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Post-Hospital Discharge Venous Thromboembolism in Colorectal Surgery

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Abstract

Background There are limited data regarding the criteria for prophylactic treatment of venous thromboembolism (VTE) after hospital discharge. We sought to identify risk factors of post-hospital discharge VTE events following colorectal surgery.

Methods The NSQIP database was utilized to examine patients developed VTE after hospital discharge following colorectal surgery during 2005–2013. Multivariate analysis using logistic regression was performed to quantify risk factors of VTE after discharge.

Results We evaluated a total of 219,477 patients underwent colorectal resections. The overall incidence of VTE was 2.1 % (4556). 33.8 % (1541) of all VTE events occurred after hospital discharge. The length of postoperative hospitalization had a strong association with post-discharge VTE, with the highest risk in patients who were hospitalized for more than 1 week after operation (AOR 9.08, P\0.01). Other factors associated with post-discharge VTE included chronic steroid use (AOR 1.81, P\0.01), stage 4 colorectal cancer (AOR 1.40, P = 0.03), obesity (AOR 1.37, P\0.01), age[70 (AOR 1.21, P = 0.04), and open surgery (AOR 1.36, P\0.01). Patients who were hospitalized for more than 1 week after an open colorectal resections had a 12 times higher risk of post-discharge VTE event compared to patients hospitalized less than 4 days after a laparoscopic resection (AOR 12.34, P\0.01).

Conclusions VTE is uncommon following colorectal resections; however, a significant proportion occurs after patients are discharged from the hospital (33.8 %). The length of postoperative hospitalization appears to have a strong association with post-discharge VTE. High-risk patients may benefit from continued VTE prophylaxis after discharge.

Introduction

Venous thromboembolism (VTE) is a major preventable US health problem and is one of the leading causes of morbidity, mortality, and prolonged hospitalization in surgical patients [1–3]. It has been estimated that 5–10 % of all in-hospital deaths are a direct result of pulmonary thromboembolic events and 31 % of hospitalized patients are at risk of VTE in the US [3–5]. It is important to identify high-risk patients to an attempt to decrease morbidity and mortality of such patients.

There are a large number of published studies focusing on prevention of VTE by implementation of in-hospital VTE prophylaxis. Numerous predictors of VTE have been described in the literature. Some of the reported predictors include low serum albumin level, American Society of Anesthesiologists (ASA) score greater than two, pregnancy, malignancy, diabetes, chronic steroid use, and obesity [1, 6-8]. However, the risk of VTE persists after hospital discharge in all patients [1, 9–11]. Two recently published studies reported that 30 % of all VTE events occurred after hospital discharge following colorectal surgery [1, 10]. Our previously published article showed that 34.6 % of patients with PE and 29.3 % of patients with DVT after colorectal surgery will be diagnosed after discharge [1]. Extension of VTE prophylaxis to the post-discharge period in high-risk patients has been suggested in previous studies as well as in American Society of Colon and Rectal Surgeons and the American Society of Clinical Oncology guidelines [1, 12–15]. A previously published article showed a reverse correlation

between scores on DVT prophylaxis process measures and the identification of VTE [16]. However, there are limited data regarding patients who continue to be at high risk for developing VTE after hospital discharge following colorectal surgery, and no data in the NSQIP database to elucidate the clinical measures were utilized in this patient population. Therefore, our aim is to report the risk factors for VTE after hospital discharge following colorectal surgery and evaluate the risks by diagnoses and procedure type.

Materials and methods

A retrospective review of the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database was performed to identify patients who underwent colorectal resections during 2005–2013. ACS NSQIP is a nationally validated program that prospectively collects detailed clinical data of surgical patients preoperatively through 30 days after operation in the United States [17]. Approval for the use of the NSQIP patient-level data in this study was obtained from the institutional review board of the University of California, Irvine Medical Center and NSQIP. We sampled all patients who underwent colorectal resections based on the following Current Procedural Terminology (CPT) codes: 44140–44160, 44204–44212, 44227, 44625, 45110–45114, 45119, 45120, 45123–45135, 45397, 45402, 45550, and 45395. Indications of colorectal resections were extracted according to the International Classification of Diseases, 9th Revision, clinical modifications (ICD-9-CM) codes from the NSQIP database (Table 1). Patients who underwent colorectal surgery without colon or rectal resection and patients younger than 18 years were excluded from this study. Post-discharge VTE was defined according to NSQIP original variables of hospitalization length, length from hospital admission to operation, and length from operation to complications of deep vein thrombosis (DVT) and pulmonary embolism (PE).

