Observational Study

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Impact of trauma designation levels on survival of drowning victims

An observational study from trauma centers in the United States

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Abstract

Drowning causes significant morbidity and mortality. Healthcare regionalization aims at improving patient outcomes. This study examines the impact of trauma center level designation on survival of drowning victims.

Retrospective cohort study utilizing the National Trauma Data Bank (NTDB) 2015. Descriptive, bivariate and multivariate analyses were conducted.

The 212 patients were included. Mean age was 33.58 (±20.02) years with 69.3% (n=147) males. Patients were mostly taken to Level I (n=107, 50.5%) and II (n=81, 32.8%) centers, requiring admission (43.5% (n=96), 23.1% (n=49) and 8.5% (n=18) to Intensive Care, floor, and Operating Room, respectively). Overall hospital discharge survival was 83.5% (n=177). After adjusting for confounders, there was no significant difference in survival of patients taken to Level I compared to Level II and III centers.

This study did not identify a survival benefit for patients with drowning related injuries when taken to Level I compared to Level II or III Trauma centers. Further outcome studies are needed in organized trauma systems to improve field triage criteria for specific injury mechanisms.

Abbreviations: ACS = American College of Surgeons, ED = emergency department, EMS = emergency medical services, GCS = Glasgow Coma Scale, ICD-CM = International Classification of Diseases Clinical Modifications, ICU = intensive care unit, IQR = interquartile range, ISS = Injury Severity Score, NEDS = Nationwide Emergency Department Sample, NTDB = National Trauma Data Bank, SBP = systolic blood pressure, SD = standard deviation, WHO = World Health Organization.

Keywords: drowning, outcome, survival, trauma

1. Introduction

Drowning contributes to significant mortality. According to the World Health Organization (WHO), drowning is the 3rd leading cause of death and is responsible for 7% of unintentional injury related mortality, with 360,000 annual deaths worldwide.[1] Children, males and individuals with access to water are at increased risk of drowning.[1] The economic cost is also significant. In the United States, the financial burden of coastal drowning alone is more than 270 million US dollars per year.[1] Characteristics of drowning victims and associated clinical outcomes have been previously described. Predictors of poor outcomes include male gender, presence of specific chronic conditions and motor vehicle traffic injuries.[2] Complications of drowning include aspiration pneumonia,[3] and poor neurologic outcome resulting from hypoxic brain injury.[4]

Regionalized healthcare in the United States aims at improving patient outcomes, resources' utilization and at minimizing cost of care.[5] The designation of trauma centers is often labelled as a successful example of regionalization.[6] Trauma Centers in the US are categorized through verification from the American College of Surgeons (ACS) or through designation by the State.[7] Previous studies have been conducted to examine the association between trauma center level and patient outcomes in specific patient populations: These included patients with traumatic brain injury,[8] those undergoing early thoracotomy[9] and patients arriving to trauma centers with no signs of life.[10]

This study examines the impact of trauma center level classification (both ACS verification and State Designation) on survival to hospital discharge of patients with drowning injuries in the United States.

2. Methods

2.1. Study design and setting

Data from the National Trauma Data Bank (NTDB), which is the largest trauma registry in the United States, is gathered from over 900 facilities and released on an annual basis.[11] The total number of records included so far in NTDB has exceeded 6 million.[12] The inclusion of patients in NTDB is done using International Classification of Diseases (ICD) codes for trauma related injuries. Patients with ICD-9-CM diagnosis 800.00–959.9 (excluding

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905-909 (late effects of injury), 910-924 (blisters, contusions, abrasion, and insect bites), 930-939 (foreign bodies)) who were admitted, or died after receiving any evaluation or treatment or were dead on arrival" are usually included in the database[12] The dataset also contains pre-hospital, Emergency Department (ED) and hospital information including patient demographics, injury details, injury severity and outcomes.[13]

