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Trauma center designation level and survival of patients with chest wall instability

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ABSTRACT

Introduction: Chest wall instability is a potentially life-threatening condition that should be evaluated at a trauma center. While patients with chest wall instability are sent to different trauma center levels, the impact of this on outcomes has not been evaluated yet. This study examines survival to hospital discharge of patients with chest wall instability treated at different trauma center levels.

Methods: This is an observational retrospective cohort study analyzed data from National Trauma Data Bank (NTDB) 2017 dataset. The study sample consisted of adult patients who presented with chest wall instability or deformity and for whom the ED disposition was recorded. Descriptive analysis was carried out. Hospital information, patients' demographic and clinical characteristics, and dispositions were compared based on the main independent variable "trauma designation level. This was followed by LASSO regression to determine the impact of the trauma designation level on patients' survival after controlling for most of the extracted factors from NTDB to conduct this study.

Results: The study sample consisted of 1172 patients sustaining chest wall instability or deformity. Most patients were males (78.2%) and had a median age of 52 years. Most were taken to level I (51.5%) or level II (43.2%) trauma centers. The overall survival to hospital discharge was 78.2%. After adjusting for confounders, no difference in patients' survival was noticed between those taken to level II [OR = 1.000; 95% confidence interval (CI): 0.976–1.025] or III [OR = 1.000; 95% CI: 0.993–1.007] trauma centers and those taken to level I centers.

Conclusion: Survival rates for patients having chest wall instability were similar when transported to level II or level III versus level I centers. This finding can help guide pre-hospital field triage criteria for this specific type of injury and highlights the need for more outcome research in organized trauma systems.

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1. Introduction

Chest wall trauma is a common occurrence. One out of four trauma patients die due to thoracic injury or its complications [1]. Approximately half a million patients presented to emergency departments (EDs) in the United States in 2013 with an injury to their bony thorax, and about 200,000 of those were hospitalized [2]. Moreover, chest wall instability (e.g., flail chest) is a potentially life-threatening condition resulting from chest wall trauma. It is defined as a fracture of at least three adjacent ribs broken in at least two planes, resulting in impaired paradoxical movement of the chest wall and leading to respiratory insufficiency [3]. Flail chest leads to mortality in nearly a third of the patients and is highly associated with pulmonary contusion, pneumothorax, and hemothorax [4]. Patients often require mechanical ventilatory support and develop significant respiratory complications [5].

Patients with chest wall instability are usually triaged to different trauma center levels. Trauma centers are designated level I to level V by states and/or the American College of Surgeons (ACS) based on the resources and the level of care available to be provided to patients presenting with trauma. A level I center is able to provide the highest level of care, whereas a level IV or V center can provide stabilization for transfer to a center with a higher level of care [6]. Higher trauma center level designation (level I compared to II and III) has been shown to be associated with improved outcome with patients presenting with motor vehicle transport injuries [7].

The current recommendation by the Centers for Disease Control and Prevention (CDC) field triage is that patients with chest wall instability or deformity (e.g., flail chest) should be transported to a facility that provides the highest level of care within the defined trauma system [8]. There is extensive literature on management (operative versus

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non-operative) and disposition (trauma center need) for trauma patients with chest wall instability [2,9]. However, the impact of trauma center level designation on mortality and morbidity has not been explored yet. In this study we examine the evidence behind this recommendation by comparing the survival rates of patients with chest wall instability who were treated at trauma centers with different designation levels in the United States.

2. Methods

We conducted a retrospective study using the 2017 US National Trauma Data Bank (NTDB) to identify trauma patients presenting with chest wall instability. "The 2017 National Trauma Data Bank (NTDB) provides an updated analysis of the largest aggregation of US trauma registry data ever assembled. In total, the NTDB now contains more than 8 million records" [10].

Sample selection from NTDB was performed based on the following variable: trauma center criteria: chest wall instability or deformity (e.g., flail chest). This yielded a sample of 1534 records (Fig. 1).

We excluded patients whose age was not recorded ($n = 32$) and pediatric patients (≤15 years old: $n = 29$) similar to other trauma studies [11]. Moreover, exclusion criteria involved patients with unknown ED outcome (undetermined ED discharge disposition (unknown ($n = 15$), left against medical advice (n = 1); transferred to another hospital ($n = 44$); other ($n = 5$) such as jail, institutional care facility, mental health) and those who underwent an inter-hospital facility transfer ($n = 240$). We also excluded cases for whom the trauma designation level was not recorded ($n = 19$). Further, patients who presented with mode of transportation other than ground ambulance or helicopter ambulance ($n = 8$) or those with unknown/ not recorded mode of transportation (n = 1) were excluded. A total of 1172 patients met the inclusion criteria and constituted the study sample.

The collected variables included patient demographics (e.g.: age, sex, ethnicity), transport mode, hospital characteristics (facility level: bed size, hospital teaching status), trauma mechanism, severity and type of injury, and ED and hospital discharge dispositions.

The abbreviated injury scale (AIS) severity was divided into two groups:

- Group 1 [AIS <3]: it included any patients for whom the AIS severity was recorded as being minor or moderate injury.
- Group 2 [AIS ≥3]: it included any patients for whom the AIS severity was recorded as being serious, or severe, or critical, or maximum/ virtually unsurvivable injury.

