Original Investigation

Venous Thromboembolism After Trauma
When Do Children Become Adults?

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IMPORTANCE No national standardized guidelines exist to date for venous thromboembolism (VTE) prophylaxis after pediatric trauma. While the risk of VTE after trauma is generally lower for children than for adults, the precise age at which the risk of VTE increases is not clear.

OBJECTIVE To identify the age at which the risk of VTE after trauma increases from the low rate seen in children toward the higher rate seen in adults.

DESIGN, SETTING, AND PARTICIPANTS Multivariable logistic regression models were used to estimate the association between age and the odds of VTE when adjusting for other VTE risk factors. Participants included 402 329 patients 21 years or younger who were admitted following traumatic injury between January 1, 2008, and December 31, 2010, at US trauma centers participating in the National Trauma Data Bank.

MAIN OUTCOMES AND MEASURES Diagnosis of VTE as a complication during hospital admission.

RESULTS Venous thromboembolism was diagnosed in 1655 patients (0.4%). Those having VTE were more severely injured compared with those not having VTE and more frequently required critical care, blood transfusion, central line placement, mechanical ventilation, and surgery. The risk of VTE was low among younger patients, occurring in 0.1% of patients 12 years or younger, but increased to 0.3% in patients aged 13 to 15 years and to 0.8% in patients 16 years or older. These findings remained when adjusting for other factors, with patients aged 13 to 15 years (adjusted odds ratio, 1.96, 95% CI 1.53-2.52; $P < .001$) and patients aged 16 to 21 years (adjusted odds ratio, 3.77; 95% CI, 3.00-4.75; $P < .001$) having a significantly higher odds of being diagnosed as having VTE compared with patients aged 0 to 12 years. These findings were consistent across the level of injury severity and the type of trauma center.

CONCLUSIONS AND RELEVANCE The risk of VTE varies considerably across patient age and increases most dramatically at age 16 years, after a smaller increase at age 13 years. These findings can be used to guide future research into the development of standardized guidelines for VTE prophylaxis after pediatric trauma.

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Adult patients hospitalized after major trauma are at high risk of venous thromboembolism (VTE), comprising deep venous thrombosis (DVT) and pulmonary embolism (PE).[1] Therefore, pharmacologic VTE prophylaxis with low-molecular-weight heparin (LMWH) is a well-established practice after major trauma in all adult patients without contraindications.[2,3] However, the risk of VTE after pediatric trauma has been estimated to be low, approximately one-seventh the risk seen in adults.[4] Because of this lower risk, most surgeons have concluded that VTE prophylaxis is unnecessary for pediatric patients following trauma.

No national standardized guidelines for VTE prophylaxis after pediatric trauma exist to date. The precise age at which the risk of VTE increases is not clear; therefore, the specific age at which VTE prophylaxis is warranted is also unknown. Likely as a result, the use of pharmacologic VTE prophylaxis after pediatric trauma varies significantly, particularly among adolescents. Among trauma inpatients aged 11 to 15 years, a survey of 133 US trauma centers found that 13% of centers use LMWH often or always, 25% sometimes, and 62% rarely or never.[5] Among those aged 16 to 20 years, 57% of centers used LMWH often or always, 23% sometimes, and 20% rarely or never.

The objective of this study was to identify the age at which the risk of VTE after trauma increases from the low rate seen in children toward the higher rate seen in adults. We hypothesized that the risk of VTE after trauma would increase significantly at a precise and identifiable age independent of other VTE risk factors. These findings could then be used to guide further research on the most appropriate use of pharmacologic VTE prophylaxis after trauma, particularly among the adolescent population, for which practice varies widely.

Methods

Data Source

The study was approved as exempt by The Johns Hopkins Medicine Institutional Review Board, and informed consent was waived. This study used data from the National Trauma Data Bank (NTDB), which is a registry of US trauma data that is maintained by the American College of Surgeons and includes hospitalized patients with codes of 800.00 to 959.9 in the *International Classification of Diseases, Ninth Revision* (*ICD-9*).[6] Beginning in 2008, data collection was based on the National Trauma Data Standard, a standardized definition of the information that should be submitted to the NTDB by participating hospitals[6]; therefore, this study used a merged data set that included admission years 2008 to 2010.

