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Are hospitals delivering appropriate VTE prevention? The venous thromboembolism study to assess the rate of thromboprophylaxis (VTE start)

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Abstract The 7th conference of the American College of Chest Physicians (ACCP7) provides recommendations on the type, dose, and duration of thromboprophylaxis in hospitalized patients at risk of venous thromboembolism (VTE), but the extent to which hospitals follow these criteria has not been well studied. Discharge and billing records for patients admitted to any of 16 acute-care hospitals from January 2005 to December 2006 were obtained. Patients 18 years or older who had an inpatient stay $\geq$2 days and no apparent contraindications for thromboprophylaxis were grouped into the categories of critical care, surgery and medically ill before being assessed for additional VTE risk factors based on the diagnostic criteria outlined in ACCP7. For patients at risk, the recommended type (mechanical or pharmacologic), dose, and duration of thromboprophylaxis was identified based on the guidelines and compared to the regimen actually received, if any. Among the 258,556 hospitalized patients, 68,278 (26.4%) were determined to be at risk of VTE without apparent contraindications for thromboprophylaxis. The proportions of patients who received the appropriate type, dose, and duration of thromboprophylaxis were 10.5, 9.8, and 17.9% for critical care, medical, and surgical patients, respectively. Of those at risk, 36.8% received no thromboprophylaxis and an additional 50.2% received thromboprophylaxis deemed inappropriate for one or more reasons. The implementation of ACCP7 guidelines for type, dosage, and duration of thromboprophylaxis is low in patients at risk of VTE. There is a need for physicians and health systems to improve awareness and implementation of recommended thromboprophylaxis.

Keywords Venous thromboembolism · Guidelines · Health care quality

Abbreviations

ACCP	American college of chest physicians
ACCP7	American college of chest physicians 7th and most recent guidelines
ENDORSE	Epidemiologic international day for the evaluation of patients at risk for venous thromboembolism in the acute hospital care setting
ICD-9-CM	International classifications of diseases, 9th revision, clinical modification
IMPROVE	International medical prevention registry on venous thromboembolism
LOS	Length of stay

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VTE	Venous thromboembolism
VTE START	Venous thromboembolism study to assess the rate of thromboprophylaxis

Introduction

The American College of Chest Physicians (ACCP) has issued guidelines for the prevention of venous thromboembolism (VTE) since 1986. The 7th and most recent update of these guidelines (ACCP7), published in 2004, are based on a comprehensive assessment of the literature on risk factors and effective thromboprophylaxis regimens [1]. These guidelines identify specific groups of medical and surgical patients at risk of VTE and provide recommendations for the type (mechanical, pharmacologic, or combination), dose and duration of thrombo- prophylactic measures. The Joint Commission on Accreditation of Healthcare Organizations and the National Quality Forum have recognized the importance of using thromboprophylaxis to prevent VTE in hospitalized patients [2]. Moreover, in 2007 two new quality indicators were added to Medicare's Surgical Care Improvement Project: Thromboprophylaxis ordered for surgery patient, and thromboprophylaxis within 24 h pre/post surgery[3].

Despite the long-standing availability of evidence-based guidelines for thromboprophylaxis, compliance with these in hospitalized patients at risk has remained low. Previous retrospective studies using patient chart reviews have shown that 25 to 84% of hospitalized patients are at risk of VTE and that only 23 to 46% of these patients receive any form of thromboprophylaxis [4–10]. However, assessments of evidence-based thromboprophylaxis are more clinically meaningful when all of the criteria for appropriate thromboprophylaxis are measured. To date, no studies have assessed the appropriateness of thromboprophylaxis against ACCP7 recommendations for the type, dose, and duration of therapy. Assessments using electronic discharge-summary and billing records offer the advantage of including large samples of patients at risk for VTE and the ability to assess not only the rate of thromboprophylaxis but also its appropriateness with respect to type, dose and duration. The primary aim of this project was to support quality improvement efforts at selected US hospitals by measuring implementation of ACCP7 guidelines for type, dose, and duration of thromboprophylaxis across a broad range of medical and surgical conditions.

Methods

Data source

The Venous Thromboembolism Study to Assess the Rate of Thromboprophylaxis (VTE START) was part of a quality improvement initiative designed to help hospitals assess and improve their use of appropriate thromboprophylaxis. A Steering Committee of researchers and clinical experts in thromboprophylaxis were responsible for the design and implementation of the project. Participation was offered by the Steering Committee to a convenience sample of acute-care hospitals of various sizes in urban and rural areas of the Midwest and Southwest. Of 16 that participated, 13 hospitals were affiliated with a single health system, and two hospitals had implemented some type of a prophylaxis program during the 2005–2006 period. Participating hospitals provided electronic patient-level discharge-summary and billing records for 2005–2006. Discharge-summary records contained demographic data (age, gender, race), admission and discharge dates, referral source and type of insurance. Primary and secondary codes for diagnoses and procedures (in International Classifications of Diseases, 9th revision, Clinical Modification [ICD-9-CM] format) and specialty of the attending or admitting physician were also available. Billing records provided daily information on inpatient services provided and pharmacy data describing medication type, quantity, and dose. Hospital-level data included bed count and indicators for teaching or non-teaching, rural or urban, and for-profit or non-profit.

All patient records were de-identified by the hospitals in compliance with the Privacy Rule of the Health Insurance Portability and Accountability Act of 1996 [13]. The study protocol was approved or exempted by the Institutional Review Board governing each participating institution. After the study, participating hospitals were provided the pooled results for all 16 hospitals as well as the results specific to their institution for purposes of comparison and use in their quality improvement initiatives.

