Burns 51 (2025) 107363

Contents lists available at ScienceDirect

Burns

journal homepage: www.elsevier.com/locate/burns

Increased prehospital mortality in patients with combined burns and trauma in Canada: Analysis of a provincial trauma registry database

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ARTICLE INFO

Keywords:
Prehospital
Mortality
Burns
Wounds and injuries
Trauma

ABSTRACT

Introduction: The combination of burns and non-thermal trauma may have a synergistic effect on mortality. Our objective was to determine if burn patients with concomitant trauma are at increased risk of mortality in both the prehospital and in-hospital settings.

Methods: Data were collected from a population-based provincial trauma registry (2001–2019). Characteristics and outcomes of patients with trauma/burns were compared to isolated burn patients using t-tests, chi-square analysis and Fisher's exact tests. Risk ratios (RRs) were calculated to evaluate the impact of concomitant trauma on mortality, stratified by % total body surface area (TBSA) and injury severity score (ISS). Firth's penalized maximum likelihood estimation (PMLE) approach was used to fit multivariable logistic regression models to the outcomes of prehospital mortality and in-hospital mortality.

Results: Of 436 burn patients, 29.8 % (130/436) had combined trauma/burns. Prehospital mortality in the trauma/burns group was 57.7 % (75/130) versus 43.1 % (132/306) in isolated burn patients. Prehospital mortality risk was highest in trauma/burn patients with % TBSA $\geq$ 70 (RR 3.87, 95 % CI 2.99–4.99) or ISS $\geq$ 25 (RR 2.49, 95 % CI 1.84–3.36). Concomitant trauma was associated with increased odds of prehospital mortality (OR 2.42, 95 % CI 1.27–4.69), but had no impact on in-hospital mortality.

Conclusions: Prehospital mortality was increased in patients with combined burns and trauma.

1. Introduction

The combination of burns and non-thermal injuries may have a synergistic effect that results in higher mortality [1,2]. In North America, approximately 5–7 % of burn patients suffer severe and often life-threatening trauma, commonly caused by motor vehicle collisions, explosions, and industrial accidents [1–3]. Challenges in clinical management can arise during patient assessment (missed injuries), triage (trauma center vs. burn center), and hospital admission (multidisciplinary care coordination, resource allocation) [4,5]. Poor recognition, assessment, and management may result in suboptimal outcomes [3–5]. Elevated risk of mortality has been associated with % total body surface area (TBSA), greater severity of traumatic injury, inhalation injury, number of organ systems involved, and increasing age [1–3,6–8].

Previous studies using the National Trauma Data Bank (NTDB) found combined trauma/burn patients were at increased risk of mortality compared to isolated burn or trauma-only patients [6,7,9]. Although similar synergistic effects were reported in single-center studies conducted at sites in the United States [3,10], United Kingdom [8], and Singapore [11], others have reported no mortality increase for trauma/burn patients. Krasnoff et al. observed that length of stay (LOS) was longer in pediatric trauma/burn patients, but there was no difference in mortality compared to trauma-only patients [12]. Concomitant trauma did not impact mortality in a 35-year analysis of data from a burn center in Switzerland [13], and a nationwide analysis of data from the Japan Trauma Data Bank observed lower mortality in trauma/burn patients compared to isolated burns [14]. These studies all evaluated in-hospital mortality as the outcome.

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https://doi.org/10.1016/j.burns.2024.107363
Accepted 24 December 2024
Available online 26 December 2024

While it is known most injury-related deaths occur at the scene or during transport to hospital [15], there is a lack of evidence regarding the risk of prehospital mortality in patients with combined trauma/-burns. The primary objective of this study was to determine the effect of combined trauma/burns on mortality in the prehospital setting. As a secondary objective, we evaluated in-hospital mortality, LOS and need for mechanical ventilation among trauma/burn patients surviving to hospital.

2. Methods

2.1. Study setting and design

The Canadian province of Nova Scotia has an inclusive trauma system where patients receive care by a dedicated trauma team and have early access to speciality consultation. The Nova Scotia Trauma Registry (NSTR) database is a population-based registry capturing data on all major traumas at two level 1 trauma centers (1 adult, 1 pediatric) and eight regional level 3 trauma centers across the province. The NSTR collects data on all burn traumas with an Injury Severity Score (ISS) ≥ 12. The registry also capture data on all prehospital trauma deaths in the province directly from the Nova Scotia Medical Examiner Service.

Using NSTR data from April 1 2001 and March 31 2019, we conducted a retrospective analysis of all burn patients injured in Nova Scotia. Ethical approval was obtained from the Institutional Review Board (File #: 1025669; December 2, 2020) and included a waiver of consent for participation. This study was performed in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for observational studies [16]. To maintain privacy, cell sizes less than 5 are reported as "$n < 5$" [adjacent cells may be reported as $n > 5$]).

