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Characteristics and clinical outcomes of patients with combined burns and trauma in Japan: Analysis of a nationwide trauma registry database

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ABSTRACT

Introduction: Patients with combined burns and trauma are often seen in the United States. The combination of trauma with burns increases mortality. In contrast, the characteristics and outcomes of these cases remain unknown in Japan. This study investigated the characteristics and outcomes of trauma associated with burns in Japan.

Methods: This multicenter retrospective cohort study was conducted by utilizing data from the Japan Trauma Data Bank for the period between 2004 and 2017. We evaluated the characteristics of burn patients (n = 5783) divided into two groups: burns only (n = 5537) and combined burns and trauma (n = 246). Clinical characteristics, including patient background, severity of trauma, injury mechanism, total body surface area affected, injury location, treatments, and clinical outcomes, were examined.

Results: Most patients in both the groups were injured by flames. The number proportion of patients with 40–89% of the total body surface area affected was 1069/5537 (19.3%) in the burn-only group and 23/246 (9.3%) in the combined burn and trauma group. The in-hospital mortality was 1006/5537 (18.2%) in the burn-only group and 17/246 (6.9%) in the combined burn and trauma group.

Conclusions: We demonstrated the characteristics of Japanese patients with burns only compared with those with combined burns and trauma. Flames were the main cause of burns, and in-hospital mortality was lower in the combined burn and trauma group associated with a smaller burn area.

1. Introduction

Burn injuries represent a global public health issue; according to the World Health Organization, 11 million people worldwide are severely burned every year and require medical treatment, resulting in 180,000 deaths [1]. In the United States, 486,000 patients receive medical treatment for burns

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annually, and 40,000 patients are hospitalized, including 30,000 at hospital burn centers, resulting in 3275 deaths [2]. Regarding epidemiology of trauma, 4.4 million people die yearly because of trauma, accounting for nearly 8% of all deaths worldwide [3]. Trauma is a major cause of death in younger generations [4].

Combined burns and trauma occur when an individual experiences both burns and traumatic injuries simultaneously. This type of injury is caused by events such as car accidents, industrial accidents, explosions, or fires. Trauma combined with burns increases mortality, and combined burns and trauma are relatively common in the United States [5]. A previous study demonstrated that combined burns and trauma accounts for 18.1% of all burn injuries, although this study included old data and showed a decreasing incidence rate year by year [5]. In contrast, the incidence of this type of injury in Japan remains unknown.

To elucidate the characteristics of combined burns and trauma, both trauma and burn information is required. The Japan Trauma Data Bank (JTDB) primarily registers trauma patients but also includes burn patients' information. Some studies using the JTDB have revealed characteristics of certain types of burns; associations between mortality and helicopter transportation, self-inflicted burns, and explosions were investigated [6–8]. The JTDB may have value in clarifying the clinical characteristics of combined burns and trauma.

This study aimed to elucidate the characteristics of combined burns and trauma in Japan using the JTDB.

2. Materials and methods

2.1. *Study design and data collection*

This multicenter retrospective cohort study was conducted utilizing data from the JTDB for the period between January 2004 and December 2017 [9].

The Japanese Association for Acute Medicine and the Japanese Association for the Surgery of Trauma collaboratively created the JTDB in 2003, a nationwide trauma registry, with the aim of enhancing and guaranteeing the quality of trauma care in Japan. During this study period, the JTDB encompassed 264 major emergency hospitals, accounting for 95% of all the tertiary-level emergency medical centers in Japan [10]. Tertiary-level emergency hospitals have capabilities equivalent to those found in level I trauma centers in the United States. Patients with a total Abbreviated Injury Scale (AIS) score of 3 or higher are mandatorily registered regardless of trauma or burns, while the registration of those with a total AIS score < 3 depends on institutional policy.

Regarding burn facilities, there were 102 specialized burn care facilities in Japan as of April 2023, and 86 of these facilities are also included in the JTDB; 32.6% (86/264) of specialized burn care facilities were involved in this cohort [9, 11, 12]. There are no standardized transfer protocols within the trauma system in Japan, whereas many burn patients are managed according to the transfer protocol issued by the American Burn Association [13]. Data were prospectively collected at each hospital via an internet registration system from participating institutions. Data registration was performed by physicians or medical assistants who had trained in an AIS coding course. The scope of emergency physician duties varies depending on the hospital in Japan. The predominant model of care is such that the emergency physician would continue to be the primary physician after admission if the patients require treatment in intensive care units. If not, plastic surgeons, orthopedics, general surgeons, or other physicians would be the primary physician based on the patient's medical specialty requirements.

