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Outcomes of basic versus advanced prehospital life support in severe pediatric trauma

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ABSTRACT

Objective: The role of basic life support (BLS) vs. advanced life support (ALS) in pediatric trauma is controversial. Although ALS is widely accepted as the gold standard, previous studies have found no advantage of ALS over BLS care in adult trauma. The objective of this study was to evaluate whether ALS transport confers a survival advantage over BLS among severely injured children.
Methods: A retrospective cohort study of data included in the Israeli National Trauma Registry from January 1, 2011, through December 31, 2020 was conducted. All the severely injured children (age < 18 years and injury severity score [ISS] ≥16) were included. Patient survival by mode of transport was analyzed using logistic regression.
Results: Of 3167 patients included in the study, 65.1% were transported by ALS and 34.9% by BLS. Significantly more patients transported by ALS had ISS ≥25 as well as abnormal vital signs at admission. The ALS and BLS cohorts were comparable in age, gender, mechanism of injury, and prehospital time. Children transported by ALS had higher in-hospital mortality (9.2% vs. 0.9%, $p < 0.001$). Following risk adjustment, patients transported by ALS teams were significantly more likely to die than patients transported by BLS (adjusted OR 2.27, 95% CI 1.05–5.41, $p = 0.04$). Patients with ISS ≥50 had comparable mortality rates in both groups (45.9% vs. 55.6%, $p = 0.837$) while patients with GCS <9 transported by ALS had higher mortality (25.9% vs. 11.5%, $p = 0.019$). Admission to a level II trauma center vs. a level I hospital was also associated with increased mortality (adjusted OR 2.78 (95% CI 1.75–4.55, $p < 0.001$).
Conclusions: Among severely injured children, prehospital ALS care was not associated with lower mortality rates relative to BLS care. Because of potential confounding by severity in this retrospective analysis, further studies are warranted to validate these results.

1. Introduction

Trauma is the leading cause of death and disability among children [1]. Although injury prevention is the ultimate goal, well-structured trauma systems decrease morbidity and mortality after injury [2]. Prehospital care is a part of the “chain of survival”, stretching from the site of injury to the trauma center (TC) where definitive care is provided [3]. Prehospital care is generally classified into basic life support (BLS) and advanced life support (ALS) levels. BLS-level care is usually provided by emergency medical technicians and includes a limited set of interventions, such as external hemorrhage control, oxygen

Abbreviations: TC, trauma center; BLS, basic life support; ALS, advanced life support; INTR, Israeli National Trauma Registry; ISS, Injury Severity Score; MVC, motor vehicle collision; ED, emergency department; HR, heart rate; SBP, systolic blood pressure; GCS, Glasgow Coma Scale; SI, shock index; AIS, Abbreviated Injury Score; EMS, emergency medical services; MDA, Magen David Adom; STROBE, Strengthening the Reporting of Observational studies in Epidemiology; OR, odds ratio; CI, confidence interval.

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supplementation, bag-valve-mask ventilation, and spinal immobilization. ALS personnel, usually paramedics or physicians, receive additional training and are capable of performing more advanced procedures on scene and en route. These include advanced airway management, vascular access, chest decompression, and medication administration, among others.

ALS is widely accepted as the gold standard of prehospital trauma care. However, its efficacy, compared to BLS, has been questioned. Although randomized trials comparing ALS with BLS are unlikely, multiple retrospective studies have found no advantage of ALS over BLS care in regard to mortality and neurological outcomes in both blunt and penetrating adult trauma patients [3-5]. Extrapolating findings from these studies to the pediatric population is difficult: the epidemiology of pediatric trauma differs from adults, with a higher proportion of falls and head trauma and a lower prevalence of hemorrhagic shock and chest injuries [6-8]. In addition, most prehospital clinicians do not routinely take care of severely injured children, and there is a gap in the quality of care provided to pediatric patients as compared to adults [9].

The objective of this study was to evaluate the relationship between the clinical outcomes of pediatric trauma victims and the level of prehospital care. Using the Israeli National Trauma Registry (INTR), we evaluated whether ALS is associated with better survival among severely injured pediatric patients when compared to BLS prehospital care.