The investigated factors included demographic data (age, race, and gender), comorbidities, operation length, surgical approach (laparoscopic vs. open), type of procedures, type of admission (emergent vs. non-emergent), indications for surgery, length of stay, and postoperative complications of DVT and PE with the exact day of complications after operation. The rates of postoperative DVT and PE during hospitalization and following hospital discharge were examined. Risk adjusted analysis was performed to identify predictors of post-hospital discharge VTE. Although we had multiple variables in this study and we adjusted the results with multiple conditions, the lack of data on chemo- and mechanical prophylaxis is a major flaw which greatly hampers the ability to draw any firm conclusions.

Table 1 Patients' indications for surgery and procedures codes

Procedure	CPT code[a]	Indication of surgery	ICD-9 CM Code[b]
Colostomy closure	44227, 44625	Rectal prolapse	569.1
		Colon perforation	569.83
Pelvic exenteration	45126	Colorectal hemorrhage	569.3, 578, 578.0–578.9
		Mesenteric ischemia	557.0
Total colectomy	44150–44158, 44210–44212	Peritonitis	567.0, 567.1, 567.2, 567.21, and 567.29
		Ulcerative colitis	556, 556.0–556.9
		Malignancy other than colorectal origin	197.5
Partial colectomy	4140–44144, 44160, 44204–44206, 45402, 45550	Obstruction	560, 560.0, 560.2, 560.8, 560.81, 560.89, and 560.9
		Fistula	596.1, 619.1, 569.81
		Diverticulosis	562.10 and 562.12
Proctectomy	45110–45114, 45119, 45120, 45123, 45130, 45135, 45397, 45395	Colorectal cancer	153, 154, 153.0–153.9, 154.0, 154.1, 230.3, and 230.4
		Crohn's disease	555, 555.0–555.9
		Diverticulitis	562.11 and 562.13
Anterior resection	44145, 44146, 44147, 44207, 44208	Benign colorectal tumor	211.3 and 211.4
		Closure or revision of colostomy	569.6, 569.60–569.69

[a] Current Procedural Terminology (CPT) codes

[b] International Classification of Diseases, 9th Revision, clinical modifications (ICD-9-CM) codes

Statistical analysis

Statistical analyses were conducted using SPSS_ software, Version 22 (SPSS Inc., Chicago, IL). The main analysis method was multivariate analysis using logistic regression to explore the independent association between perioperative factors and complications of DVT and PE. In order to report risk adjusted data, adjustments were made for all the variables of the study. For each variable, the adjusted odds ratio (AOR) with a 95 % confidence interval was calculated. Statistical significance was set at P\0.05.

Results

We identified 219,477 patients who underwent colorectal resections during 2005–2013. The median age of all patients was 62 years, and 114,078 (52 %) were female.
The majority of the patients were Caucasian (86.1 %), and the most common comorbidities were hypertension (48.7 %) and diabetes mellitus (14.5 %). Demographic data of patients are reported in Table 2.

Among all patients who underwent colorectal surgery during this period, 4556 (2.1 %) developed postoperative VTE, of which 1.5 % had DVT and 0.7 % had PE. Median hospitalization lengths in patients with and without VTE were 14 and 6 days, respectively (CI 6.61–7.36, P\0.01).
The unadjusted mortality rates in patients with and without VTE were 7.9 and 2.7 %, respectively. After adjusting for comorbidities, risk of mortality was higher in patients with VTE (AOR 1.22, CI 1.02–1.46, P = 0.02).