Study population

Patients 18 years and older at admission, who had an inpatient stay $\geq$2 days between January 1, 2005 and December 31, 2006, were eligible for inclusion. Patients meeting one or more of the following were excluded from the analyses: (1) transferred from another acute-care facility where they may have already received thromboprophylaxis; (2) pregnancy-related discharge diagnosis owing to precautions for anticoagulant use in pregnant women; (3) other conditions where thromboprophylaxis could be contraindicated were also excluded based on ICD-9-CM diagnosis and procedure codes for active bleeding or indicating a potentially high risk of bleeding due to certain liver diseases, malignant hypertension, certain blood diseases, active peptic ulcer and renal dysfunction; and (4) discharge diagnosis of VTE in order to distinguish between VTE prophylaxis and treatment.

Patients at risk

Patients were grouped into potentially at-risk cohorts based on ACCP7 guidelines. We created mutually exclusive groups of critical care, surgical, and medical patients based on hospital discharge-summary and billing records. For example a patient was flagged as critical care if he/she had a billing code indicative of time he/she spent in critical care unit. Surgical and medical patients were identified using ICD9-CM diagnosis and procedure codes indicative of the surgery and condition of interest (see Table 1, technical appendix). Patients were placed in the most severe group for which they qualified (critical care being the highest in severity and medical conditions being the lowest) For instance a trauma patient who required surgery was classified as surgery. Next, they were subclassified into seven mutually exclusive diagnostic groups adapted from ACCP7 (see Table 1) [1]. Surgical procedures were classified as non-major (operations other than abdominal lasting <45 min) or major (any intra-abdominal operation and any other operations lasting ≥45 min) [14]. Low, moderate and high levels of surgical risk were defined based on ACCP7 risk factors [1]. The final determination of at-risk status and recommended thromboprophylaxis was based on assessments of "additional risk factors" as specified in ACCP7 [1]. Risk factors were identified using relevant ICD9-CM diagnoses and procedure codes. Risk factors such as smoking and immobility that are difficult to determine using ICD9-CM codes were not captured.

Study measures

The primary endpoint was the rate of appropriate thromboprophylaxis. This assessment was based upon ACCP7 recommendations for each cohort of patients at risk. Appropriate thromboprophylaxis rates were determined using four criteria: (1) whether the patient received any thromboprophylaxis; (2) whether the appropriate type of thromboprophylaxis (mechanical or pharmacologic) was used; (3) whether the pharmacologic regimen (if any) was given at a dose greater or equal to the minimum recommended daily dose; and (4) whether the regimen was administered for greater or equal to the recommended number of days. ACCP7 recommends thromboprophylaxis for the length of stay (LOS) for patients at risk of VTE. However, for medical patients, duration was considered sufficient in this study if thromboprophylaxis was received for LOS minus 1 day to accommodate partial days of stay. For surgical patients, duration of LOS minus 2 days was considered sufficient to accommodate partial days of stay and procedures for which thromboprophylaxis is not recommended on the day of surgery. Duration of prophylaxis for pharmacologic agents was calculated by summing up the number days for which a relevant billing code was recorded. For mechanical prophylaxis, duration was calculated as the total number of days between the first billing date during which a relevant billing code was recorded and the discharge date. The rate of appropriate thromboprophylaxis was calculated as the total number of appropriately treated patients divided by the number of patients at risk of VTE. Appropriate thromboprophylaxis rates were determined for the full study period and for each calendar quarter, as well as by primary attending physician specialty, hospital characteristics and LOS.

The study's secondary endpoint was the proportion of all hospitalized patients at risk of VTE. This was calculated as the total number of patients at risk divided by the total number of discharged patients.

Results

Patient population and characteristics

Of 258,556 patients for whom data were available, 135,954 (53%) met at least one exclusion criterion (Fig. 1). After establishing the main diagnostic groups (critical care, surgical, and medical) and applying the additional risk-factor criteria specified in ACCP7, we identified 68,278 patients at risk of VTE (26.4%). Of these, approximately equal percentages were critical care, surgical, and medical patients. Most patients were female, elderly, and Caucasian with an average LOS of 5.3 days, attended by internists and primary care physicians, and insured by public (mostly Medicare and Medicaid) or commercial health insurance (Table 1).

Rate of appropriate thromboprophylaxis

A total of 43,125 patients, or 63.2% of those at risk of VTE, received some type of mechanical or pharmacologic thromboprophylaxis (Table 2). This rate was greatest for critical care patients, followed by surgical then medical. However, only 12.9% of at-risk patients received appropriate type and dose and duration based on ACCP7 criteria (20.4% of those receiving any thromboprophylaxis). The rate of appropriate thromboprophylaxis was highest for surgical patients, followed by critical care and medical patients (17.9, 10.5, and 9.8%, respectively). Among documented physician specialties, the rate of appropriate thromboprophylaxis was highest for orthopedics followed by cardiology (32.0 and 18.3%, respectively), but still poor overall. Across all categories, 87.1% of at-risk patients received either no thromboprophylaxis or inappropriate thromboprophylaxis.