The Ethics Committee of Juntendo University Urayasu Hospital granted approval for this study (reference number: U17–0010). Because of the retrospective and anonymized nature of this study, the requirement for informed consent was waived. This research was performed according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement for observational studies [14].

2.2. *Study participants*

The study included individuals aged 18 years or older who were burn patients. We excluded patients with cardiopulmonary arrest on arrival and whose total body surface area (TBSA) affected by burns was unknown. The eligible patients were segregated into two groups. One group was the burn-only (BO) group, and the other was the combined burn and trauma (BT) group.

2.3. *Variables and outcomes*

This study involved the examination of clinical characteristics, including patient background (age, sex, and vital signs on arrival at emergency department), AIS score, injury severity score (ISS), injury mechanism, TBSA affected, focused assessment with sonography for trauma (FAST) examination, injury location, treatment approaches, and patient outcomes. The AIS offers a standardized terminology for characterizing injuries and categorizes the type of trauma and its anatomical severity. The AIS assesses severity using a 6-point scale. The ISS is calculated by summing the squares of the highest severity level in the top three severely injured anatomical areas [15]. The TBSA affected was assessed using ordinal values that corresponded to the AIS. Table 1 shows the AIS score corresponding with the TBSA affected. The primary outcome was in-hospital mortality, and secondary

Table 1 – AIS score for TBSA.

AIS	TBSA
1	2nd degree $< 10\%$ 3rd degree ≤ 100 cm^2 (face ≤ 25 cm^2)
2	2nd or 3rd degree 10–19% 3rd degree > 100 cm^2 (face > 25 cm^2)
3	2nd or 3rd degree 20–29%
4	2nd or 3rd degree 30–39%
5	2nd or 3rd degree 40–89%
6	2nd or 3rd degree $\geq 90\%$

AIS, Abbreviated Injury Scale; TBSA, total body surface area.

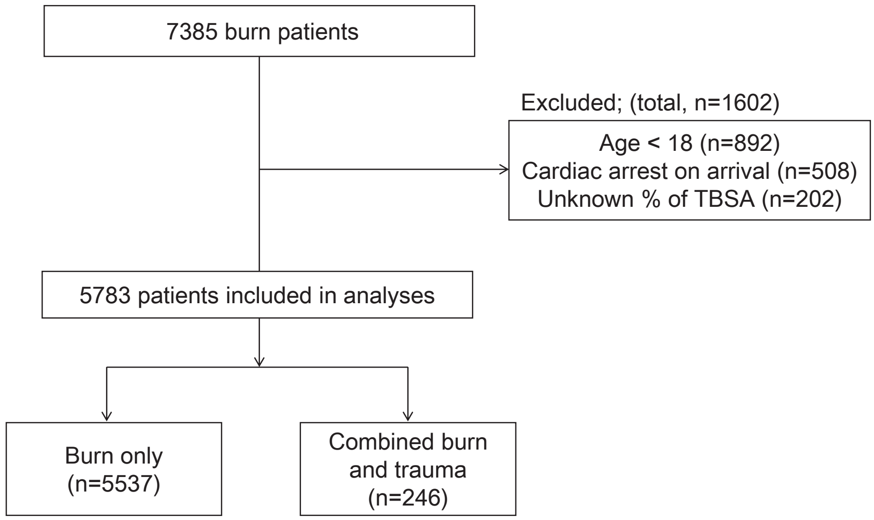

Fig. 1 – Study flow diagram of this study.

outcomes were baseline characteristics and variations in treatments between the groups.

2.4. *Subgroup analysis*

To clarify the underlying mechanisms of trauma in burn patients, we performed subgroup analysis to compare the characteristics and clinical outcomes of patients with combined burns and trauma divided by major mechanisms of injuries.

2.5. *Statistical analysis*

Continuous and ordinal variables are presented as medians and interquartile ranges (IQRs). We analyzed continuous variables for significance using the Mann–Whitney U test. Categorical variables are presented as counts and percentages. We analyzed binary and categorical variables for significance using either the χ^2 test or Fisher's exact test. All statistical analyses were conducted utilizing IBM SPSS version 28 (IBM Corp., Armonk, NY, USA).