Among VTE events, 1541 (33.8 %) were identified after hospital discharge. Post-hospital discharge DVT and PE were reported in 1067 and 615 patients, respectively. 74.1 % of post-discharge VTE events were diagnosed in the first 2 weeks following discharge. Although the overall rate of

diagnosed VTE events decreased from 2.4 % in 2005 to 1.9 % in 2013, there was a steady increase in the percentage diagnosed post-discharge, from 31.6 % in 2005 to 38.3 % in 2013. When examining the post discharge VTE events, the frequency of DVT identification in the first, second, third, and fourth weeks after operation were 37.6, 30.2, 19.2, and 13 %, respectively. Also, the rates of diagnosed PE in the first, second, third, and fourth weeks after operation were 43, 26.4, 18.1, and 12.5 %, respectively (Fig. 1). Patients who were hospitalized for less than 4 days, between 4 and 7 days, and more than 7 days had different rates of postoperative VTE (Fig. 2). During the first week after discharge, the rates of diagnosed DVT and PE increased compared to the discharge day (Figs. 2, 3). For patients who were hospitalized for fewer than 4 days, the rate of diagnosed VTE was quite low but increased in the first 4 days after hospital discharge (Fig. 2).

Risk adjusted analysis of factors associated with post-discharge VTE in colorectal surgery is stated in Table 3 and includes factors such as chronic steroid use (AOR 1.81, P\0.01), stage 4 colorectal cancer (AOR 1.40, P = 0.03), obesity (AOR 1.37, P\0.01), hypoalbuminemia (AOR 1.22, P = 0.03), and age greater than 70 (AOR 1.21, P = 0.04) which all increased the risk of post-discharge VTE. Also, compared to patients who were hospitalized for less than 4 days, patients hospitalized for more than 7 days (AOR 9.08, P\0.01) and those hospitalized between four and 7 days (AOR 5.32, P\0.01) had significantly higher frequency of post-hospital discharge VTE.

Table 4 estimates the increased risk of post-hospital discharge VTE associated with the presence of multiple risk factors after colorectal surgery. For example, patients who underwent open colorectal resections and were hospitalized for more than 7 days with one of the comorbidities, including steroid use, obesity, stage 4 colorectal cancer, or age more than 70 years, had approximately a 14 times greater risk of post-discharge VTE compared to patients who underwent laparoscopic surgery and were hospitalized for less than 4 days without the mentioned comorbid conditions.

Finally, Table 5 reports the risk adjusted analysis of VTE by surgical procedure and indication of surgery. Among all colorectal procedures, total colectomy was associated with the highest risk of post-discharge VTE (AOR 1.98, P\0.01). Also, among indications of surgery, mesenteric ischemia (AOR 4.55, P = 0.01), and colorectal perforation (AOR 3.18, P = 0.04) were associated with the highest rates of post-discharge VTE.

Table 2 Perioperative and demographic factors of patients who underwent colon and rectal surgery