The leading reason for failure to meet ACCP7 criteria (Table 2) was no thromboprophylaxis at all (36.8% of

Table 1 Characteristics of patients at risk of VTE in 2005–2006, by major diagnostic group ($n = 68,278$)

Patient characteristics	Critical care	Surgery				Medical				Total
		General, vascular, gynecologic, laparoscopic, and urologic	Orthopedic	Neurosurgery	Total surgery	Trauma, spinal cord, injuries, and, burns	General medical †	Cancer	Total medical	
Number of patients at risk of VTE	21,081	15,783	7,776	1,183	24,742	1,720	19,011	1,724	22,455	68,278
Age, %										
18–39	10.2	18.7	3.3	11.2	13.5	18.5	0.0	1.0	1.5	8.5
40–49	12.1	21.6	8.4	10.1	16.9	13.5	11.8	6.9	11.6	13.7
50–59	18.6	20.2	20.6	14.9	20.1	16.8	15.5	15.0	15.5	18.1
60–69	20.7	16.2	26.2	23.1	19.7	13.2	18.6	24.0	18.6	19.7
70+	38.3	23.3	41.6	40.8	29.9	38.0	54.1	53.0	25.8	40.0
Race, %										
Caucasian	81.8	77.0	88.5	80.6	80.8	85.1	84.2	87.9	84.6	82.3
African American	7.7	10.2	3.6	4.6	7.9	3.8	7.3	6.1	6.9	7.5
Asian	0.9	1.1	0.4	0.7	0.8	0.8	0.8	0.6	0.8	0.8
Hispanic	6.8	9.2	4.6	11.7	7.9	8.7	5.3	3.8	5.5	6.8
Other	0.8	0.9	0.7	0.9	0.8	0.2	0.5	0.3	0.4	0.7
Not documented	2.0	1.6	2.2	1.5	1.8	1.4	1.9	1.2	1.8	1.9
Gender, %										
Male	51.1	35.8	36.8	50.9	36.8	41.0	40.1	45.1	40.6	42.5
Female	48.9	64.2	63.2	49.1	63.2	59.0	59.9	54.9	59.4	57.5
Not documented	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Length of staty, days(SD)	6.3 (6.4)	5.3 (5.2)	4.3 (2.5)	4.6 (5.2)	5.0 (4.5)	5.6 (4.8)	4.5 (2.9)	6.1 (4.4)	4.7 (3.3)	5.3 (4.9)
Referral source, %										
Physician	61.6	56.2	58.3	65.3	57.3	69.7	56.9	56.7	57.9	58.8
ER	35.2	42.9	41.2	33.6	41.9	28.4	42.0	42.1	41.0	39.5
Other	3.1	0.9	0.6	1.0	0.8	1.9	1.0	1.2	1.1	1.6
Not documented	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Primary attending physician specialty‡, %										
Cardiology	22.9	1.7	0.1	0.3	1.1	0.2	6.8	4.6	6.1	9.5
Internal medicine and primary care	43.6	24.0	7.4	4.3	17.9	26.7	76.5	55.7	71.1	43.3
Neurology	8.6	0.9	6.1	54.1	5.0	1.6	0.7	0.2	0.8	4.7
Oncology	0.7	3.0	0.1	0.5	1.9	0.1	0.1	18.3	1.5	1.4
Orthopedic	1.9	1.6	72.8	14.0	24.5	34.4	0.6	1.3	3.3	10.6
Surgery	9.4	37.6	0.8	3.6	24.4	28.0	1.1	3.1	3.3	12.8
Other	9.4	28.2	10.2	22.4	22.3	4.1	7.1	10.3	7.1	13.3
Not documented	3.7	3.1	2.5	0.8	2.8	4.8	7.0	6.6	6.8	4.4

Table 1 continued

Patient characteristics	Critical care	Surgery				Medical				Total
		General, vascular, gynecologic, laparoscopic, and urologic	Orthopedic	Neurosurgery	Total surgery	Trauma, spinal cord, injuries, and, burns	General medical †	Cancer	Total medical	
Payer type, %										
Public §	48.4	32.5	48.1	47.3	38.1	44.0	63.8	62.8	62.2	49.2
Commercial	43.7	59.3	49.1	46.3	55.5	39.6	30.9	34.6	31.9	44.1
No insurance	7.2	7.0	0.8	1.7	4.8	10.9	4.8	2.2	5.1	5.6
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Not documented	0.8	1.1	2.0	4.6	1.6	5.5	0.5	0.4	0.9	1.1
Number of additional VTE risk factors**, %										
No risk factors	12.2	24.0	51.2	65.1	34.5	0.3	44.2	0.0	37.5	28.6
1 or more risk factors	87.8	76.0	48.8	34.9	65.5	99.7	55.8	100.0	62.5	71.4
1 risk factor	34.4	41.5	36.6	25.3	39.2	71.6	41.4	1.0	40.6	38.2
2+ risk factors	53.4	34.5	12.2	9.6	26.3	28.1	14.4	99.0	21.9	33.2

Classifications and risk factors are adapted from the 7th ACCP Guidelines [1]

† General medical includes heart failure, severe respiratory disease, acute myocardial infarction, stroke, and severe infectious disease

‡Cardiology: cardiology, cardiovascular disease, or cardiology/electrophysiology; internal medicine and primary care: family practice, family nurse practitioner, general practice, hospitalist, or internal medicine; oncology: oncology or radiation oncology; surgery: cardiothoracic surgery, general surgery, neurosurgery, plastic and reconstructive surgery, or unspecified surgical specialty; orthopedic: orthopedic or orthopedic surgery; other: adult nurse practitioner, anesthesiology, critical care, dentist, dermatology, emergency medicine, family nurse practitioner, gastroenterology, hematology, nephrology, ophthalmology, pathology, physical medicine/rehabilitation, physician assistant, podiatry, pulmonary, rheumatology, urology, pediatric medicine, radiology, or ear/nose/throat; not documented: could not be determined from the data due to missing values