Study Population and Covariates of Interest

All patients 21 years or younger who were admitted following traumatic injury were included in this study. Patients who were dead on arrival or who died in the emergency department were excluded. Patients who were discharged home, transferred to another facility, or left against medical advice from the emergency department were also excluded.

The outcome of interest was VTE (DVT or PE) diagnosed as a complication during the course of patient treatment. Final discharge disposition was also examined. The following covariates were addressed and considered for statistical modeling: patient demographics (including age, sex, race/ethnicity, and insurance status) and Glasgow Coma Scale (GCS) scores, the presence of obesity as a comorbidity, and the type and severity of traumatic injury (blunt, penetrating, or burn), as well as blood transfusion, central line placement, specific injury patterns, major surgical operations, intubation or days of mechanical ventilation, and length of critical care and length of stay in the hospital. The Injury Severity Score (ISS) was used to quantify the severity of trauma. Injuries to specific anatomic locations were identified using the Abbreviated Injury Scale score, with a severe injury being defined as a score of 3 or higher in a particular anatomic location.

Major surgery was defined as the following *ICD-9* operation codes: nervous system (01.xx-05.xx), respiratory system (30.xx-34.xx), cardiovascular system (35.xx-39.xx), hematopoietic and lymphatic system (ie, spleen operations) (40.xx-41.xx), digestive system (42.xx-54.xx), urinary system (55.xx-59.xx), and musculoskeletal system (77.xx-78.xx, 79.20-79.39, 79.50-79.69, 79.80-79.99, 81.xx, and 83.xx-84.xx).[7] The *ICD-9* codes for central line placement (38.93, 38.95, 38.97, 39.65, 89.62, 89.63, 89.64, and 89.66) and transfusion of blood products (99.00-99.09) were also examined.

Statistical Analysis

Characteristics of patients with and without VTE were compared using *t* tests or Wilcoxon rank sum tests for continuous variables and χ^2 tests or Fisher exact tests of independence for categorical variables. Multiple logistic regression models were used to evaluate the independent association of covariates with the diagnosis of VTE. Alternative models were compared using the Akaike information criterion. Age was categorized based on examination of the age-specific, unadjusted risks of VTE after confirming that doing so improved the models. The models were adjusted for center-level clustering to account for the lack of independence of patients cared for within trauma centers in terms of their likelihood to be diagnosed as having VTE.[8] Only covariates with missing data not exceeding 10% were considered for inclusion in the models. Missing data in the included covariates were handled using the missing indicator method, in which missing data are categorized as unknown, thereby allowing patients with missing data to contribute all other data points to the regression analyses.[9]

Given the possibility that older patients may also generally have higher injury severity, an interaction term was introduced into the models to assess for possible effect modification by injury severity on the relationship between age and the development of VTE. In addition, a subgroup analysis that included only patients with very severe injuries (ISS, ≥25) was performed. Finally, a sensitivity analysis was performed that included only patients treated in American College of Surgeons–verified or state-verified pediatric trauma centers that reported providing all acute care services for patients up to age 21 years. All tests were 2-sided, with statistical significance set at $\alpha = .05$. All analyses were performed using commercially available software (STATA 12.1/MP; StataCorp LP).

Table 1. Characteristics of the Study Population 21 Years or Younger in the National Trauma Data Bank (2008-2010), Stratified by the Presence of Venous Thromboembolism (VTE) as a Complication During Admission