We extracted the body region and the nature of injury from the first diagnosis. We combined two variables, ACS verification level and state designation, into a new variable: trauma designation level. The highest level was assigned to the newly created variable.

The injury severity score (ISS) body regions consisted of the following categories: 1) head or neck - including cervical spine, 2) face - including the facial skeleton, nose, mouth, eyes and ears, 3) chest - thoracic spine and diaphragm, 4) abdomen or pelvic contents - abdominal organs and lumbar spine, 5) extremities or pelvic girdle - pelvic skeleton, and 6) external. Each patient can sustain several injuries in different body regions that are coded as yes/no.

The primary outcome was defined as survival to hospital discharge.

An exemption from the institutional review board at the American University of Beirut (Beirut, Lebanon) was obtained for the use of the de-identified NTDB dataset.

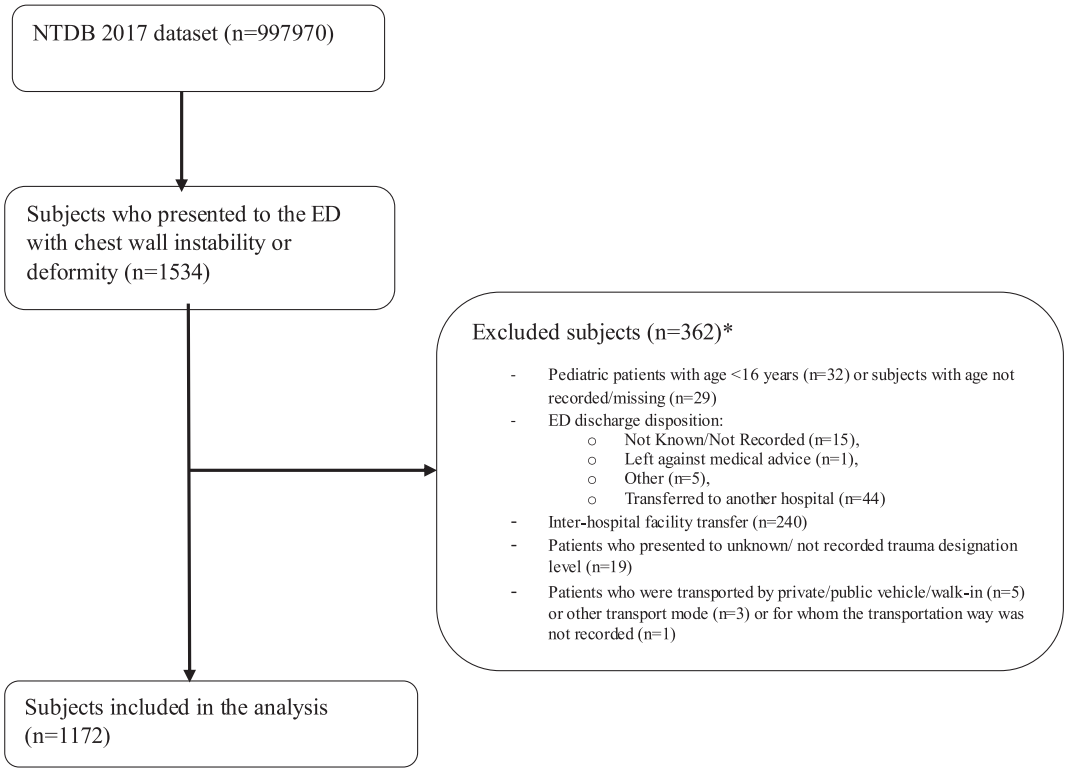
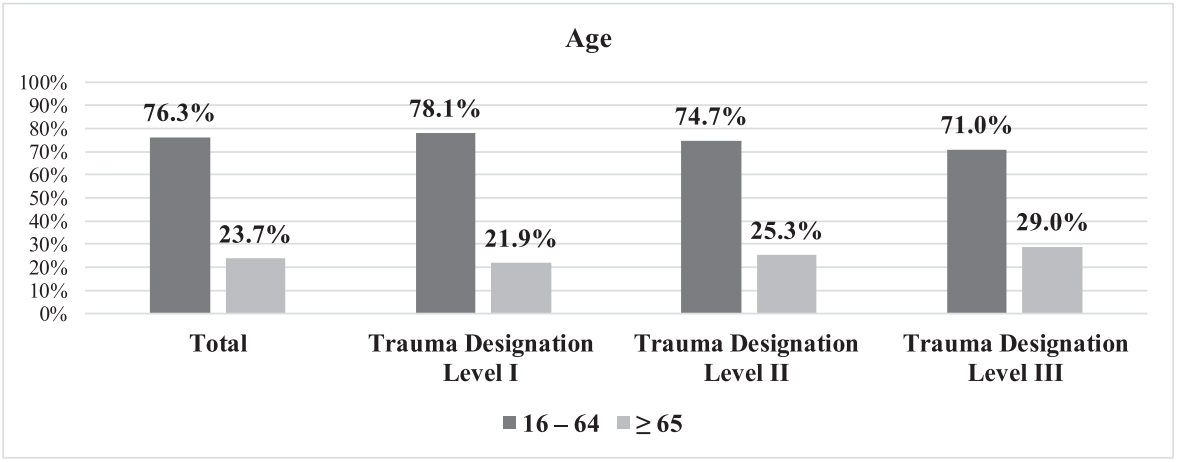


