01	1.67 (1.03–2.73)	.04
Indication for surgery				
Diverticulitis	1 [Reference]	NA	1 [Reference]	NA
Malignant neoplasm	1.41 (0.95–2.11)	.09	1.09 (0.71–1.67)	.70
Inflammatory disease	1.79 (1.30–2.47)	<.01	1.79 (1.06–3.02)	.03
History of VTE	6.85 (5.02–9.35)	<.01	7.58 (5.07–11.32)	<.01
Operative				
Minimally invasive approach	0.41 (0.31–0.54)	<.01	0.76 (0.48–1.19)	.23
Pelvic operation	0.70 (0.56–0.87)	.002	0.94 (0.64–1.39)	.77
American Society of Anesthesiologists class				
1	1 [Reference]	NA	1 [Reference]	NA
2	1.38 (0.51–3.74)	.52	1.87 (0.38–9.13)	.44
3	3.94 (1.36–11.42)	.01	3.33 (0.63–17.62)	.16
4	9.89 (3.52–27.79)	<.01	5.11 (0.87–30.06)	.07
5	7.43 (2.06–26.82)	.002	11.06 (0.33–371.93)	.18
Tumor stage ≥3	2.27 (1.66–3.10)	<.01	1.60 (0.92–2.78)	.09
Outcomes				

	Univariate Unadjusted Risk of 90-d VTE		Multivariable Adjusted Risk of 90-d VTE	
Variable	**OR (95% CI)**	***P* Value**	**OR (95% CI)**	***P* Value**
Operative time	1.00 (1.00–1.00)	.001	1.00 (1.00–1.00)	.002
Length of stay	1.04 (1.01–1.06)	.01	1.05 (1.01–1.09)	.01
Year				
2006	1 [Reference]	NA	1 [Reference]	NA
2007	2.19 (1.27–3.77)	.01	9.08 (0.26–319.04)	.22
2008	1.46 (0.64–3.34)	.37	6.95 (0.20–238.63)	.28
2009	1.92 (0.86–4.31)	.11	11.34 (0.33–392.83)	.18
2010	1.62 (0.71–3.69)	.25	7.41 (0.22–244.82)	.26
2011	2.57 (1.18–5.60)	.02	15.94 (0.57–442.97)	.10

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); NA, not applicable; OR, odds ratio.

Table 3

Unadjusted and Adjusted Risk Factors for 90-Day Composite Adverse Event (CAE)

	Univariate Unadjusted Risk of 90-d CAE		Multivariable Adjusted Risk of 90-d CAE[a]	
Variable	**OR (95% CI)**	***P* Value**	**OR (95% CI)**	***P* Value**
Demographics				
Age	1.04 (1.02–1.05)	<.01	1.04 (1.02–1.05)	<.01
Male sex	1.21 (0.97–1.52)	.10	1.24 (1.00–1.54)	.05
Charles Comorbidity Index				
0	1 [Reference]	NA	1 [Reference]	NA
1	1.66 (1.31–2.10)	<.01	0.81 (0.55–1.18)	.27
2	4.19 (3.36–5.23)	<.01	1.03 (0.61–1.73)	.92
≥3	7.15 (5.28–9.68)	<.01	1.56 (0.75–3.25)	.23
BMI ≥30	0.99 (0.87–1.12)	.85	1.15 (0.86–1.53)	.34
Nonelective procedure	6.25 (5.02–7.79)	<.01	1.98 (1.39–2.81)	<.001
Indication for surgery[b]				
Diverticulitis	1 [Reference]	NA	1 [Reference]	NA
Malignancy	1.18 (0.95–1.46)	.14	0.93 (0.72–1.19)	.56
Inflammatory disease	1.36 (1.05–1.75)	.02	1.53 (1.06–2.23)	.03
History of VTE	4.33 (3.24–5.79)	<.01	5.14 (3.42–7.71)	<.01
Operative				
Minimally invasive approach	0.28 (0.22–0.36)	<.01	0.62 (0.43–0.91)	.01
Pelvic operation	0.55 (0.45–0.66)	<.01	0.83 (0.63–1.10)	.19
American Society of Anesthesiologists class				
1	1 [Reference]	NA	1 [Reference]	NA
2	1.64 (0.69–3.91)	.26	2.41 (0.47–12.47)	.29
3	6.88 (2.81–16.85)	<.01	4.31 (0.84–22.14)	.08
4	37.03 (15.41–89.02)	<.01	8.62 (1.55–47.85)	.01
5	96.58 (42.81–217.87)	<.01	12.57 (0.69–227.85)	.09
Tumor stage ≥3	1.43 (1.11–1.85)	.01	1.38 (0.89–2.13)	.15

	Univariate Unadjusted Risk of 90-d CAE		Multivariable Adjusted Risk of 90-d CAE[a]	
Variable	**OR (95% CI)**	***P* Value**	**OR (95% CI)**	***P* Value**
Operative time	1.00 (1.00–1.00)	.04	1.00 (1.00–1.00)	<.01
Outcomes				
Length of stay	1.04 (1.01–1.06)	.003	1.05 (1.02–1.08)	.003
Year				
2006	1 [Reference]	NA	1 [Reference]	NA
2007	1.84 (1.17–2.88)	.01	6.92 (0.91–52.55)	.06
2008	1.49 (0.81–2.71)	.20	6.26 (0.84–46.67)	.07
2009	1.79 (1.02–3.14)	.04	8.60 (1.16–63.50)	.04
2010	1.50 (0.92–2.46)	.11	5.98 (0.92–38.82)	.06
2011	1.90 (1.11–3.28)	.02	11.00 (1.75–69.10)	.01

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); NA, not applicable; OR, odds ratio; VTE, venous thromboembolism.

[a] Adjusted for all other variables listed.

[b] Excludes “other” indication category.