Characteristic	No VTE (n = 400 674)	VTE (n = 1655)	*P* Value
Age, mean (SD), y	12.5 (6.8)	17.2 (4.7)	<.001
Female sex, %[a]	31.1	25.5	<.001
Race/ethnicity, %[b]			<.001
White	59.1	61.2	
Black	17.9	21.2	
Other	23.0	17.6	
Insurance status, %			.002
Private	41.0	40.6	
Public	29.2	26.8	
Self-pay	11.5	10.9	
Other or unknown	18.3	21.7	
Obesity, %	0.6	3.5	<.001
Mechanism of injury, %[a]			<.001
Blunt	78.9	75.9	
Penetrating	10.7	18.9	
Burn	3.5	1.6	
Other	7.0	3.6	
Injury Severity Score, %[a]			<.001
Mild, <9	47.5	4.5	
Moderate, 9-15	29.2	18.0	
Severe, 16-24	14.7	22.4	
Very severe, 25-75	8.6	55.1	
Glasgow Coma Scale score, %[b]			<.001
Mild injury, 13-15	90.4	48.0	
Moderate injury, 9-12	2.3	6.2	
Severe injury, 3-8	7.3	45.8	
Abbreviated Injury Scale score ≥3, %			
Head	17.3	39.8	<.001
Spine	1.2	8.1	<.001
Chest	12.3	46.7	<.001
Abdomen and pelvis	4.6	21.6	<.001
Lower extremities	8.1	33.9	<.001
Intubation, %	9.5	63.4	<.001
Mechanical ventilation, mean (SD), d	0.5 (2.8)	8.8 (11.9)	<.001
Required critical care, %	26.5	86.1	<.001
Length of stay in the intensive care unit, mean (SD), d	1.1 (3.9)	14.1 (14.7)	<.001
Blood transfusion, %[b]	2.6	21.5	<.001
Major surgery, %[b]	33.2	88.7	<.001
Central line placement, %[b]	5.0	35.0	<.001
Length of stay in the hospital, mean (SD), d	4.0 (6.8)	25.8 (22.0)	<.001

[a] Missing in 1% or less of admissions.

[b] Missing in 6% or less of admissions.

Results

Study Population

Between January 1, 2008, and December 31, 2010, a total of 402 329 patients aged 21 years or younger were admitted following traumatic injury at 718 participating trauma centers. A total of 1655 patients (0.4%) were diagnosed as having VTE during their admission, of which 1249 (0.3%) were diagnosed as having DVT alone, 332 (0.08%) as having PE alone, and 74 (0.02%) as having both DVT and PE.

Compared with those not having VTE, patients diagnosed as having VTE were significantly different with regard to every variable examined (**Table 1**). Those with VTE were significantly older, were more likely to be male, and (although uncommon) were more likely to be obese. Those with VTE were also significantly more severely injured, as measured by the ISS, the GCS score, and the presence of severe injuries in various anatomic locations, and had increased need for critical care, blood transfusion, mechanical ventilation, central line placement, and surgery. Patients who developed VTE required intubation in 63.4%, needed critical care in 86.1%, underwent major surgery in 88.7%, had a very severe injury (ISS, 25-75) in 55.1%, and had signs of a severe head injury (GCS score, 3-8) in 45.8%. As expected given this increased severity, patients with VTE also had a significantly longer length of stay in the hospital overall, as well as in the intensive care unit in particular.

Outcomes After VTE

Patients with VTE more frequently required transfer to another facility (rehabilitation, skilled nursing, long-term care, intermediate care, or another acute care hospital) compared with patients without VTE (**Table 2**). Of those with VTE, 51.8% were transferred to another facility, and 43.8% were discharged home. Of those without VTE, 6.0% were transferred to another facility, and 92.2% were discharged home. In addition, those having VTE more frequently died during their hospital admission (4.4%) compared with those not having VTE (1.8%).

Table 2. Outcomes of Admission for Traumatic Injury Among Patients 21 Years or Younger in the National Trauma Data Bank (2008-2010), Stratified by the Presence of Venous Thromboembolism (VTE) as a Complication During Admission

Outcome	% No VTE (n = 400 674)	% VTE (n = 1655)	*P* Value
Discharged to home	92.2	43.8	<.001
Transferred to other facility	6.0	51.8	<.001
Death	1.8	4.4	<.001