3. Results

Among 7385 burn patients registered during the study period, the study included 5783. The BO and BT groups included 5537 and 246 patients, respectively (Fig. 1). Table 2 provides a summary of patient characteristics. It is noteworthy that individuals in the BO group were significantly older than those in the BT group (median [IQR]: 61 [43–76] for the BO group vs. 51 [39–66] for the BT group, $p < 0.001$). Most individuals in the study population were males, with a particularly high representation in the BO group. Flames were the primary cause of injuries and burns. Explosion injuries were more common in the BT group than in the BO group. Furthermore, the proportion of patients with 40–89% of the TBSA affected was greater in the BO group than in the BT group.

Table 3 shows the results of the FAST examination and the types of injuries in all patients. The rate of FAST positivity was relatively low in both the groups. Furthermore, FAST examination was not always conducted. In the BT group, injuries to the upper and lower extremities were the most frequently occurring injury type.

A comparison of the treatments and outcomes between the BO and BT groups is shown in Table 4. In both the groups, the majority of patients were hospitalized in the intensive care unit. The patients were most often treated by emergency physicians (BO group, 81.8% and BT group, 80.5%), followed by plastic surgeons. The results did not specify whether multiple specialists were involved in the treatment or not. Approximately half of the patients were discharged (BO group, 49.4% and BT group, 58.9%), and the others were transferred to another hospital. The in-hospital mortality was greater in the BO group than in the BT group, with rates of 18.2% and 6.9%, respectively.

Because flames and explosions were major causes of trauma, we performed subgroup analysis in patients with combined burns and trauma divided by flame and explosion mechanisms (Additional file 1). The participants in the flame group were significantly older than those in the explosion group (median [IQR]: 55 [44–71] years vs. 46 [33.5–57.5] years, $p = 0.006$). The flame group also showed a lower proportion of males, lower rate of upper extremity injuries, and lower proportion of < 10 of the TBSA affected. The clinical outcomes regarding where patients were discharged to showed no significant difference between the groups ($p = 0.60$).

4. Discussion

This study investigated the attributes of BT cases in Japan. The mortality rate within the hospital for the BO group was 18.2%, and approximately half the hospitalized patients were discharged to home. On the contrary, the BT group had only 6.9% in-hospital mortality, and more patients returned home. The leading mechanism of injury was flames, which was

Table 2 – Comparison of baseline characteristics of the burn-only and combined burn and trauma groups.

	Burn-only (n = 5537)	Combined burn and trauma (n = 246)	P-value
Age (years)	61 (43, 76)	51 (39, 66)	< 0.001
Sex, male	3559/5537 (64.3)	184/246 (74.8)	0.001
Systemic blood pressure on ED arrival	144 (124, 166)	139 (123, 158)	0.014
Diastolic blood pressure on ED arrival	84 (71, 97)	81 (70, 96)	0.24
Heart rate on ED arrival	97 (83, 110)	96 (80, 110)	0.25
Respiratory rate on ED arrival	20 (17, 24)	20 (18, 25)	0.47
Temperature on ED arrival	36.5 (36.0, 37.0)	36.5 (35.9, 37.0)	0.65
GCS on ED arrival	15 (14, 15)	15 (14, 15)	0.15
ISS	9 (4, 25)	10 (5, 18)	0.09
RTS	7.84 (7.55, 7.84)	7.84 (7.55, 7.84)	0.59
Mechanism of injury			< 0.001
Flame	3635/5537 (65.7)	135/246 (54.9)	
Hot water	806/5537 (13.9)	21/246 (8.5)	
Explosion	341/5537 (6.2)	29/246 (11.8)	
Chemical	201/5537 (3.6)	15/246 (6.1)	
Others	553/5537 (10.0)	46/246 (18.7)	
TBSA (%)			< 0.001
< 10	1409/5537 (25.4)	96/246 (39.0)	
10–19	889/5537 (16.1)	50/246 (20.3)	
20–29	1368/5537 (24.7)	56/246 (22.8)	
30–39	637/5537 (11.5)	20/246 (8.1)	
40–89	1069/5537 (19.3)	23/246 (9.3)	
> 90	165/5537 (3.0)	1/246 (0.4)	

ED: emergency department; GCS: Glasgow coma scale; ISS: injury severity score; RTS: revised trauma score; TBSA: total body surface area.
Missing data: sex, male = 1, diastolic blood pressure on ED arrival = 229, heart rate on ED arrival = 104, respiratory rate on ED arrival = 486, temperature on ED arrival = 632, GCS on ED arrival = 319.
Data are presented as median (interquartile range) except for sex, mechanism of injury, and TBSA, which are presented as numbers (%).

similar in both the groups. The incidence of patients with TBSA affected between 40–89% was greater in the BO group than in the BT group. Most patients were treated by an emergency physician and were hospitalized in the intensive care unit.

