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Venous thromboembolism during combat operations: a 10-y review

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ABSTRACT

Background: This article examines the incidence of venous thromboembolism (VTE) in combat wounded, identifies risk factors for pulmonary embolism (PE), and compares the rate of PE in combat with previously reported civilian data.

Methods: A retrospective review was performed of all U.S. military combat casualties in Operation Enduring Freedom and Operation Iraqi Freedom with a VTE recorded in the Department of Defense Trauma Registry from September 2001 to July 2011. The Military Amputation Database of all U.S. military amputations during the same 10-y period was also reviewed. Demographic data, injury characteristics, and outcomes were evaluated.

Results: Among 26,634 subjects, 587 (2.2%) had a VTE. This number included 270 subjects (1.0%) with deep venous thrombosis (DVT), 223 (0.8%) with PE, and 94 (0.4%) with both DVT and PE. Lower extremity amputation was independently associated with PE (odds ratio [OR], 1.70; 95% confidence interval [CI], 1.07–2.69). A total of 1003 subjects suffered a lower extremity amputation, with 174 (17%) having a VTE. Of these, 75 subjects (7.5%) were having DVT, 70 (7.0%) were having PE, and 29 (2.9%) were found to have both a DVT and a PE. Risk factors found to be independently associated with VTE in amputees were multiple amputations (OR, 2; 95% CI, 1.35–3.42) and above the knee amputation (OR, 2.11; 95% CI, 1.3–3.32).

Conclusions: Combat wounded are at a high risk for thromboembolic complications with the highest risk associated with multiple or above the knee amputations.

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1. Introduction

Tissue injury in conjunction with both the inflammatory response and the delayed inhibition of fibrinolysis places the trauma patient at increased risk for venous thromboembolic events, which are major sources of morbidity and mortality in this population [1]. In fact, after surviving the first 24 h, pulmonary embolism (PE) is the third most common cause of death after trauma [2–5]. The incidence of venous thromboembolism (VTE), which include deep venous thrombosis (DVT) and PE in hospitalized trauma patients, ranges from less than 1%–58% depending on the population studied, detection methods (i.e., venography, color flow Doppler, and spiral computer tomography), prophylactic anticoagulation strategies used, and other factors [2–13]. This variability between studies makes it difficult to assess the risk of VTE for an individual patient and apply treatment strategies to optimize care. This is particularly true for combat casualties, which

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have different and oftentimes more severe injuries, require longer transportation times with extended immobilization, and frequently cannot receive pharmacologic prophylaxis of VTE because of the risk of bleeding. The purpose of this study was to determine the incidence of VTEs among combat casualties injured during wartime to better predict those patients who are at increased risk of VTE (DVT and PE). Additionally, we hypothesized that (1) the incidence of VTE in combat wounded is higher than in civilian trauma, and (2) the risk factors for VTE between military and civilian cohorts are different.

2. Methods

This retrospective study was conducted under a protocol approved by the San Antonio Military Medical Center Institutional Review Board. The Department of Defense Trauma Registry (DoDTR) (Fort Sam Houston, TX), formerly known as the Joint Theater Trauma Registry, was queried for data on United States military service members who were injured during Operation Enduring Freedom (OEF) or Operation Iraqi Freedom (OIF) and sustained a VTE (DVT and PE) from September 2001 through July 2011. This includes all VTEs identified at level III (Combat Support Hospital in theater of war), level IV (Landstuhl Regional Medical Center [LRMC], regional evacuation center in Landstuhl, Germany), and level V (participating military tertiary care centers within the United States). Patients reported as killed in action or dead on arrival were excluded from analysis. Patients with VTEs were identified using *International Classification of Disease*, ninth edition, and Abbreviated Injury Scale (AIS) 2005 injury codes. Complications at all facilities were identified using *International Classification of Disease*, ninth edition codes. The dominant injury mechanism was categorized as explosive device, gunshot wound, motor vehicle accident, helicopter crash, or machinery and equipment. Injury Severity Score (ISS), AIS, injury date, and complications when in theater were collected from the DoDTR.

2.1. Data analysis

A list of VTE risk factors was assembled by military doctors with experience with VTE during OEF and OIF and included previously identified risk factors from civilian trauma studies [2,12]. For each risk factor, subjects with a DVT were compared against those patients with a PE and an odds ratio was calculated. Once a lower extremity amputation was identified as the risk factor for PE, then demographics, injury characteristic, and amputation level were collected from the Military Amputation Database (MAD) (Extremity Trauma and Amputation Center of Excellence, Fort Sam Houston, TX). The MAD contains demographic information on all United States military personnel who underwent amputations between October 1, 2001 and July 30, 2011. MAD is not specific to any service branch or treatment facility and defines a major extremity amputation as an amputation proximal to the carpal or tarsal bones of a limb [14]. The following data were extracted from the MAD for each service member suffering an amputation: age at injury, date of injury, date of first amputation, amputation level, and a brief narrative history of the injuring event and acute medical care provided. Additional information pertaining to the injury and treatment of each amputee was obtained from the DoDTR.

2.2. Statistical analysis

Variables for the univariate analysis were identified from previous risk factors present in the civilian population and those unique to a theater of war (e.g., explosive mechanism of injury and theater of operation) [6,12–15]. Continuous variables were reported as medians (with interquartile ranges the 25th and 75th percentiles) and compared using Student *t*-test or Mann–Whitney test, whichever is most appropriate. Categorical variables were reported as numbers and percentages and were compared using χ^2-test. In defining independent risk factors for VTE, significance was set at $P < 0.05$. Risk factors associated with PE were entered into a logistic regression model. Backward elimination was then applied so that only factors with *P* values <0.20 were included in the final model. A logistic regression model, followed by backward elimination was also used for amputee risk factor identification.

3. Results

From September 2001 through July 2011, there were 26,634 subjects available for analysis; 587 subjects (2.2%) developed a VTE (Fig. 1). Of these, there were 270 subjects (1.0%) with DVT, 223 (0.8%) with PE, and 94 (0.4%) with both DVT and PE. Of those who developed VTE, 12% were identified in theater, whereas 36% and 52% were identified at level IV (LRMC) and level V tertiary care centers in the United States, respectively. Overall, a higher percentage of casualties who developed VTE had an ISS >10, were injured with an improvised explosive device (IED), or suffered a penetrating injury (Table 1). After univariate analysis (Table 2), risk factors associated with PE included injury in OIF and blunt mechanism of injury. Of these subjects with a PE, 3.5% died. During multivariate analysis, the only independent risk factor for PE was lower extremity amputation (Table 3).

A total of 1003 of 26,634 combat casualties (3.7%) suffered lower extremity amputations; 174 (17.3%) of these subjects with lower extremity amputations developed VTEs (Fig. 1).

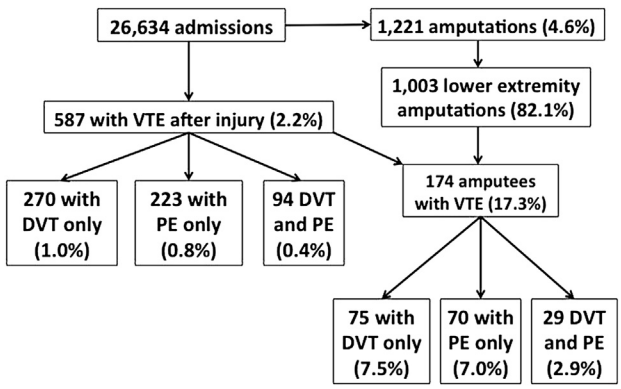

Fig. 1 – VTE consort diagram.