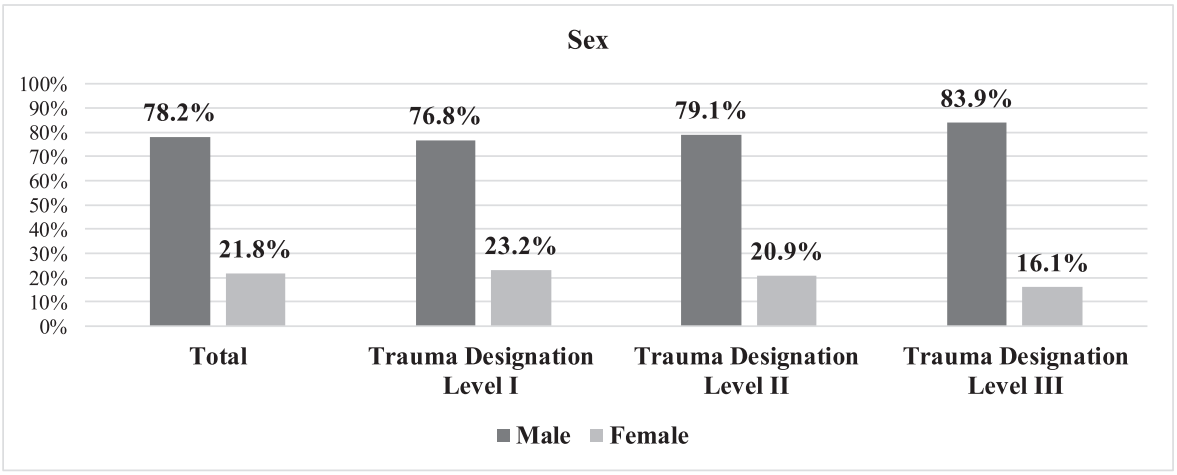
Fig. 1. Flowchart displaying the inclusion and exclusion criteria of patients with chest wall instability.
NTDB = National Trauma Data Bank; ED = Emergency Department.
* There are overlaps among the categories of the excluded variables. More specifically, some patients who had inter-hospital facility transfer had as ED disposition one of the excluded categories. Also, some patients whose age was not recorded or were 15 years or younger were transferred or had as ED disposition one of the excluded categories. These overlaps explain why the final number on which the data analysis was conducted cannot be calculated just by subtracting the number of excluded patients from the selected sample.

2.1. Statistical analyses

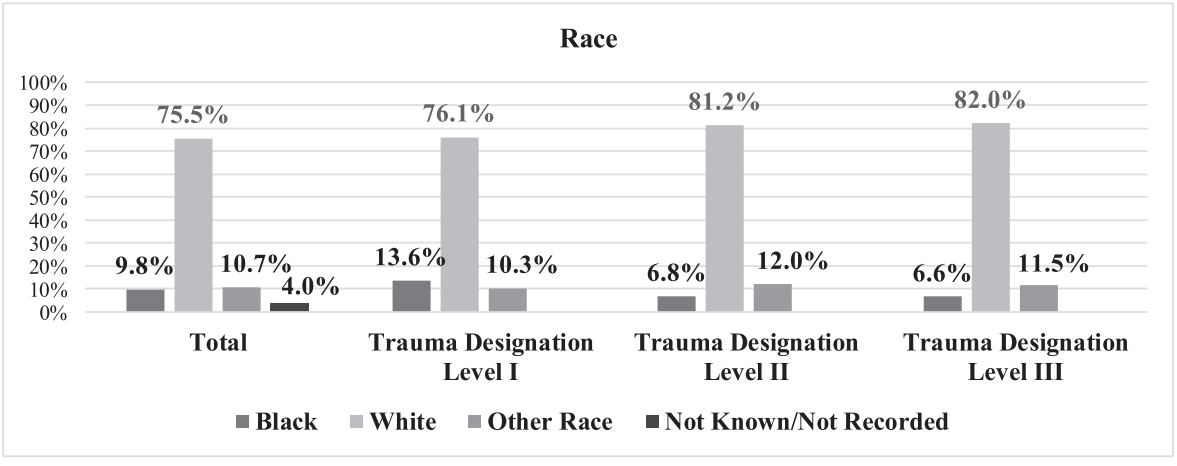
All statistical analyses were carried out using the Statistical Package for the Social Sciences, version 24 (SPSS Inc., Chicago, IL). Frequencies and percentages were presented to describe the categorical variables. Median and interquartile range (IQR) were calculated to summarize age variable. Pearson's chi-square or Fisher's exact tests were used to tabulate hospital information, patients' demographic and clinical characteristics, and dispositions by the main independent variable "trauma designation level". A multivariable analysis was carried out. More specifically, the least absolute shrinkage and selection operator (LASSO) was then conducted to build the best fitting predictive model of the survival of patients sustaining chest wall instability. The penalty term λ was selected using the ten-fold-cross-validation. This regression technique handles multicollinearity by reducing the likelihood of overfitting. Also, LASSO regression enhances the prediction accuracy



P-value = 0.244



P-value = 0.358



P-value = 0.006

Fig. 2. Demographic characteristics of the total study sample and by trauma designation level.

and interpretability of the produced model. Thereby, the LASSO model allowed us to examine the association between trauma designation level and patients' survival to hospital discharge after controlling for most extracted factors from NTDB 2017 to implement this study. The trauma type and injury intentionality variables were not included in the regression analysis because almost all patients had blunt injuries that were unintentional. *P*-value of ≤0.05 was used to denote statistical significance.