§ Public payers include medicare, medicaid, veteran's health, and Indian health service

** Defined as any additional risk factors beyond the actual diagnostic groups. Risk factors were determined using primary and secondary diagnosis and procedure codes. In addition to the risk factors defined by each of the seven diagnostic groups, 71.4% of at-risk patients had at least one additional risk factor for VTE and 33.2% had two or more risk factors. The top three risk factors for all patients were heart/respiratory failure (34.7%), acute medical illness (25.7%) and surgery (17.3%)

at-risk patients). Additionally, patients frequently received thromboprophylaxis regimens that were of the inappropriate type (25.4% of at-risk patients); appropriate type but inadequate dose and insufficient duration (13.9%); appropriate type and sufficient duration but inadequate dose (8.3%); and appropriate type and adequate dose but insufficient duration (2.7%). Of patients who received any thromboprophylaxis, 25.3% received it on only 1 day, 16.1% on 2 days and 15.2% on 3 days; it was most often initiated on the first day of the stay (67.4%).

Over the 2-year study period, the overall (critical care, surgery and medical conditions combined) quarterly rates of appropriate thromboprophylaxis reflected modest improvement, from 11.6% in the first quarter of 2005 to 14.5% in the last quarter of 2006. However the rate of improvement over time varied across the individual cohorts (Fig. 2). The rate of appropriate thromboprophylaxis varied according to hospital characteristics. Higher rates of appropriate thromboprophylaxis were observed for large hospitals compared to small hospitals (Table 3). Patients were also more likely to receive thromboprophylaxis based on ACCP7 in urban, teaching, and for-profit hospitals.

Discussion

This study demonstrates that the 7th ACCP guidelines for type, dose and duration of thromboprophylaxis were not implemented to a high degree in participating hospitals. While nearly two-thirds of patients at risk of VTE received some form of thromboprophylaxis, fewer than one in seven (or about one in five of those who received any thromboprophylaxis) received the appropriate type, dose and duration. The proportions of patients receiving appropriate

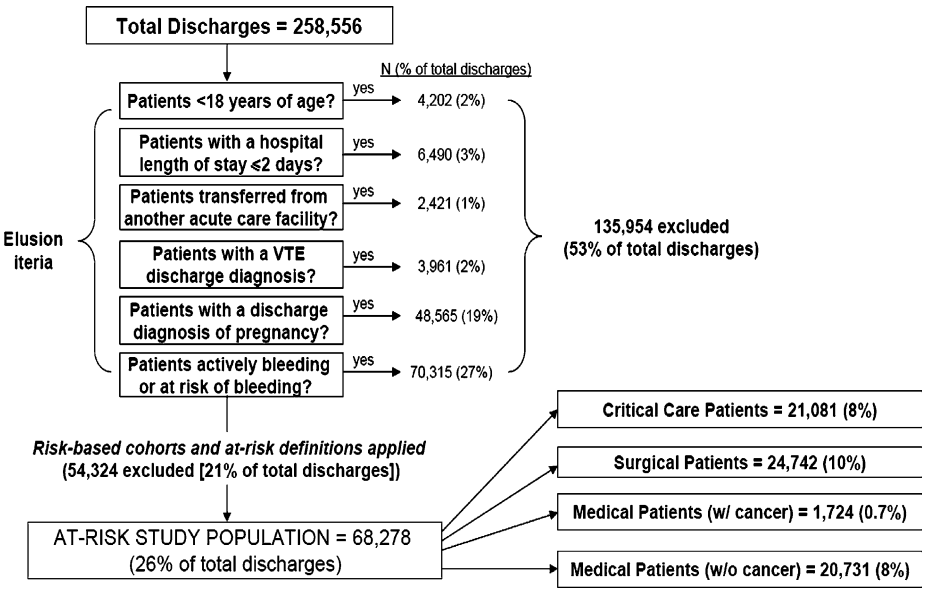

Fig. 1 Construction of study sample

thromboprophylaxis were alarmingly low for every diagnostic group, physician specialty, hospital category, and time period studied.

Hospitals may have intended to implement ACCP7 to varying degrees, and this may partially explain the low levels of appropriate thromboprophylaxis observed in our study. However, the use of alternative guidelines or standards for thromboprophylaxis is unlikely to explain the absence of any thromboprophylaxis in 37% of at-risk patients. Indeed, the high rate of omission of any form of thromboprophylaxis in medical and surgical patients found in this study is consistent with the findings of other studies [5, 11, 12, 16]. In those patients who did get thromboprophylaxis, the regimen did not reflect ACCP7 guidelines nearly 80% of the time, and the leading cause was inappropriate type (e.g., giving mechanical only when pharmacologic was indicated). Thus, our findings demonstrate a persistent and worrisome gap in the performance of evidence-based thromboprophylaxis for hospitalized patients at participating institutions.