2. Materials and methods

2.1. Data collection and definitions

The study population consisted of all the severely injured pediatric patients defined as patients younger than 18 years with an Injury Severity Score (ISS) ≥16 admitted to one of the hospitals included in the INTR between January 2011 and December 2020. This ISS threshold was chosen to select patients with severe injury in keeping with most trauma literature. This is also the threshold generally used to classify patients requiring TC care or full trauma team activation [10]. Moreover, because very few children with an ISS < 16 would likely die during admission, the threshold helped prevent dilution of the main effect in which we were interested [11].

We excluded patients transported by private or police vehicles, as well as those who were dead on arrival. Patients were also excluded if they had incomplete records for the primary outcome of in-hospital mortality or were transferred to or from another hospital.

We extracted the following data from the INTR:

1. Demographics: age, gender
2. Type of injury: penetrating, blunt
3. Mechanism of injury: motor vehicle collision (MVC), fall, other (burns, violence, and other unintentional injuries)
4. Prehospital airway interventions: bag-mask ventilation and endotracheal intubation
5. Time from ambulance dispatch to hospital arrival (prehospital time)
6. Vital signs at admission to the emergency department (ED): oxygen saturation, heart rate (HR), systolic blood pressure (SBP), and Glasgow Coma Scale (GCS). The pediatric GCS was utilized for pre-verbal children [12]. In addition, the shock index (SI), defined as HR divided by SBP, was calculated for each patient. A high SI was defined as >1.2 for children ≤6 years, >1 for children 7–12 years, and > 0.9 for children >12 years [13,14].
7. Receiving hospital level: level I or level II TC
8. Length of hospital stay
9. ISS, using standard categories (1–15, 16–24, 25–49, and 50–75) [15].
10. Abbreviated Injury Score (AIS) for head, thorax, abdomen, and extremities, with AIS scores ≥4 considered severe

The primary outcome of this study was survival to hospital discharge, defined as the patient leaving the hospital alive or being transferred to a long-term care or rehabilitation facility.

2.2. Study design and setting

This was a retrospective cohort study based on the INTR. The registry includes detailed information regarding trauma patients hospitalized in all six level I TC and 15 level II centers, which together treat >95% of trauma patients in Israel. All the TCs in Israel are mixed, treating both adult and pediatric patients. The database does not include patients who died at the scene, en route, or who were discharged home following treatment in the ED. The data included in the registry is recorded by trained trauma registrars at each TC, under the supervision of a trauma director and trauma coordinator. Electronic files are transferred regularly to the National Center for Trauma and Emergency Medicine Research where additional quality control is carried out [16,17].

Emergency medical services (EMS) in Israel are provided mainly by the Magen David Adom (MDA) organization augmented by volunteer-based first-responder programs, medical corps teams, and some private carriers. MDA operates 169 stations with a fleet of over 1000 ambulances and two helicopters. MDA, as well as other EMS providers, run two-tier EMS responses: BLS and ALS. The BLS ambulances (~65% of ambulances) are staffed mainly by emergency medical technicians and occasionally by paramedics. These vehicles are equipped to provide basic treatment (external hemorrhage control, oxygen supplementation, bag-valve-mask ventilation, spinal immobilization, etc.). Most of the ALS teams are staffed by paramedics who are capable of providing advanced interventions including advanced airway management, intravenous and intraosseous access, medications administration (analgesic and sedative agents, tranexamic acid, intravenous fluids, etc.), and chest decompression. Some ALS teams also had physicians as part of their staff (specifically, some MDA teams between January 2011 and December 2015; some military teams; and some private ambulances).

Local policy dictates that the assignment of ALS or BLS ambulances is based on availability and proximity. In addition to the closest team, an ALS ambulance is dispatched based on certain criteria conveyed during the request for help. Some of the criteria that dictate ALS activation include high-risk mechanism of injury (e.g. high-speed crash; vehicle entrapment; ejection from vehicle; pedestrian/bicyclist struck by vehicle; fall from high), high-risk anatomical injury (e.g. penetrating injury to head, neck, torso or extremities proximal to elbow/knee; amputation proximal to wrist/ankle; suspected spinal cord injury), altered level of consciousness, respiratory distress/arrest, seizures, and severe blood loss. In Israel, the median response time (time from ambulance dispatch to arrival to the scene) is eight minutes and in 95% of cases, this time is <20 min. The median hospital transport time is 15 min and 95% of the patients arrive at a hospital within 35 min [18]. The BLS teams do not delay patient care or transport while waiting for ALS personnel, and transfer from BLS to ALS (or vice versa) en route is discouraged except during prolonged transportation. As the INTR does not have an indicator for patients who are transferred from BLS to ALS units (or vice versa) en route, in this study, the team that provided care at the time of hospital arrival was credited with the transportation.