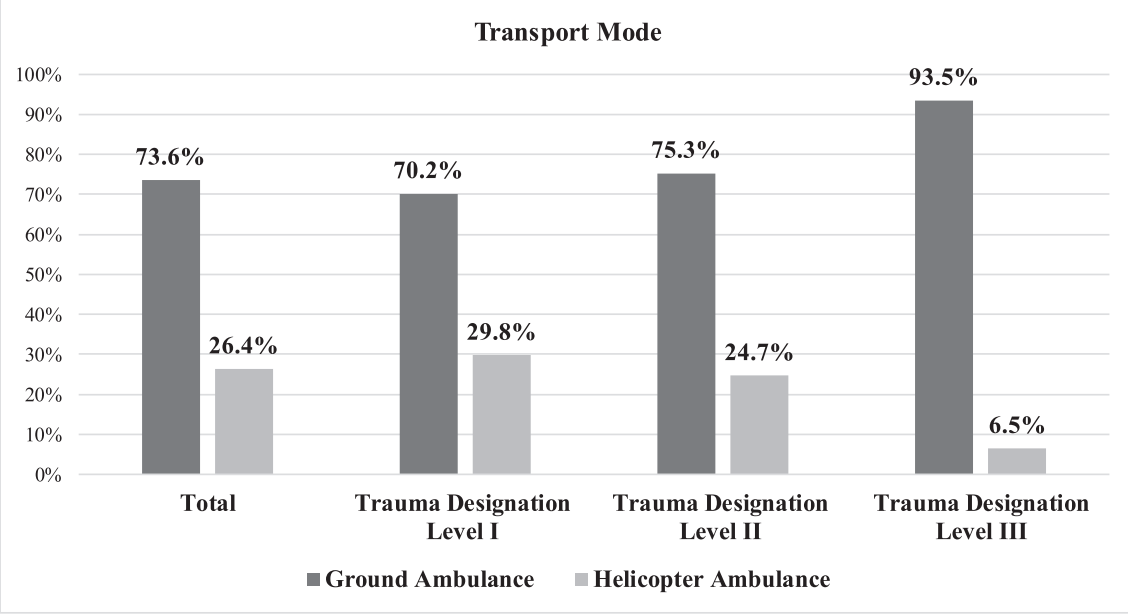
3. Results

The demographic characteristics of the 1172 patients included in the study are illustrated in Fig. 2.

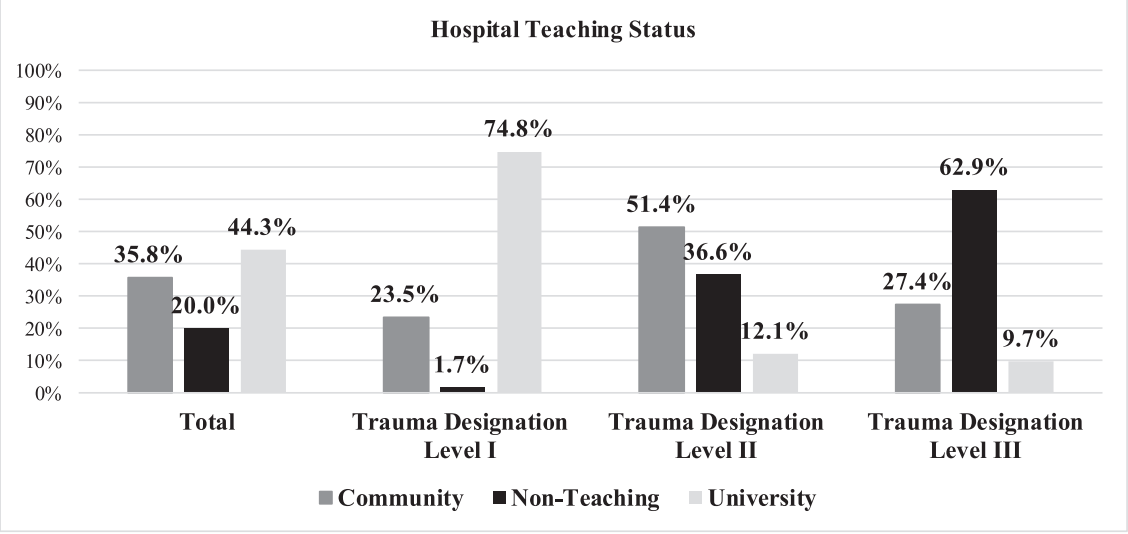
The median age was 52 years (IQR: 64–37) with the majority of patients being in the age group of 16–64 years (76.3%). Most patients were males (78.2%), and white (75.5%). Coverage was mainly by private insurance (45.1%) [data not shown]. Ground ambulance (73.6%) was the most common transport mode (Fig. 3). Moreover, most patients were transferred to level I (51.5%) or level II (43.2%) trauma centers.