Hawkins et al. were the first to analyze patients with BT in the United States using the National Trauma Data Bank (NTDB) [16]. Their study showed that patients with BT whose burn and trauma were more severe had significantly increased mortality. Notably, they found that even minor trauma increased mortality in patients with BT. Thereafter, Grigorian et al. analyzed patients with BT using the NTDB between 2007 and 2015 [5]. They showed that the TBSA impacted the mortality of all patients with BT. Meanwhile, the severity of injury only impacted the mortality of patients with BT who had < 20% TBSA affected. For patients with burns, mortality is related to age, TBSA affected, burn type, and occurrence of inhalation injury [17–19]. For trauma patients, mortality is associated with the Glasgow Coma Scale score, mechanism of injury, ISS, and head injury [20,21].

Our findings suggest that the in-hospital mortality rate was the greatest in the BO group owing to the TBSA affected. The burn area was the greatest in patients in the BO group, which is considered a direct cause of death. Patients with BT

Table 3 – Results of the FAST examination and types of injuries in burn patients.

	Burn-only (n = 5537)	Combined burn and trauma (n = 246)	P-value
FAST			
Positive	14/5537 (0.3)	3/246 (1.2)	
Negative	615/5537 (11.1)	69/246 (28.0)	
Not conducted	4509/5537 (81.4)	157/246 (63.8)	
Unknown	180/5537 (3.3)	9/246 (3.7)	
Injury lesion			-
Head	-	41/246 (16.7)	
Face	-	70/246 (28.5)	
Neck	-	3/246 (1.2)	
Thorax	-	36/246 (14.6)	
Abdomen and pelvis	-	6/246 (2.4)	
Cervical spine	-	29/246 (11.8)	
Upper extremity	-	57/246 (23.2)	
Lower extremity	-	61/246 (24.8)	

FAST: focused assessment with sonography for trauma. Missing data: FAST = 227. Data are presented as numbers (%).

Table 4 – Comparison of treatments and outcomes of the burn-only and combined burn and trauma groups.

	Burn-only (n = 5537)	Combined burn and trauma (n = 246)	P-value
Treatments			
Intubation before arrival	269/5537 (4.9)	11/246 (4.5)	0.47
Blood transfusion within 24 h from arrival	251/5537 (4.5)	9/246 (3.7)	0.60
Admission			0.46
ICU	4561/5537 (82.4)	196/246 (79.7)	
General word	742/5537 (13.4)	41/246 (16.7)	
Others	119/5537 (2.1)	7/246 (2.8)	
Died at ED	20/5537 (0.4)	0/246 (0)	
Primary physician after admission			< 0.001
Emergency physician	4528/5537 (81.8)	198/246 (80.5)	
Plastic surgeon	526/5537 (9.5)	23/246 (9.3)	
Orthopedics	10/5537 (0.2)	8/246 (3.3)	
General surgeon	86/5537 (1.6)	6/246 (2.4)	
Others	261/5537 (4.7)	9/246 (3.7)	
Discharged place			< 0.001
Home	2734/5537 (49.4)	145/246 (58.9)	
Another hospital	1444/5537 (26.1)	65/246 (26.4)	
Died	1006/5537 (18.2)	17/246 (6.9)	
Others	77/5537 (1.4)	7/246 (2.8)	

ICU: intensive care unit; ED: emergency department. Missing data: blood transfusion within 24 h from arrival = 194, admission = 97, primary physician after admission = 128, discharged place = 288. Data are presented as numbers (%).

may have had a low severity of trauma, which could have caused a lower mortality rate.

Our findings show that combined burns and trauma are rare in Japan. In the United States, it is not uncommon for burns and trauma to occur simultaneously (combined burns and trauma account for 18.1% of all burn injuries) [5]. Most literature on combined burns and trauma primarily includes North American studies. Battaloglu's study showed the infrequency of this specific combination of injury patterns in the United Kingdom, particularly when compared with that in the United States [22].