Factors	Patients without VTE ($N = 214{,}921$)[b]	Patients with in-hospital VTE ($N = 3015$)[b]	Patients with post-hospital discharge VTE ($N = 1541$)[b]
Age			
Mean ± SD (year)	61 ± 15	66 ± 15	62 ± 16
Median (year)	62	68	65
Sex			
Male	102,847 (47.9 %)	1513 (50.2 %)	734 (47.7 %)
Race			
White	168,773 (86.1 %)	2308 (83.7 %)	1270 (88.1 %)
African American	19,408 (9.9 %)	389 (14.1 %)	148 (10.3 %)
Asian	5622 (2.9 %)	42 (1.5 %)	15 (1 %)
Other	2156 (1.1 %)	19 (0.7 %)	8 (0.6 %)
Admission			
Emergency	28,217 (13.1 %)	991 (32.9 %)	285 (18.5 %)
Surgical approach			
Laparoscopic	83,059 (38.6 %)	533 (17.7 %)	497 (32.3 %)
Open	131,862 (61.4 %)	2482 (82.3 %)	1044 (67.7 %)
Comorbidity			
Hypertension	104,309 (48.5 %)	1794 (59.5 %)	749 (48.6 %)
Diabetes	31,079 (14.5 %)	583 (19.3 %)	229 (14.9 %)
Smoking	40,095 (18.7 %)	544 (18 %)	224 (14.5 %)
Steroid use[f]	16,220 (7.5 %)	431 (14.3 %)	229 (14.9 %)
COPD[e]	12,298 (5.7 %)	339 (11.2 %)	97 (6.3 %)
Stage 4 colorectal cancer	10,787 (5 %)	301 (10 %)	116 (7.5 %)
Dyspnea	19,670 (9.2 %)	530 (17.6 %)	177 (11.5 %)
Renal failure need for dialysis	21,77 (1 %)	59 (2 %)	11 (0.7 %)
Weight loss	10,766 (5 %)	301 (10 %)	88 (5.7 %)
CVA[c]	79,75 (3.7 %)	227 (7.5 %)	65 (4.2 %)
Ascites	2785 (1.3 %)	130 (4.3 %)	23 (1.5 %)
Congestive heart failure	2276 (1.1 %)	90 (3 %)	17 (1.1 %)
Bleeding disorders	10,694 (5 %)	398 (13.2 %)	105 (6.8 %)
Body mass index			
Mean ± SD	28 ± 6.8	28.1 ± 7.3	28.9 ± 6.7
Median	27	28	28
Other factors			
ASA score more than two[d]	109,764 (51.1 %)	2373 (78.8 %)	903 (58.7 %)
Dependency before surgery[h]	12,369 (5.8 %)	537 (17.9 %)	102 (6.6 %)
Serum albumin level, Mean ± SD (g/dL)[a]	3.6 ± 0.7	3.1 ± 0.8	3.5 ± 0.7
White blood cell count, Mean ± SD (cells × 109/L)[A]	8.2 ± 4.3	10.1 ± 6.2	8.6 ± 4.5
Anesthesia length, Mean ± SD (min)[a]	224 ± 104	246 ± 126	232 ± 108
Preoperative sepsis[g]	22,851 (10.7 %)	949 (31.5 %)	226 (14.7 %)

[a] Standard deviation

[b] Venous thromboembolism

[c] Cerebrovascular accident/stroke with or without neurological deficit and hemiplegia

[d] American Society of Anesthesiologists

[e] Chronic obstructive pulmonary disease

[f] Administration of oral or parenteral corticosteroid medications in the 30 days prior to surgery for a duration of more than 10 days

[g] Preoperative sepsis, septic shock, and systemic inflammatory response syndrome

[h] Partially or complete dependency before surgery

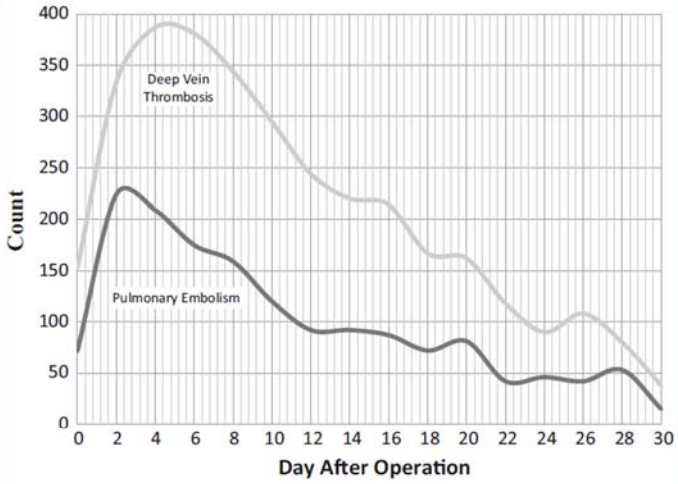

Fig. 1 Timing of postoperative deep vein thrombosis and pulmonary embolism after operation in colorectal surgery