Clinical and injury characteristics are presented in Tables 1 and 2. At presentation, patients commonly had an injury severity score (ISS) ≥ 16 (59.1%), an abbreviated injury scale (AIS) ≥3 (82.1%), a Glasgow Coma Scale (GCS) of 13–15 (66.4%), and were hemodynamically stable with a systolic blood pressure (SBP) ≥ 90 mmHg (80.0%). Most injuries were unintentional (94.3%), blunt (95.8%), and due to motor vehicle traffic (MVT) or fall (80.2%). Injury types were mostly fracture (47.3%) and internal organ injury (32.8%). Moreover, the torso was the most frequently injured body region (58.4%).

Patients were mainly admitted from the emergency department (ED) to the intensive care unit (ICU) (41.0%); while only 0.5% were sent to an observation unit for <24 h and 3.0% were discharged home.



P-value <0.001



P-value <0.001

Fig. 3. Transport mode and hospital teaching status of the total study sample and by trauma designation level.

Table 1
Clinical characteristics of the total study sample and by trauma designation level.

	Total	Trauma designation level			*p*-value
	N = 1172	I (*N* = 604)	II (*N* = 506)	III (*N* = 62)	
Comorbidity					
No	479 (40.9%)	229 (37.9%)	214 (42.3%)	36 (58.1%)	0.006
Yes	693 (59.1%)	375 (62.1%)	292 (57.7%)	26 (41.9%)	
ISS					
≤15	479 (40.9%)	237 (39.2%)	213 (42.1%)	29 (46.8%)	0.392
≥16	693 (59.1%)	367 (60.8%)	293 (57.9%)	33 (53.2%)	
AIS					
<3	210 (17.9%)	114 (18.9%)	82 (16.2%)	14 (22.6%)	0.317
≥3	962 (82.1%)	490 (81.1%)	424 (83.8%)	48 (77.4%)	
GCS					
Severe ≤8	331 (28.2%)	160 (26.7%)	149 (30.2%)	22 (37.3%)	0.230*
Moderate 9–12	43 (3.7%)	25 (4.2%)	15 (3.0%)	3 (5.1%)	
Mild 13–15	778 (66.4%)	415 (69.2%)	329 (66.7%)	34 (57.6%)	
Not known/Not recorded	20 (1.7%)				
SBP					
<90	194 (16.6%)	85 (14.3%)	91 (19.0%)	18 (29.5%)	0.004
≥90	938 (80.0%)	508 (85.7%)	387 (81.0%)	43 (70.5%)	
Not known/Not recorded	40 (3.4%)				
Transfusion blood (4 h)					
No	797 (68.0%)	430 (72.0%)	359 (74.3%)	8 (66.7%)	0.581*
Yes	295 (25.2%)	167 (28.0%)	124 (25.7%)	4 (33.3%)	
Not known/Not recorded	80 (6.8%)				
Alcohol screen					
No	372 (31.7%)	159 (26.6%)	185 (37.5%)	28 (45.9%)	<0.001
Yes	779 (66.5%)	438 (73.4%)	308 (62.5%)	33 (54.1%)	
Not known/Not recorded	21 (1.8%)				
Alcohol screen result					
Negative screening	587 (75.4%)	341 (77.9%)	218 (70.8%)	28 (84.8%)	0.046*
Mild to moderate	130 (16.7%)	61 (13.9%)	64 (20.8%)	5 (15.2%)	
Severe	62 (8.0%)	36 (8.2%)	26 (8.4%)	0 (0%)	
Drug screen					
No	901 (76.9%)	452 (79.7%)	397 (82.5%)	52 (83.9%)	0.435
Yes	209 (17.8%)	115 (20.3%)	84 (17.5%)	10 (16.1%)	
Not known/Not recorded	62 (5.3%)				

* indicates that the Fisher's exact test was used to calculate the p-value.

Few patients (9.0%) arrived with no signs of life. The overall survival to hospital discharge was 78.2% (Table 3).

In the bivariate analysis, helicopter ambulance more frequently transported patients to a level I or II trauma center (29.8% and 24.7%) than to a level III trauma center (6.5%). Level I centers were more likely to be university teaching institutes (74.8%), level II centers were more likely to be community hospitals (51.4%), and level III centers were more likely to be non-teaching facilities (62.9%) (Fig. 3). Patients with comorbidities were more likely to be transported to level I than level II or III trauma centers (62.1% vs. 57.7% and 41.9% respectively). No statistically significant association was found between the patients' AIS severity and the trauma designation levels. Patients with SBP < 90 were more likely to present to level III (29.5%) rather than to level II (19.0%) or level I (14.3%) centers (Table 1). Internal organ injury was more commonly found in level I centers (37.4% vs. 29.6% and 16.1% in levels II and III respectively); whereas, patients with superficial wounds and contusion were more likely to be treated in level III centers (11.3% vs. 8.1% and 7.1% in levels II and I respectively). All patients' ISS body regions, except for head or neck, were equally distributed among the three trauma level centers (Table 2). Patients taken to level I trauma centers (82.5%) had significantly higher overall survival to hospital discharge than those taken to level II (74.7%) and III (66.1%) trauma centers (Table 3).

