Use of Low-Molecular-Weight Heparin and a Deep Vein Thrombosis Protocol to Prevent DVT in Elderly Patients With Trauma

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Abstract

Thromboembolic events (TEs), including pulmonary embolisms (PEs), are life threatening. Older patients with trauma are at significantly higher risk for these complications. In March 2003, a deep vein thrombosis (DVT) prophylaxis protocol was implemented for use in all trauma patients admitted to our hospital. Here we report on the results of using this protocol for patients aged 65 years or older.

A risk-stratified DVT/PE prophylaxis protocol was developed, incorporating specific injuries and history and physiologic parameters, which favored aggressive therapy and included patients at highest risk for dying from PEs. Between March 2003 and June 2005, these data were collected on all trauma patients admitted to our level I hospital. Comparisons were made with historical controls (patients admitted in 2002, before implementation of this protocol).

TE rates for the study period trended lower for patients aged 65 or older (6.4% vs 2.2%, *P*<.1). This protocol did not increase the incidence of bleeding events in this patient population.

Protocol-based, risk-adjusted DVT/TE prophylaxis is safe and efficacious in elderly trauma patients who are at increased risk for TEs.

Thromboembolic events (TEs), such as deep vein thrombosis (DVT) and pulmonary embolism (PE), are common in patients with trauma.[1] The range of DVT rates in this population is 5% to 58%.[1,2] Depending on how aggressively PEs are sought, the rates vary from 1% to 2% and reflect the severity of patient injuries and age.[3,4] Investigators have emphasized the importance of age as an associated risk factor in the development of DVT.[5,6] In addition, presence of orthopedic injuries, most commonly spine, long bone, or pelvic fractures, have been shown to be associated with an increase in the incidence of DVT and TEs.[5,7] The major concern with development of DVT is a PE, and the elderly patient with trauma is least likely to be able to survive such an event. In addition to posing a risk of PE, DVT may lead to postthrombotic syndrome, with chronic venous stasis, leg swelling, pain, and ulcerations.

Given the consequences of DVT, attempts have been made to develop guidelines for prophylaxis in various patient populations.[8] Recently, low-molecular-weight heparin (LMWH) has been shown to be helpful in decreasing the incidence of DVT.[9-11] Furthermore, Schiff and colleagues[12] showed that LMWH may be superior to other pharmacologic agents used for DVT prophylaxis.

To be effective, each protocol must be well designed, based on available information, and implemented properly and formally.[10] A major concern in using pharmacologic DVT prophylaxis is bleeding. In addition, despite the thoroughness of a protocol, some patients may still experience a TE.

Our trauma service created and implemented a DVT prophylaxis protocol using LMWH for 26 months before implementing this protocol hospital-wide. This study reviewed the safety and efficacy of this protocol in our elderly trauma population, including patients with an orthopedic injury.

Materials and Methods

Using a modified Delphi approach, our multidisciplinary trauma performance improvement team developed a risk-stratified DVT/PE prophylaxis protocol in an effort to standardize DVT/PE prophylaxis in our patients with trauma. The original protocol incorporated not only specific injuries but also pertinent history and physiologic parameters to determine the recommended prophylactic regimen to be followed (Appendix A). Attempts were made to identify patients most likely to benefit from the more costly and potentially more risky LMWH. More aggressive therapy was always favored in patients at highest risk for dying from a PE. Duplex scanning was also prescribed in the guideline. Before implementation, general surgery trauma residents and orthopedic residents, as well as core faculty on both services, were instructed on the details of the protocol and its use. Each group was

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Table I. Demographics of Patients in Each Group[a]

Group	2002-E	2002-Y	2003-E	2003-Y	2004-E	2004-Y	2005-E1	2005-Y1	2005-E2	2005-Y2
Patients, No.	125	1222	137	1125	179	1303	130	559	229	673
E:Y ratio	1:10	1:10	1:8	1:8	1:7	1:7	1:4	1:4	1:3	1:3
Mean TRISS	.861	.921	.870	.915	.829	.898	.877	.892	.914	.920
Median ISS	9	9	9	9	10	10	13	9	9	9
Mean age, y	76	34	78	35	77	35	77	37	79	38

Abbreviations: 1, first half of 2005; 2, second half of 2005; E, elderly (≥65 years old); ISS, Injury Severity Score; TRISS, Trauma and Injury Severity Score; Y, younger (<65 years).
[a]*P* value not significant for all between-groups comparisons, except age; 2005 was split because of a guideline change.