The NTDB public release dataset of 2015 was utilized for this retrospective cohort study. The total number of patients in the dataset was 917,865. Patient sustaining drowning injuries, that is, those who had "drowning/submersion" listed under the variable "mechanism" in the dataset, were considered eligible. Age was subclassified into pediatric for 15 years and below and adult for 16 years and above, similar to other trauma studies.[14] Patients who had undetermined age (value=–99) were excluded. Additional exclusion criteria were: patients with unknown outcomes (ED disposition not known/not recorded, not applicable, discharged against medical advice), unknown hospital dispositions and transfers to other facilities including jail, institutional care, mental health. Trauma center level was examined as a combination of ACS (pediatric or adult) and State Designation, with the highest level considered the trauma center level.[15] Patients who were taken to an unverified trauma center (ACS pediatric, adult or State Designation) were also excluded (Fig. 1).

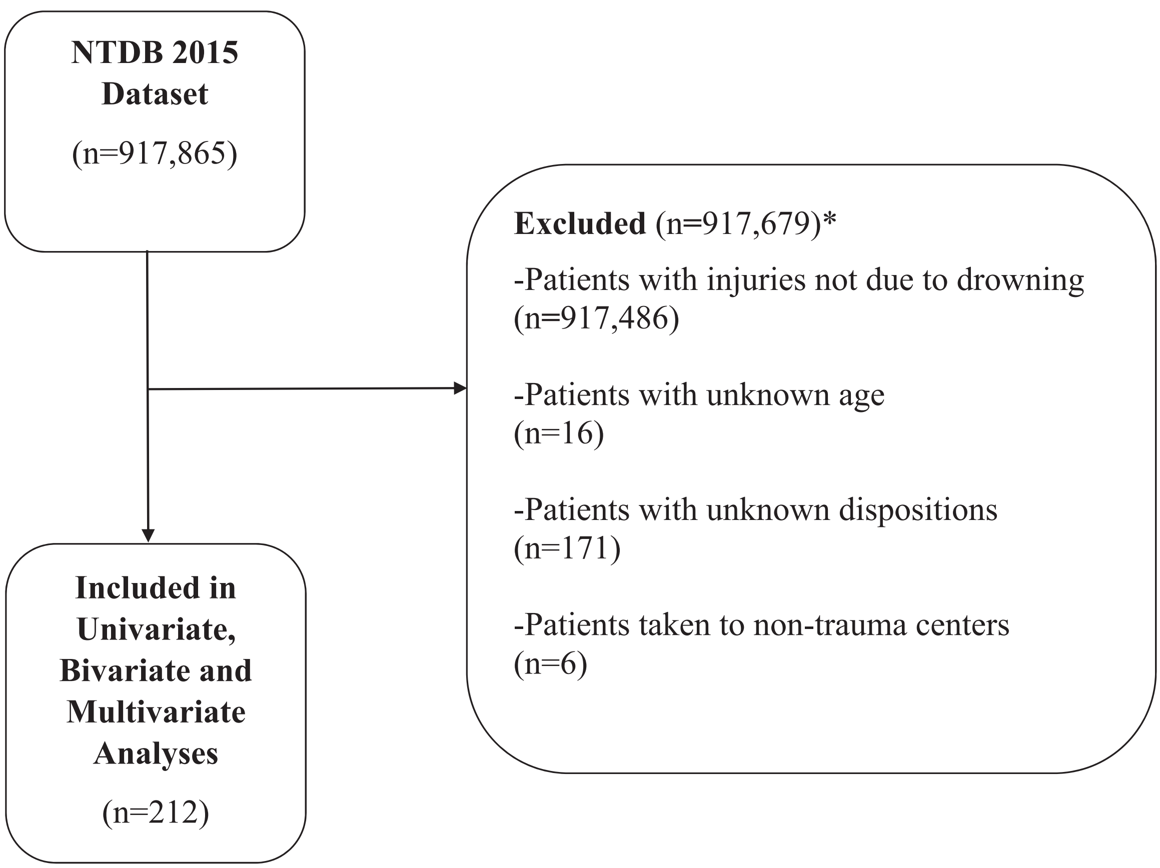
The Institutional Review Board office at the American University of Beirut provided an exemption for the use of this de-identified dataset.