VTE and Age

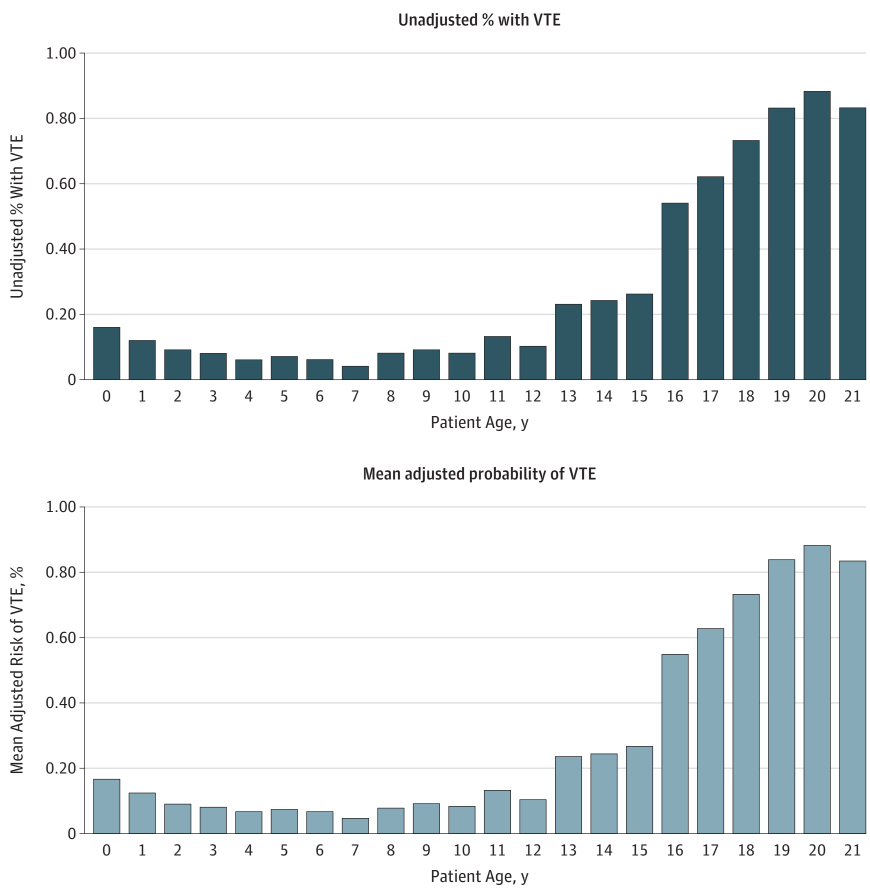
Unadjusted

The unadjusted risk of VTE was low (<0.2%) for all ages up to and including 12 years (**Figure**). Venous thromboembolism was more common in those aged 13 to 15 years, with a risk ranging from 0.2% to 0.3%. The risk of VTE then increased dramatically, more than doubling at age 16 years to 0.5% and climbing consistently thereafter until age 20 years. In fact, 82.8% of the VTE cases identified in this study were diagnosed in patients 16 years or older. Overall, VTE was diagnosed in 0.1% of those aged 0 to 12 years, in 0.3% of those aged 13 to 15 years, and in 0.8% of those aged 16 to 21 years.

Adjusted

After adjusting for other factors, the risk of VTE remained low among younger patients and was significantly increased among

Figure. Unadjusted and Adjusted Risk of Venous Thromboembolism (VTE) After Trauma Across Patient Age



The mean adjusted probabilities of VTE are from a multiple logistic regression model.

adolescents and young adults (Figure). Specifically, patients aged 13 to 15 years had an almost 2-fold higher odds of being diagnosed as having VTE compared with patients aged 0 to 12 years (adjusted odds ratio [aOR], 1.96; 95% CI, 1.53-2.52; $P < .001$), and patients aged 16 to 21 years had an almost 4-fold higher odds of being diagnosed as having VTE compared with patients aged 0 to 12 years (aOR, 3.77; 95% CI, 3.00-4.75; $P < .001$) (**Table 3**). In addition, patients aged 16 to 21 years had significantly higher odds of VTE compared with those aged 13 to 15 years (aOR, 1.92; 95% CI, 1.57-2.36; $P < .001$).

No significant interaction was identified between patient age and injury severity ($P > .10$ for all interaction terms), suggesting that the relationship between age and VTE was not modified by injury severity. In addition, in the subgroup analysis that included only patients with very severe injuries (ISS, ≥25), the inferences remained the same, with patients aged 13 to 15 years (aOR, 1.75; 95% CI, 1.19-2.57; $P = .004$) and patients aged 16 to 21 years (aOR, 3.13; 95% CI, 2.28-4.31; $P < .001$) having significantly higher odds of VTE compared with patients aged 0 to 12 years.

Finally, among patients treated in verified pediatric trauma centers that provide all acute care services for patients up to age 21 years, the relationship between age and VTE risk remained. Patients aged 13 to 15 years (aOR, 2.39; 95% CI, 1.18-4.38; $P = .01$) and patients aged 16 to 21 years (aOR, 4.89; 95% CI, 2.73-8.74; $P < .001$) had significantly higher odds of VTE compared with patients aged 0 to 12 years.