VTE START is, to our knowledge, the only study that has assessed the appropriateness of thromboprophylaxis in multiple US hospitals using the 7th ACCP guidelines for type, dose, and duration. Previous retrospective studies using patient chart reviews have shown that 25 to 84% of hospitalized patients are at risk of VTE and that only 23 to 46% of these patients receive any form of thromboprophylaxis [4–8]. However, these studies were based on relatively small samples of patients (range: 100–4124) with medical conditions and relied on the 6th ACCP or non-ACCP guidelines. Two recent, large international registries, using chart review, assessed the use of thromboprophylaxis against ACCP7 [9, 10]. However, the ENDORSE study of 68,183 patients in 32 countries [9] did not include duration of thromboprophylaxis, and the IMPROVE study of 15,156 patients in 12 countries [10] did not assess the appropriateness of the type of the thromboprophylaxis received. Two other recent studies [11, 12] used electronic databases of patient records to assess the appropriateness of thromboprophylaxis against the 6th rather than the 7th ACCP guidelines. Yu and colleagues [11] reported appropriate thromboprophylaxis in only 13.3% of patients across a similar range of diagnostic groups. Amin and colleagues [12] found the rate of appropriate thromboprophylaxis to be 33.9% among high-risk medical patients. It is worth noting that there is no significant difference between the 6th and the 7th ACCP guidelines in terms of the criteria for appropriate prophylaxis, therefore the bases of the results from our study should be comparable to the bases of the results obtained from those published studies.

Our results should be interpreted in light of several limitations. First, we employed discharge-summary and billing data to assess risk status and appropriateness of thromboprophylaxis. While such electronic data allow for rapid and efficient analysis of all patients in an institution, there is the possibility of measurement error because certain risk factors cannot be fully assessed based on discharge and billing records. This may have led to inaccurate assumptions about a patient's at-risk status or appropriate thromboprophylaxis regimen. For example, we determined that 26% of all hospitalized patients were at risk of VTE and had no apparent contraindications for thromboprophylaxis. These results are similar to other studies using

Table 2 Rates of any and appropriate VTE prophylaxis among patients at risk of VTE ($n = 68,278$)

	N at risk	Received any prophylaxis		Received no prophylaxis		Received appropriate type, dose, and duration o prophylaxis, % of total at risk	Reason for inappropriate prophylaxis, percent of N at risk			
		N	%	N	%		Inappropriate type	Appropriate type and dose but in sufficient duration	Appropriate type and duration but in appropriate dose	Appropriate type inappropriate dose insufficient duration
Critical care	21,081	15,726	74.6	5,355	25.4	10.5	35.7	4.1	13.9	10.5
Surgery	24,742	16,410	66.3	8,332	33.7	17.9	17.1	3.0	7.3	21.0
General, vascular, gynecologic and urologic surgery										
General	8,922	5,203	58.3	3,719	41.7	7.5	12.2	2.6	8.9	27.1
Major vascular surgery	2,860	2,020,	70.6	840	29.4	9.1	16.5	11.5	29.3	4.2
Major gynecologic	2,669	1,269	47.5	1,400	52.5	7.5	1.1	3.9	0.3	34.7
Laparoscopic surgery	378	259	68.5	119	31.5	41.8	5.3	5.0	5.6	10.8
Major urologic	954	540	56.6	414	43.4	31.6	3.9	1.7	2.8	16.7
Orthopedic surgery										
Elective hip arthroplasty	2,106	1,856	88.1	250	11.9	37.5	38.6	0.2	0.0	11.8
Elective knee arthroplasty	3,746	3,313	88.4	433	11.6	40.2	33.6	0.4	0.1	14.2
Knee arthroscopy	1	1	100.0	0	0.0	0.0	100.0	0.0	0.0	0.0
Hip fracture surgery	814	637	78.3	177	21.7	17.1	45.9	1.2	4.4	9.6
Elective spine surgery	1,109	700	63.1	409	36.9	31.0	9.8	1.4	3.1	17.8
Neurosurgery	1,183	612	51.7	571	48.3	5.2	2.7	0.8	3.3	39.6
Risk level										
Low	8	4	50.0	4	50.0	0.0	0.0	0.0	0.0	5.7
Moderate	3,910	2,076	53.1	1,834	46.9	14.7	9.8	6.4	15.5	6.5
High	20,824	14,330	68.8	6,494	31.2	18.5	18.5	2.4	5.7	23.7
Medical Conditions	22,455	10,989	48.9	11,466	51.1	9.8	24.7	1.1	4.2	9.2
Trauma, spinal cord injury, burns										
Trauma	1,700	1,027	60.4	673	39.6	38.2	16.5	0.0	0.0	5.7
Acute spinal cord injuries	13	6	46.2	7	53.8	0.0	0.0	0.0	23.1	23.1
Burns	7	3	42.9	4	57.1	0.0	42.9	0.0	0.0	0.0
General medical										
Heart failure	2,738	1,626	59.4	1,112	40.6	9.8	29.7	0.5	3.1	16.3
Severe respiratory disease	5,257	2,406	45.8	2,851	54.2	7.3	26.6	0.6	2.9	8.3
Acute myocardial infarction	864	727	84.1	137	15.9	27.8	32.8	11.5	10.4	1.7
Stroke	1,654	863	52.2	791	47.8	7.0	31.3	0.7	1.4	11.8
Severe infectious disease	8,498	3,430	40.4	5,068	59.6	5.4	22.1	0.6	3.7	8.6
Cancer	1,724	901	52.3	823	47.7	4.4	22.2	2.0	15.5	8.1