The Israeli EMS guidelines dictate that the ambulance services should triage suspected major trauma patients directly to level 1 TCs when transport time is expected to be <40 min. “Suspected major trauma” is defined by local EMS as patients suffering from an injury involving three or more of the following anatomic regions: head, face, chest, abdomen, pelvis, or long bones; or the presence of a high-risk mechanism of injury [e.g. high-speed crash; vehicle entrapment; ejection from vehicle; pedestrian/bicyclist struck by vehicle; or fall from high]. Otherwise, patients are either evacuated to the closest hospital for stabilization with subsequent transfer to a level 1 TC as appropriate or transferred directly to a level I TC by helicopter. Patients suspected to have suffered from isolated severe traumatic brain injury (defined as any penetrating head injury, suspected skull fracture, or GCS < 15) are transferred to the closest hospital with neurosurgical capabilities. If the EMS team deems a patient too unstable for a longer transport to a level I TC, he is transported to the nearest hospital for initial stabilization. BLS teams and paramedic-staffed ALS teams are not allowed to pronounce death or discontinue resuscitation in pediatric patients.

The study was approved by the Institutional Review Board of Sheba Medical Center (approval number 5138–18 SMC). Individual patient consent was waived because all data in the INTR are anonymous. The Strengthening the Reporting of Observational studies in Epidemiology (STROBE) statement was used to guide reporting of this research [19].

2.3. Statistical analysis

Patients' characteristics were summarized with descriptive statistics. Categorical variables were reported as frequencies and percentages and continuous variables as medians with interquartile ranges (IQR). Baseline characteristics and unadjusted mortality rates between patients transported by BLS and those transported by ALS teams were compared using $\chi 2$ and Mann–Whitney *U* test.

Because patients transported by ALS are presumably at higher risk of death than those transported by BLS, we used logistic regression modeling to determine the odds of death among ALS relative to BLS-transported trauma victims, controlling for potential confounders: age, gender, type and mechanism of injury, receiving hospital level, GCS at ED arrival, and ISS were included in the model.

Previous studies have found that GCS is highly predictive of mortality in pediatric trauma patients and performs comparably to more comprehensive physiological scores such as the Pediatric Trauma Score and the Revised Trauma Score [20-22]. This may be explained by the fact that traumatic brain injury and anoxia are the main causes of death among injured children, while death from hemorrhage is rare [23]. We used GCS at ED admission as it is influenced not only by the severity of the injury but also by the level of prehospital care.

The ISS is an anatomic score and independent predictor of survival following severe pediatric trauma [11,24]. Some previous works suggest that ISS should be included as a categorical rather than a continuous variable for statistical or analytical purposes, as single ISS values have little prognostic meaning [15,25]. However, ISS values of BLS and ALS groups may distribute differently across the range of each ISS category. Given the above, we performed the logistic modeling twice, once with ISS as a continuous variable and once as a categorical variable. We decided a priori that the categorical analysis would be the one on which we would draw our conclusions, but that if there were a substantial discrepancy between the results of the two analyses, we would urge caution in their interpretation.

Finally, given the long study period and changes in the trauma treatment guidelines, as well as ambulance staffing in MDA, we also investigated the effect of the time trends (i.e., the year of admission) on the results of the analysis.

The association between independent variables and the predefined outcome was quantified using odds ratios (OR) and 95% confidence intervals (CI). Missing data were handled by listwise deletion. The model's discriminative ability was measured via a concordance index (c-index). We considered a *p*-value of 0.05 statistically significant. Data analysis was conducted with SAS software, version 9.4 (SAS Institute, Cary, NC, USA).