Other VTE Risk Factors

Age-specific differences in the risk of VTE were independent of other variables that were significantly associated with the diagnosis of VTE. Specifically, self-pay status and race/ethnicity other than black or white were associated with a lower odds of VTE, while obesity, intubation, blood transfusion, decreasing GCS score, central line placement, increasing injury severity, major surgical procedures, and longer length of stay in the hospital were associated with a higher odds of VTE (Table 3).

Table 3. Association of Various Patient Characteristics With the Likelihood of Developing Venous Thromboembolism (VTE) During Hospital Admission After Traumatic Injury

Characteristic	Adjusted Odds Ratio (95% CI)[a]	*P* Value
Age, y		
0-12	1 [Reference]	
13-15	1.96 (1.53-2.52)	<.001
≥16	3.77 (3.00-4.75)	<.001
Female sex	0.92 (0.83-1.03)	.10
Race/ethnicity		
White	1 [Reference]	
Black	0.98 (0.84-1.14)	.80
Other	0.68 (0.56-0.81)	<.001
Obesity	3.03 (2.25-4.08)	<.001
Injury Severity Score		
Mild, <9	1 [Reference]	
Moderate, 9-15	3.95 (3.07-5.08)	<.001
Severe, 16-24	5.94 (4.55-7.75)	<.001
Very severe, 25-75	7.19 (5.39-9.60)	<.001
Glasgow Coma Scale score		
Mild injury, 13-15	1 [Reference]	
Moderate injury, 9-12	1.34 (1.02-1.77)	.04
Severe injury, 3-8	1.31 (1.11-1.55)	.002
Mechanism of injury		
Blunt	1 [Reference]	
Penetrating	1.01 (0.86-1.17)	.90
Burn	1.11 (0.70-1.74)	.70
Other	0.79 (0.57-1.10)	.20
Insurance		
Private	1 [Reference]	
Public	1.00 (0.86-1.11)	.90
Self-pay	0.76 (0.62-0.94)	.01
Other or unknown	1.19 (0.97-1.46)	.09
Central line placement	1.33 (1.12-1.57)	.001
Blood transfusion	1.47 (1.21-1.77)	<.001
Intubation	2.54 (2.05-3.14)	<.001
Major surgery	3.84 (2.97-4.99)	<.001
Length of stay in the hospital, per day	1.03 (1.03-1.03)	<.001

[a] The adjusted odds ratios of VTE are from a multiple logistic regression model adjusting for all variables in the table.

Discussion

This large national study of pediatric and adolescent patients admitted for traumatic injury during a 3-year period found that the most dramatic increase in the risk of VTE occurred at age 16 years, after a smaller increase at age 13 years. Most important, the increased risk of VTE among these older patients was independent of other factors significantly associated with the development of VTE, specifically obesity, race/ethnicity, and insurance status, as well as intubation, GCS score, injury severity, blood transfusion, central line placement, and surgery, and length of stay in the hospital, suggesting that this increased risk was not merely due to greater severity of injury or the presence of other VTE risk factors among older patients. In addition, this relationship between age and VTE risk was not modified by injury severity.

Venous thromboembolism is considered the most common preventable cause of hospital death among adults and has been identified by the surgeon general as a major national priority.[10,11] However, previous studies[4,12-18] have found a low risk of VTE after pediatric trauma, with estimates ranging from 0.3 to 3.3 VTE cases per 1000 trauma admissions. Similarly, low rates of VTE have been found in the general hospitalized pediatric population,[19-21] although the diagnosis of VTE in children has increased in recent years.[22] Our study found an overall risk of 0.4%, or 4 VTE cases per 1000 patients, among all patients 21 years or younger who were admitted to the hospital following traumatic injury. Ultimately, the specific rate identified depends entirely on the choice of study population (ie, all patients seen at trauma centers vs only those admitted vs only those severely injured, etc). For example, in studies[23,24] limited to children admitted to the intensive care unit, a VTE risk as high as 5% to 6% has been found. While the NTDB has historically underreported complications,[25,26] the quality of data used in our study was improved significantly given the implementation of the National Trauma Data Standard.