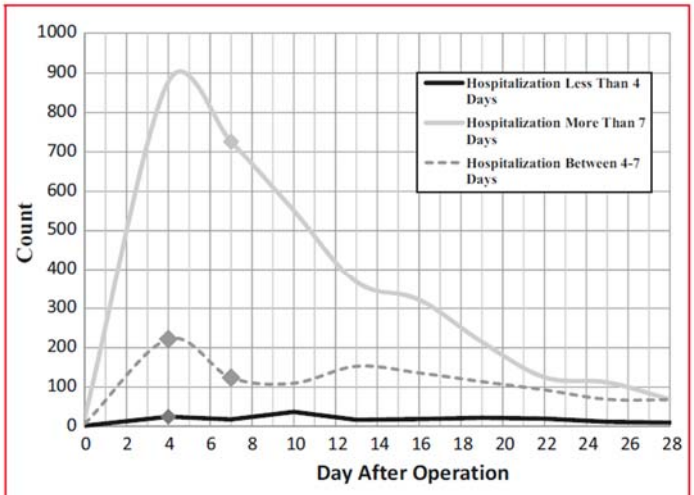

Fig. 2 Timing of postoperative venous thromboembolism embolism according to hospitalization length in colorectal surgery

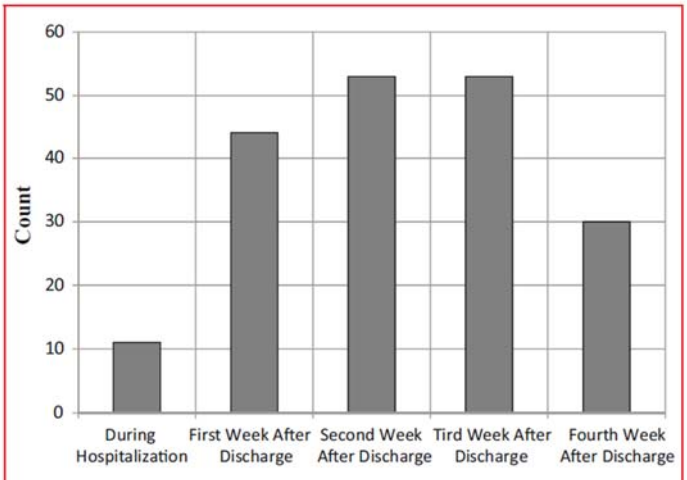

Fig. 3 Timing of venous thromboembolism in patients who were discharged from hospital within 4 days after colorectal operations

Discussion

Postoperative VTE following colorectal resections is associated with a significant increase in mortality and hospitalization length. This study reveals that the rate of VTE after colorectal surgery is about 2.1 %, which is in line with previous reports of 2 % in the literature [1, 10]. Although the reported rate may appear insignificant, it is higher than VTE rates after other non-colorectal procedures, such as cholecystectomy (0.4 %), total hip replacement (0.9 %), total knee replacement (1.7 %), and hysterectomy (0.8 %) [18]. In addition, our study reinforces the importance of using prophylactic methods to decrease the VTE risk after colorectal surgery, as it is associated with significant increase in mortality and length of hospital stay.

Post-discharge VTE following colorectal resections are going to be seen more frequently. In terms of trends in the rate of post-discharge VTE over time, we found the rate of diagnosed VTE events following colorectal operations decreased from 2.4 % in 2005 to 1.9 % in 2013 which can be related to better prophylactic treatment of VTE following colorectal operations. However, we found a steady increase in diagnosis of post-discharge VTE events from 31.6 % in 2005 to 38.3 % in 2013. It can be related to the decrease in hospitalization length of patient who underwent colorectal resections with utilization of minimally invasive approaches. Some high-risk patients may benefit from continuing post-discharge VTE prophylactic treatment.

Prophylactic treatment of VTE after hospital discharge may be beneficial, particularly for high-risk patients who underwent colorectal surgery. In our study, 33.8 % of patients with postoperative VTE occurred after discharge. This is in line with prior studies, which report that 30 % of VTE events occurred after discharge following colorectal surgery [1, 7]. Surprisingly, we found a steady increase in the distribution of post-discharge VTE, from 31.6 % in 2005 to 38.3 % in 2013. This study supports previous suggestions in the literature regarding prophylactic treatments of patients who are at high risk of developing VTE upon leaving the hospital [1, 10]. Although a recently published clinical trial was not able to identify any significant risk or benefit of chemoprophylactic treatment of VTE after post-discharge in non-surgical patients [9], there are limited data with regard to such therapy in surgical patients, and further studies are indicated to compare benefits and disadvantages of post-hospital discharge VTE prophylaxis in colorectal surgery.