Table 2 continued

	N at risk	Received any prophylaxis		Received no prophylaxis		Received appropriate type, dose, and duration o prophylaxis, % of total at risk	Reason for inappropriate prophylaxis, percent of N at risk			
		N	%	N	%		Inappropriate type	Appropriate type and dose but in sufficient duration	Appropriate type and duration but in appropriate dose	Appropriate type inappropriate dose insufficient duration
Primary attending physician specialty*										
Cardiology	6,480	5,769	89.0	711	11.0	18.3	47.9	6.6	11.7	4.6
Internal medicine and primary care	29,566	16,573	56.1	12,993	43.9	7.7	28.1	1.9	8.6	9.8
Neurology	3,226	1,922	59.6	1,304	40.4	8.2	13.6	2.7	9.8	25.2
Oncology	970	706	72.8	264	27.2	7.3	12.3	3.6	22.1	27.5
Orthopedic	7,205	6,042	83.9	1,163	16.1	32.0	34.1	0.8	1.4	15.5
Surgery	8,755	6,100	69.7	2,655	30.3	13.4	15.9	4.2	12.3	23.9
Other	9,093	5,099	56.1	3,994	43.9	14.1	14.1	3.0	6.5	18.4
Not documented	2,983	914	30.6	2,069	69.4	9.3	7.4	1.4	2.1	10.4
Total	68,278	43,125	63.2	25,153	36.8	12.9	25.4	2.7	8.3	13.9

*Cardiology: cardiology, cardiovascular disease, or cardiology/electrophysiology; internal medicine and primary care: family practice, family nurse practitioner, general practice, hospitalist, or internal medicine; oncology: oncology or radiation oncology; surgery: cardiothoracic surgery, general surgery, neurosurgery, plastic and reconstructive surgery, or unspecified surgical specialty; orthopedic: orthopedic or orthopedic surgery; other: adult nurse practitioner, anesthesiology, critical care, dentist, dermatology, emergency medicine, family nurse practitioner, gastroenterology, hematology, nephrology, ophthalmology, pathology, physical medicine/rehabilitation, physician assistant, podiatry, pulmonary, rheumatology, urology, pediatric medicine, radiology, or ear/nose/throat; not documented: could not be determined from the data due to missing values

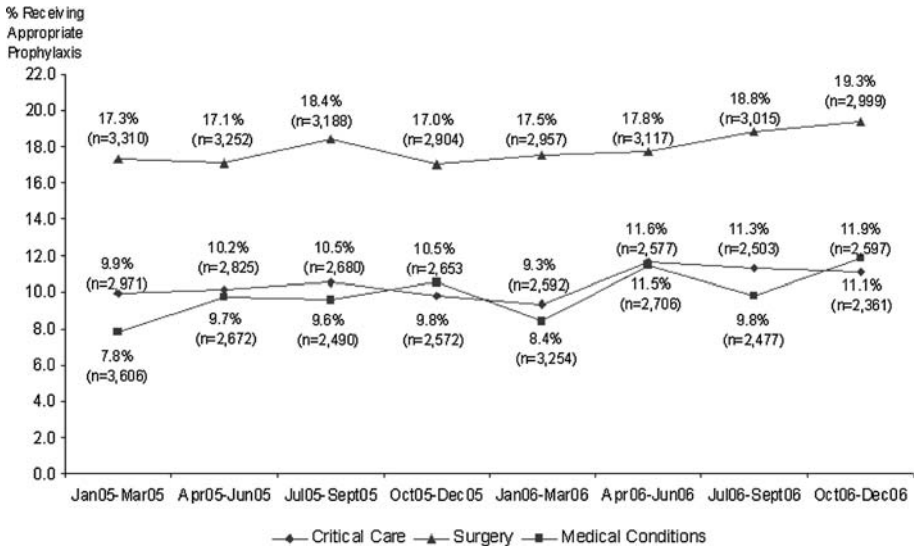

Fig. 2 Patients at risk of VTE who received appropriate prophylaxis by diagnostic group over time ($n = 68,278$)

Table 3 Rates of any and appropriate VTE prophylaxis among patients at risk of VTE, by hospital characteristics ($n = 68,278$)

Hospital characteristic	Total at risk, N	Received any prophylaxis		Received no prophylaxis		Received appropriate type, dose, and duration of prophylaxis % of N at risk	Reason for inappropriate prophylaxis, percent of N at risk			
		N	%	N	%		Inappropriate type	Appropriate type and dose but insufficient duration	Appropriate type and duration but inappropriate dose	Appropriate type but insufficient duration
Number of beds										
0–100	5,567	2,825	50.7	2,742	49.3	11.9	24.9	1.0	4.9	8.0
101–500	36,957	21,242	57.5	15,715	42.5	11.3	22.1	2.9	6.7	14.5
501–1000	25,754	19,058	74.0	6,696	26.0	15.4	30.2	2.8	11.4	14.2
1000+	–	–	0.0		0.0	0.0	0.0	0.0	0.0	0.0
Geographic location										
Urban	59,740	39,523	66.2	20,217	33.8	13.6	26.0	3.0	9.2	14.3
Rural	8,538	3,602	42.2	4,936	57.8	8.4	20.7	0.5	1.9	10.6
Teaching status										
Teaching	10,791	6,191	57.4	4,600	42.6	15.6	19.1	2.1	3.0	17.6
Non-Teaching	57,487	36,934	64.2	20,553	35.8	12.4	26.5	2.8	9.3	13.2
Type										
Not-for-profit	57,487	36,934	64.2	20,553	35.8	12.4	26.5	2.8	9.3	13.2
For-profit	10,791	6,191	57.4	4,600	42.6	15.6	19.1	2.1	3.0	17.6
Payer mix										
Public	33,601	20,507	61.0	13,094	39.0	10.3	27.7	1.8	7.7	13.5
Commercial	30,088	19,826	65.9	10,262	34.1	15.5	23.1	3.7	8.8	14.8
Other	4,589	2,792	60.8	1,797	39.2	15.6	22.8	2.8	9.3	10.4