Before controlling for confounders, patients taken to level II and III trauma centers had similar survival to hospital discharge as those taken to level I centers [odds ratio (OR) = 1.005, 95% confidence interval (CI): 0.966–1.046; OR = 1.000, 95% CI: 0.962–1.041 for level II and III trauma centers respectively]. After adjusting for confounders, also no difference in patients' survival was noticed between those taken to level II [OR = 1.000; 95% CI: 0.976–1.025] or III [OR = 1.000; 95% CI: 0.993–1.007] trauma centers and those taken to level I centers (Table 4).

4. Discussion

Chest wall trauma is common and accounts for a quarter of all deaths from trauma [1]. Chest wall instability or deformity is a rare but potentially life-threatening condition. CDC field triage currently recommends that patients with chest wall instability or deformity should be transported to a facility that provides the highest level of care within the defined trauma system (usually level I) [8].

This is the first study that evaluates the impact of trauma center level designation on survival of patients presenting with chest wall instability or deformity. The results of this study showed better survival to hospital discharge of patients taken to level I centers. However, after adjusting for confounding factors, multivariable analysis showed no statistically significant survival benefit.

Our findings were in line with those from other studies that examined specific trauma subpopulations. A study done by Livingston et al. showed no difference in mortality between patients cared for in level I and level II trauma centers among burn and trauma victims. This study had a similar study population, who were mostly males and had a mean age of 39–41 years [12]. Similarly, two other studies by Checchi et al. and Dakessian et al. found no impact of trauma center verification level on overall survival of patients with high-risk penetrating thoracic trauma or drowning [13,14]. Clinical severity and comorbidities were among confounding factors used to assess impact on outcomes and the absence of survival benefit across trauma centers of different level is unlikely to be related to transportation of less severe traumas, with less comorbidities, to facilities with lower trauma center verification levels.

Trauma patients presenting with blunt chest wall trauma require proper resuscitation, trauma teams, anesthesiology and operating

Table 2
Injury characteristics of the total study sample and by trauma designation level.

	Total	Trauma designation level			p-value
	N = 1172	I (N = 604)	II (N = 506)	III (N = 62)	
Trauma type					
Blunt	1123 (95.8%)	576 (96.2%)	490 (97.2%)	57 (93.4%)	0.365*
Penetrating	37 (3.2%)	21 (3.5%)	12 (2.4%)	4 (6.6%)	
Other/unspecified	4 (0.3%)	2 (0.3%)	2 (0.4%)	0 (0%)	
Not known/Not recorded	8 (0.7%)				
Injury intentionality					
Unintentional	1105 (94.3%)	565 (94.2%)	483 (95.8%)	57 (93.4%)	0.289*
Self-inflicted	16 (1.4%)	9 (1.5%)	7 (1.4%)	0 (0%)	
Assault	41 (3.5%)	25 (4.2%)	13 (2.6%)	3 (4.9%)	
Undetermined & Other	3 (0.3%)	1 (0.2%)	1 (0.2%)	1 (1.6%)	
Not known/Not recorded	7 (0.6%)				
Mechanism of injury					
Fall	186 (15.9%)	88 (14.9%)	91 (18.3%)	7 (11.7%)	0.375
MVT	754 (64.3%)	398 (67.2%)	317 (63.9%)	39 (65.0%)	
Other[a]	208 (17.7%)	106 (17.9%)	88 (17.7%)	14 (23.3%)	
Not known/Not recorded	24 (2.0%)				
Nature of injury					
Fracture	554 (47.3%)	268 (44.5%)	252 (49.8%)	34 (54.8%)	0.002
Internal organ injury	385 (32.8%)	225 (37.4%)	150 (29.6%)	10 (16.1%)	
Open wound	66 (5.6%)	39 (6.5%)	23 (4.5%)	4 (6.5%)	
Superficial and contusion	91 (7.8%)	43 (7.1%)	41 (8.1%)	7 (11.3%)	
Other[b]	74 (6.3%)	27 (4.5%)	40 (7.9%)	7 (11.3%)	
Not Known/Not Recorded	2 (0.2%)				
Body region					
Extremities	148 (12.6%)	78 (13.0%)	58 (11.5%)	12 (19.4%)	0.247*
Head and neck	258 (22.0%)	145 (24.1%)	103 (20.4%)	10 (16.1%)	
Spine and back	73 (6.2%)	37 (6.1%)	35 (6.9%)	1 (1.6%)	
Torso	685 (58.4%)	340 (56.5%)	306 (60.5%)	39 (62.9%)	
Unclassifiable by body region & unspecified	6 (0.5%)	2 (0.3%)	4 (0.8%)	0 (0%)	
Not known/Not recorded	2 (0.2%)				
ISS body region: Head or neck					
No	650 (55.5%)	319 (52.8%)	286 (56.5%)	45 (72.6%)	0.010
Yes	522 (44.5%)	285 (47.2%)	220 (43.5%)	17 (27.4%)	
ISS body region: Face					
No	987 (84.2%)	503 (83.3%)	428 (84.6%)	56 (90.3%)	0.334
Yes	185 (15.8%)	101 (16.7%)	78 (15.4%)	6 (9.7%)	
ISS body region: Chest					
No	128 (10.9%)	71 (11.8%)	52 (10.3%)	5 (8.1%)	0.558
Yes	1044 (89.1%)	533 (88.2%)	454 (89.7%)	57 (91.9%)	
ISS body region: Abdomen or pelvic contents					
No	703 (60.0%)	355 (58.8%)	308 (60.9%)	40 (64.5%)	0.587
Yes	469 (40.0%)	249 (41.2%)	198 (39.1%)	22 (35.5%)	
ISS body region: Extremities or pelvic girdle					
No	504 (43.0%)	253 (41.9%)	217 (42.9%)	34 (54.8%)	0.146
Yes	668 (57.0%)	351 (58.1%)	289 (57.1%)	28 (45.2%)	
ISS body region: External					
No	320 (27.3%)	161 (26.7%)	136 (26.9%)	23 (37.1%)	0.205
Yes	852 (72.7%)	443 (73.3%)	370 (73.1%)	39 (62.9%)	