Flames were the main cause of burns; however, there were some explosion injuries. In 2019, nearly 2 million traffic accidents occurred in the United States, and 36,000 people lost their lives in traffic crashes. However, in Japan, only 38,000 people were involved in traffic accidents, and 4000 people died in 2019 [23,24]. The lower number of traffic accidents in Japan compared with that in the United States may be why fewer cases of combined burns and trauma occur in Japan (302 vs. 594 people per 100,000 population) [23,24]. In Japan, the incidence of flame burns exceeds that in the United States [16], and there are fewer explosion injuries, which might be due to environmental differences, including the traffic accident rate. In the United States, the mortality of BT patients with ≥ 20% of TBSA affected was not associated with the severity of trauma [5]. In contrast, trauma severity was not associated with mortality in any patients with burns and trauma in this study as the severity of the trauma was low. The high incidence of flame burns may have contributed to the mortality rate.

We realized that FAST examinations were not conducted in many cases in the present study (BO group 81.4%, BT group 63.8%). FAST emerged in the early 1990 s and spread as one of the most commonly used tools for detecting torso trauma [25]. Currently, guidelines recommend performing FAST for all trauma patients because FAST is convenient, easy, and considered a useful screening tool [26]. According to our findings, there was a low rate of FAST examinations. Thus, it may be necessary to increase the rate of FAST examinations for suspected trauma patients. In contrast, the FAST positivity rate was very low (BO group 0.3%, BT group 1.2%). Previous studies have demonstrated that FAST is useful but has very low sensitivity for detecting abdominal injuries [27]. Detecting minor intra-abdominal hemorrhages can be challenging due to the limited sensitivity of FAST. Further investigation is required to evaluate the usefulness of FAST in burn patients in Japan.

The subgroup analysis indicated that higher TBSA of burns was noted in the flame than in the explosion group, whereas trauma severity was similar. Additionally, there were no differences in where patients were discharged to or in mortality. This suggests that similar trauma severity may affect mortality more than burn severity. However, this analysis includes only a small number of patients, and future larger studies are needed to investigate trauma's effect on mortality in combined trauma and burn patients.

Our study had several strengths. The AIS is a universally recognized and extensively utilized scoring system for evaluating the severity of trauma [7, 10, 28]. Additionally, this was a nationwide registry study conducted in Japan, and we analyzed the data of many patients with BO and BT.

Our study also had several limitations. First, patients were registered at individual facilities, resulting in incomplete registration of all burn patients in the JTDB [29]. Second, important variables were missing from the dataset. Missing some information regarding the injury's cause and mechanism could have affected the results. In particular, we only included mechanisms of burns and lacked those of trauma, which could lead to underestimating the number of patients with combined burns and trauma. Furthermore, if the injury was too severe in BT patients, it may have only been registered as trauma in the JTDB and not categorized as a burn. Third, the lesion, degree of burn, and actual TBSA were unknown because TBSA in the JTDB was recorded based on the AIS. The outcomes could have varied even among patients with the same AIS score, particularly for an AIS score of 5, which included a wide range of TBSA (40–89%) [7]. Fourth, this study investigated data from 2004 to 2017, and therefore, only included data before the COVID-19 pandemic. Characteristics may have changed in current clinical settings. Finally, only a few studies have reported using the JTDB datasets for patients with burns [6–8]. Thus, the validity of this study remains unclear. In the future, if we can link these JTDB data to the burn database, it would improve our understanding of this topic.

5. Conclusions

We described the differences in the characteristics between BO and BT patients in Japan. Flames were the main cause of burns, and in-hospital mortality was lower in the BT group associated with a smaller burn area. Coexisting trauma was not significantly associated with mortality in any patient with BT in this study. The effect of coexisting trauma in burn patients remains unclear and requires more information and a need to validate our results using other cohorts or datasets.

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CRediT authorship contribution statement

Yasuaki Kumakawa and Yutaka Kondo conceptualized and YKo analyzed the JTDB data. YKu drafted main manuscript and YKo revised the drafting of manuscript. All the authors discussed interpretation of results. All the authors also have read, critically reviewed, and approved final version of the manuscript.

Declaration of Competing Interest

The authors declare no conflicts of interest related to this study.

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YKu and YKo conceptualized the study. YKo analyzed the JTDB data. YKu drafted the main manuscript. YKo revised the draft manuscript. All the authors discussed the interpretation of results. All the authors have read, critically reviewed, and approved the final version of the manuscript.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.burns.2024.04.009.

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