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Level 1 Trauma Centers and OEF/OIF Emergency Departments:

Comparison of Trauma Patient Populations

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Abstract

Introduction: Brooke Army Medical Center (BAMC), the largest military hospital and the only Level 1 Trauma Center in the DoD, cares for active duty, retired uniformed services personnel, and beneficiaries. In addition, BAMC works in collaboration with the Southwest Texas Regional Advisory Council (STRAC) and University Hospital (UH), San Antonio's other Level 1 Trauma Center, to provide trauma care to residents of the city and 22 counties in southwest Texas from San Antonio to Mexico (26,000 square mile area). Civilian-military partnerships are shown to benefit the training of military medical personnel, however to date there are no published reports specific to military personnel experiences within emergency care. The purpose of the current study was to describe and compare DoD and civilian trauma center patient populations, as well as determine if DoD Level I trauma cases were representative of patients treated in OEF/OIF emergency department settings.

Materials and Methods: We obtained a non-human research determination from the US Air Force 59th Medical Wing Institutional Review Board and the University of Texas Health Science Center at San Antonio Institutional Review Board. Data on emergency department patients treated between the years 2015 and 2017 were obtained from the two Level I trauma centers (BAMC and UH, located in San Antonio, Texas); data included injury descriptors, ICU and hospital days, and department procedures.

Results: Two-proportion *Z*-tests indicated trauma patients were similar across trauma centers on injury type, injury severity, discharge status, yet differed significantly in terms of mechanism of injury and regions of injury. BAMC received significantly greater proportions of patients injured from falls, firearms and with facial and head injuries than UH, which received significantly greater proportion of patients with thorax and abdominal injuries. In addition, a significantly

greater proportion of patients spent more than two days in the ICU and greater than two total hospital days at BAMC than in UH. In comparison to military emergency departments in combat zones, BAMC had significantly lower rates of blood product administration and endotracheal intubations.

Conclusions: The trauma patients treated at a military level one trauma center were similar to those treated in the civilian level one trauma center in the same city, indicating the effectiveness of the only DoD Level 1 Trauma Center to provide experience comparable to that provided in civilian trauma centers. Further research is needed to determine if providers trained at level 1 trauma centers result in successful performance when deployed.

Introduction

The Military Health System (MHS) is the global health system of the Department of Defense (DoD) and includes over 50 military hospitals and 600 clinics. Its purpose, under the direction of the Defense Health Agency (DHA), is to support service members and their families. The primary objectives are to maintain a medically ready fighting force, as well as a ready medical force to care for the war fighter.[1] Within this system is Brooke Army Medical Center (BAMC), the largest military hospital and the only Level 1 Trauma Center in the DoD. While caring for active duty, retired uniformed services personnel, and beneficiaries, BAMC also provides burn and trauma casualty care to civilians. BAMC works in collaboration with the Southwest Texas Regional Advisory Council (STRAC) and University Hospital (UH), San Antonio's other Level 1 Trauma Center, to provide trauma care to residents of the city and 22 counties in southwest Texas from San Antonio to Mexico (26,000 square mile area).[2] There are no Level 2 centers in the region, which allows both UH and BAMC to avoid some of the dilution experienced by trauma centers in other large urban areas. In addition to serving its patient population, BAMC serves as a platform to provide and maintain trauma casualty care skills for military medical personnel.

In response to concerns about the readiness of military medical personnel to care for traumatically injured combat casualties, the National Defense Authorization Act for 1996 required the DoD to implement training programs within civilian trauma centers.[3] In the years to follow, several civilian-military partnerships were established to support training and sustaining readiness in trauma care for military medical personnel.[4,5] The published reports describing the benefit of these affiliations focus on surgical case exposure for surgeons.[6-11] The surgical caseloads experienced by military surgeons in civilian Level 1 Trauma Centers far exceeded the exposure in in-garrison military hospitals. In general, experience in civilian Level 1 Trauma

Centers exposed military surgeons to a comprehensive trauma practice and supported sustainment of combat surgical skills.[7-11]

There is limited published data related to the emergency care experiences in Level 1 Trauma Centers, or the emergency care exposure needs of military emergency medicine providers. To our knowledge this is the first report describing the overall trauma patient population treated at the only Level 1 Trauma Center in the DoD. The purpose of this study was to characterize and compare the trauma patient populations treated at the DoD Level 1 Trauma Center and the civilian Level 1 Trauma Center in a major metropolitan city. A secondary purpose was to determine if the populations were representative of the trauma patients treated in a combat setting.