3. Results

Of the 110,227 children included in the INTR from January 1, 2011, to December 31, 2020, a total of 3167 patients were included in the study after applying the inclusion and exclusion criteria (Fig. 1). Of the included patients 2062 (65.1%) were transported by ALS teams. Two hundred six (10.0%) of the patients treated by ALS teams were transported by helicopter EMS. A level I TC was the primary destination

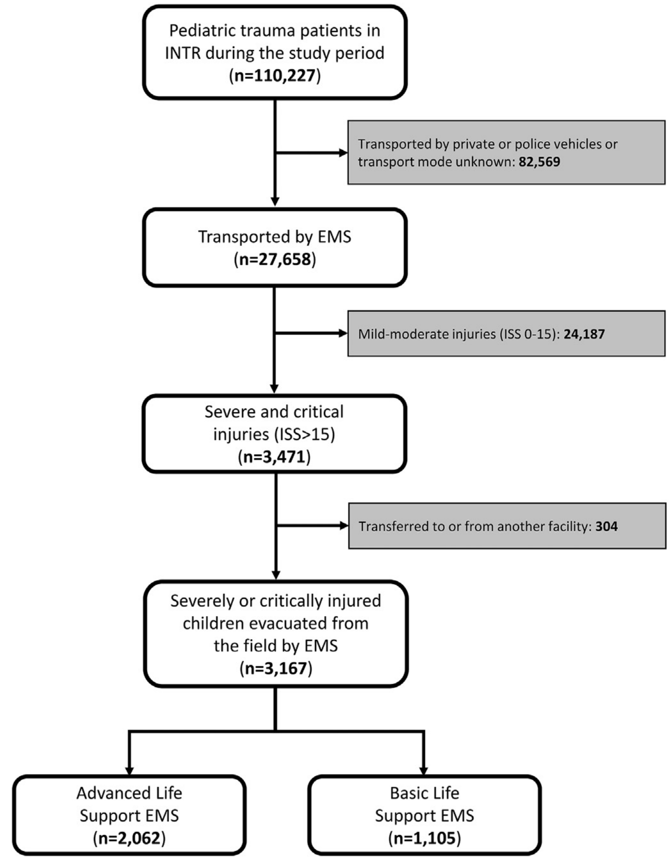

Fig. 1. Study flow chart.
INTR- Israeli National Trauma Registry; EMS- Emergency medical services; ISS- Injury Severity Score.

of the EMS teams in 2393 (75.6%) cases. More patients treated by ALS teams were transported to level I TCs (80.5% vs. 66.3%, $p < 0.001$).

The most common mechanisms of injury were MVC (53.5%) and falls (28.8%). Only 213 children (6.7%) suffered from penetrating injuries, 80.0% of them caused by stabbing or gunshot wounds, and 83.1% of them were transported by ALS teams.

Significantly more patients transported by ALS sustained critical injuries, defined by ISS 25–49 and ≥ 50 (46.5% vs. 23.0% and 4.8% vs. 0.8%, $p < 0.001$, respectively). More patients transported by ALS teams suffered from severe injuries (AIS ≥ 4) involving more than one body region (11.7% vs. 1.9%, $p < 0.001$). In the BLS group, 51.2% were diagnosed with an isolated severe head injury compared to 43.8% in the ALS group ($p < 0.001$). At admission to the ED, more patients treated by the ALS teams had GCS < 9 (33.8% vs. 5.5%, $p < 0.001$), oxygen saturation <90% (4.1% vs. 1.5%, $p < 0.001$), and high shock index (35.8% vs. 26.6%, $p < 0.001$). The ALS and BLS cohorts were comparable in age, gender, mechanism of injury, and prehospital time. Full demographic and injury information is provided in Table 1.

Prehospital airway interventions were more common in patients treated by ALS responders: 138 patients (6.7%) were ventilated by a bag valve mask in the ALS group compared to 9 (0.8%) in the BLS group ($p < 0.001$). Endotracheal intubation was performed by ALS teams in 483 (23.4%) patients. Intravenous fluids were given to 779 (37.8%) patients in the ALS group vs. 58 (5.3%) in the BLS group ($p < 0.001$). Splinting of suspected fractures was also performed more frequently by ALS teams, with 1277 (62.2%) ALS patients vs. 343 (31.0%) BLS patients splinted in the field ($p < 0.001$).