2.2. Data analysis

Statistical analyses were performed using Statistical Package for the Social Sciences (SPSS 24.0). Categorical variables were presented by calculating their frequencies and percentages whereas continuous variables were summarized as mean ± standard deviation (SD), median and interquartile range (IQR). Comparisons of trauma levels (I, II and III) and categorical variables were carried out by the Pearson Chi-Square test or the Fisher Exact test. A multivariate analysis was done to examine the impact of trauma center level designation on patient outcomes. The variable "trauma designation levels" was included in the model as the main independent variable. *P* value of ≤.05 was used to denote statistical significance.

3. Results

A total of 212 patients sustaining drowning injuries were included in this study. The majority of patients were adults (≥16 years) and the mean age was 33.58 (± 20.02) years. Male gender and White race were predominant (n=147, 69.3% and n=166, 78.3%, respectively). More than half of patients were previously healthy



*Patients who underwent inter-hospital facility transfer also had one of the excluded categories with regards to ED disposition. This overlap explains why the final number on which the data analysis was conducted cannot be calculated by subtracting the number of excluded patients from the selected sample.

Figure 1. Inclusion and exclusion flowchart.

without any pre-existing comorbidities (n=123, 58.0%). The most common mode of transportation was ground ambulance (n=137, 64.6%) and patients were taken mostly to university and community hospitals (n=98, 46.2% and n=89, 42.0%, respectively). Most common geographic locations of hospitals were South (n=85, 40.1%) and West (n=65, 30.7%) US regions. Patients sustaining drowning injuries were mostly taken to Level I (n=107, 50.5%) and Level II (n=81, 38.2%) centers. Intensive Care Unit (ICU) was the most common disposition from the ED (n=96, 43.5%), followed by floor bed (n=49, 23.1%). Regarding hospital disposition, most patients were discharged home (n=121, 57.1%) or transferred to other destinations (n=38, 17.9%). Overall survival was 83.5% (n=177) (Table 1).

Most of these injuries were unintentional (n=199, 93.9%) occurring in a public setting (building/street/recreation) (n=112, 52.8%). Internal organ injuries were sustained in 56.1% (n=119) and fractures in 39.6% (n=84) of cases. Head and neck were most commonly body areas injured (n=115, 54.2%), followed by torso (n=63, 29.7%), spine and back (n=61, 28.8%) and extremities (n=46, 21.7%). More than 2 thirds of patients had an Injury Severity Score (ISS) of 15 or lower (n=114, 67.9%). Prehospital Glasgow Coma Scale (GCS) was <13 in 41.6% (n=64) of patients and Systolic Blood Pressure was ≤90 mmHg in 21.4% (n=31) of patients. Alcohol use was reported in 24.5% (n=52) and drug use was reported in 15.1% (n=32) of patients. The median total elapsed time from Emergency Medical Services (EMS) dispatch to ED arrival was 49 minutes (IQR 35-79) (Table 2).

Table 1

General characteristics.