Methods

We obtained a non-human research determination from the US Air Force 59th Medical Wing Institutional Review Board and the University of Texas Health Science Center at San Antonio Institutional Review Board. Data requests were submitted to the Trauma Registries for BAMC and UH. We included all traumatic injuries from any mechanism of injury (MOI) treated at either facility from January 1, 2015 to December 31, 2017. We excluded patients less than 18 years of age. Data elements in the query included demographic information, injury descriptors, diagnoses, emergency department procedures, and outcome data (ventilation, intensive care unit (ICU), and hospital days). We used the International Classification of Disease, version 9 (ICD-9-PCS) procedure codes provided by the BAMC query to determine incidence of procedures performed in the emergency department at BAMC (see Appendix for list of ICD-9-PCS codes). We utilized data published by Schauer et al. (2019) to provide rates of procedures performed on patients treated in in-theater military emergency department settings.

Statistical Analysis

Descriptive statistics on sex, age, MOI, and injury severity and type, injury body region, and procedures acquired from BAMC and UH data were calculated using Microsoft Excel version 2016.[12] For a representation of the distribution of injury severity, the ISS data were categorized into groups: minor (1-15), moderate (16-25), severe (26-50), and critical (51-75). Descriptive statistics included counts and percentages with 95% confidence intervals [95% CI] for categorical variables and medians with interquartile ranges (IQR) for continuous variables. We conducted two-proportion *Z*-tests to examine differences between samples in categorical variables (e.g., injury type; procedure categories).

Results

The final sample for BAMC consisted of 10,158 patients (69.2% male, Age_{med} = 48, IQR = 30-67), and for UH 14,129 patients (65.3% male, Age_{med} = 43, IQR = 28-61). Demographic and injury characteristics for ED patients seen in each facility are displayed in Table 1. Two-proportion *Z*-tests indicated there were no significant differences in injury types between the two centers; blunt trauma was the most common injury type (~83% for both centers). For MOI, BAMC treated a significantly greater proportion of falls in comparison to UH (35.4% versus 30.4% ; $Z = 4.68$, $p < .001$). BAMC also received a greater proportion of patients with injuries due to firearms, with the difference marginally significant (7.1 versus 4.7; $Z = 1.99$, $p = 0.054$). Of note, UH received a significantly greater proportion of patients with injuries due to ‘other’ mechanisms (e.g., fires, assault, bites) than BAMC (30.6% versus 24.2%; $Z = -4.53$, $p < .001$)

Injury region and severity are displayed in Table 2. The majority of patients treated within BAMC and UH suffered lower and upper extremity injuries. BAMC received a significantly greater proportion of patients with face injuries (35.1% versus 29.1%; $Z = 6.43$, $p <$

.001) and external injuries (14.1% versus 6.9%; $Z = 5.84$, $p < .001$) than UH, as well as a marginally significant greater proportion of head injuries (34.1% versus 31.9%; Z = 2.47, $p = .049$). UH received significantly greater proportions of patients with thorax injury than BAMC (28.0% versus 24.3%; Z = -3.33, $p = .002$), as well as injuries to the abdomen (18.0% versus 15.4%; Z = -2.16, $p = .039$). There were no significant differences in proportions of moderate to critical injured patients between the two centers; however, UH received a significantly greater proportion of patients with minor injuries than BAMC (79.9% versus 77.3%; Z = -4.20, $p < .001$). Finally, BAMC received a significantly greater proportion of patients with severe head injuries than UH (88.5% versus 86.3%; Z = 4.79, $p < .001$).