The relative rarity of VTE in pediatric trauma patients seems to have led most surgeons to conclude that pharmacologic VTE prophylaxis is unnecessary, although practices vary considerably among adolescent trauma patients.[5] At our institution, patients 15 years or older are admitted to the adult trauma service and treated as adults. They undergo risk assessment and are administered pharmacologic prophylaxis primarily with LMWH (enoxaparin sodium [30 mg] subcutaneously twice per day) when deemed appropriate using a computerized clinical decision support tool that assesses VTE risk factors and contraindications to prophylaxis.[27] On the other hand, patients younger than 15 years are admitted to the pediatric trauma service and are not routinely given pharmacologic prophylaxis. These institutional practices, along with the lack of national consensus about which children and adolescents should receive VTE prophylaxis after trauma, motivated us in the present study to more closely examine the specific age at which the risk of VTE increases after traumatic injury.

Consistent with our study, increasing age has been identified in other studies[19,28,29] as a risk factor for VTE among hospitalized children. Age is also a well-known risk factor for VTE after trauma in the adult population.[7,30] However, the association between patient age and the risk of VTE after pediatric trauma has often been assumed to be a gradual, linear increase in VTE risk with increasing age. Instead, we found a generally low and constant risk of VTE among younger children, after which the risk of VTE rose quickly toward previously estimated "adult" levels of risk.[7] It is important to emphasize that our identification of an increased VTE risk beginning at age 13 years and to a greater extent at age 16 years must be considered general estimates more so than precise thresholds. In other words, although in a large population we have identified that the VTE risk increased at these ages, significant individual variability with regard to growth patterns and hormonal changes is also likely among these adolescents. While previous studies[19,28] have also found a higher risk of VTE among children younger than 1 year, the risk of VTE in children that young in the present study (although slightly higher) was considerably lower than that in older adolescent patients.

Other risk factors for VTE after pediatric trauma that must be considered include higher ISS, lower GCS score, the use of central venous catheters, and craniotomy, laparotomy, and spinal operations, as well as head, thoracic, abdominal, lower extremity, and spinal injuries.[4,13,16,31] In addition, a significantly higher risk of VTE has been found in severely injured patients requiring critical care.[24] These risk factors, along with consideration of the ages identified in this study at which VTE risk begins to rise considerably, may allow for the development of a more standardized approach to recognize a subset of pediatric trauma patients at significant risk of VTE that would justify the use of prophylaxis with LMWH. Implementation of such a standardized approach to VTE prevention has been shown to improve VTE prophylaxis rates among hospitalized pediatric patients[32] and adult trauma patients[27] and decrease the incidence of VTE among critically ill children after trauma.[23]

The primary limitation of this study is the potential for surveillance bias, a significant problem when examining rates of VTE after trauma.[33-35] In other words, variation may exist in the detection of the outcome (VTE in this case) at different levels of the examined exposure (age in this case). Ideally, we could have closely examined duplex ultrasonography use to better assess this potential for surveillance bias. However, only 23.6% of the patients diagnosed as having DVT in this study were recorded as undergoing ultrasonography, demonstrating how such diagnostic studies are poorly captured in the NTDB, a limitation that has also been noted when using other administrative databases.[36] However, even if studies to investigate for VTE were indeed completed more frequently among older patients, this difference could be due not only to bias among care providers toward a higher suspicion for VTE among older patients but also to the increased necessity for VTE studies based on signs or symptoms that accompany the actual presence of VTE.

Significant variation in screening practices for asymptomatic DVT in high-risk trauma patients also exists[37]; this practice is likely more common at adult trauma centers compared with pediatric ones. To explore the possibility that older patients in this study had an increased VTE risk simply because they were more likely to be treated at adult trauma centers (where screening is more common), our sensitivity analysis examined a more homogeneous subset of patients treated only at pediatric trauma centers and found that the same relationship between age and VTE risk remained even in those centers with likely more uniform (and less common) VTE screening practices.