	Frequency (N=212)	Percentage
Age (Mean ± SD) (33.58 ± 20.02)		
Pediatric (≤15)	42	19.8%
Adult (≥16)	170	80.2%
Gender		
Male	147	69.3%
Female	65	30.7%
Race		
White	166	78.3%
Black or African American	20	9.4%
Other*	19	9.0%
Not known/not recorded	7	3.3%
Co-morbidities		
Yes	89	42.0%
No	123	58.0%
Mode of transportation		
Ground ambulance	137	64.6%
Helicopter ambulance	43	20.3%
Public/private vehicle	27	12.7%
Other	5	2.4%
Hospital teaching status		
University	98	46.2%
Community	89	42.0%
Non-teaching	25	11.8%
Hospital geographic location		
South	85	40.1%
West	65	30.7%
Midwest	32	15.1%
Northeast	30	14.2%
Trauma level		
I	107	50.5%
II	81	38.2%
III	24	11.3%
Patient disposition (ED)		
Intensive care unit (ICU)	96	43.5%
Floor bed (general admission, non-specialty unit bed)	49	23.1%
Operating room	18	8.5%
Home with services	1	0.5%
Home without services	16	7.5%
Deceased/expired	16	7.5%
Telemetry/step-down unit	10	4.7%
24-Hour observation unit	6	2.8%
Patient disposition (hospital)		
Discharged home or self-care (routine discharge)	121	57.1%
Transferred to other destination	38	17.9%
Deceased/expired	19	9.0%
Left against medical advice or discontinued care	1	0.5%
Not applicable (deceased in ED/ discharged home from ED)	33	15.6%
Died ED/hospital		
Yes	35	16.5%
No	177	83.5%

* Other Race includes Asian, Native Hawaiian or Other Pacific Islander, Other Race.

Table 2

Event and injury characteristics.

	Frequency (N=212)	Percentage
Injury intentionality		
Unintentional	199	93.9%
Self-inflicted	7	3.3%
Assault	5	2.4%
Undetermined	1	0.5%
Location of injury		
Public building and street and recreation	112	52.8%
Home and residential institution	36	17.0%
Industry and farm and mine	4	1.9%
Unspecified and other	55	25.9%
Not known/not recorded	5	2.4%
Nature of injury		
Internal organ	119	56.1%
Fractures	84	39.6%
Open wounds	58	27.4%
Sprains and strains	25	11.8%
Others*	19	9.0%
Unspecified	27	12.7%
Region of Injury		
Head and neck	115	54.2%
Torso	63	29.7%
Spine and back	61	28.8%
Extremities	46	21.7%
Unclassifiable	13	6.1%
Injury severity score		
≤ 15	144	67.9%
≥ 16	65	30.7%
Not known/not recorded	3	1.4%
Glasgow coma scale from emergency medical services		
Mild (13–15)	90	58.4%
Moderate (9–12)	10	6.5%
Severe (≤ 8)	54	35.1%
Missing=58 (27.4%)		
Systolic blood pressure from emergency medical services		
≥91		
≤90	114	78.6%
Missing=67 (31.6%)	31	21.4%
Alcohol use		
Yes	52	24.5%
No	142	67.0%
Not known/not recorded	18	8.5%
Drug use		
Yes	32	15.1%
No	165	77.8%
Not known/not recorded	15	7.1%
	Median	**IQR (Q1-Q3)**
Time from EMS dispatch to ED arrival (N=173)	49	35–79

* Amputations, Blood Vessels, Crush, Dislocation, System Wide, and Late Effects.

Table 3

Bivariate analysis.

	Trauma designation level			
	I (N=107)	II (N=81)	III (N=24)	*P* value
Age*				
Pediatric	29 (27.1%)	11 (13.6%)	2 (8.3%)	.027
Adult	78 (72.9%)	70 (86.4%)	22 (91.7%)	
Hospital teaching status				
University	82 (76.6%)	16 (19.8%)	0 (0%)	<.001
Community	23 (21.5%)	59 (72.8%)	7 (29.2%)	
Non-teaching	2 (1.9%)	6 (7.4%)	17 (70.8%)	
Hospital geographic location				
South	50 (46.7%)	28 (34.6%)	7 (29.2%)	
West	21 (19.6%)	33 (40.7%)	11 (45.8%)	.023
Midwest	21 (19.6%)	8 (9.9%)	3 (12.5%)	
Northeast	15 (14.0%)	12 (14.8%)	3 (12.5%)	
Nature of injury				
Internal organ	66 (61.7%)	47 (58.0%)	6 (25.0%)	.004
Sprains and Strains	7 (6.5%)	13 (16.0%)	5 (20.8%)	.038
Region of injury				
Head and neck	65 (60.7%)	42 (51.9%)	8 (33.3%)	.044
Extremities and unclassifiable	31 (29.0%)	14 (17.3%)	12 (50.0%)	.005
Died in ED/hospital				
Yes	22 (20.6%)	11 (13.6%)	2 (8.3%)	.275
No	85 (79.4%)	70 (86.4%)	22 (91.7%)	