Outcomes and discharge status are displayed in Table 2. A significantly greater proportion of BAMC ED patients spent more than two days in the ICU (23.0% versus 17.7%; $Z = 4.40$, $p < .001$) and in the hospital (46.6% versus 43.8%; $Z = 2.97$, $p = .005$) than UH ED patients; there were no differences in proportion of patients who spent more than two days on a ventilator ($Z = -1.21$, $p = .193$). BAMC had a greater proportion of patients alive at discharge than UH, with difference marginally significant (98.9% versus 98.7%; Z = -2.08, $p = .045$).

We compared procedures performed on BAMC ED patients to procedures performed on combat casualties treated in emergency departments in Iraq and Afghanistan, using data from Schauer et al.[13] Within the BAMC sample, the majority of patients underwent diagnostic procedures, including computerized tomography (CT) scans (70.3%), x-rays (70.1%), and ultrasound scans (23.8%). Other common procedures included orthopedic reductions (6.2%), endotracheal airway (5.6%), and tube thoracotomy (4.8%). Other critical procedures occurred at lower rates, including fasciotomy (2.1%), temporary tracheostomy (1.5%), and canthotomy (0.1%). Two-proportion *Z*-tests revealed a significantly greater proportion of combat casualties

received PRBC (26.4% versus 5.7%; $Z = 11.79$, $p < .001$), platelets (11.1% versus 2.0%; $Z = 4.44$, $p < .001$), and fresh or frozen plasma (23.5% versus 3.0%; $Z = 9.10$, $p < .001$) than BAMC patients. In addition, significantly greater proportions of combat casualties received endotracheal airways (11.9% versus 5.6%; $Z = 4.60$, $p < .001$), x-rays (79.9% versus 70.1%; $Z = 17.24$, $p < .001$), and CT scans (73.5% versus 70.3%; $Z = 5.27$, $p < .001$). A significantly greater proportion of BAMC patients underwent orthopedic reductions than combat casualties (6.2% versus 1.5%; $Z = -4.59$, $p < .001$).

Discussion

We found little differences between the trauma patients treated at the military level 1 trauma center, BAMC, and those treated at the closest civilian level 1 trauma center, UH. The centers had similar injury types and injury severity, indicating parity between the hospitals. A significantly greater proportion of patients at BAMC spent more than 2 days in hospital and in the ICU in comparison to UH, possibly related to the higher incidence of severe head injury in the BAMC population. In addition, though not statistically significant BAMC also treated more patients with an ISS in the severe category (7.1% verses 4.6%). During our study period UH treated 3,971 more adult trauma patients than BAMC, therefore the exposure rates per physician would be higher in the civilian center. Based on numbers of EM physicians and trauma surgeons staffing each facility, both groups would have higher case exposures at UH (63% and 61% more cases, respectively).

Differences were seen in the mechanism of injury, with BAMC treating significantly more patients injured from falls and firearms. Many of the falls treated at BAMC are older adult dependents with prior service who are routed to BAMC due to eligibility for Military Health System care. Proportions of blunt (BAMC: 83% and UH: 83.5%) and penetrating (BAMC:

16.9% and UH 14.7%) injuries were similar to those observed in another urban civilian level one trauma center (81.5% and 15.7%, respectively).[8] Based on published reports from recent conflicts in Iraq and Afghanistan, the majority of patients treated in combat settings had penetrating injuries (29% - 63%) due to explosives (48.3% - 77.0).[14-18] Except for in instances of terroristic bombing or mass shootings, trauma centers outside of war zones do not typically treat high numbers of patients with blast injuries.

For injury regions, BAMC treated more patients with facial and head injuries and a greater portion were severe head injuries. University Hospital saw more patients with thorax and abdominal injuries. In combat casualties, the most common body regions injured were extremities (23.9 to 49.7%) and head/neck (14.8 to 57.5%).[13-15] This is not surprising, considering the most common mechanism of injury during recent conflicts was improvised explosive device.