2.2. Data collection

Criteria for NSTR inclusion are an appropriate International Classification of Diseases (ICD) External Cause of Injury Code and at least one of the following: Injury Severity Score (ISS) ≥ 12 for blunt, burn or drowning/asphyxia, ISS ≥ 9 for penetrating trauma, or death (due to appropriate injury mechanism) at the scene, emergency department (ED) or within 24 h of admission to a regional hospital or tertiary care center.

The study cohort was identified from the NSTR using ICD-10-CA diagnostic codes (Supplemental Table 1). Data collection included age, sex, ISS, % TBSA, burn type, initial carboxyhemoglobin level, cause of injury, intent, injury location (urban vs rural), transport mode (ground, air [helicopter, fixed-wing aircraft]), intubation (scene or ED), trauma team activation (TTA), and patient comorbidities. The primary outcome of interest was prehospital mortality. Secondary outcomes included in-hospital mortality, LOS (in-hospital, intensive care unit [ICU]), and days requiring mechanical ventilation. Any missing values are reported in the results tables.

2.3. Data analysis

Patients were grouped based on ICD-10-CA injury codes as having either combined trauma/burns (≥ 1 burn-related injury and ≥ 1 non-thermal injury) or isolated burns (≥ 1 burn-related injury and zero non-thermal injuries). We compared characteristics and outcomes of these two groups using t-tests, chi square analysis, Fisher's exact test and the Mann-Whitney test. The Revised Baux score (rBaux) was calculated using the following formula: age + % TBSA + 17* (*inhalation injury, 1 = yes, 0 = no) [17]. The impact of non-thermal injuries on mortality was evaluated by comparing risk ratios (RRs) between trauma/burn and isolated burn patients, stratified by % TBSA (0–19 = minor; 20–49 = intermediate; 50–69 = moderate; ≥ 70 = severe) and by injury severity using ISS (1–15 = minor/moderate; 16–24 = severe; ≥ 25 = very severe).

Two regression models were constructed to determine the association between combined trauma/burns and the outcomes of prehospital mortality and in-hospital mortality with following risk factors included as covariates: age, sex, rBaux score, and ISS. To mitigate bias resulting from the limited sample of our dataset, we employed Firth's penalized maximum likelihood estimation (PMLE) approach for model development. This method provides a more reliable alternative to conventional maximum likelihood estimation (MLE) as has been demonstrated in similar contexts [18]. Firth's PMLE was implemented using the logistf R package [19]. Any patients with missing variables were excluded from the relative risk analysis and from the regression models. All p-values were two-sided with a significance level of < 0.05. Statistical analyses were performed using IBM SPSS Statistics Version 28 (Armonk, NY: IBM Corp) and with R Statistical Software (R version 4.3.1 [2023–06–16 ucrt] – "Beagle Scouts" Copyright (C) 2023).

3. Results

3.1. Characteristics of the study cohort

During the 18-year study period, 436 major trauma cases involved burns and 29.8 % (130/436) of these patients had concomitant trauma (Fig. 1). Table 1 compares characteristics between the trauma/burns and isolated burns groups. Patients with trauma/burns suffered more severe injuries (median ISS [IQR] 34.5 [56.2] vs. 25.0 [34.0], $p < 0.001$) and had larger-sized burns (median % TBSA [IQR] 77.5 [83.0] vs. 40.0 [67.0], $p = 0.025$). These patients tended to be younger than those with isolated burns (41.3 ± 22.1 years vs. 47.5 ± 23.9 years, $p = 0.012$) and were more likely to have injured themselves intentionally (8.8 % vs. 3.4 %, $p = 0.028$). Patients with isolated burns were more likely to be transported by a combination of ground and air transport (23.9 % vs. 12.3 %, $p = 0.006$), and to be intubated at the scene or in the ED (42.2 % vs. 30.8 %, $p = 0.026$). Activation of the trauma team occurred more often in cases of combined trauma/burns (44.6 % vs. 22.2 %, $p < 0.001$). The two groups were similar regarding patient sex, injury location (rural vs. urban), initial carboxyhemoglobin levels, presence of inhalation injury, rBaux scores, and comorbidities.

3.2. Clinical outcomes

Patient outcomes in the prehospital and in-hospital settings are reported in Table 2. Overall mortality in the study cohort was 65.6 % (286/436), with nearly half of all deaths occurring prehospital (47.5 %, 207/436). Over half of trauma/burn patients died at the scene or during transport (57.7 %, 75/130), compared to 43.1 % (132/306) of isolated burn patients ($p = 0.006$). Among the 229 patients that survived to hospital, more patients in the isolated burn group required ICU admission (44.1 % vs. 30.0 %, $p = 0.007$) and died in-hospital (20.9 % vs. 11.5 %, $p = 0.021$). The two groups were similar regarding ICU LOS, in-hospital LOS, and mechanical ventilation. In the 62 patients (22 trauma/burns, 40 isolated burns) with missing data on % TBSA, prehospital mortality occurred in 36 cases (10 trauma/burns, 26 isolated burns) and 19 patients died in-hospital (7 trauma/burns, 12 isolated burns).

