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Prolonged ICU stay and its association with 1-year trauma mortality: An analysis of 19,000 American patients

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ABSTRACT

Introduction: Prior research on patients with traumatic injury suggests high in-hospital survivability. However, little is known about their long-term outcomes, especially in the context of a prolonged ICU length-of-stay (LOS). We sought to determine the association between prolonged ICU-LOS and 1-year survival in trauma patients.

Methods: TRICARE claims data (2011–2015) were queried for trauma patients with an Injury Severity Score > 9. Risk-adjusted Cox models were used to determine the influence of prolonged ICU LOS on 1-year mortality.

Results: Of 19,155 patients included, 40% were admitted to the ICU. The overall 1-year mortality was 3.9% and 4.7% in patients with ICU LOS >9 days. In the multivariable model older age (55–64 vs. 18–24 years) (HR: 47.8, CI:20.8–109.9), prior comorbidities (>1 vs. 0) (HR: 2.6, CI: 2.1–3.2), discharge disposition (transfer vs discharge) (HR: 2.3 CI: 1.7–3.1) and ICU-LOS (>7 vs. 1 days) (HR:2.6, CI:1.7–4.0) were associated with 1-year mortality.

Conclusion: Prolonged ICU-LOS is a risk factor for 1-year mortality in trauma patients. But an overall high survival (>96%) reinforces the justification for such use of the ICU in trauma patients when clinically necessary.

Introduction

Intensive care units (ICU) patients are a challenging clinical population that, by definition, have complex medical and/or surgical issues necessitating critical care and an extensive amount of resources. While, these patients make up a small proportion of the total hospital patient population, they account of a significant chunk of the total resource utilization.[1] Within this group, patients with extended time in the ICU pose a unique conundrum, as prolonged ICU stay has been identified to be independently associated with heightened mortality.[2] Prolonged ICU stay may thus be viewed by many, not only as intensive, but as an unhelpful form of aggressive critical care.[3] Prior reports suggest a high long-term mortality rate for these patients even after hospital discharge, with one study documenting a rate of more than 40%.[2] With the cost of ICU treatment increasing every year,[4] the debate regarding the usefulness of prolonged ICU care has intensified, with the pendulum swinging towards end-of-life care discussions for such patients.[5]

Trauma ICU patients represents a distinct group of patients within this population, as they lack demographic and clinical factors associated with worse survival, such as advanced age and prior comorbid conditions.[6,7] Therefore, the actual utility of prolonged ICU stay for this particular subset of patients remains unknown. Recent work has demonstrated that trauma patients with prolonged ICU stay who survive the initial few days of ICU have an overall in-hospital survival approximating 9%.[3] However, the association of prolonged ICU stay with long-term mortality remains

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unclear, largely due to the lack of national trauma surveillance with long-term follow-up.

In this context, the objectives of this study were to determine the 1-year survival of trauma patients after index hospitalization and to evaluate the association of ICU stay with 1-year trauma mortality. This study was performed using TRICARE claims, as this substrate provides a unique national population of patients with the capacity for long-term observation.

Methods

Data source

The military health system (MHS) database was queried for TRICARE Prime beneficiary healthcare data for 2011–2015. TRICARE is the Department of Defense (DoD) healthcare insurance plan that covers more than 9.4 million enrollees across the United States.[8] The beneficiaries of TRICARE insurance include active-duty and retired military personnel and their dependents. TRICARE is not responsible for care delivered in combat zones or care provided at Veterans Affairs (VA) healthcare facilities. Beneficiaries may receive care at military hospitals funded by the DoD or civilian hospitals, where TRICARE acts an insurance provider. TRICARE data has been used in a number of surgical and non-surgical studies and the demographic characteristics of this population has been shown to closely resemble those of the U.S. general population under the age of 65 years.[9–11] This data source was selected for the study because the population insured through TRICARE is largely stable over time and the reliability of data reporting has been established in previous work.[9–12]

The study data was used under a data use agreement with the Uniformed Services University and the study was deemed exempt from full review by our institutional review board. All patient data were de-identified.

Study population

Trauma patients between the ages of 18 and 64 years were identified using International Classification of Disease 9th revision, Clinical Modification (ICD-9 CM) codes (800–999). Burn patients, patients with foreign body related injuries and late complications related to trauma were excluded from the analysis. Additionally, patients with Injury Severity Score (ISS) less than 9 and patients who died during index hospitalization were also excluded from the study. The rationale for excluding patients who died during hospitalization was to limit adverse influence on determinations regarding 1-year survival for trauma patients who survived the hospitalization, as the low rates of in-hospital mortality for trauma patients with prolonged ICU stay has already been established. Patients were surveyed for death up to 1 year following the index hospitalization.