Even with the existing civilian-military partnerships, there has been ongoing concern that the peacetime mission of the MHS, the provision of routine care to active duty and their dependents, is not sufficient to maintain medical readiness for wartime deployments.[19] The MHS has an initiative referred to as the clinical readiness program, designed to define knowledge, skills, and abilities (KSAs) for combat casualty care, required for deploying providers. The KSAs inform training content and competency evaluation for deployment, as well as provide metrics to determine at what level a treatment facility provides opportunities to obtain KSAs.[19, 20] The initial focus was on completing and testing KSAs for general surgery, followed by orthopedic surgery, emergency medicine, and other disciplines. BAMC provides routine military/beneficiary care, as well as trauma care to military and civilian patients. Military emergency physicians are required to work at least 80 hours per year in a level 1 trauma center.[21]

Providers assigned to BAMC more than meet this requirement, while others meet this expectation within the established civilian/military partnerships. We compared the experiences of BAMC personnel to those of medical personnel in a civilian hospital.

In our comparison of procedures performed at BAMC to those performed in the in-theater emergency departments, the most notable differences were in the larger number of endotracheal intubations performed, and blood products administered to the combat casualty patients. All other procedures were performed at similar rates when comparing BAMC to the combat setting, with the exception of orthopedic reduction, x-rays, and CT scans (increased in BAMC patients).[13] The MHS Readiness Dashboard for emergency medicine lists 14 required procedures for deployment readiness.[22] Opportunities to perform five, plus 3 additional, of the listed procedures were provided in the BAMC ED, however we were not able to determine specific metrics of procedure performance per provider.

The results of our study demonstrate the important role of the only DoD Level 1 Trauma center in supporting the readiness of emergency care providers. We also elucidate an opportunity to increases trauma exposure by building on the relationship between BAMC and the UH trauma centers. The San Antonio Uniformed Services Health Education Consortium (SAUSHEC) has an established partnership with UH, which allows military trainees to complete rotations in the UH trauma center.[23] Expanding this agreement to include military emergency medicine providers would increase trauma case exposure, and result in enhanced readiness. Further research and more detailed data are needed on the case metrics and experiences of emergency medicine providers. The MHS can use the data to determine what additional learning experiences are required to meet the recommended KSA requirements for combat casualty care.

Limitations

The current study is not without limitations. This study is based on registry data and we are unable to link the procedures or other data to specific provider type. We can only describe the exposure potential in each setting. While data support the notion that medical personnel trained at BAMC are able to perform procedures critical for emergency care in war zones, they do not provide information on the quality or successful performance of personnel. In spite of the fact that we submitted similar data requests to the two trauma registries, the returned data sets were different and made some comparisons difficult to complete. ICD-9-PCS codes were used to calculate frequency of procedures within the BAMC sample and these codes may not fully account for all procedures performed in the military ED settings.

Conclusions

The trauma patients treated at a military level one trauma center were similar to those treated in the civilian level one trauma center in the same city, indicating the effectiveness of the only DoD Level 1 Trauma Center to provide experience comparable to that provided in civilian trauma centers. Further research is needed to determine if providers trained at level 1 trauma centers result in successful performance when deployed.