3.3. Impact of burn size and injury severity

Table 3 shows rates and RRs for prehospital and in-hospital mortality in trauma/burn patients, stratified by % TBSA and ISS. Relative to isolated burns, risk of prehospital mortality among trauma/burn patients was greatest in patients with ISS ≥ 25 (RR 2.49, 95 % CI 1.84–3.36) or with ≥ 70 % TBSA (RR 3.87, 95 % CI 2.99–4.99). The lowest risk of prehospital mortality was observed in patients with 20–49 % TBSA (RR 0.20, 95 % CI 0.12–0.33) and with ISS 16–24 (RR 0.13, 0.06–0.28). Similarly, risk of in-hospital mortality was highest in patients with % TBSA ≥ 70 (RR 1.96, 95 % CI 1.23–3.10) and ISS ≥ 25 (RR 1.71, 95 % CI

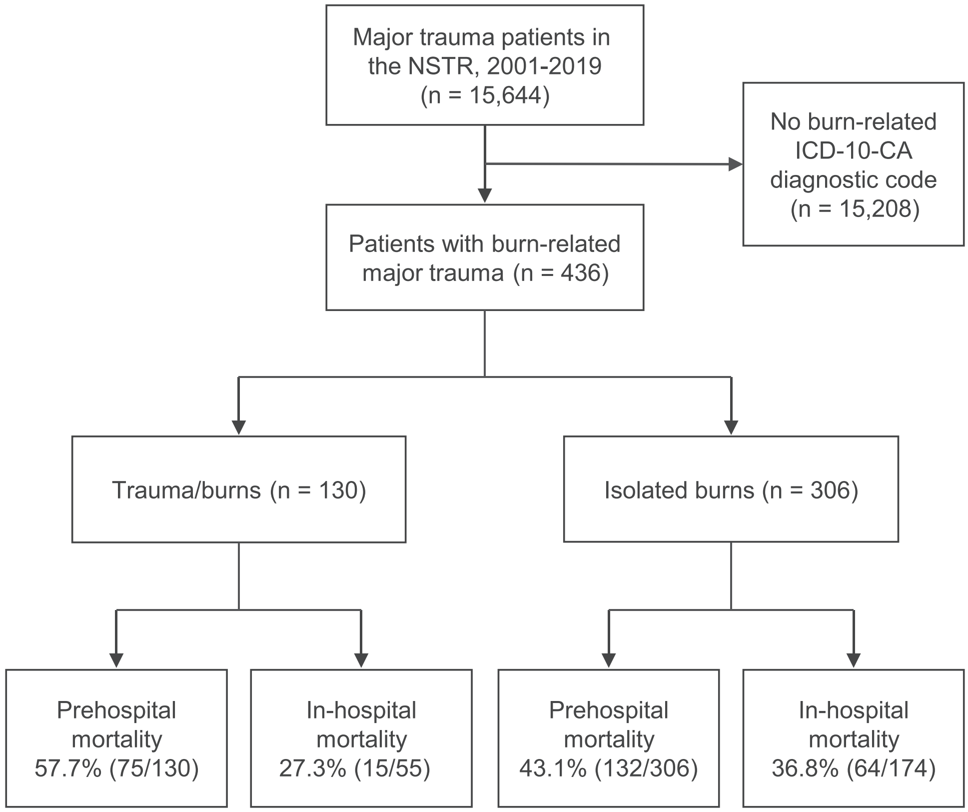

Fig. 1. Flow chart of patient selection and mortality outcomes.

1.17–2.49), and lowest in those with 20–49 % TBSA (RR 0.53, 95 % CI 0.34–0.83) and ISS 16–24 (RR 0.43, 0.26–0.72).

3.4. Predictors of prehospital and in-hospital mortality

Two penalized logistic regression models were constructed to explore the relationship between risk factors and mortality in the prehospital and in-hospital settings (Table 4). Patients with concomitant trauma had increased odds of prehospital mortality (OR 2.42, 95 % CI 1.27–4.69) compared to those with isolated burns. Independent predictors of prehospital mortality included female sex (OR 2.32, 95 % CI 1.24–4.44), rBaux (OR 1.04, 95 % CI 1.03–1.06) and decreasing age (OR 0.97, 95 % CI 0.95–0.98). Among patients surviving to hospital, concomitant trauma was not associated with in-hospital mortality. Similar to the prehospital model, in-hospital mortality was associated with female sex (OR 4.49, 95 % CI 1.88–11.34) and rBaux (OR 1.02, 95 % CI 1.01–1.05). Unlike the prehospital model, mortality was associated with increasing age in the in-hospital setting (OR 1.03, 95 % CI 1.01–1.06). Nagelkerke R^2 values for both models indicated a strong relationship between predictors and outcomes.

4. Discussion

In this study of combined trauma/burns, prehospital mortality was observed in 57.7 % of the trauma/burns group (compared to 43.1 % in isolated burns). Risk of prehospital mortality was greatest in patients with TBSA $\geq$ 70 % (RR 3.87) and ISS $\geq$ 25 (RR 2.49). A greater proportion of isolated burn patients required ICU admission and died during their hospital stay (20.9 % vs. 11.5 %). Upon regression analysis, the odds of prehospital mortality were over 2 times greater in the trauma/burns group (OR 2.42). The presence of combined trauma/burns was not associated with in-hospital mortality.