hospital discharge-summary and billing data (13–31%)[11, 15] but at the lower end of the range of results from chart-based evaluations (25–84%)[4–8, 16]. This may be due to our large sample representing more categories of patients than previous studies, but it may also reflect our liberal exclusion criteria for potential bleeding risk, which

increased the number of patients for whom thromboprophylaxis was contraindicated and reduced the proportion at risk of VTE. Our approach is consistent with previous studies using discharge-summary and billing data[11, 12], and reflects a desire to under-estimate rather than over-estimate the proportion of patients at risk of VTE. With this in mind, it is worth noting that we had no access to patients' clinical history such as recent (<30 days) GI bleeding, therefore we might have been overestimated the at risk population as described herein. Similarly, we may have overestimated the number of patients receiving appropriate thromboprophylaxis because we imposed no upper bound on dose and a low threshold for appropriate duration. Both of these criteria reflect our intent to be as liberal as possible where there was uncertainty in our ability to determine appropriate thromboprophylaxis. Finally, our small sample of 16 hospitals was not intended to be nationally representative, and the fact that 13 of them were part of a single hospital system may have reduced the variance within the sample. Further, the observed variation in the rate of prophylaxis across the participating hospitals are likely to be confounded due the fact that some of these hospitals had some initiative in place for improving prophylaxis. The extent to which the low levels of thromboprophylaxis found in these hospitals reflect the levels in other US hospitals is unknown.

Our results demonstrate an alarmingly low degree of implementation of the 7th ACCP guidelines and imply the need for urgent action by physicians and health systems to assess risk and deliver appropriate thromboprophylaxis. Interventions in the form of educational programs, risk stratification, critical pathways and alert tools have been effective in increasing the rate of thromboprophylaxis [8, 11, 17–19]. An additional strength of this project was the delivery of benchmarking reports to participating hospitals, for use in the development and evaluation of their own quality improvement initiatives. Institutions may find that analyzing their administrative databases on all patients is a more efficient and comprehensive method than manual chart abstraction of small samples of patients for assessing thromboprophylaxis rates and the impact of quality improvement initiatives.

Conclusions

This study demonstrates the significant gap between evidence-based thromboprophylaxis recommendations and actual clinical practice in a large sample of hospitalized patients. More than 25% of hospitalized patients were at risk of VTE, but fewer than one in seven of these patients received thromboprophylaxis that met criteria for recommended type, dose and duration. We recommend intensive efforts to improve the degree of implementation of current guidelines for appropriate thromboprophylaxis.

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Appendix

See Tables 4, 5

Table 4 Criteria for determining appropriate prophylaxis by study cohort

Study cohort	Additional stratification	Appropriate prophylaxis
Critical care		
Critical care	• All patients	*Type*: LDUH or LMWH
	• Major trauma or orthopedic surgery	Dose: See minimum prophylaxis dose in Table 5, technical appendix.
		Duration: LOS-1 (medical) LOS-2 (surgical)
		Type: LMWH
		Dose: See minimum prophylaxis dosein Table 5, technical appendix.
		Duration: LOS -1 (trauma) LOS-2 (orthopedic surgery)

Table 4 continued

Study cohort	Additional stratification	Appropriate prophylaxis
General, transplant, vascular, gynecologic, urologic, laparoscopic surgery		
General	• Non-major surgery, age less than 40, additional risk factors, or • Non-major surgery, age 40–60, regardless of risk factors, or • Major surgery, age less than 40, regardless of risk factors	*Type*: LDUH, LMWH, GCS or IPC Dose: LDUH (10,000 units/day); LMWH (≤3,400 IU/day) Duration: LOS-2
	• Non-major surgery, age 60 or older, and with or without risk factors, or • Major surgery, greater than 60 years of age, and with no risk factors, or • Major surgery in patients <40, additional risk factors, or • Major surgery in patients between the ages of 40–60	*Type*: LDUH, LMWH Dose: LDUH (15,000 units/day), LMWH (>3,400 IU/day) Duration: LOS-2
	• Major surgery with greater than 60 years of age with additional risk factors	*Type*: LDUH + (GCS or IPC), or LMWH + (GCS or IPC) Dose: LDUH (15,000 units/day), LMWH (>3,400 IU/day) Duration: LOS-2
Transplant	*Note*: This is part of general surgery and will be treated as such	Same as general surgery
Vascular	None	*Type*: LDUH or LMWH Dose: See minimum prophylaxis dose in Table 5, technical appendix. Duration: LOS-2
Gynecologic	• Major GYN surgery (benign disease) and no additional risk factors	*Type*: LDUH, LMWH, or IPC Dose: LDUH (10,000 units/day) LMWH(≤3,400 IU/day) Duration: LOS-2
	• Major GYN surgery with malignant GYN neoplasms, regardless of risk factors	*Type*: LDUH, LMWH, IPC or LDUH/LMWH with GCS/IPC
	• Major GYN surgery(benign disease) and additional risk factors	Dose: LDUH 15,000 units/day) LMWH (>3,400 IU/day) Duration: LOS-2
	• Laproscopic GYN procedures with additional risk factors	*Type*: LDUH, LMWH, IPC, or GCS Dose: See minimum prophylaxis dose in Table 5, technical appendix. Duration: LOS-2
Urologic	• One or no risk factors	*Type*: LDUH or GCS or IPC Dose: LDUH (10,000 units/day) Duration: LOS-2
	• Two or more risk factors	*Type*: LDUH + GCS or IPC, LMWH + GCS or IPC Dose: LDUH (10,000 units/day), LMWH (See minimum prophylaxis dose in Table 5, technical appendix.) Duration: LOS-2
Laparoscopic	None	*Type*: LDUH, LMWH, GCS, IPC Dose: See minimum prophylaxis dose in Table 5, technical appendix. Duration: LOS-2
Orthopedic Surgery		
Elective hip arthroplasty	None	*Type*: LMWH, fondaparinux or VKA Dose: LMWH (>3,400 IU/day), Fondaparinux (2.5 mg/day), VKA (regardless of the dose) Duration: LOS-2