Outcomes of interest

The outcome of interest for this study was 1-year mortality after trauma related hospitalization.

Variables

Patient demographics (age, beneficiary category, biologic sex, race, socio-economic status, geographic region), clinical characteristics (ISS, ICU length of stay [LOS], length of hospitalization, discharge disposition, Charlson Comorbidity Index[13] [CCI]) and environment of care (civilian vs military hospital) were considered covariates in the analysis and were adjusted for in the final multivariable model.

Age was categorized as 18–24, 25–34, 35–44, 45–54 and 55–64. Geographic regions were based on census regions (South, Mid-West, West, Northeast). ISS was calculated with the ICD-PIC[14] program in Stata 14.0 using ICD-9 CM diagnostic and procedure codes and divided into three categories, 9–14, 15–24 and > 24. CCI was also calculated using the same program and categorized as 0, 1 and > 1.

Sponsor rank was used as a proxy for socio-economic status, with enlisted junior personnel considered to be representative of the lower socio-economic strata. This approach has been previously used in a number of studies using military healthcare data and the outcomes for this rank stratification have been validated against civilian healthcare data.[10,15,16]

Statistical analysis

For this analysis, ICU LOS was considered the main predictor for 1-year mortality after trauma related hospitalization. Unadjusted differences in outcome were evaluated using the chi square test. Additionally, survival curves were constructed to visualize the difference in mortality for the various categories of ICU LOS categories. Multivariable Cox Proportional Hazards, with right sided censoring for patients lost to follow-up, adjusted for demographics, clinical characteristics and environment of care, was used to determine predictors of 1-year trauma mortality. A subset analysis without active-duty military personnel was performed to determine the generalizability of the findings.

Re-weighted estimating equations were used to account for missing race information in the data. This approach has previously been used for TRICARE data and has been reported to be a highly effective approach in reducing bias due to missing race information.[9,17] For this method, the probability of race being missing is calculated for each patient, using a logistic regression model base on other demographic characteristics. The inverse of these probabilities is then used as survey weights in the final analysis.

An a-priori two-sided level of significance was set at $p < 0.05$. All statistical analyses were performed using Stata version 14.0 (Stata Corp., College Station, TX).

Results

Demographics, clinical characteristics and environment of care

A total of 19155 patients met inclusion criteria and were considered in the final analysis. In the cohort, 11466 (59.9%) patients had no ICU stay during hospitalization, 2300 (12%) had 1 day in the ICU, 4346 (22.7%) 2–9 days and 1043 (5.4%) more than 9 days. Age was evenly distributed across the cohort (Table 1). A majority of the cohort was active-duty military personnel, 8263 (43.1%), Male, 13078 (68.3%) and White 1315 (68.7%). Only 3308 (17.3%) patients were from the upper socio-economic strata (Officers) and 4896 (25.6%) were considered as deriving from lower socioeconomic strata (Enlisted Junior). Overall, 178 (0.9%) patients had sepsis with 89 (8.5%) patients having sepsis in >9 ICU-days category.

A total of 13664 patients (71.3%) had ISS 9–14, while only 1185 (6.2%) had ISS greater than 24. The median total hospital LOS was 5 days with an interquartile range of 3–10 days. A majority of patients (16060 [83.8%]) were discharged home.

Among the cohort, 5612 (29.3%) were treated at military hospitals and 13543 (70.7%) received care at civilian healthcare facilities.

Table 1
Distribution of demographic, clinical and environment of care characteristics by ICU stay.