In the United States, Hawkins et al. were the first to use the NTDB to investigate the effect of combined trauma/burns on mortality [7]. Their analysis of data from 1994 to 2002 revealed increased mortality in patients with combined trauma and minor burns (% TBSA = 1–25) compared to isolated minor burns (RR 5.00), and in patients with combined trauma and severe burns (% TBSA $\geq$ 76) versus isolated severe burns (RR 1.45). Grigorian et al. expanded on this work by comparing NTDB data from 2007 to 2015 with 1994–2002 to determine whether improvements in critical care and multidisciplinary approach over time had impacted trauma/burn patient mortality [6]. Although they found mortality had decreased in burn patients with minor trauma (ISS 1–15) during 2007–2015 (OR 2.45 vs. OR 4.04), they also observed a small yet significant increase in mortality for burn patients with severe trauma (ISS $\geq$ 26) (OR 1.37 vs. OR 1.26). While % TBSA was found to impact mortality in all trauma/burn patients, the impact of injury severity was only seen in trauma/burn patients with % TBSA < 20 %. Later, Martin et al. used NTDB data from 2007 to 2012 to investigate the impact of combined trauma/burns on mortality in traumatic brain injury (TBI) patients [9]. Mortality was increased in patients with combined TBI/burns compared to isolated burns (OR 4.22), and in patients with TBI/burns versus non-TBI trauma patients (OR 3.33). Several single-center studies have reported similar results to those described above [3,8,10,11]; however, other investigations have not observed increased mortality among combined trauma/burn patients. Using 35 years of data from a burn center in Switzerland, Getzmann et al. found concomitant trauma had no impact on mortality in burn patients [13]. In a propensity-matched study of pediatric burn patients, Krasnoff et al. analysed data from the Pediatric Trauma Quality Improvement Program (TQIP) between 2014 and 2016 and found no mortality difference between trauma/burn and trauma-only patients [12]. More recently, Kumakawa et al. analysed data from the Japan Trauma Data Bank between 2004 and 2017 and observed lower mortality in adult trauma/burn patients (6.9 %) compared to isolated burns (18.2 %) [14]. The authors suggested that greater % TBSA in the isolated burns group contributed to the higher rate of in-hospital mortality.

In our study of major trauma patients in Nova Scotia, we observed no

Table 1
Characteristics of patients with combined trauma/burns versus isolated burns.

Characteristics	Trauma/Burns (n = 130)	Isolated Burns (n = 306)	p-value	Overall (n = 436)
Age, mean ± SD	41.3 ± 22.1	47.5 ± 23.9	0.012	45.7 ± 23.5
Male sex, n (%)	93 (71.5)	213 (69.6)	0.687	306 (70.2)
ISS, n (%)			0.272	
Very severe (≥ 25)	92 (70.8)	194 (63.4)		286 (65.6)
Severe (16–24)	19 (14.6)	63 (20.6)		82 (18.8)
Mild/Moderate (1–15)	19 (14.6)	39 (16.0)		68 (15.6)
ISS, median [IQR]	34.5 [56.2]	25.0 [34.0]	< 0.001	26.0 [58.0]
% TBSA, n (%)			< 0.001	
≥ 70	57 (43.8)	87 (28.4)		144 (33.0)
50–69	6 (4.6)	31 (10.1)		37 (8.5)
20–49	18 (13.8)	103 (33.7)		121 (27.8)
0–19	27 (20.8)	45 (14.7)		72 (16.5)
% TBSA, median [IQR]	77.5 [83.0]	40.0 [67.0]	0.021	47.0 [69.0]
Burn type, n (%)				
Thermal	104 (80.0)	271 (88.6)	0.018	375 (86.0)
Inhalation	73 (56.2)	190 (62.1)	0.246	263 (60.3)
Electrical	10 (7.7)	5 (1.6)	0.003	15 (3.4)
Chemical	n < 5	n < 5	0.617	5 (1.1)
Initial COHb, (%/mg) mean ± SD	28.9 ± 26.9	28.4 ± 27.9	0.902	28.6 ± 27.5
rBaux score, mean ± SD	110.1 ± 50.0	107.2 ± 45.7	0.588	108.0 ± 46.9
Primary cause of injury, n (%)			< 0.001	
Thermal/flame burns	83 (63.8)	264 (86.3)		347 (79.6)
MVC	n > 5	n < 5		25 (5.7)
Scald	n < 5	18 (5.9)		19 (4.4)
Electrical injuries	7 (5.4)	6 (2.0)		13 (3.0)
Assault	n < 5	n > 5		13 (3.0)
Self-harm	6 (4.6)	6 (2.0)		12 (2.8)
Other	7 (5.4)	0 (0)		7 (1.6)
Intentional injury, n (%)	11 (8.8)	10 (3.4)	0.028	21 (5.0)
Injury location, n (%)			0.242	
Urban	58 (44.6)	135 (44.1)		193 (44.3)
Rural	38 (29.2)	110 (35.9)		148 (33.9)
Transport mode, n (%)			0.006	
Ground ambulance	40 (30.8)	103 (33.7)		143 (32.8)
Ground & air transport	16 (12.3)	73 (23.9)		89 (20.4)
Intubation (scene/ED), n (%)	40 (30.8)	129 (42.2)	0.026	169 (38.8)
Trauma Team Activation, n (%)	25 (44.6)	39 (22.2)	< 0.001	64 (27.6)
Comorbidities,[a] n (%)			0.124	
Mental health disorders	5 (3.8)	24 (7.8)		29 (6.7)
Use of alcohol/ tobacco	5 (3.8)	16 (5.2)		21 (4.8)
History of cardiac issues	8 (6.2)	10 (3.3)		18 (4.1)
Benign hypertension	n < 5	n > 5		10 (2.3)
Other	19 (14.6)	43 (14.1)		62 (14.2)