Postoperative length of stay can be used to estimate risk of post-discharge VTE after colorectal procedures. Our results show that patients who remained hospitalized after surgery for more than 1 week have nine times greater risk of developing post-hospital discharge VTE compared to patients who were hospitalized for fewer than 4 days. We estimate that patients who underwent open colorectal resections and were hospitalized for more than 1 week after operation with one of the following comorbidities(obesity, chronic steroid use, stage 4 colorectal cancer, age more than 70 years, and hypoalbuminemia) had at least 14 times higher risk of developing post-discharge VTE compared to patients who underwent laparoscopic colorectal resections and were hospitalized for fewer than 4 days after operation without any of the aforementioned comorbid conditions (Table 4). Although prolonged chemoprophylaxis for up to 4 weeks has been suggested for high-risk patients by the American Society of Clinical Oncology and American Society of Colorectal Surgeons, there are no specific guidelines for the length of VTE prophylaxis after hospital discharge [12, 15]. Considering that our study reports that 74.1 % of post-discharge VTE events happen within 2 weeks of discharge and the highest risk of post-discharge VTE exists in patients who were hospitalized for more than 1 week after operation, we suggest extending post-hospital discharge VTE prophylaxis for at least 2 weeks after discharge in this population, especially in the presence of additional VTE risk factors. However, considering the

retrospective nature of this study, further clinical trials are needed to come up with specific guidelines in these high-risk patients, such as timeline of VTE prophylaxis after hospital discharge.

Table 3 Risk adjusted analysis of factors associated with post-hospital discharge venous thromboembolism in colon and rectal surgery patients

Variables	Adjusted odds ratio	95 % Confidence interval	*P* value
Age			
Age >70	1.21	1.005–1.46	0.04
Admission			
Emergency admission	1.28	0.98–1.66	0.06
Surgical approach			
Open surgery	1.36	1.11–1.68	<0.01
Comorbidity			
Steroid use	1.81	1.39–2.35	<0.01
Stage 4 colorectal cancer	1.40	1.02–1.92	0.03
Dyspnea	1.02	0.80–1.31	0.81
Renal failure need for dialysis	0.61	0.27–1.39	0.24
CVA	0.97	0.70–1.34	0.87
Bleeding disorders	1.07	0.78–1.46	0.67
Weight loss	0.96	0.69–1.33	0.82
Dependency before surgery[b]	0.85	0.63–1.15	0.31
Hospitalization after surgery			
Hospitalization < 4 days	Reference	Reference	Reference
Hospitalization between 4 and 7 days	5.32	3.96–7.15	<0.01
Hospitalization more than 7 days	9.08	6.60–12.49	<0.01
Other factors			
Body mass index ≥ 30	1.37	1.15–1.62	<0.01
Hypoalbuminemia[c]	1.22	1.01–1.47	0.03
ASA score more than two[a]	0.95	0.79–1.15	0.63
Preoperative sepsis[c]	0.88	0.67–1.16	0.37
Anesthesia length	1	1–1.001	0.30

[a] The American Society of Anesthesiologists score more than two

[b] Partially or complete dependency before surgery. Preoperative sepsis, septic shock, and systemic inflammatory response syndrome

[c] Serum albumin level lower than 3.5 g/dL

Table 4 Multivariate risk estimating of post-hospital discharge venous thromboembolism in colon and rectal surgery patients