Table II. Total Incidence of TEs (Deep Vein Thrombosis, Pulmonary Embolism) and Incidence of TEs for Each Group

	No. (%) of Patients				
Group	Total	DVT	PE	TE	*P* Value[a]
2002-E	124	7 (5.6%)	3 (2.4%)	8 (6.4%)	
2002-E with F/OI	58 (46%)			5 (8.6%)	.1
2003-E	137	2 (1.4%)	1 (0.72%)	3 (2.2%)	
2003-E with F/OI	45 (33%)			3 (6.7%)	.1
2004-E	79	6 (3.4%)	3 (1.7%)	8 (4.5%)	
2004-E with F/OI	67 (37%)			7 (10.4%)	.1
2005-E1	130	3 (2.3%)	1 (0.76%)	4 (3.1%)	
2005-E1 with F/OI	59 (45%)			4 (6.8%)	NS
2005-E2	229	2 (0.87%)	4 (1.7%)	6 (2.1%)	
2005-E2 with F/OI	139 (61%)			4 (2.9%)	NS

Abbreviations: 1, first half of 2005; 2, second half of 2005; DVT, deep vein thrombosis; E, elderly (≥65 years old); F/OI, fracture or orthopedic injury; NS, not significant; PE, pulmonary embolism; TE, thromboembolic event.
[a]*P* = .1 for 2002-E with F/OI vs 2005-E2 with F/OI.

regularly and repeatedly reacquainted with the protocol.

The protocol was implemented in March 2003 and used continually through June 2005; it was implemented hospital-wide the last 6 months of 2005. The major difference between these protocols is that, in the hospital-wide version, LMWH was recommended for all trauma patients who required pharmacologic prophylaxis, and a printed physician order form was included to further improve adherence. Although the hospital-wide protocol no longer incorporated duplex scanning, such scanning had become standard practice among trauma team members. Both protocols were reviewed and approved by our hospital pharmacy and therapeutics committee, and both were approved by the human subjects committee.

Our trauma registry was interrogated for 2002, the year before protocol implementation, to determine historical DVT and PE rates for all patients with trauma. Hospital discharge codes were also investigated and cross-referenced with the trauma registry to ensure that all patients were included.

Prospective data from March 2003 through June 2006 were collected for all patients admitted to the trauma service. Data collected included age; DVT; PE; prophylaxis used; injuries; Trauma and Injury Severity Score (TRISS); Injury Severity Score (ISS); outcomes; and adverse events, including bleeding. The data were separated by patient age on admission—age 65 or older vs age younger than 65. DVT was documented in cases in which Doppler ultrasound or computed tomography (CT) showed a DVT above the knee or within the internal jugular and axillary veins. Below-knee clots were monitored; only those that progressed above the knee were considered DVTs. All suspected PEs were confirmed by CT. Patients with more than 1 PE or DVT were counted only once for TEs. Patients admitted to the neurosurgical service often did not receive pharmacologic DVT prophylaxis because of the risk of bleeding and were not included in the study. Two-tailed χ^2 analysis was performed to compare results.