ISS: Injury Severity Score; TBSA: total body surface area, COHb: carboxyhemoglobin; MVC = motor vehicle collision; ED: emergency department. Missing data: % TBSA = 62; rBaux = 72; Initial COHb = 127; Injury location = 95.

[a] Some patients had > 1 comorbidity.

Table 2
Patient outcomes in the prehospital and in-hospital settings.

Outcome	Trauma/Burns (n = 130)	Isolated Burns (n = 306)	p-value	Overall (n = 436)
Prehospital				
Mortality, n (%)	75 (57.7)	132 (43.1)	0.006	207 (47.5)
In-Hospital[a]				
ICU admission, n (%)	39 (30.0)	135 (44.1)	0.007	174 (39.9)
ICU LOS, mean ±SD	11.6 ± 16.3	18.2 ± 44.5	0.283	16.6 ± 39.6
Overall LOS, mean±SD	28.6 ± 31.8	30.5 ± 57.6	0.818	30.1 ± 52.5
Ventilator days, mean±SD	7.6 ± 11.6	6.6 ± 9.3	0.523	6.8 ± 9.9
Mortality, n (%)	15 (11.5)	64 (20.9)	0.021	79 (18.1)

ICU: Intensive care unit; LOS: length of stay.

Table 3
Risk ratio for prehospital mortality and in-hospital mortality in combined trauma/burn patients stratified by total body surface area and by injury severity score.

Outcome	Patient Group	Number (%)	Deaths (%)	RR	CI
Prehospital mortality (n = 436)	% TBSA[a] (n = 374)				
	≥ 70	144 (38.5 %)	121 (32.4 %)	3.87	2.99–4.99
	50–69	37 (9.9 %)	17 (4.5 %)	1.00	0.70–1.45
	20–49	121 (32.4 %)	15 (4.0 %)	0.20	0.12–0.33
	0–19	72 (19.3 %)	18 (4.8 %)	0.49	0.33–0.75
	ISS (n = 436)				
	≥ 25	286 (65.6 %)	171 (39.2 %)	2.49	1.84–3.36
	16–24	82 (18.8 %)	6 (1.4 %)	0.13	0.06–0.28
	1–15	68 (15.6 %)	30 (6.9 %)	0.92	0.69–1.22
In-hospital mortality (n = 229)	% TBSA[a] (n = 203)				
	≥ 70	23 (11.3 %)	12 (5.9 %)	1.96	1.23–3.10
	50–69	20 (9.9 %)	12 (5.9 %)	2.29	1.48–3.52
	20–49	106 (52.2 %)	22 (10.8 %)	0.53	0.34–0.83
	0–19	54 (26.6 %)	14 (6.9 %)	0.84	0.50–1.40
	ISS (n = 229)				
	≥ 25	115 (50.2 %)	50 (21.8 %)	1.71	1.17–2.49
	16–24	76 (33.2 %)	14 (6.1 %)	0.43	0.26–0.72
	1–15	38 (16.6 %)	15 (6.5 %)	1.18	0.76–1.83

ISS: Injury Severity Score; TBSA: total body surface area.
Missing data: % TBSA = 62.

difference in in-hospital mortality between trauma/burn and isolated burn patients; however, patients with combined trauma/burns had significantly greater odds of dying at the scene of injury or during transport. Unlike some previous studies, our analysis included pediatric burn patients who differ from adults in their response to thermal injury [20]. Unlike Japan where the incidence of combined trauma/burns is rare (4 % of burn admission), 30 % of all burn patients in Nova Scotia (including prehospital deaths) and 24 % of burn admissions to hospital had concomitant trauma. These injuries are even more common in the United States where Hawkins et al. showed that 43 % of all burn admissions in the NTDB suffered combined trauma [7]. Although it has

Table 4
Regression analysis of the association between patient variables and the outcomes of prehospital mortality and in-hospital mortality.