	Total		0		1		2–9		>9	
	19155	100%	11466	59.9%	2300	12.0%	4346	22.7%	1043	5.4%
Demographics										
Age, (years)										
18–24	4816	25.1%	2569	22.4%	664	28.9%	1260	29.0%	323	31.0%
25–34	3733	19.5%	2036	17.8%	504	21.9%	939	21.6%	254	24.4%
35–44	1547	8.1%	889	7.8%	191	8.3%	360	8.3%	107	10.3%
45–54	4359	22.8%	2636	23.0%	486	21.1%	982	22.6%	255	24.4%
55–64	4700	24.5%	3336	29.1%	455	19.8%	805	18.5%	104	10.0%
Beneficiary Category										
Active Duty	8263	43.1%	4523	39.4%	1130	49.1%	2079	47.8%	531	50.9%
Retired	4253	22.2%	2512	21.9%	477	20.7%	1000	23.0%	264	25.3%
Dependent	4543	23.7%	2889	25.2%	500	21.7%	947	21.8%	207	19.8%
Other	1885	9.8%	1398	12.2%	171	7.4%	282	6.5%	34	3.3%
Missing	211	1.1%	144	1.3%	22	1.0%	38	0.9%	7	0.7%
Sex										
Female	6077	31.7%	4207	36.7%	592	25.7%	1092	25.1%	186	17.8%
Male	13078	68.3%	7259	63.3%	1708	74.3%	3254	74.9%	857	82.2%
Race										
White	13151	68.7%	7846	68.4%	1592	69.2%	3004	69.1%	709	68.0%
Black	1849	9.6%	1083	9.4%	211	9.2%	430	9.9%	125	12.0%
Asian	687	3.6%	387	3.4%	98	4.3%	169	3.9%	33	3.2%
Other	1034	5.4%	625	5.4%	138	6.0%	218	5.0%	53	5.1%
Missing	2434	12.7%	1525	13.3%	261	11.4%	525	12.1%	123	11.8%
Sponsor Rank										
Officer	3308	17.3%	2157	18.8%	364	15.8%	654	15.0%	133	12.3%
Enlisted Senior	10213	53.3%	6157	53.7%	1177	51.2%	2308	53.1%	571	54.8%
Enlisted Junior	4896	25.6%	2669	23.3%	681	29.6%	1240	28.5%	306	29.3%
Other	527	2.8%	339	3.0%	56	2.4%	106	2.4%	26	2.5%
Missing	211	1.1%	144	1.3%	22	1.0%	38	0.9%	7	0.7%
Region										
South	10402	54.3%	6243	54.4%	1200	52.2%	2365	54.2%	594	60.0%
Northeast	743	3.9%	469	4.1%	91	4.0%	146	3.4%	37	3.6%
West	6058	31.6%	3486	30.4%	794	34.5%	1459	33.6%	319	30.6%
Midwest	1440	7.5%	913	8.0%	154	6.7%	291	6.7%	82	7.9%
Missing	512	2.7%	355	3.1%	61	2.6%	85	2.0%	11	1.0%
Clinical Characteristics										
ISS[a]										
9–14	13664	71.3%	9688	84.5%	1418	61.6%	2239	51.5%	319	30.6%
15–24	4305	22.5%	1553	13.5%	767	33.4%	1584	36.4%	401	38.4%
>24	1185	6.2%	225	2.0%	115	5.0%	522	12.0%	323	31.0%
Missing	1	0%	0	–	0	–	1	0%	0	–
LOS^{+} (IQR^{++})	5	(3–10)	5	(3–8)	4	(2–6)	7	(5–10)	22	(16–33)
Discharge Disposition										
Discharge	16060	83.8%	9566	83.4%	1955	85.0%	3627	83.5%	912	87.4%
Transfer	2293	12.0%	1127	9.8%	333	14.5%	707	16.3%	126	12.1%
Other	802	4.2%	773	6.7%	12	0.5%	12	0.3%	5	0.5%
Charlson Comorbidity Index										
0	14675	76.6%	8516	74.3%	1851	80.5%	3425	78.8%	883	84.7%
1	2574	13.4%	1676	14.6%	261	11.4%	540	12.4%	97	9.3%
>1	1906	10.0%	1274	11.1%	188	8.2%	381	8.8%	63	6.0%
Sepsis	178	0.9%	23	0.2%	5	0.2%	61	1.4%	89	8.5%
Environment of Care										
Military Hospital	5612	29.3%	3697	32.2%	695	30.2%	1060	24.4%	160	15.3%
Civilian Hospital	13543	70.7%	7769	67.8%	1605	69.8%	3286	75.6%	883	84.7%

[a] Injury Severity Score, + Length of Stay in Days, ++ Inter Quartile Range.

1-Year mortality by patient characteristics

In the 1-year following index hospitalization for trauma 739 (3.9%) patients died. Mortality was concentrated in higher aged patients, with 609 (13%) dying among those aged 55–64 years compared as compared to only 8 (0.2%) patients aged 18–24 years ($p < 0.01$). Patients transferred to another hospital, those with two or more comorbid conditions and those suffering mainly head, and neck and extremity injuries also exhibited higher 1-year mortality (Table 2). Patients with longer ICU stay (>9 days) also had a higher mortality rate as compared to one day in the ICU (4.7% vs 3.1% [$p < 0.01$]; Fig. 1).