Table 4 continued

Study cohort	Additional stratification	Appropriate prophylaxis
Elective knee arthroplasty	None	*Type*: LMWH, Fondaparinux or VKA
		Dose: LMWH (>3,400 IU/day), Fondaparinux (2.5 mg/day), VKA (regardless of the dose)
		Duration: LOS-2
Knee arthroscopy	None	*Type*: LMWH
		Dose: See minimum prophylaxis dose in Table 5, technical appendix.
		Duration: LOS-2
Hip fracture surgery		*Type*: LMWH, fondaparinux, VKA, LDUH
		Dose: LMWH(>3,400/day) Fodaparinux (2.5 mg/day) VKA (regardless of dose) LDUH (10,000 units/day)
		Duration: LOS-2
Elective spine surgery	• One or no additional risk factors	*Type*: LDUH, LMWH, IPC, or GCS
		Dose: See minimum prophylaxis dose in Table 5, technical appendix.
		Duration: LOS-2
	• Two or more risk factors	*Type*: LDUH + (any GCS or IPC), LMWH + (any GCS or IPC)
		Dose: See minimum prophylaxis dose in Table 5, technical appendix.
		Duration: LOS-2
Neurosurgery		
Neurosurgery	• Age less than 40 with additional risk factor	*Type*: LMWH, UFH, IPC or GCS
		Dose: See minimum prophylaxis dose in Table 5, technical appendix.
		Duration: LOS-2
	• Age 40 or above regardless of risk factors	*Type*: LMWH + (IPC or GCS), or UFH + (IPC or GCS)
		Dose: See minimum prophylaxis dose in Table 5, technical appendix.
		Duration: LOS-2
Trauma, spinal cord injuries, burns		
Trauma	None	*Type*: LMWH, GCS or IPC
		Dose: See minimum prophylaxis dose in Table 5, technical appendix.
		Duration: LOS-1
Spinal cord injuries	None	*Type*: LMWH, LMWH + IPC, or LDUH + IPC
		Dose: See minimum prophylaxis dose in Table 5, technical appendix.
		Duration: LOS-1
Burns	None	*Type*: LDUH or LMWH
		Dose: See minimum prophylaxis dose in Table 5, technical appendix.
		Duration: LOS-1
Acutely Ill medical patients		
Heart failure	None	*Type*: LDUH or LMWH
		Dose: See minimum prophylaxis dose in Table 5, technical appendix.
		Duration: LOS-1

Table 4 continued

Study cohort	Additional stratification	Appropriate prophylaxis
Severe respiratory infection	None	*Type*: LDUH or LMWH Dose: See minimum prophylaxis dose in Table 5, technical appendix. Duration: LOS-1
Acute myocardial infraction	None	*Type*: LDUH or LMWH Dose: See minimum prophylaxis dose in Table 5, technical appendix. Duration: LOS-1
Stroke	None	*Type*: LDUH or LMWH Dose: See minimum prophylaxis dose in Table 5, technical appendix. Duration: LOS-1
Severe infectious disease	None	*Type*: LDUH or LMWH Dose: See minimum prophylaxis dose in Table 5, technical appendix. Duration: LOS-1
Cancer		
Without surgery (medical conditions)		Assessed according to the accompanying medical condition

Table 5 Label based dosing for pharmacologic prophylaxis and the minimum dose per day utilized in the study

Drugs	Label prophylaxis dosing regimen	Minimum (per day)
Fondaparinux		
Fondaparinux (Arixtra®)—THR, TKR, HFS, abdominal surgery	2.5 mg SQ QD	2.5 mg
UFH		
Heparin	5,000 USP units SQ 2–3 times per day; 7,500 USP units SQ 2 times per day	10,000 IU SQ
LMWH		
Tinzaparin (Innohep®)	75 units/kg	4,500 IU*
Dalteparin (Fragmin®)—THR, abdominal surgery, medically ill	2,500–5,000 anti-Xa IU SQ QD	2,500 IU
Enoxaparin (Lovenox®)—THR, TKR, abdominal surgery, medically ill	30 mg SQ BID or 40 mg QD (obese patient = 40 mg BID; renal dosing = 30 mg QD)	30 mg (3,000 IU)
VKA		
Warfarin	2–10 mg PO QD adjusted to INR = 2–3	2 mg

*Assuming an average body weight of 60 KG

BID: twice daily; *HFS* hip fracture surgery; *INR* international normalized ratio; *IU* international units; *SQ* subcutaneous; *QD* once daily; *THR* total hip replacement; *TKR* total knee replacement

Sources: Package labeling; Nutescu EA, Wittkowsky AK, Dobesh PP, Hawkins DW, Dager WE. Choosing the appropriate antithrombotic agent for the prevention and treatment of VTE: a case-based approach. *Ann Pharmacother* 2006 Sep;40(9):1558-71. Epub 2006 Aug 15

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