Methods: A Department of Defense database was queried for hospital admissions of a previously published cohort of service members initially wounded in Iraq and Afghanistan between October 2001 and January 2005. Cohort admission data were collected from October 2001 to February 2008. Body region injured was assigned using International Classification of Diseases Ninth Edition primary diagnosis codes. Resource utilization was calculated using the 2008 Department of Defense billing calculator.

Results: Our cohort consisted of 1,337 service members with 2,899 admissions. Three hundred forty-one service members had 670 readmissions. Of rehospitalizations, 64% were for extremity injuries making up 66% of all rehospitalization days. Seventy percent of service members injured had at least one admission for extremity injury. Wound debridement made up 12% of all readmissions, and 92% of these were for extremity injuries. The estimated cost of rehospitalization for extremity injuries for this conflict to date is $139 million.

Conclusions: Extremity injuries have been shown to result in the greatest long-term disability and require the greatest resource utilization during initial treatment. This study demonstrates that they also are the most frequent cause of rehospitalization and require the greatest resource utilization during rehospitalization.

Key Words: Rehospitalization, Combat trauma, Resource utilization.

Background: Frequency of rehospitalization and associated resource requirements are unknown for combat casualties. Differences may also exist in readmission rates for injuries to separate body regions. This study investigates rehospitalization of combat casualties with a hypothesis that extremity injuries cause the greatest number of readmissions and require the greatest resources to treat.

The epidemiology of wartime casualties from the current conflicts has been the subject of rigorous evaluation. \(^1\)–\(^4\) Study of the injury patterns and wounding characteristics from the current conflicts in Iraq and Afghanistan have demonstrated the predominance of extremity wounds in combat trauma with impressive statistics such as 82% of all casualties having at least one extremity injured. \(^1\) Once evacuated, the established resource allocation for treatment in the inpatient environment is 64% of all costs associated with initial hospitalizations are for service members with a primary diagnosis of extremity injury. \(^3\) Also, injured service member outcomes have been investigated with 70% of those service members with an extremity injury as their primary disabling condition found unfit for active duty. \(^4\)

Even with these extensive previous studies, there remains a void of knowledge in the course of combat casualty treatment. The time between initial hospitalization and ultimate disability disposition has not yet been evaluated. This encompasses a period with repeat inpatient episodes, planned and unplanned, as well as outpatient visits with a variety of specialty service care. It has previously been hypothesized that initial inpatient cost requirements for extremity injuries would underestimate the percentage of costs for all inpatient visits borne by these injuries as service members with extremity injuries may require rehospitalization at a disproportionate rate compared with other body regions injured. \(^3\) In addition, patients with multiple injuries may require initial care of head or abdominal injuries, and then long-term care for extremity injuries. This is consistent with several studies of polytrauma in civilian patients which demonstrate that functional outcomes and long-term disability are driven primarily by the lower extremity injury regardless of the presence or severity of other injuries. \(^5\)–\(^10\) In addition, this principle has been borne out in the disability outcomes where patients had an extremity injury as their primary source of disability at a greater percentage than those who had a primary extremity injury on initial hospitalization. \(^4\) The initial hospitalization may be for head/neck or thoracoabdominal trauma; however, the disability is driven by the extremity injury. Furthermore, rehospitalization for complications is a predictor for poor outcome in extremity trauma, \(^5\) portending higher rates of disability for these service members.

Understanding patterns of injury and resource utilization in this treatment period of rehospitalization may allow for optimization of patient outcomes with benefits for both military personnel and civilian trauma patients with extremity injuries. This study investigates the rehospitalization of combat casualties with a hypothesis that extremity injuries cause the greatest number of rehospitalizations and require the greatest resource utilization.

MATERIALS AND METHODS

Under an institutional review board-approved protocol, the patient population for this study was adopted from a previous large-scale investigation of the spectrum of injuries in the current conflicts which consisted of 3,102 casualties.
# Rehospitalization after combat injury

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approximately 27% of the estimated casualties for the time period studied. The subjects were identified from the Joint Theater Trauma Registry (JTTR) that was queried for service members consecutively entered in the database for injuries in Operation Iraqi Freedom and Operation Enduring Freedom from October 2001 through January 2005. The JTTR is a registry that collects information on service members injured in the theater of operations and follows their care until arrival at a military medical treatment facility in the United States. The results of the query were limited to include injured service members treated and evacuated and those classified as died of wounds. Excluded were service members classified as killed in action, returned to duty within 72 hours, or sustaining nonbattle injuries. The remaining cohort approximated those service members wounded in action and not returned to duty.