Children transported by ALS had higher overall mortality than those transported by BLS (9.2% vs. 0.9%, $p < 0.001$) with an unadjusted relative risk of mortality of 10.18 (95% CI 9.94–15.25, $p < 0.001$). Among

Table 1
Demographic and injury characteristics of severely injured children by type of emergency medical services transport ($n = 3167$)

	Advanced life support ($n = 2062$)	Basic life support ($n = 1105$)	*p-value*
Age (years)			0.83
Median (IQR)	10 (4,15)	10 (5,15)	
Male gender, n (%)	1511 (73.3%)	818 (74.0%)	0.68
Penetrating injury, n (%)	177 (8.6%)	36 (3.3%)	***<0.001***
Mechanism of injury			0.97
Fall, n (%)	549 (26.6%)	362 (32.7%)	
Motor vehicle collision, n (%)	1102 (53.4%)	592 (53.6%)	
Other*, n (%)	411 (20.2%)	151 (13.7%)	
Time from dispatch to hospital arrival (min)			0.76
Median (IQR)	57 (42,75)	56 (42,79)	
Unknown (%)	637 (30.9%)	296 (26.8%)	
Receiving Level I trauma center, n (%)	1660 (80.5%)	733 (66.3%)	***<0.001***
Vital signs at emergency department admission			
Glasgow Coma Scale, n (%)			
3–8	698 (33.8%)	61 (5.5%)	
9–14	350 (17.0%)	137 (12.4%)	***<0.001***
15	933 (45.3%)	886 (80.2%)	
Unknown	81 (3.9%)	21 (1.9%)	
Oxygen saturation < 90%, n (%)	85 (4.1%)	16 (1.5%)	***<0.001***
Unknown	172 (8.4%)	72 (6.5%)	
High Shock Index, n (%)	739 (35.8%)	293 (26.6%)	***<0.001***
Unknown	104 (5.0%)	45 (4.1%)	
Injury severity score, n (%)			
Median (IQR)	25 (18–30)	18 (16–24)	
16–24	1005 (48.7%)	842 (76.2%)	***<0.001***
25–49	958 (46.5%)	254 (23.0%)	
≥50	99 (4.8%)	9 (0.8%)	
Injured body region, n (%)			***<0.001***
Isolated severe head injury (AIS ≥4)	903 (43.8%)	566 (51.2%)	
Isolated severe chest injury (AIS ≥4)	281 (13.6%)	126 (11.4%)	
Isolated severe abdomen injury (AIS ≥4)	125 (6.1%)	121 (11.0%)	
Isolated severe extremities injury (AIS ≥4)	19 (1.0%)	5 (0.5%)	
Isolated severe external injury (AIS ≥4)	103 (5.0%)	37 (3.3%)	
Multiple severe injuries	241 (11.7%)	21 (1.9%)	
No regions with AIS 4+	390 (18.9%)	229 (20.7%)	
Length of hospital stay (days)			***<0.001***
Median (IQR)	7.0 (4,15)	5.0 (3,8)	
Total in-hospital mortality, n (%)	190 (9.2%)	10 (0.9%)	***<0.001***
Mortality in the ED	41 (2.0%)	3 (0.3%)	***<0.001***

AIS- Abbreviated Injury Scale.
Statistically significant *p*-values ($p \le 0.05$) are in bold and italicized.
* Other includes burns, violence, and other unintentional blunt or penetrating injuries.

patients with ISS of 25–49 the hospital mortality rate of those transported by ALS was 14.7% vs. 2.0% in the BLS group ($p < 0.001$). Patients with ISS ≥50 had comparable mortality rates in both groups (45.9% vs. 55.6%, $p = 0.84$) (Fig. 2a). ALS patients with GCS <9 at admission had a significantly higher mortality rate compared to those transported by BLS with GCS <9 (25.9% vs. 11.5%, $p = 0.019$) (Fig. 2b).