Covariate	Prehospital Mortality			In-Hospital Mortality		
	OR	CI	P Value	OR	CI	P Value
Trauma/burns (REF Isolated burns)	2.42	1.27–4.69	0.007	0.77	0.28–2.03	0.607
Age	0.97	0.95–0.98	< 0.001	1.03	1.01–1.06	0.011
Female sex (REF Male sex)	2.32	1.24–4.44	0.008	4.49	1.88–11.34	< 0.001
rBaux	1.04	1.03–1.06	< 0.001	1.02	1.01–1.05	0.002
ISS (REF 1–15)						
≥ 25	0.84	0.30–2.40	0.736	0.98	0.31–3.17	0.974
16–24	0.34	0.10–1.15	0.084	0.34	0.10–1.13	0.078

ISS: Injury Severity Score.

been suggested that the increased in-hospital mortality often observed in trauma/burn patients is more of a function of injury severity rather than burn severity [3,21], the converse has also been reported [1]. Previously identified risk factors for in-hospital mortality in trauma/burn patients include increasing age, sex, % TBSA, ISS, rBaux, head injury, and inhalation injury [1–3,5–8,22,23]. Inhalation injuries were common in our study (>50 %) and increasing rBaux was associated with mortality in both the prehospital and in-hospital settings as has been reported in the literature [23]. While others report greater incidence of inhalation injury in burn patients with concomitant trauma [2,9], we observed similar incidence between the two groups in our study. Female sex was predictive of mortality in both the prehospital and in-hospital settings, in agreement with previous studies showing female burn patients suffer higher mortality compared to males [22,24].

Unlike trauma care, there is no "golden hour" in burn medicine which determines further clinical course [25]. Conversely, the effects of severe burns are slow to start, but once they begin, they are complex, long-lasting and can impact every system in the body. Beyond taking adequate care of airways and circulation, emergency prehospital measures such as estimating TBSA, calculating the optimal amount of fluid to infuse, and the mode of transport to definitive care have minimal effect on prognosis [25]. Rather, what is of critical importance is taking precautions to prevent hypothermia [26] and ensuring the burn wounds do not interfere with basic resuscitation and stabilization. Patients who present with any burn injury should be evaluated as trauma patients using the Advanced Trauma Life Support (ATLS) and/or Advanced Burn Life Support (ABLS) principles, focusing on the primary and secondary surveys [27]. Injuries may be missed if these initial trauma surveys are distracted or compromised by the presence of burns [5]. Further challenges can arise with intracranial pressure monitoring, chest tube insertion, fractured and burned extremities, and the diagnosis and management of intra-abdominal injuries [1,2].

Developing an optimal treatment strategy for patients with combined trauma/burns requires a solid understanding of the independent temporal changes for each injury and a balanced multidisciplinary approach [4]. Having an organized approach to the initial assessment and management of trauma/burn patients with early access to speciality services can improve outcomes and long-term quality of life [5]. This approach is supported by new algorithms for triage and initial management [28], along with ongoing improvements in ATLS, ABLS and clinical practice guidelines [29–33]. While these advances have improved care, management of the severely burned patient remains a long-term process to address the local burn wound as well as the systemic, psychological, and social consequences of the injury [4,5]. The survivors must now begin a long journey of rehabilitation and physiotherapy for their non-thermal injuries, a process which may be hindered by difficulties with mobilization due to their burns.

This study has several strengths to highlight. The analysis included 18 years of data from a population-based trauma registry which collects data on all major trauma patients across the province including deaths at the scene or during transport. Patients were grouped using ICD-10-CA coding [34] and subcategorized by burn and injury severity similar to previous reports [6,7].

Despite these strengths, this study has limitations. Our study population was limited to major trauma patients that met NSTR criteria for inclusion, making it difficult to compare our results with other studies that included trauma patients across the complete range of injury severity. Some variables were missing values, notably % TBSA which was missing in 14.2 % of patients in our study. A recent study from Israel reported % TBSA was missing in 67.5 % of burn patients seen in the Emergency Department due to failure on the part of non-burn physicians to accurately and completely document burn injuries [35]. Furthermore, the NSTR does not collect data on other important considerations in this patient population such as the collocation of burn and fracture injuries, the training level of the providers, and treatments provided in the prehospital setting. As a retrospective analysis on an existing dataset, our results cannot be used to imply causality, instead we report the strong correlation between combined burns/trauma and pre-hospital mortality. Furthermore, our findings may not be generalizable to other regions as they are based on the province of Nova Scotia which has an older population, unique geography, and an inclusive provincial trauma system.

5. Conclusion

Burn patients in Nova Scotia with concomitant trauma were at increased risk of prehospital mortality. Those at greatest risk were patients with TBSA ≥ 70 % or ISS ≥ 25. Concomitant trauma was not significantly associated with in-hospital mortality. Further studies are needed to validate this synergistic effect of burns and trauma on mortality in the prehospital settings.

Ethics approval

Ethics approval was obtained from the Nova Scotia Health Research Ethics Board (File #: 1025669, December 2, 2020).