Data relating to patients’ hospital admissions were queried from the Military Health System Executive Information/Decision Support Medical Metrics (M2) database, which is a central repository of detailed clinical, financial, and beneficiary information for Military Health System operations. Data points collected for each of the identified service members were the Diagnosis-Related Group (DRG), International Classification of Diseases 9th edition (ICD9) coding for primary diagnosis, and length of stay (LOS) for each inpatient admission. All admission events for each service member from October 2001 to February 2008 were collected.

The Department of Defense (DoD) uses the DRG prospective payment system for determining the charges associated with inpatient hospitalization. This DRG billing system was accepted for use by Medicare in 1983 to set levels of reimbursement for inpatient admissions and subsequently adopted by the DoD. A DRG is a grouping of ICD9 diagnoses that are similar in resource utilization required during hospital admission. The dollar value billing charge generated in this model encompasses all treatment-related resources for the entire hospital stay including but not limited to surgical costs; radiographs; medications; and physician, nursing, and ancillary personnel support. In this model, the calculated billing charge is equivalent to the resource utilization required for the treatment of injured service members.

The DRG for a particular admission is determined by a grouping algorithm that takes several admission characteristics into account including the patient’s primary diagnosis (identified by ICD9 code), secondary diagnoses, surgical procedures, age, gender, and discharge disposition. These data points are extracted from hospital charts by coders, and the DRG is determined independent of the treating physicians. This system responds to complexity of disease or injury by adjusting for disease severity for each group and for LOS.

Our model for determining billing charges was in accordance with the procedures set forth for DoD and Veterans Affairs. This begins with Adjusted Standard Amount (ASA), which is a dollar value specific to each medical treatment facility and based on local wage differences and related medical education costs. To eliminate variation in the calculation of charges for the same injury due to different treatment facilities, the ASA for each of these calculations was standardized to the Brooke Army Medical Center (Fort Sam Houston, TX) rate for fiscal year 2008. Each DRG has a specific ASA multiplier that gives a base rate. That rate is modified in a billing calculator for outlier admissions requiring greater or less resources as determined by the patient’s LOS.

The results from the inpatient billing model and the disability benefit calculation were extrapolated to the total current combat-injured population. This was accomplished using available casualty data as of April 2, 2010, which counted 17,011 service members wounded in action and not returned to duty.

Analysis of this data was performed by body region injured according to the criteria described by Churchill. Previous study of this cohort identified an average of 4.2 wounds per casualty, often in different body regions. For this reason, it was necessary to determine a primary body region injured to associate with each set of admission data. The results of searches for DRG and primary ICD9 code for each admission and injury descriptions from the JTTR were used to assign each service member to four groups: head/neck, thorax, abdomen, and extremity. Of note, in this classification, spine injuries are categorized based on the region (head/neck, thorax, or abdomen) that they occur and are not counted as extremity injuries. In addition, pelvis injuries are calculated in the abdominal group. Polytetrauma patients were categorized by the primary ICD9 code for the admission as coded for billing by the treating facility. Each admission episode was classified individually to evaluate differences in body region injured which accounted for rehospitalization.

A hospitalization episode was defined as a unique entry in the M2 database for a given service member characterized by dates, DRG, ICD, and LOS data exclusive of any other hospitalization episode. The rehospitalizations analyzed in this study excluded the first two admission episodes of record as these were most often continuous from the date of injury and only identified as separate events in the database due to evacuation from theater.

**RESULTS**

Of 3,102 casualties in this time period, 1,566 were combat wounded and evacuated from theater. Complete data were available for 1,337 and these were included in this study. A total of 2,899 hospitalizations were identified for an average of 2.2 per service member (range 1–12) with distribution further illustrated in Figure 1. The initial two hospitalizations of each service member were excluded from analysis leaving 341 service members with 670 rehospitalizations. Nine hundred ninety-six patients did not require rehospitalization after evacuation. The 341 service members represent 26% of the current combat-injured population. Twelve percent required multiple readmissions. Sixty-four percent of rehospitalizations were for extremity injuries making up 66% of all rehospitalization days and 67% of all costs (Table 1). Eight of the 10 most common DRGs for readmission were almost exclusively coded for extremity injuries (Table 2).
Wound debridements were evaluated as a separate group. Greater than 12% of all admissions had debridement DRG codes, and they were among the most common individual DRG codes (440, 287, 266, 265, 264, and 217) assigned. Extremity injured service members were treated in 92% of these debridement hospitalizations. The most common ICD9 codes for rehospitalization (Table 3) show a predominance of extremity injury complication-related diagnoses.