Predictors of 1-year mortality

In the risk adjusted model, longer ICU stay (>9 days vs 1 day) was also a significant predictor of mortality (Hazards Ratio [HR]: 2.6, 95% Confidence Interval [CI]: 1.7–4.0) (Table 3). Older age (55–64 years vs 18–24 years) was also a predictor of 1-year mortality (HR: 47.8,CI: 20.8–109.9). No other demographic

Table 2
Mortality by select demographic and clinical characteristics.

	Total	Died	Percentage
	19155	739	3.9%
Age (years) $p < 0.01$			
18–24	4816	8	0.2%
25–34	3733	7	0.2%
35–44	1547	4	0.3%
45–54	4359	111	2.6%
55–64	4700	609	13.0%
ICU Stay (days) $p < 0.01$			
0	11466	463	4.0%
1	2300	72	3.1%
2–9	4346	154	3.5%
>9	1043	50	4.7%
Injury Severity Score $p < 0.01$			
9–14	13664	568	4.2%
15–24	4305	151	3.5%
>24	1185	20	1.7%
Discharge Disposition $p < 0.01$			
Discharge	16060	579	3.6%
Transfer	2293	99	4.3%
Other	802	61	7.6%
Area of maximum injury $p < 0.01$			
Head and Neck	4497	197	4.4%
Face	37	0	0%
Chest	3201	43	1.3%
Abdomen	852	8	0.9%
Extremities	8097	469	5.8%
External	40	0	0%
Poly trauma	2431	22	0.9%
Charlson Comorbidity Index $p < 0.01$			
0	14675	238	1.6%
1	2574	199	7.7%
>1	1906	302	15.8%

Table 3
Risk-adjusted cox regression for 1-year mortality.

	Hazards Ratio	95% CI
Age (Years)		
18–24	1.0	Reference
25–34	1.6	0.5–5.0
35–44	0.5	0.1–4.2
45–54	9.8	4.3–22.5
55–64	47.8	20.8–109.9
Sex		
Female	1.0	Reference
Male	1.1	0.7–1.8
Race		
White	1.0	Reference
Black	0.7	0.5–1.1
Asian	0.6	0.3–1.1
Other	1.1	0.8–1.5
Sponsor Rank		
Officer	1.0	Reference
Enlisted Senior	0.8	0.7–1.0
Enlisted Junior	1.2	0.6–2.1
ICU Stay (Days)		
1	1.0	Reference
2–9	1.1	0.8–1.4
>9	2.6	1.7–4.0
0	0.8	0.6–1.1
Injury Severity Score		
9–14	1.0	Reference
15–24	1.0	0.8–1.3
>24	1.2	0.7–2.0
LOS	1.0	1.0–1.1
Discharge Disposition		
Discharge	1.0	Reference
Transfer	2.3	1.7–3.1
Other	1.4	1.1–2.0
Charlson Comorbidity Index		
0	1.0	Reference
1	1.5	1.2–1.9
>1	2.6	2.1–3.2

Adjusted for age, sex, race, beneficiary category, sponsor rank, geographic region, injury severity score, discharge disposition, Charlson comorbidity index and environment of care.

characteristic, including sex, race and socio-economic status, was a significant predictor of mortality. Additionally, discharge dispositions (transfer vs discharge) (HR: 2.3 CI: 1.7–3.1) and CCI (>1 vs 0) (HR: 2.6, CI: 2.1–3.2) were significant predictors of 1-year mortality after trauma hospitalization. ISS and length of hospitalization were not significant predictors of mortality in the multivariable model.

Discussion

This study of 19155 American patients admitted to the ICU demonstrated an overall 1-year mortality of 3.9% after trauma related hospitalization. Unsurprisingly, mortality was associated with advanced age (45 years and above), prolonged ICU stay (10 or more days), transfer to another hospital (compared to discharged to home) and presence of prior comorbid conditions.

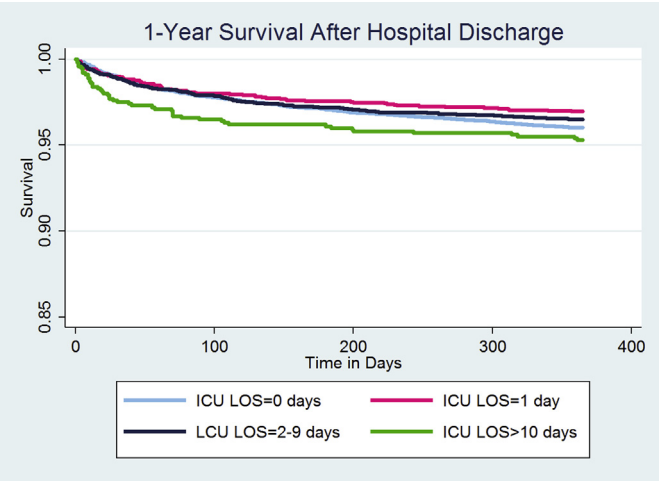

Fig. 1. Kaplan Meier survival estimates for patients after discharge.