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors

Presentations at conferences

Presented as a podium presentation at the 2023 Trauma Association of Canada Annual Scientific Meeting and Congress, April 20–21, in Edmonton, Alberta. Presented as a poster at the 2022 London Trauma Conference, December 6–10, in London, England. Presented as a poster at the 2024 Trauma Association of Canada Annual Scientific Meeting and Congress, May 8–10, in Halifax, Nova Scotia.

Author contributions

This study was conceived by R.S.G. All authors (R.S.G., J.N., J.R., M. E., N.K.) contributed to designing the study. Data acquisition and analysis was performed by M.E. and N.K. All authors contributed to interpreting the data, drafting and critically revising the manuscript. All authors have provided final approval of the version to be published and have agreed to be accountable for all aspects of the work presented in the manuscript.

Consent to participate

Waiver of consent was granted by the Nova Scotia Health Research Ethics Board.

Consent for publication

Waiver of consent was granted by the Nova Scotia Health Research Ethics Board.

Declaration of Competing Interest

None.

Acknowledgements

The authors thank Karen Ssebazza, Nova Scotia Trauma Registry Coordinator, for assisting with study design and data collection from the NSTR. Data used in this research were made available by Nova Scotia Health. Any opinions expressed by the authors do not necessarily reflect the opinion of Nova Scotia Health.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.burns.2024.107363.