After adjustment for demographics, type and mechanism of injury, receiving hospital level, GCS, and ISS, patients transported by ALS teams were significantly more likely to die than patients transported by BLS (adjusted OR 2.27, 95% CI 1.05–5.41, $p = 0.04$). Other risk factors associated with increased mortality were older age, higher ISS, GCS 3–8 at admission to the ED, mechanism of injury, and admission to a level II hospital versus a level I TC. The complete results of the multivariate analysis are provided in Table 2. The model included 3065 patients (96.8%) and its c-index was 0.95 (95% CI 0.94–0.96, $p < 0.001$). When ISS was included in the model as a continuous (rather categorical) variable, transportation by ALS teams was still associated with increased mortality with an adjusted OR of 2.4 (95% CI 1.1–5.7, $p = 0.03$). The addition of the time trend did not significantly change the results of the analysis, as well. When the year of admission was incorporated into the model, transportation by the ALS team was associated with increased mortality with an adjusted OR of 2.32 (95% CI 1.02–5.64, $p = 0.04$). Other risk factors for increased mortality were also not affected by these changes.

4. Discussion

In this large-scale nationwide retrospective cohort study, we found that ALS transport and prehospital care do not improve outcomes of severely injured children, as compared with BLS. Although due to the retrospective nature of the study, there is a potential for residual and unmeasured confounding by severity, these findings are important as they identify an additional component of prehospital trauma care that may be associated with significant differences in mortality and may provide an opportunity to improve the pediatric prehospital trauma care system.

Multiple studies demonstrated that among adult trauma patients prehospital ALS care is not associated with a significant survival advantage and may be associated with increased mortality [4,5,26]. Most of these studies were retrospective and observational. However, the Ontario Prehospital Advanced Life Support (OPALS) major trauma study was a before-after system-wide controlled clinical trial involving 17 cities in Ontario, Canada, that evaluated data of 2867 trauma patients before and after ALS program implementation [27]. The researchers found that the implementation of full ALS programs did not decrease mortality or morbidity for major trauma patients. Moreover, among patients with GCS < 9, survival was lower during the ALS phase. Longer prehospital times and a higher number of prehospital procedures may account for these differences. Sampalis et al. found that for each

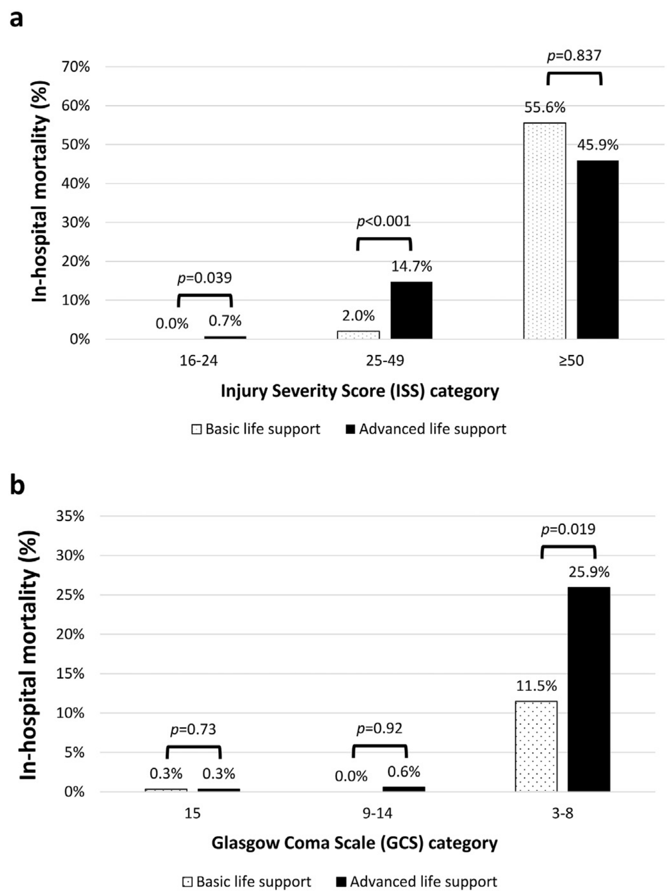

Fig. 2. The relationships between prehospital mode of transport, in-hospital mortality, injury severity score (a), and Glasgow Coma Scale at admission to the emergency department (b).

Table 2
Multiple variable logistic regression analysis for in-hospital mortality ($n = 3065$).