Variables that were not presented due to the lack of significant difference between Trauma Designation Levels: Gender, Race, Co-morbidities, Mode of Transportation, Patient Disposition (ED), Patient Disposition (Hospital), Injury Intentionality, Location of Injury, Injury Severity Score, Glasgow Coma Scale, Systolic Blood Pressure, Alcohol Use, and Drug Use.

* Games-Howell post-hoc test was used to identify the significant groups: $1<2<3$

Results of the bivariate analysis are shown in Table 3. Patients taken to a Level I center were significantly more likely to be treated at a university hospital in the South region and were more likely to have sustained internal organ and head and neck injury. Those taken to a Level II center were significantly more likely to be taken to a community hospital in the West and to have internal organ and head and neck injury. Patients taken to a Level III center were significantly more likely to be treated at a non-teaching hospital in the West and to have both internal organ and sprain and strain injuries in addition to injury of extremities with regards to region. Overall survival of drowning patients to hospital discharge was 79.4% (n=85) in Level I, 86.4% (n=70) in Level II and 91.7% (n=22) in Level III (Table 3).

After adjusting for potential confounders including patient demographics and comorbidities, hospital teaching status, location and trauma level, mode of patient transportation and injury details, there was no statistical difference in survival to hospital discharge of drowning patients between those taken to Level I and II centers and Level I and III centers (Table 4).

4. Discussion

Drowning is usually classified as a mechanism of injury and drowning victims are considered trauma patients.[16] This is the first study that examines the impact of trauma center levels on survival of patients with drowning related injuries. Survival to hospital discharge ranged from 79.4% (n=85) in Level I to 91.7% (n=22) in Level III. Multivariate analysis showed no survival benefit for patients when taken to Level I compared to Levels II and III centers.

Previous literature regarding impact of different trauma center levels on outcomes reported conflicting results. A study using the Pennsylvania Trauma Systems Foundation registry found no difference in survival between Level I and Level II centers for patients with traumatic injuries. Mechanisms of injury were broadly classified as either blunt or penetrating, and patients with thermal injuries were excluded. The unadjusted mortality rate at Level I centers was higher than that at Level II centers, but no difference was found after adjusting for confounders.[17] These findings are in line with our study which included only a specific

Table 4

Logistic regression model.

	Unadjusted OR (95% CI)	Unadjusted *P* value	Adjusted OR (95% CI)	Adjusted* *P* value
Trauma level (I)				
II	1.647 (0.748–3.629)	0.216	1.770 (0.649–4.831)	.265
III	2.847 (0.622–13.038)	0.178	2.853 (0.436–18.681)	.274

* Variables that were included in the model are: age, gender, race, hospital teaching status, trauma designation level, Geographic region for the hospital, comorbidity, Injury Intentionality as defined by the CDC Injury Intentionality Matrix, the Mode of Transportation, The Injury Severity Score reflecting the patient's injuries directly submitted by the facility regardless of the method of calculation, ICD-9 body region as defined by the Barell Injury Diagnosis Matrix (Fractures, Internal organ, Open wounds, Sprains and Strains, Unspecified), Nature of injury as defined by the Barell Injury Diagnosis Matrix (Extremities and unclassifiable by site, Head and Neck, Spine and Back, Torso).

subset of trauma patients with drowning related injuries. Other studies however reported improved outcomes in Level I centers compared to Level II in other trauma subpopulations including patients with cardiovascular and high-grade liver injuries,[18] or those with severe traumatic brain injury.[8] Furthermore, Cudnic et al described survival benefit for patients taken to Level I centers, compared to Level II in a study that included different types of traumatic injuries using the Ohio Trauma Registry.[19] All the above-mentioned studies, however, did not incorporate both ACS Verification and State Designation in classifying trauma centers and used only 1 type of trauma classification while our study used a combination of both levels to assess the impact on outcomes.