The numbers of patients who were initially admitted for a nonextremity injury, but later were readmitted for an extremity injury, were also evaluated. Of the 527 patients admitted initially for a nonextremity body region injury, 337 (64%) required a readmission. Of the service members who required readmission in this group, 130 (39%) had a primary ICD9 diagnosis of extremity injury for at least one subsequent admission. Of the 810 service members with initial diagnosis of an extremity injury, 555 (69%) required readmission. Of these service members, 103 (19%) were subsequently readmitted with a primary diagnosis of injury to a nonextremity body region.

After 3- to 6-year follow-up of this cohort of 1,337 service members, 70% of patients had at least one admission episode with a primary diagnosis of an extremity injury. The estimated cost of readmissions for extremity injuries in this cohort alone is nearly $35 million.

The total resources for inpatient treatment from time of injury throughout the multiple hospitalizations were $79 million, of which 67% was for extremity injuries. Extrapolating this to the total combat-injured population to date yields inpatient resource utilization of just over $1 billion, of which over $667 million is required for extremity injuries. The estimated cost of rehospitalization to date is $208 million, of which $139 million is required for extremity injuries.

**DISCUSSION**

The predominance of extremity wounds in combat trauma and the resource burden borne by initial hospitalization for these injuries has been previously investigated.1–4 These investigations raised the question of the quantity of...
resources required throughout the course of care to include subsequent hospitalizations. Potential implications of these data include guiding patient expectations and improving care delivery and optimization of resource allocation to facilitate this care. This extends beyond direct care and also impacts allocation of resources for research and development of new treatment paradigms to facilitate efficient delivery of care in the military managed care environment.

This study had primary findings that 70% of all combat casualties had at least one admission episode with an extremity injury as a primary diagnosis and that extremity injuries require 68% of all resource dollars required for follow-up hospitalizations. The percentage of patients is higher than had previously been reported for rates of admission due to combat trauma from the current conflicts. It approaches the overall incidence of an extremity trauma which was reported as present in 82% of casualties by Owens et al. in 2007. These figures indicate that if an extremity trauma occurs, even in the presence of other serious polytrauma, the chances are very high that the patient will at some point require hospitalization for primary treatment of that extremity injury.

The finding of costs associated with readmission of extremity injuries (67%) is consistent with the findings of Masini et al. in the investigation of initial inpatient resource utilization, where 64% of all resources went toward extremity injuries. It also is similar to the 69% of patients with extremity injury as the primary disabling condition for veterans in extremity injuries. This could be predicted based on the civilian trauma literature that describes extremity injuries as a significant factor driving patients’ functional outcomes and return to work even with other polytrauma issues.

This hypothesis that rehospitalization would favor extremity injuries was based on an assumption that patients with multiple injuries, which are common in combat trauma, may initially require care of head or abdominal injuries and also will need care over a longer period of time for extremity injuries. This was evaluated by assessing the crossover of patients from one group to another. The findings were that nearly double the percentage of patients had crossover from nonextremity injuries to extremity injuries as primary diagnoses than patients who went from extremity to nonextremity injuries. This could be predicted based on the civilian trauma literature that describes extremity injuries as a significant factor driving patients’ functional outcomes and return to work even with other polytrauma issues.

Limitations of this study include those inherent to its retrospective design including the inability to specifically identify the exact surgical procedures performed on admission or extent of an individual injuries’ contribution toward patient resource consumption. Another limitation is the inability to estimate the cost of outpatient treatment and rehabilitation in our system, as these data are not catalogued in this database. Along these same lines, determination of durable medical equipment costs, such as wheelchairs, ambulatory assist devices, prosthetics, and orthotics in our patient population, is not catalogued in a searchable fashion and was unable to be determined. Some civilian studies suggest that prosthetics alone can have a significant long-term cost impact in a young patient. In addition, the military records were the only source used and so there is potential for underestimation of the data from patients who have left the military medical to receive care in the private sector or in the Veterans Affairs system which is a separate entity. The greatest strength of this study is the cohort size and the single data repository kept for inpatient military medical records. Areas of future study may include guiding patient expectations and improving care delivery and optimization of resource allocation.
include evaluating the specific injury and rehospitalization patterns that characterize service members who will likely not be able to continue on active duty to streamline the medical board process and provide realistic expectations for the injured service members.

This study demonstrates that extremity injuries require the greatest inpatient resource utilization beyond initial hospitalization. This is a marker both for increased disability and greater outpatient resource utilization. This study adds weight to the growing body of evidence that combat extremity injuries require the greatest utilization of medical resources in all phases of combat casualty care.

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