Parameter	Adjusted Odds Ratio for mortality (95% CI)	*p-value*
Age category (years)		
0–4	Reference	–
5–9	0.33 (0.19–0.57)	***<0.001***
10–17	0.42 (0.27–0.65)	***<0.001***
Gender (female)	1.30 (0.87–1.93)	0.20
Type of injury		
Blunt	Reference	–
Penetrating	1.69 (0.80–3.55)	0.17
Mechanism of injury		
Fall	Reference	–
Motor vehicle collision	1.78 (1.09–2.96)	**0.02**
Other*	2.49 (1.27–4.72)	***0.007***
Receiving hospital (Level I trauma center)	0.36 (0.23–0.57)	***<0.001***
Glasgow coma scale category		
15	Reference	–
9–14	1.00 (0.14–4.46)	0.99
3–8	44.36 (20.39–116.88)	***<0.001***
Injury severity score category		
16–24	Reference	–
25–49	9.55 (4.62–23.16)	***<0.001***
≥50	35.72 (15.43–94.23)	***<0.001***
Prehospital level of care		
Basic Life Support	Reference	–
Advanced Life Support	2.27 (1.05–5.41)	***0.04***

CI- confidence interval.
The model included 3065 patients (96.8%) and its c-index was 0.95 (95% CI 0.94–0.96, $p <$ 0.001).
Statistically significant *p*-values ($p \leq 0.05$) are in bold and italicized.
* Other includes burns, violence, and other unintentional blunt or penetrating injuries.

additional minute spent during prehospital care, the odds of dying increased by 5% [28]. Similar findings were demonstrated by Gauss et al [29]. In urban trauma systems, prehospital endotracheal intubation is associated with greater mortality when compared with bag-valve-mask ventilation en route [30]. Vascular access is established in the vast majority of ALS patients without any proven survival benefit and intravenous infusion of crystalloids may have a harmful effect on bleeding patients [31,32]. Prehospital administration of plasma was associated with reduced mortality among bleeding patients only when the transport time was longer than 20 min [33]. These findings were not confirmed in pediatric trauma patients among whom death from hemorrhage is uncommon [23].

Our knowledge regarding the relationship between the prehospital level of care and clinical outcomes of injured children is scant. Children comprise only 5–10% of total EMS patients and most EMS teams, treating mainly adult patients, have only limited experience in the clinical assessment and treatment of severely injured children [9,34]. In contrast to adult casualties, a recent study of 597 pediatric trauma patients in Sweden found that longer transport time after major pediatric trauma was not associated with adverse outcomes [35]. However, in accordance with studies in adult patients, prehospital intubation was shown to have no benefit or harm during various resuscitative scenarios [36-38]. Not only was the benefit of this intervention not clearly shown, but this high-skill and high-risk procedure is often performed without a clear indication and carries a high rate of complications (10–39%) among children intubated by EMS [39,40]. Only a few studies evaluated the association between the level of prehospital care and clinical outcomes. Orr et al. found that pediatric specialized transport teams have better outcomes compared to nonspecialized teams. Interestingly, these teams performed fewer major interventions than nonspecialized teams [41]. Brown et al. found that scene transport by helicopter EMS was associated with improved odds of survival compared with ground EMS in pediatric trauma patients, despite longer prehospital times [42]. To the best of our knowledge, the only study that compared the outcomes of severely injured children treated by physician-staffed ALS versus BLS was conducted in Finland in 1994 and included 121 patients. The authors found an improved outcome for those treated by ALS teams [43]. Our findings are different. After adjusting for injury severity, the odds of death for ALS transports were 2.27 times that for BLS transports (95% CI 1.05–5.41), although the prehospital times did not differ significantly between the groups. The differences were most prominent in patients with ISS of 25–49 (mortality rates of 2.0% vs. 14.7%, $p <$ 0.001) and among those with GCS < 9 (11.5% vs. 25.9%, $p = 0.02$). We speculate that these differences may be related to the tendency to perform advanced procedures, such as intravascular access establishment, endotracheal intubation, medication administration, and splinting of suspected fractures in these patients. We found that ALS may have a small advantage for the most severely injured patients (ISS ≥ 50). However, the differences did not reach statistical significance (45.9% vs. 55.6%, $p = 0.84$), possibly due to the small number of patients in this group (108 patients).