Trauma patients constitute a small proportion of the ICU population but utilized a disproportionately large amount of ICU resources due to the need for prolonged intensive care.[1,18] With limited ICU resources, increasing costs of ICU care and well documented low long-term survival of ICU patients even after successful hospital discharge, the debate is heating up regarding the futility of prolonged ICU care.[2,3,19] To counter this narrative, a number of studies have come out that demonstrate a significantly lower in-hospital mortality rate for trauma ICU patients as compared to non-trauma ICU patients (86–88%).[1,19] Kisat et al. have reported that patients with more severe injuries are more likely to die early during the ICU stay, but those who survive the initial injuries, have a very high chance of survival (93.2% overall survival).[3]

One key factor missing in arguments used to justify prolonged ICU care for trauma patients is long-term survival for these patients beyond hospitalization. Due to the unique nature of the TRICARE database, our is one of the first national level studies to demonstrate that trauma patients with prolonged ICU stay have a good overall long-term survival rate, boosting the case for prolonged ICU care for trauma patients. The reason for this improved survival is related to younger age and limited number of co-morbidities encountered among most trauma patients.

The finding that Injury severity was not associated with long-

term mortality can be explained by the cohort selection for this analysis. All patients who died during the index hospitalization were excluded from the analysis, as in-hospital mortality has previously been studied. Kisat et al. have demonstrated that most of the in-hospital deaths in trauma patients were within the first few days of ICU stay and as ICU stay increased beyond 1 week, the odds of in-hospital mortality plummeted.[3] Those who survive the initial period of ICU care seem to have a high chance of survival up to hospital discharge. Our findings build upon this study and demonstrate that not only do these patients have better chances of in-hospital survival but most of them have very low 1-year mortality.

It is important to recognize that our study cohort was derived from a young population and prior work has demonstrated that geriatric population has a higher likelihood of delayed mortality when compared to younger patients with similar injury severity.[20] The findings in this study, hence, may not be completely applicable to the geriatric population, that make up an ever-increasing proportion of the U.S. trauma population. However, the Eastern association for the surgery of trauma, in its geriatric trauma guidelines, concludes that there is evidence the warrants intensive in-hospital care in these patients as a significant proportion of those who survive hospitalization go on to achieve their preinjury level of independence.[21]

Limitations

We acknowledge the following limitations in this work. Foremost, this study was performed on administrative healthcare data that was not collected for research purposes. In addition to the potential for bias introduced by data entry personnel, such administrative data lack clinical granularity. We attempted to account for the possibility of bias by using validated clinical indices for disease severity and comorbid conditions such as ISS and CCI; and performing multivariable models for establishing association. However, unmeasured confounders might influence our results due to lack of nuanced details, such as the use of mechanical ventilation. Additionally, due to the lack of clinical information in the database, the cause of death for patients could not be determined, limiting the conclusions we can draw from these findings. We also acknowledge that there are some unmeasured aspects of military-affiliated populations that might influence the findings of the study and impair generalizability as a result. To mitigate this phenomenon, we performed sensitivity analyses by excluding all active-duty military personnel from the cohort. Interestingly, there are no meaningful differences in the results of sensitivity testing when compared to our primary findings. Moreover, our analysis was limited to patients between the ages of 18 and 64 years, hence these findings may not be generalizable to the pediatric and geriatric population. Finally, the database lacked any information on functional outcomes among trauma survivors, limiting our capacity to determine ultimate functional status and quality of life. As many trauma survivors are young individuals with a long life-expectancy at the time of injury, these facets of trauma care should be considered in future work.

Conclusion

Prolonged ICU stay, and advanced age are significantly associated with 1-year trauma mortality but survival after trauma related hospitalization remains high (more than 96%). ICU care for trauma patients can be resource intensive but given the high long-term survival of these patients, we conclude that such care is justified when deemed clinically necessary.

Authors' contribution

MAC, AJS, TPK, ZC and AHH made significant contributions towards the conception and design of the study. MAC, TPK and AHH were responsible for data acquisition. MAC performed data analysis. MAC, AJS, TPK, ZC and AHH contributed to interpretation of results. MAC and AJS drafted the manuscript and TPK, ZC and AHH revised the manuscript for intellectual content. All authors gave final approval for this version of the manuscript.

Disclosure

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amjsurg.2019.01.025.

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