Mortality rates of patients with submersion injuries in the United States have been previously reported. In a study utilizing Nationwide Emergency Department Sample (NEDS), overall mortality in this subgroup of patients was found to be 9.5% at hospital discharge. Both adult and pediatric patients were included.[2] In comparison, overall mortality in our study was higher (n=35, 16.5%). This higher mortality rate can be attributed to different factors including sample selection and characteristics of the different databases used for the studies. While NEDS database consists of patients seen in EDs from a sample of US hospitals which include trauma centers and other non-designated hospitals,[20] NTDB enrolls patients only based on specific ICD codes pertaining to traumatic injuries.[13] Additionally, patients in NEDS present to different types of EDs and might have lower clinical severity compared to those presenting to designated trauma centers based on prehospital triage criteria in the US.

Interpreting the results of this study requires an understanding of how trauma center verification and designation are done. The primary difference in level classification is that Level I centers require 24-hour in-house coverage of specialists, whereas Level II require immediate coverage which is not necessarily in-house.[21] A previous study examining this criterion did not identify a difference in outcomes with out-hospital or in-hospital response of attending surgeon, provided that response is within a defined period of time.[22] Moreover, Level I centers require a minimum annual patient load of critically injured patients in addition to research aimed at improving trauma care.[21] No increase in survival was however reported with higher trauma center volumes both at state level (New York)[23] and nationwide using the NTDB.[24]

The lack of significance in survival of drowning patients between Level I and II is of specific importance regarding field triage. ACS verification and State designation of trauma centers should ideally guide prehospital patient transports from scene and referrals from other hospitals to specialized centers for trauma care. Prehospital agencies also use facility categorization to develop standardized triage criteria and to identify appropriate receiving facilities for patients with acute medical emergencies and trauma. As per the guidelines set forth by Centers of Disease Control and Prevention, drowning is not listed as a subtype of "mechanism of injury".[25] These patients are subsequently triaged by other criteria, namely physiologic and anatomic, the former of which is dependent on patient vitals and Glasgow Coma Scale. Patients with GCS score of ≤13 or a Systolic Blood Pressure (SBP) of <90 mmHg are usually transferred to facilities of "highest level of care within the defined trauma system" which are generally Level I.[25] Drowning patients fitting the criteria of GCS and SBP were 41.6% (n=64) and 21.4% (n=31), respectively in our study. In the absence of a significant observed survival advantage for patients treated at a specific Trauma center level, prehospital guidelines can safely triage drowning victims to any Level trauma center based on geographic proximity.

The limitations of this study are related to the dataset used and to its retrospective nature. Patients declared dead on the scene are not transported to the Emergency Department which could have resulted in overestimation of the survival rate. Hospitals also differ by the quality of the data they include in the dataset even though this is constantly reviewed part of quality assurance.[12] Nonetheless, this is the first study to report on the impact of trauma center level classification on the survival of patients presenting with drowning injuries while utilizing the largest and hence most representative trauma registry in the United States.

5. Conclusion

Trauma centers categorization is an essential element of health-care regionalization that aims at improving survival and trauma patient outcomes. In this study, there was no difference in survival to hospital discharge for patients with drowning related injuries when taken to Level I compared to level II or III centers. This warrants further outcome studies to better tailor field triage criteria for specific injury mechanisms.

Author contributions

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