* indicates that the Fisher's exact test was used to calculate the p-value.
[a] Other mechanism of injury includes: Cut/pierce & Firearm & Machinery & Pedal cyclist, other & Pedestrian, other & Transport, other & Natural/environmental, Other & Struck by, against & Other specified and classifiable & Other specified, not elsewhere classifiable & Unspecified.
[b] Other nature of injury includes: Amputation & Blood vessel & Crushing & Dislocation & Other effects of external causes & Other specified injury & Unspecified injury.

room (OR) teams, diagnostic testing, intensive care treatment, and cardiothoracic/orthopedic intervention at times. These are all present in level I and level II centers. The main difference between level I and level II centers is research and publication requirements which does not affect the outcome of our study population. Also, level I centers provide rehabilitation services for trauma patients, which extends beyond the scope of this study and does not affect survival to hospital discharge as an outcome. Level III trauma centers do not have immediate coverage by trauma/anesthesia/OR teams on-site, but they have them promptly available [15].

All trauma level centers have radiology interpretation within 30 min. Level III centers do not accommodate for neurosurgical cases but can arrange transfer. In our study, 22.0% of the study population had head and neck injury (unknown severity) without impact on survival [16].

In contrast to our results, decreased mortality has also been previously reported in the literature among trauma patients with specific injuries being transferred to level I trauma centers compared to level II and III centers. Oliphant et al. and Elsemesmani et al. showed improved survival of patients with pelvic ring injuries and patients with motorcycle crash related injuries respectively when cared for in level I vs. level II trauma centers [17,18]. Moreover, a study by Dakessian et al. found a survival benefit for patients with MVT injuries treated at level I vs. level II or III centers [7]. In our study, patients presenting with trauma due to MVT constituted 64.3% of the study population, yet no survival benefit was found in level I vs. level II or III centers. Furthermore, Demetriades et al., who also used the same NTDB database, found a significant relationship between trauma center level and specific severe injuries (cardiovascular, liver injury, and complex pelvic fractures) [19]. Similarly, a study by Dubose et al. found higher mortality and higher

Table 3
Emergency department (ED) and hospital Dispositions of the total study sample and by trauma designation level.

	Total	Trauma designation level			*p*-value
	N = 1172	I (N = 604)	II (N = 506)	III (N = 62)	
ED discharge disposition					
Floor bed (general admission, non-specialty unit bed)	260 (22.2%)	131 (21.7%)	117 (23.1%)	12 (19.4%)	<0.001
Observation unit (unit that provides <24 h stays)	6 (0.5%)	3 (0.5%)	3 (0.6%)	0 (0%)	
Telemetry/step-down unit (less acuity than ICU)	73 (6.2%)	37 (6.1%)	30 (5.9%)	6 (9.7%)	
Home with services & Home without services	35 (3.0%)	27 (4.5%)	8 (1.6%)	0 (0%)	
Deceased/Expired	137 (11.7%)	45 (7.5%)	75 (14.8%)	17 (27.4%)	
Operating room	181 (15.4%)	99 (16.4%)	74 (14.6%)	8 (12.9%)	
Intensive Care Unit (ICU)	480 (41.0%)	262 (43.4%)	199 (39.3%)	19 (30.6%)	
ED discharge disposition					
Deceased/Expired	137 (11.7%)	45 (7.5%)	75 (14.8%)	17 (27.4%)	<0.001*
Admitted	1000 (85.3%)	532 (88.1%)	423 (83.6%)	45 (72.6%)	
Discharged	35 (3.0%)	27 (4.5%)	8 (1.6%)	0 (0%)	
Hospital discharge disposition					
Deceased/Expired	118 (10.1%)	61 (10.1%)	53 (10.5%)	4 (6.5%)	0.035
Left against medical advice or discontinued care	8 (0.7%)	5 (0.8%)	2 (0.4%)	1 (1.6%)	
Discharged to home or self-care (routine discharge)	440 (37.5%)	243 (40.2%)	179 (35.4%)	18 (29.0%)	
Transferred to other destination	434 (37.0%)	223 (36.9%)	189 (37.4%)	22 (35.5%)	
Not Applicable	172 (14.7%)	72 (11.9%)	83 (16.4%)	17 (27.4%)	
Died ED/Hospital					
No	917 (78.2%)	498 (82.5%)	378 (74.7%)	41 (66.1%)	<0.001
Yes	255 (21.8%)	106 (17.5%)	128 (25.3%)	21 (33.9%)	
Signs of life					
Arrived with no signs of life	106 (9.0%)	37 (6.1%)	56 (11.1%)	13 (21.0%)	<0.001
Arrived with signs of life	1066 (91.0%)	567 (93.9%)	450 (88.9%)	49 (79.0%)	

* indicates that the Fisher's exact test was used to calculate the p-value.

rate of progression of insult in patients presenting with traumatic brain injuries to level II compared to level I trauma centers [20]. All such severe, as well as, other minor injuries were included in our study with no perceivable mortality benefit; fractures constituted 47.3% of our study population, internal organ injury constituted 32.8%, and head and neck injuries constituted 22.0%.