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Table 1

Level 1 Trauma Center ED Patient and Injury Characteristics

	BAMC (N = 10,158)	University Hospital (N = 14,129)	*p*
Gender, %			
Male	69.2 [68.3 – 70.1]	65.3 [64.5 – 66.1]	<.001
Female	30.8 [29.9 - 31.7]	34.7 [34.0 – 35.5]	.001
Injury Type, %			
Blunt	83.0 [82.3 – 83.7]	83.5 [82.9 – 84.1]	.248
Penetrating	16.9 [16.2 – 17.6]	14.7 [14.2 – 15.3]	.078
Burn	<0.1	1.3 [1.2 – 1.6]	.394
Other	0.1 [0.0 – 0.1]	0.3 [0.2 - 0.4]	.395
Mechanism of Injury, %			
Blast	0.3 [0.2 – 0.5]	0	-
GSW	7.1 [6.7 – 7.7]	4.7 [4.3 – 5.0]	.054
MVC	32.8 [31.9 – 33.7]	33.9 [33.1 – 34.7]	.244
Fall	35.4 [34.4 – 36.3]	30.4 [29.7 – 31.2]	<.001
Other†	24.2 [23.3 – 25.0]	30.6 [29.9 – 31.4]	<.001
Unknown	0.1 [0.1 – 0.2]	0.5 [0.3 – 0.6]	.392
Missing	<0.1 [0.0 – 0.1]	0	-

Note. GSW, gunshot wound; MVC, motor vehicle crash.
†Category inclusive of injuries due to motorcycle collisions, animals, machinery, bites, assault, suffocation, sports, fire and other burn mechanisms, and contact with knife or other sharp objects.

Table 2

Level 1 Trauma Center ED Patients Injury Severity and Outcomes

	BAMC (*N* = 10,158)	University Hospital (*N* = 14,129)	*p*
Injury Region, %			
Head	34.1 [33.1 – 35.0]	31.9 [31.1 – 32.7]	.049
Face	35.1 [34.9 – 36.8]	29.1 [28.3 – 29.8]	<.001
Neck	3.9 [3.6 – 4.3]	4.0 [3.7 – 4.3]	.399
Thorax	24.3 [23.4 – 25.1]	28.0 [27.3 – 28.8]	.002
Abdomen	15.4 [14.7 – 16.1]	18.0 [17.4 – 18.6]	.039
Spine	16.9 [16.2 – 17.6]	14.6 [14.0 -15.2]	.058
Upper Extremity	34.3 [33.4 – 35.3]	35.6 [34.8 – 36.4]	.201
Lower Extremity	35.1 [34.1 – 36.0]	36.0 [35.2 – 36.8]	.265
External	14.1 [13.4 – 14.8]	6.9 [6.5 – 7.3]	<.001
Missing	1.9 [1.6 – 2.1]	4.3 [3.9 – 4.6]	.109
Injury Severity, %			
Minor	77.3 [76.5 – 78.2]	79.9 [79.2 – 80.5]	<.001
Moderate	13.2 [12.5 – 13.8]	10.8 [10.3 – 11.3]	.062
Severe	7.1 [6.6 – 7.6]	4.6 [4.3 – 5.0]	.056
Critical	0.5 [.4 - .7]	0.4 [0.3 – 0.5]	.398
ISS, median (IQR)	8 (4-14)	5 (2-12)	.109
Head Injury Severity, %			
Mild	7.5 [7.0 – 8.0]	7.8 [7.3 – 8.2]	.391
Moderate	2.8 [2.5 – 3.2]	2.6 [2.3 – 2.9]	.392
Severe	88.5 [87.9 – 89.1]	86.3 [85.7 – 86.8]	<.001
Outcomes, %			
>2 Vent Days	5.4 [4.9 – 5.8]	6.9 [635 – 7.4]	.193
>2 ICU Days	23.0 [22.2 – 23.8]	17.9 [17.3 – 18.6]	<.001
>2 Hospital Days	46.6 [45.6 – 47.6]	43.8 [42.9 – 44.6]	.005
Discharge Status, %			
Alive	98.9 [98.7 – 99.1]	98.6 [98.4 – 98.8]	.045
Dead	1.1 [0.9 – 1.3]	1.3 [1.1 – 1.5]	.394
Unknown	<0.1	0.1 [0.0 – 0.1]	.399

Note. IQR, interquartile range; ICU, intensive care unit. Frequencies of injured body regions are based on Abbreviated Injury Scale scores; categories are not mutually exclusive. Injury severity categories based on ISS values; Minor (1-15), Moderate (16-25), Severe (26-50), Critical (51-75). Head injury severity categories based on GCS values; Mild (3-8), Moderate (9-12), Severe (13-15).