Results

Of the 5682 patients enrolled in the study, 800 were age 65 or older (mean age, 77 years). There were no differences in TRISS or ISS between the age groups. The number of older patients with trauma increased considerably between the start of data collection and the end of 2005. The ratio of elderly to nonelderly patients enrolled in the study increased from 1:1 (2002) to 1:3 (2005). Mean ages

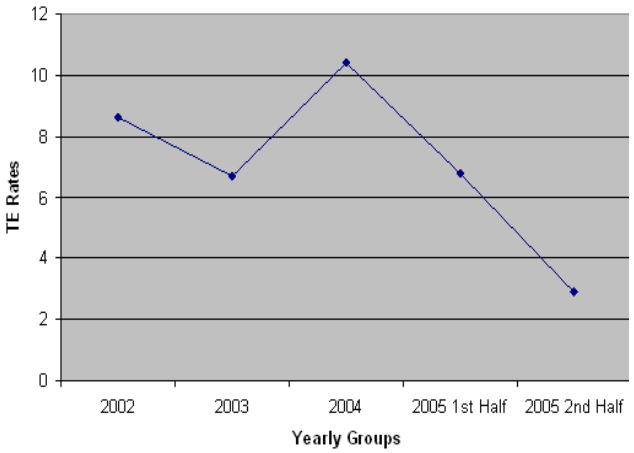

Figure. Thromboembolic event (TE) rates for trauma patients aged 65 or older with an orthopedic injury, over time.

of the elderly and nonelderly groups did not differ during the study (Table I).

The percentage of elderly patients with an orthopedic injury also increased between the start of enrollment in 2003 (33%) and the end of 2005 (61%) (Table II). The TE rate was higher in elderly patients with an orthopedic injury than in elderly patients without an orthopedic injury and in trauma patients younger than age 65. For elderly patients, the TE rate decreased during the study, but this change was not significant ($P>.05$); the same was true for elderly patients with an orthopedic injury (TE rate decreased from 8.6% to 2.9%; $P = .1$) (Table II). More important, these decreases were maintained over time (Figure). In late 2005, the TE rate for elderly trauma patients with an orthopedic injury (2.9%) nearly equaled that for elderly patients without an orthopedic injury (2.1%).

Total number of TEs remained similar over the study period, as the population of patients generally increased, leading to an overall lower rate over time. As the study continued and the prophylaxis protocol was adopted hospital-wide, the number of TEs associated with incorrect prophylaxis decreased to 0 (Table III). Over the entire study, there was only 1 significant bleeding episode potentially related to the protocol. The patient, who was in the 2002 pre-protocol unfractionated heparin group, had a 4-unit gastrointestinal bleed. Over the study, 2 patients had complications associated with inferior vena cava filters. In one case, the filter clotted, and the patient required long-term anticoagulation; in the other case, an atrial tear developed while the filter was being placed, and the patient died. Both patients had absolute contraindications to anticoagulation at time of filter placement and known DVTs. During this study, there was no increase in the number of postoperative wound infections in the orthopedic or the general trauma patients.

Discussion

TEs (including PEs leading to death), particularly in elderly patients, are not terribly uncommon. Using venography, Geerts and colleagues [1,13] found a DVT rate of 58% and a proximal DVT rate of 18%. On the other hand, with use of serial duplex examinations in a similar patient population, Knudson and colleagues[1,2] found a lower DVT rate. Integral to prevention of DVTs is the subsequent prevention of PEs, which are more common among patients with DVTs. An estimated 18 DVTs occur for each PE that is found.[5,14] The incidence may be even lower when more sensitive means of detecting PEs (eg, multi-slice CT) are used. In the trauma population, PE rates (1%-2%) vary according to injury severity. The exact incidence of PE has been studied by many investigators. Maxwell and colleagues,[3] using ventilation-perfusion scans and pulmonary angiography to diagnosis PE, found a rate of 0.9%, whereas McMurtry and colleagues[4] used pulmonary angiography and found a rate of 0.4%. Results from these studies confirmed that certain injury patterns and comorbid health states could raise the risk of TE. High among these risks is older age, with increased risks starting at age 40.[5]