Among other variables independently associated with increased mortality in our cohort was treatment in level II TCs (OR 2.8) rather than in level I TCs. Studies in adult trauma patients were similar to this finding [44]. Previous studies also found that centralization of pediatric trauma patients in dedicated TCs is associated with better outcomes [45,46]. This survival advantage was not demonstrated for level I dual TCs (both general/pediatric) although severe pediatric trauma patients treated in higher volume adult centers had better outcomes than those treated in lower volume centers [47,48]. As all TCs in Israel are dual TCs, our findings support the claim that high-volume level I

TCs treating both children and adults may have an advantage over smaller TCs for the treatment of severely injured children.

Although our findings are based on a nationwide cohort, as Israel is a small urban country with relatively short evacuation times, they should be extrapolated with caution to rural settings with prolonged evacuation times and to countries with mainly physician-staffed EMS. In addition, our cohort includes predominantly blunt trauma patients making our findings relevant mainly to this population. However, the prevalence of penetrating trauma among children is variable, ranging from 2% to 20%, in different countries [49,50]. Our study has some additional limitations. First, patients' assignment to the two transport groups was nonrandomized, and more severely injured patients were preferentially assigned to the ALS group. Although our mortality multivariate model could efficiently distinguish between the positive and negative cases with a very high c-index (0.95, 95% CI 0.94–0.96), it was limited to the data available in the INTR. Potential confounding risk factors for mortality were not included in the risk-adjustment process. For example, although the prehospital times were not different for the ALS and BLS groups, they were not included in the model due to a large amount of missing data. Although the admission vital signs reflect the injury severity and the effect of prehospital care, the prehospital vital signs could potentially enable more accurate adjustment of the model. However, these were not included in the analysis due to a large amount of missing data. The exact level of treatment (paramedic vs. physician) is also not included. An additional parameter not included in INTR is a transfer from BLS to ALS (or vice versa) en route. The INTR does not have an indicator for patients who are transferred from BLS to ALS units (or vice versa) en route. Although discouraged by the guidelines, these transfers may lead to additional bias. Furthermore, we expect that such transfers would prolong the evacuation time, and no such difference was observed between the groups. Second, our study included only a small group of patients with an ISS ≥ 50, therefore our ability to offer a recommendation for that subset of patients is limited, though our data suggest that these extremely ill children may benefit from ALS response. Unfortunately, ISS is not a useful tool for field triage, as it cannot be calculated in prehospital settings. Third, as this study is based on the INTR, it includes only hospitalized patients; casualties who died at the scene or en route were not included (patients who were declared dead in the ED are included in the INTR). It should be noted that BLS teams and paramedic-staffed ALS teams are not allowed to pronounce death or discontinue resuscitation in pediatric patients. Therefore, we believe that the death of only a few children was declared on scene or en route by physician-staffed ALS teams. In addition, the registry does not include long-term outcomes following patient discharge.

5. Conclusion

Among severely injured children (ISS ≥ 16), prehospital ALS care was not associated with lower mortality rates relative to BLS measures. Our findings suggest that rapid transport to definitive surgical care in high-volume TCs with only BLS-level interventions may result in improved survival compared with more advanced prehospital care. However, because of potential confounding by severity in this retrospective analysis, further studies are warranted to validate these results.

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DATA statement

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

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CRediT authorship contribution statement

Danny Epstein: Writing – original draft, Validation, Supervision, Project administration, Methodology, Investigation, Conceptualization. **Sharon Goldman:** Writing – review & editing, Methodology, Investigation, Formal analysis, Data curation. **Irina Radomislensky:** Writing – review & editing, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation. **Aeyal Raz:** Writing – review & editing, Methodology, Investigation, Conceptualization. **Ari M. Lipsky:** Writing – review & editing, Methodology, Formal analysis, Conceptualization. **Shaul Lin:** Writing – review & editing, Supervision, Methodology, Investigation, Conceptualization. **Moran Bodas:** Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Methodology, Investigation, Data curation, Conceptualization.

Declaration of Competing Interest

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