Table 3

Types of Procedures Performed on Combat Casualties and BAMC ED Patients

Procedure	Combat Casualty†	BAMC	*p*
Blood Product Administration			
Whole Blood	1.5% [1.4 – 1.7]	0.3% [.2 - .4]	.331
PRBC	26.4% [25.9 – 26.9]	5.7% [5.2 – 6.1]	<.001
Platelets	11.1% [10.7 – 11.5]	2.0% [1.7 – 2.2]	<.001
FFP	23.5% [23.0 – 24.0]	3.0% [2.7 – 3.3]	<.001
Cryoprecipitate	7.0% [6.7 – 7.3]	0.1% [0.0 – 0.2]	.235
Advanced Airway			
Endotracheal Airway	11.9% [11.6 – 12.3]	5.6% [5.2 – 6.1]	<.001
Temporary Tracheostomy	-	1.5% [1.2 – 1.7]	-
Cricothyrotomy	0.2% [0.1 – 0.2]	0	-
Chest Interventions			
Tube thoracotomy	4.6% [4.4 – 4.9]	4.8% [4.4 – 5.2]	.393
Thoracotomy	0.5% [0.4 – 0.5]	0.7% [0.5 – 0.9]	.388
Vascular Access/Circulatory Interventions			
Arterial access	4.7% [4.5 – 5.0]	2.3% [2.0 – 2.6]	.090
CPR	0.1% [1.0 – 1.3]	0.6% [0.5 – 0.9]	.374
Diagnostics			
Ultrasound	22.2% [21.8 – 22.7]	23.8% [23.0 – 24.6]	.118
X-ray	79.9% [9.4 – 80.4]	70.1% [69.2 – 71.0]	<.001
Computed tomography	73.5% [79.0 – 74.0]	70.3% [69.4 – 71.2]	<.001
Other			
Canthotomy	0.1% [0.1 – 0.2]	0.1% [0.1 – 0.2]	.399
Nasogastric intubation	1.4% [1.3 – 1.6]	2.9% [2.6 – 3.2]	.142
Orthopedic reduction	1.5% [1.4 – 1.6]	6.2% [5.7 – 6.7]	<.001
Fasciotomy	0.1% [0.0 – 0.1]	2.1% [1.8 – 2.4]	.237

Note. Data derived from ICD-9 PCS codes. Sub-categories for SAMMC are not mutually exclusive. PBRC = packed red blood cells; FFP = frozen or fresh plasma; CPR = cardiopulmonary resuscitation.
†Data extracted from Schauer et al. (2019)

Appendix

Table A1

ICD-9 PCS for Selected Procedures

Procedure	ICD-9 PCS Codes
Blood Product Administration	
Whole Blood	99.03
PRBC	99.04
Platelets	99.05
FFP	99.07
Cryoprecipitate	99.06
Advanced Airway	
Endotracheal Airway	96.04, 96.03
Temporary Tracheostomy	31.10
Chest Interventions	
Tube thoracotomy	34.04
Thoracotomy	34.02
Vascular Access/Circulatory Interventions	
Arterial access	38.91
CPR	99.63, 93.93, 99.60-99.62, 99.64, 99.69
Diagnostics	
Ultrasound	88.70-88.79
X-ray	87.49, 87.44, 87.1, 87.16, 87.17, 87.2 87,.22 87.23, 87.24, 87.4, 87.43, 88.1, 88.19, 88.2, 88.21, 88.22, 88.23, 88.27, 88.28, 88.29, 88.33, 88.39, 88.49, 88.74
Computed tomography	88.01, 87.03, 87.41, 87.71
Other	
Canthotomy	8.51
Nasogastric intubation	96.07, 96.08
Orthopedic reduction	79.00-79.09,79.41-79.42,79.46,79.70-79.79
Fasciotomy	82.12, 83.14