Postoperative hospitalization length	Surgical technique	Risk factors	Estimated increased risk of post-hospital discharge VTE[c]
Less than 4 days	Open surgery	Obesity	1.86 Times
		Age >70	1.64 Times
		Hypoalbuminemia[a]	1.65 Times
		Chronic steroid use	2.46 Times
		Stage 4 colorectal cancer	1.90 Times
		Without risk factor	1.36 Times
	Laparoscopic surgery	Obesity	1.37 Times
		Age >70	1.21 Times
		Hypoalbuminemia[a]	1.22 Times
		Chronic steroid use	1.81 Times
		Stage 4 colorectal cancer	1.40 Times
		Without risk factor	[b]
Between 4 and 7 days	Open surgery	Obesity	9.91 Times
		Age >70	8.74 Times
		Hypoalbuminemia[a]	8.82 Times
		Chronic steroid use	13.08 Times
		Stage 4 colorectal cancer	10.12 Times
		Without risk factor	7.23 Times
	Laparoscopic surgery	Obesity	7.28 Times
		Age >70	6.43 Times
		Hypoalbuminemia[a]	6.49 Times
		Chronic steroid use	9.62 Times
		Stage 4 colorectal cancer	7.44 Times
		Without risk factor	5.32 Times
More than 7 days	Laparoscopic surgery	Obesity	12.43 Times
		Age >70	10.98 Times
		Hypoalbuminemia[a]	11.07 Times
		Chronic steroid use	16.43 Times
		Stage 4 colorectal cancer	12.71 Times
		Without risk factor	9.08 Times
	Open surgery	Obesity	16.90 Times
		Age >70	14.93 Times
		Hypoalbuminemia[a]	15.05 Times
		Chronic steroid use	22.33 Times
		Stage 4 colorectal cancer	17.26 Times
		Without risk factor	12.34 Times

[a] Serum albumin level lower than 3.5 g/dL

[b] The reference group in comparison

[c] Venous thromboembolism

Table 5 Risk adjusted analysis of post-discharge venous thromboembolism in colorectal surgery by indication of surgery and procedure type

Variables	Rate of post-discharge VTE (%)[a]	Adjusted odds ratio	95 % Confidence interval	*P* value
Type of the procedure				
Colostomy closure[b]	0.8	–	–	–
Total colectomy	4.4	1.98	1.26–3.10	<0.01
Pelvic exenteration	4.3	0.88	0.22–3.48	0.85
Partial colectomy	2.2	1.46	1.01–2.10	0.04
Proctectomy	1.6	1.27	0.72–2.24	0.40
Anterior resection	1.4	1.27	0.80–2.02	0.30
Indication of surgery				
Rectal prolapse[b]	0.5	–	–	–
Colon perforation	5	3.18	1.01–10.90	0.04
Colorectal hemorrhage	4.5	4.06	0.77–21.33	0.09
Mesenteric ischemia	4.2	4.55	1.35–15.33	0.01
Peritonitis	4.1	1.42	0.32–6.17	0.63
Ulcerative colitis	3.8	1.70	0.69–4.18	0.24
Malignancy other than colorectal origin	2.5	1.57	0.67–3.69	0.29
Obstruction	3	1.64	0.62–4.31	0.31
Fistula[c]	2.4	1.73	0.62–4.79	0.29
Diverticulosis	2.2	2.48	0.75–8.15	0.13
Colorectal cancer	2	1.48	0.75–2.92	0.25
Crohn's disease	1.7	1.31	0.48–3.55	0.59
Diverticulitis	1.5	2.49	0.94–6.61	0.06
Benign colorectal tumor	1.2	1.30	0.50–3.34	0.58
Closure of colostomy	1	1.67	0.59–4.68	0.32

[a] Venous thromboembolism

[b] The reference group in multiva

[c] Includes colorectal fistula to b

Utilization of laparoscopic techniques in colorectal surgery may decrease the rate of post-hospital discharge
VTE. None of the introduced predictors of post-hospital discharge VTE in this study are reducible. However, we have found that open surgery was associated with a 36 % higher risk of post-discharge

VTE compared to laparoscopic colorectal resections. The lower rate of postoperative VTE following laparoscopic colorectal surgery compared to that of the open procedures has been previously reported [1, 19, 20]. As previously mentioned, critically ill patients who underwent emergent abdominal surgery with mesenteric ischemia and colonic perforation more commonly experience post-discharge VTE (Table 4); however, it is difficult to quantify the potential benefits of laparoscopy in these situations. Although the feasibility of laparoscopic surgery in abdominal emergencies has been reported [21–23], further studies are required to compare benefits and disadvantages of laparoscopic surgery in abdominal emergencies. In addition, our study results show that some colorectal procedures such as total colectomy have significantly higher rate of post-discharge VTE events compared to less extensive colorectal procedures such as colostomy closure, and these findings are unrelated to the patient's diagnosis (e.g., IBD). Utilization of the minimally invasive approach in total colectomy may decrease the risk of post-hospital discharge VTE in patients who undergo the procedure.