On the other hand, one study by Dakessian et al. found higher survival to hospital discharge at level II compared to level I centers for patients presenting with no signs of life to US trauma centers. They attributed this finding to possible prehospital notification and presence of performance improvement programs; Furthermore, they hypothesized the findings could be justified by the higher prevalence of residency training programs in level I centers and their association with poorer outcome [21]. In our study only 9.0% of patients arrived with no signs of life to different trauma center levels (more to level III centers [21.0%] compared to level I centers [6.1%]). Less patients died in the ED and more patients were discharged from the ED in level I centers compared to level II or III centers. It is therefore unlikely that this patient population (no signs of life) affected our results.

Current recommendation for field triage states that patients with chest wall instability or deformity (e.g., flail chest) should be transported to a facility that provides the highest level of care within the defined trauma system [8]. Our study results demonstrate that there was no survival benefit between level I and level II and III centers. This calls for revision of pre-hospital triage criteria to make transport of trauma patients with suspected chest wall instability to the nearest trauma center whether level I, II, or III instead of highest designation level.

Mortality in chest trauma is usually high, reaching up to 68.6% for flail chest [22]. This study is probably the first to examine chest wall instability at a national level, and to highlight requirements for care of the affected patients. These patients were mostly admitted to the ICU or needed surgery, while only a small percentage was admitted to a regular floor or discharged. These findings are important for education training, proper pre-hospital field triage, and subsequent resources utilization. More evidence based research is also needed to assess factors associated with outcomes other than survival in this patient population including but not limited to morbidity/disability, ICU stay, length of stay, etc.…

4.1. Limitations

Potential limitations to our study are related to the dataset used (NTDB) and to its retrospective nature. However, with a rare condition such as chest wall instability or deformity, a retrospective cohort study is suitable [23]. The NTDB also excludes patients who are declared dead on scene and were not taken to the ED. This factor could potentially overestimate survival. Consistency of data collected is usually a concern in large datasets since documentation vary from one hospital to another which may affect overall data collected from multiple hospitals. Nevertheless, NTDB is the largest trauma dataset in the United

Table 4
LASSO regression of survived patients who had chest wall instability.

	Crude		Adjusted*	
	Coefficient [standard error]	Odds ratio [95% CI[	Coefficient [standard error]	Odds ratio [95% CI[
Trauma designation				
Level (I)				
II	0.005 [0.020]	1.005 [0.966–1.046]	0.000 [0.012]	1.000 [0.976–1.025]
III	0.000 [0.020]	1.000 [0.962–1.041]	0.000 [0.003]	1.000 [0.993–1.007]

* Variables that were included in the model are: Trauma designation level, Age, Sex, Race, Ethnicity, Primary method of payment, Transport Mode, Facility level: Hospital Teaching Status, Comorbidity, Injury severity score, GCS, SBP, Transfusion blood (4 h), Mechanism of Injury, Alcohol screen, Drug screen, Nature of injury, Body region.

States, and the data is continuously monitored for variations and cleaned in order to ensure the highest possible quality [24,25] . This study examined mainly survival as the main outcome. Future studies can examine additional outcomes such as morbidity, disability, functional status, readmissions, which are not available in NTDB and can be included in future datasets. The study findings can be generalized to settings with organized trauma systems and where uniform prehospital field triage criteria are adopted by EMS agencies.

5. Conclusion

Trauma systems are designed to improve survival and trauma patient outcomes. In this study, and after adjusting for confounders, there was no survival benefit for patients having chest wall instability or deformity when transported to a level I versus a level II or level III center. This finding can guide pre-hospital field triage criteria for this specific type of injury and highlights the need for more outcome research in organized trauma systems.

Ethics approval and consent to participate

The Institutional Review Board (IRB) at the American University of Beirut approved this study.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Authors' contributions

ST and RB acquired, analyzed, and drafted the work. ME conceived, designed and substantively revised the study. ST, RB, and ME approve the submitted version and agree to be personally accountable.

Other mechanism of injury includes: Cut/pierce & Firearm & Machinery & Pedal cyclist, other & Pedestrian, other & Transport, other & Natural/environmental, Other & Struck by, against & Other specified and classifiable & Other specified, not elsewhere classifiable & Unspecified.

CRediT authorship contribution statement

Sarah I. Traboulsy: Writing – review & editing, Writing – original draft, Resources, Methodology. **Rana Bachir:** Writing – review & editing, Validation, Software, Resources, Formal analysis, Data curation. **Mazen El Sayed:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no competing interests.

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The NTDB remains the full and exclusive copyrighted property of the American College of Surgeons. The American College of Surgeons is not responsible for any claims arising from works based on the original Data, Text, Tables, or Figures.

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