The older patient with trauma is inherently different from the younger patient with trauma, particularly with respect to response to injury and treatments. Our study showed that the number of elderly patients continued to increase as a proportion of the total trauma population over the 4 years studied. Patients 65 years or older often have comorbid conditions that increase their risk for morbidity and mortality after trauma. PEs can result in a more serious course for older patients, given the frailty of their cardiovascular systems. Concurrent lung and cardiac conditions can lead to severe deterioration after PEs—as compared with the mild effects often found with PEs in younger patients. In addition, bleeding complications are less well tolerated in the older group. Patients with critical cardiac lesions are more likely to have a myocardial infarction if their hemoglobin level decreases below 10 g/dL. For this reason, any DVT

Table III. Number of Thromboembolic Events (TEs) and TEs With Incorrect Thromboprophylaxis During Each Period

Period	No. of TEs	No. of TEs With Incorrect Prophylaxis
2002	26	Not applicable
2003	12	Unavailable
2004	31	7
2005 first half	13	3
2005 second half	20	0

algorithm using pharmacologic prophylaxis must be well developed and tailored to the patient population so as not to cause excess bleeding.

Although PEs can be life-threatening, DVTs can also cause considerable morbidity. Postthrombotic syndrome, marked by chronic venous stasis ulcers, swelling, and pain in the lower extremities, can follow development of a DVT. Prandoni and colleagues[15] found that the cumulative frequency of postthrombotic syndrome after DVT was 17% (1-year follow-up) and 29% (8 year follow-up). This condition may be especially devastating for the older patient and may lead to the need for long-term, costly, and relatively unsuccessful interventions. In addition, this population often has peripheral vascular disease and diabetes, making the healing of these lesions even more difficult.

Given the morbidity and mortality of TEs in elderly patients with trauma, interest in DVT prophylaxis is significant. However, appropriate DVT prophylaxis in the setting of trauma is still controversial. Data suggest that LMWH helps prevent DVT in the general trauma population, but standard low-dose unfractionated heparin has not shown clearly to be effective.[2,11] Nevertheless, Schuerer and colleagues[10] showed that a risk-adjusted prophylaxis algorithm can decrease TE rates in high-risk trauma patients initially admitted to the surgical intensive care unit. Other investigators have reported that intermittent use of pneumatic compression devices can be as effective as LMWH in patients with trauma.[9] However, the overall DVT rate in that study population was low, possibly skewing the results. In the present study, the DVT rate was much higher in elderly trauma patients with an orthopedic injury than in elderly trauma patients without an orthopedic injury and in trauma patients younger than age 65. Therefore, elderly trauma patients with an orthopedic injury were at increased risk for PE. This finding supports development and implementation of a DVT prevention protocol that includes pharmacologic agents such as LMWH.

Several issues complicate routine use of pharmacologic prophylaxis for DVT. Bleeding is a known adverse effect of unfractionated heparin and LMWH and poses particular problems in elderly patients. LMWH is also more expensive than unfractionated heparin, and its routine use may be too expensive to apply to all patients with trauma. However, if in larger studies LMWH is found to be safer and more effective in preventing TEs, the ultimate cost savings would more than compensate for the higher price. Lastly, although there are some concerns regarding the use of LMWH and wound healing, we did not find any increase in wound problems.

As we evaluated our trauma population over time, we found that the proportion of elderly trauma patients increased. This elderly population was more likely to have had a TE before the guideline was implemented and throughout the study. In addition, we investigated the subgroup of older trauma patients with an orthopedic injury. These patients had an even higher risk for TE when compared with all other elderly patients at every time point. Over time, the 2 guidelines helped decrease the TE rate in this subgroup, from 8.6% to 2.9%, and in the entire older trauma population, but not significantly so in either group. Although the overall number of patients enrolled in this study was substantial, larger enrollment will be necessary to detect a statistically significant difference.