Our study results demonstrate that 90.8 % of VTE events in patients who were hospitalized for fewer than
4 days after surgery occurred after hospital discharge (Fig. 3). Although the overall rate in this low risk population was only 0.5 %, the rate of VTE after discharge in this group was 0.4 %. The high distribution of VTE events after discharge may be explained by the discontinuation of VTE prophylaxis in these patients after they are discharged from the hospital. However, post-hospital discharge VTE prophylaxis may not have any benefit for this low risk patients as the risk of postoperative VTE is very small which is nine times lower than patients who were hospitalized for more than 1 week after operation (0.5 vs. 4.9 %, AOR 9.08, P\0.01). Further clinical trials are needed to investigate benefits of post-hospital discharge VTE prophylaxis in patients who were hospitalized for less than 4 days.

Study limitations

This study is a large retrospective review and is subject to selection bias. We utilized ICD-9 and CPT codes to extract the data and coding errors may have been introduced due to the use of discharge data [24]. Due to the restrictions of the database, information regarding the use and method of prophylactic treatment of VTE as well as the duration of prophylactic treatment of VTE was lacking, which may over or underestimate the associations between the examined factors and postoperative VTE occurrences. Also, effectiveness and comparison of different medication and doses in prophylactic treatment of VTE were not possible. Some of the potentially important predictors that are associated with postoperative VTE were not included in this study (i.e., history of prior VTE, estrogen therapy) [6]. The actual time of occurrence of DVT and PE may be earlier than the reported day due to the delay in diagnosis and this may have affected our study results. Although NSQIP provided the variable of the discharge destination, due to missing data (more than 70 % of the study population) we could not evaluate if the risk of post-hospital VTE risk is different between the patients who are discharged to home versus to another facility. Moreover, because this database only tracts information within 30 days of surgery, additional VTE events beyond this time period are not included. Despite these limitations, this study provides a large sample size to report post-hospital discharge VTE following colorectal resection procedures.

Conclusion

Venous thromboembolism is a serious complication and associated with significant mortality and hospitalization length in colorectal patients. Overall, 2.1 % of patients undergoing colorectal resections develop VTE and 33.8 % of VTE events appear to occur after discharge. Over the past years, there was a steady upward trend in the distribution of post-hospital discharge VTE as a percentage of overall VTE rate from 31.6 % in 2005 to 38.3 % in 2013. Risk factors for post-hospital discharge VTE include open

surgery, prolonged hospitalization after operation, obesity, hypoalbuminemia, chronic steroid use, age more than 70 years, and stage 4 colorectal cancer. Postoperative hospitalization length is one of the most important factors which can be used to estimate the risk of post-discharger VTE after colorectal surgery. 74.1 % of post-discharge VTE events are recognized within 2 weeks of discharge, and the highest risk of post-discharge VTE exists in patients who are hospitalized for more than 1 week after operation. Although the retrospective nature of this study makes any conclusion difficult, we suggest that patients who remain hospitalized for more than 1 week after surgery and have risk factors for VTE continue prophylactic treatment of VTE at their discharge destination. Currently, there are no published studies evaluating post-hospital VTE occurrences in patients with prolonged hospitalization after operation. Further studies are needed to evaluate potential benefits of post-hospital discharge VTE prophylaxis in patients who were hospitalized for more than 1 week after operation.

Compliance with ethical standards

Conflict of interest Dr. Stamos has received educational Grants and speaker fees paid to the Department of Surgery, University of California, Irvine, from Ethicon, Gore, Covidien, and Olympus. Dr. Mills and Dr. Carmichael received Ethicon educational Grants paid to the Department of Surgery, University of California, Irvine. Dr. Pigazzi is a consultant for Intuitive Surgical and has also received consultancy fees and educational Grants paid to the Department of Surgery, University of California, Irvine. Dr. Moghadamyeghaneh, Dr. Fazl Alizadeh, Dr. Hwang, and Dr. Hanna have no disclosures.

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