It is important to note that (if indeed present) surveillance bias could potentially mask an increased risk of VTE at younger ages (ie, limit the identification of VTE in younger populations that are less likely to be examined for VTE), but the significant risk of VTE among older children would be stable. In other words, despite the potential for surveillance bias, one can confidently state that older adolescent patients are at considerable risk of VTE. On the other hand, one cannot definitely conclude that the risk of VTE among younger patients is minimal because the risk could be higher with additional surveillance, especially considering the frequency with which VTE can be asymptomatic.[38]

In addition to potential surveillance bias, this study is limited in that certain variables are not captured by the NTDB. For example, the use of pharmacologic or mechanical VTE prophylaxis is not included in the NTDB; therefore, variations in VTE prophylaxis across patient age could not be accounted for or examined. The absence of these data prevents the important distinction between potentially preventable VTE (ie, patients who did not receive prophylaxis) and nonpreventable VTE (ie, patients who developed VTE despite prophylaxis measures). However, in terms of identifying the age at which VTE risk increases, the use of VTE prophylaxis is likely more common among older patients compared with younger patients. Therefore, any resulting bias from this increased use of VTE prophylaxis among older patients would in fact attenuate, not exaggerate, the increased VTE risk that we report among older patients. Finally, dates of procedures and the onset of diagnoses are not provided. Without these temporal patterns, definitive causality between central line placement and the subsequent development of VTE, for example, cannot be evaluated using the NTDB.

In conclusion, this national study closely examined the relationship between age and the risk of VTE after pediatric trauma and found a dramatic increase in the risk of VTE at age 16 years, after a smaller increase at age 13 years, independent of other VTE risk factors. In fact, there appear to be defined ages at which children become more like adults in terms of their VTE risk after trauma. Given the current variability in VTE prophylaxis among these older adolescents, a considerable subset of trauma patients is likely being omitted from the appropriate use of VTE prophylaxis. The results of this study can be used to guide future research into the development of standardized guidelines for VTE prophylaxis after pediatric trauma, focusing the use of VTE prophylaxis on the most appropriate patients to reduce the risk of this preventable and costly complication.

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Invited Commentary

Venous Thromboembolism Prevention in Pediatric Trauma—Time for National Guidelines

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The prevention of venous thromboembolism (VTE), including deep venous thrombosis and pulmonary embolism, in trauma patients is an important goal for all who provide care for adult trauma patients. Venous thromboembolism prophylaxis is a critical component of our trauma admission orders and performance improvement program. The American College of Surgeons Trauma Quality Improvement Program in 2012 added VTE prophylaxis to its process-of-care measures and to the National Trauma Data Standard.[1]

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National evidence-based guidelines for VTE prevention in adult trauma were updated in 2012, providing specific recommendations for pharmacologic or mechanical prophylaxis.[2] But this is not true for pediatric trauma. At present, there are no national clinical practice guidelines for VTE prevention in the pediatric and adolescent trauma setting. The only guideline available is for VTE treatment in the general pediatric population.[3]

Van Arendonk and colleagues,[4] in this issue of the journal, provide important data for the trauma community confirming that age-specific differences in the risk of VTE were independent of other variables that were significantly associated with VTE. The VTE risk was significantly higher in pediatric trauma patients 13 years or older and was even higher in those aged 16 to 21 years, independent of other risk factors.

While the incidence of VTE is considerably lower in children than in adults, 2009 data document that VTE incidence in the general pediatric population has significantly increased by 70%.[5] Furthermore, the reported consequences of VTE in children are substantial, with a 9% mortality rate, a 16% to 20% pulmonary embolism rate, and a 20% postthrombotic syndrome rate.

The study by Van Arendonk and coworkers has highlighted the importance of and need for VTE prevention in pediatric trauma, and the significant strengths of this important study are clear. These include national data (from the National Trauma Data Bank) that are representative of many trauma centers, as well as a large sample size (400 674 patients without VTE vs 1655 patients with VTE) and an excellent analysis of a complex data set with multiple covariates.

A few study limitations warrant further examination. First, the cause of mortality (related to VTE or not) was unavailable. Patients with VTE had a significantly higher death rate (4.4% vs 1.8%), but the authors were unable to determine whether this increased mortality was related to VTE because of National Trauma Data Bank limitations. Second, data regarding the use and compliance of pharmacologic and mechanical VTE prophylaxis were also not available. This study could not determine what percentage of VTEs reported are potentially preventable (ie, those due to lack of VTE prophylaxis vs due to failure of VTE prophylaxis, which is commonly related to compliance issues). Third, low VTE rates may reflect underreporting. Overall low VTE rates (0.1% for patients ≤12 years, 0.3% for patients 13-15 years, and 0.8% for patients 16-21 years) and a low rate of duplex ultrasonography use (23.6%) suggest underreporting in pediatric trauma.