References

[1] Purdue GF, Hunt JL. Multiple trauma and the burn patient. Am J Surg 1989;158:536–9. https://doi.org/10.1016/0002-9610(89)90186-4.
[2] Dougherty W, Waxman K. The complexities of managing severe burns with associated trauma. Surg Clin North Am 1996;76:923–58. https://doi.org/10.1016/s0039-6109(05)70488-6.
[3] Santaniello JM, Luchette FA, Esposito TJ, Gunawan H, Reed RL, Davis KA, et al. Ten year experience of burn, trauma, and combined burn/trauma injuries comparing outcomes. J Trauma 2004;57:696–701. https://doi.org/10.1097/01.ta.0000140480.50079.a8.
[4] Sheridan RL, Greenhalgh D. Special problems in burns. Surg Clin North Am 2014;94:781–91. https://doi.org/10.1016/j.suc.2014.05.002.
[5] Rosenkranz KM, Sheridan R. Management of the burned trauma patient: balancing conflicting priorities. Burns 2002;28:665–9. https://doi.org/10.1016/s0305-4179(02)00109-2.
[6] Grigorian A, Nahmias J, Schubl S, Gabriel V, Bernal N, Joe V. Rising mortality in patients with combined burn and trauma. Burns 2018;44:1989–96. https://doi.org/10.1016/j.burns.2018.07.003.
[7] Hawkins A, MacLennan PA, McGwin Jr G, Cross JM. Rue LW 3rd. The impact of combined trauma and burns on patient mortality. J Trauma 2005;58:284–8. https://doi.org/10.1097/01.ta.0000130610.19361.bd.
[8] Battaloglu E, Iniguez MF, Lecky F, Porter K. Incidence of combined burns and major trauma in England and Wales. Trauma 2020;22:51–5. https://doi.org/10.1097/01.ta.0000130610.19361.bd.
[9] Martin R, Taylor S, Palmieri TL. Mortality following combined burn and traumatic brain injuries: an analysis of the national trauma data bank of the American college of surgeons. Burns 2020;46:1289–96. https://doi.org/10.1016/j.burns.2020.06.022.
[10] Sljivic S, Agala CB, McLean SE, Williams FN, Nizamani R, Meyer AA, et al. Outcomes in pediatric burn patients with additional trauma-related injuries. Am Surg 2023. https://doi.org/10.1177/00031348231157849.
[11] Kok YO, Sim N, Tiwari P, Wong TH, Chong SJ. Establishing a treatment protocol for concomitant major burn and trauma patients: a tropical Asian hospital's experience. Burns Trauma 2017;5:21. https://doi.org/10.1186/s41038-017-0088-6.
[12] Krasnoff CC, Grigorian A, Chin T, Joe V, Kong A, Barrios C, et al. Pediatric burn-trauma patients have increased length of stay compared to trauma-only patients: a propensity matched analysis. Burns 2021;47:78–83. https://doi.org/10.1016/j.burns.2020.04.029.
[13] Getzmann JM, Slankamenac K, Sprengel K, Mannil L, Giovanoli P, Plock JA. The impact of non-thermal injuries in combined burn trauma: a retrospective analysis over the past 35 years. J Plast Reconstr Aesthet Surg 2019;72:438–46. https://doi.org/10.1016/j.bjps.2018.10.022.
[14] Kumakawa Y, Kondo Y, Hirano Y, Sueyoshi K, Tanaka H, Okamoto K. Characteristics and clinical outcomes of patients with combined burns and trauma in Japan: analysis of a nationwide trauma registry database. Burns 2024;S0305-4179(24). https://doi.org/10.1016/j.burns.2024.04.009.
[15] Gedeborg R, Chen LH, Thiblin I, Byberg L, Melhus H, Michaelsson K, et al. Prehospital injury deaths–strengthening the case for prevention: nationwide cohort study. J Trauma Acute Care Surg 2012;72:765–72. https://doi.org/10.1097/TA.0b013e3182288272.
[16] von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, et al. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol 2008;61:344–9. https://doi.org/10.1016/j.jclinepi.2007.11.008.
[17] Osler T, Glance LG, Hosmer DW. Simplified estimates of the probability of death after burn injuries: extending and updating the baux score. J Trauma 2010;68:690–7. https://doi.org/10.1097/TA.0b013e3181c453b3.
[18] Heinze G, Schemper M. A solution to the problem of separation in logistic regression. Stat Med 2002;21:2409–19.
[19] Heinze G., Ploner M., Dunkler D., Southworth H. logistf: Firth's Bias Reduced Logistic Regression. R package version 1.20. 2013. Available at: ⟨http://cran.r-project.org/web/packages/logistf/index.html⟩.
[20] Barrios EL, Polcz VE, Moldawer LL, Rincon JC, Efron PA, Larson SD. Variables influencing the differential host response to burns in pediatric and adult patients. Shock 2023;59:145–54. https://doi.org/10.1097/SHK.0000000000002042.
[21] Brandt CP, Yowler CJ, Fratianne RB. Burns with multiple trauma. Am Surg 2002;68:240–4. https://doi.org/10.1177/000313480206800305.
[22] Karimi K, Faraklas I, Lewis G, et al. Increased mortality in women: sex differences in burn outcomes. Burns Trauma 2017;5:18. ⟨10.1186/s41038-017-0083-y⟩.
[23] Edgar MC, Bond SM, Jiang SH, Scharf IM, Bejarano G, Vrouwe SQ. The revised baux score as a predictor of burn mortality: a systematic review and meta-analysis. J Burn Care Res 2023;44:1278–88.
[24] Mehta K, Arega H, Smith NL, Li K, Gause E, Lee J, et al. Gender-based disparities in burn injuries, care and outcomes: a World Health Organization (WHO) global burn registry cohort study. Am J Surg 2022;223:157–63.
[25] Muehlberger T, Ottomann C, Toman N, Daigeler A, Lehnhardt M. Emergency pre-hospital care of burn patients. Surgeon 2010;8:101–4. https://doi.org/10.1016/j.surge.2009.10.001.
[26] Walker SB, Clack JE, Dwyer TA. An integrative literature review of factors contributing to hypothermia in adults during the emergent (ebb) phase of a severe burn injury. Burns 2024;50:1389–405. https://doi.org/10.1016/j.burns.2024.03.028.
[27] ATLS Subcommittee; American College of Surgeons' Committee on Trauma; International ATLS Working Group. Advanced Trauma Life Support (ATLS®): the ninth edition. J Trauma Acute Care Surg 2013;74:1363-6. https://doi./org/⟨10.1097/TA.0b013e31828b82f5⟩.
[28] Vercruysse GA, Alam HB, Martin MJ, Brasel K, Moore EE, Brown CV, et al. Western Trauma Association critical decisions in trauma: preferred triage and initial management of the burned patient. J Trauma Acute Care Surg 2019;87:1239–43. https://doi.org/10.1097/TA.0000000000002348.
[29] American Burn Association. ABLS Burn Life Support Course: Provider manual 2018 update. ⟨http://ameriburn.org/wp-content/uploads/2019/08/2018-abls-providermanual.pdf⟩. 2018; [accessed 27 September 2023].
[30] Emergency Health Services. Clinical Practice Guidelines 6340.03: Burns. ⟨https://www.novascotia.ca/dhw/ehs/documents/CPG/EHS6340.02%20Burns.pdf⟩; 2014 [accessed 24 April 2023].
[31] Advanced trauma life support (ATLS®). Student Course Manual. 10th ed. Chicago, United States: American College of Surgeons; 2018. 1363–6.
[32] Jeschke M., McCallum C., Baron D., Godleski M., Knighton J., Shahrokhi S. Best Practice Recommendations for the Prevention and Management of Burns. In: Foundations of Best Practice for Skin and Wound Management. A supplement of Wound Care Canada. ⟨http://www.woundscanada.ca/docman/public/health-careprofessional/bpr-workshop/1308-bpr-for-the-prevention-and-management-of-burns/file⟩; 2018 [accessed 15 September 2023].
[33] Kok YO, Sim N, Tiwari P, Wong TH, Chong SJ. Establishing a treatment protocol for concomitant major burn and trauma patients: a tropical Asian hospital's experience. Burn Trauma 2017;5:21. https://doi.org/10.1186/s41038-017-0088-6.
[34] Canadian Institute for Health Information (CIHI). Canadian Coding Standards for Version 2018 ICD-10-CA and CCI. Ottawa, ON: CIHI; 2018.
[35] Berger O, Mendelson M, Talisman R. Burn documentation in emergency department files and its impact on admission or discharge. Burns Open 2023;7:103–6. https://doi.org/10.1016/j.burnso.2023.07.002.