Maximizing the effectiveness of any protocol requires that adherence be ensured. We attempted to maximize adherence with repeated resident and faculty education, and we monitored adherence to the protocol over time. During each subsequent period, the number of TEs that occurred in patients with inappropriate prophylaxis decreased. The incidence of TE in patients who were administered the protocol inaccurately had fallen to 0 by the second half of 2005. This improvement was likely secondary to several factors. Initial use of the original protocol on the trauma services led to increased understanding of the need for DVT prophylaxis and familiarity with the protocol among the surgical residents. Then, when the protocol was implemented hospital-wide in July 2005, the protocol and printed forms were included in each admission packet. This increased adherence positively influenced the TE rate to drop to its lowest rate during the last 6 months of 2005. In fact, the rate of TE in the elderly orthopedic group approached that of the elderly nonorthopedic population during the last period. Continued adherence could likely be improved with use of a computerized order entry system. Such a system is being phased in at our hospital.

Our results show that a DVT prophylaxis algorithm that includes use of LMWH is safe. There was no bleeding attributed to LMWH in any of the more than 5000 patients enrolled in this study, and only 1 bleeding episode related to use of unfractionated heparin in the historical controls. In fact, as all patients in this study were older than age 65, almost all of them received LMWH. The service-specific protocol favored aggressive treatment for patients older than age 60, and the newer protocol prescribes LMWH to all patients with trauma. In addition, there was no increase in wound infection after initiation of the protocols. Our study results confirm that use of a DVT prophylaxis protocol that includes LMWH is safe in elderly patients with trauma.

It may be that the TE rates that we have achieved are as low as they can be. All prophylaxis protocols have failures, caused by disease or other unknown difficulties.[14] Schiff and colleagues[12] described reasons for failures in orthopedic patients who were receiving prophylaxis as prescribed. Investigators should continue to evaluate the causes for failure so that prophylaxis can be tailored to those characteristics while being kept safe for the entire population.

This study had several limitations. Patients were enrolled sequentially and were not randomized. The true DVT rate may not be known, as the DVTs found in this study were clinically apparent or were found on routine

color duplex screening as prescribed in our guideline. We are likely to have underestimated the true rate of DVTs in all groups, but this should be equal over time. If anything, we believe that postimplementation groups might be skewed to a higher rate because, by using our initial guideline accurately, we increased the number of lower extremity duplex examinations ordered for surveillance, and also likely found more incidental below-knee clots. We did not count below-knee clots as DVTs in any of the populations because these were not treated with full anticoagulation. Rather, our routine was to monitor clots with serial duplex scanning to see if they progressed to the popliteal vein or higher. When that occurred, the clots were counted and treated as DVTs.

In summary, a DVT prophylaxis protocol that uses LMWH was safe and effective in preventing TEs in elderly patients with trauma.

Authors' Disclosure Statement and Acknowledgments

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Appendix. Trauma Service Prophylaxis Algorithm

Risk Assessment for Deep Vein Thrombosis

Patient Name _____ *Hospital Registration #* _____

Admission Date _____ *Diagnosis* _____

Line	Patient has/is …	Yes	Points	Comments
1	Stable pelvic fracture without weight restrictions		1	
2	Laparotomy this visit		1	
3	Burns on ≥20% of total body surface area		1	
4	Ventilated		1	
5	Pregnant		1	
6	Age 40-60 years		1	
7	Age ≥ 60		2	
8	Body mass index >30 (weight kg / height cm / height cm × 10,000)		2	
9	Close head injury (≥12 hours after admission, Glasgow Coma Scale score <13 not attributable to ethyl alcohol or drugs)		2	
10	Compression fracture or stable spinal fracture that requires orthotics or surgical intervention (2 points maximum)		2	
11	Stable pelvic fracture with weight restrictions		2	
12	Long bone fracture (4 points maximum), except tibia/fibula (2 points)		2	
13	Unstable pelvic fracture		3	
14	Paraplegic or quadriplegic (or paresis). *Do not add points for spinal fracture		3	
15	Deep vein thrombosis in past 6 months or …		4	
16	Pulmonary embolism in past 6 months or …		4	
17	Genetic predisposition (protein C deficiency)		4	
	Lines 15-17 (4 points maximum total)			
	Total			