Original Article

Mortality of hospital walk-in trauma patients: a multicenter retrospective cohort study

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Aim: To investigate the characteristics of patients who visited the emergency department by themselves after experiencing trauma and subsequently died, and to identify the prognostic factors of mortality in such patients.

Methods: Adult patients with trauma visiting the emergency department by themselves between 2004 and 2019 in Japan were identified using a nationwide trauma registry (the Japan Trauma Data Bank). The characteristics of patients who died were compared with those who survived, and multivariable logistic regression analysis was used to determine the independent association of each preselected variable with in-hospital mortality (end-point).

Results: Of the 9753 patients eligible for analysis, 4369 (44.8%) were men, and the median age was 75 years. Of these patients, 130 (1.3%) died in the hospital. The following factors had a significant association with in-hospital mortality: age, male sex, Charlson Comorbidity Index (CCI) 3–4 and ≥5 with CCI = 0 as a reference, circumstances of injury (free fall and fall at ground level), Glasgow Coma Scale score, Shock Index ≥ 0.9, severe injuries of the head, abdomen and lower extremities, and Injury Severity Score ≥ 15.

Conclusions: Several risk factors, including older age, male sex, higher CCI, circumstances of injury (free fall and fall at ground level), lower Glasgow Coma Scale score, higher Shock Index, and severe injuries of the head, abdomen, and lower extremities, were identified as being associated with the death of trauma patients visiting the emergency department by themselves. Early identification of patients with these risk factors and appropriate treatment may reduce mortality posttrauma.

Key words: Emergency department, emergency medical service, mortality, risk factor, trauma

INTRODUCTION

TRAUMA PATIENTS CAN visit the emergency department on foot, using private cars, or by emergency medical service (EMS) transport. In Japan, ambulances are available to everyone free of charge, and the telephone triage system recommends that patients with minor injuries go to the emergency department by themselves and those with serious injuries use EMS.[1] Patients who visit the emergency department on foot or in private cars are classified as self-ambulatory; hence, they are assumed to have a less severe injury and are considered physiologically more stable than those transported by EMS. However, physicians do experience cases where injured patients visiting the emergency department by themselves fail to survive.

Previous studies have shown that posttraumatic mortality is associated with suboptimal medical care.[2] If the primary injury is less severe in patients who visit the emergency department by themselves and patients have the potential to survive, knowledge of these patient characteristics and the prognostic factors are important for better treatment strategies and improved patient outcomes. Although there are several studies on prognostic factors in general trauma patients,[3–5] data on patients visiting the emergency department by themselves are lacking.

This study aimed to investigate the characteristics of self-ambulatory patients who visited the emergency department after experiencing trauma and failed to survive, and to identify the prognostic factors of mortality in such patients.

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METHODS

THIS RETROSPECTIVE STUDY analyzed anonymized data from the Japan Trauma Data Bank (JTDB). The de-identification standard was followed to protect the confidentiality of personal information. The study was approved by the Institutional Review Board of Tokyo Metropolitan Bokutoh Hospital (Approval Number: 02-170), which waived the requirement for informed consent due to the retrospective nature of the study.

Data source

The JTDB was established in 2003 by the Japanese Association for the Surgery of Trauma (Trauma Registry Committee) and the Japanese Association for Acute Medicine (Committee for Clinical Care Evaluations). Between 2004 and 2019, a total of 288 emergency hospitals participated in the JTDB, accounting for more than 95% of tertiary emergency medical centers in Japan. Participating hospitals were required to register data of trauma patients who were admitted to each hospital. Collected data included patient characteristics, vital signs on hospital arrival, details about examination and treatment, diagnosis, and status at hospital discharge. The data collected from the JTDB registry are compiled annually and disseminated in the form of research datasets.

Study cohort

The present study included patients aged 18 years or more who experienced trauma and visited the emergency department on foot or using a private car. Only patients with a known trauma type and cause of trauma were included. The exclusion criteria were as follows: (i) cardiac arrest on hospital arrival (systolic blood pressure = 0), (ii) patients with burn injuries, (iii) unknown survival outcomes.

Definitions

The outcome of interest was in-hospital mortality. The Charlson Comorbidity Index (CCI) was calculated; CCI = 0 was considered as low; 1–2, medium; 3–4, high; and ≥5, very high.[6] The vital signs at the time of visiting the emergency department were categorized. The Glasgow Coma Scale (GCS) score was categorized as mild (14–15), moderate (9–13), and severe (<9).[7] Tachypnea and bradypnea were defined as a respiratory rate (RR) of ≥30/min and ≤9/min, respectively. Shock was defined as a Shock Index (SI) of ≥0.9.[8] Hypothermia and hyperthermia were defined as a body temperature of <36°C and >38°C, respectively. A severe injury was defined as a maximum Abbreviated Injury Scale (AIS) score of ≥3.[9] Injury Severity Score (ISS) indicates the severity of multiple trauma in patients and is calculated from AIS.[10,11]

Statistical analysis

The differences in baseline characteristics between the patients who survived and those who died were compared using the χ^2-test or Fisher's exact test for categorical data and the Mann–Whitney *U*-test for continuous data. Multivariable logistic regression analysis was used to determine the independent association of each variable with in-hospital mortality. A set of explanatory variables was preselected based on biological plausibility and previous reports.[3–5] These selected variables included age, sex, CCI, circumstances of injury, GCS score and SI on hospital arrival, presence of severe injuries of the head, face, neck, thorax, abdomen/pelvic contents, spine, upper extremities, lower extremities, or external, and ISS. Missing data were accounted for using multiple imputation methods. After applying the inclusion and exclusion criteria, 20 imputations were generated. For each imputation model, the variables listed in Table 1 were included. The coefficients of each variable for in-hospital mortality were estimated for each imputed dataset and were integrated based on Rubin's rules.[12] All statistical tests were two-tailed, and a *P*-value of <0.05 was considered statistically significant. All statistical analyses were undertaken using EZR, a graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

A TOTAL OF 372,314 patients were registered in the JTDB during the study period, and 10,464 met the study inclusion criteria. After 711 patients were excluded, 9753 were eligible for the analysis (Fig. 1). Of these, 130 (1.3%) patients died in the hospital. Table 1 describes the patient characteristics. The median age was 75 (interquartile range, 59–85) years, and 4369 patients (44.8%) were men.

Age, male sex, CCI, SI, prevalence of severe injuries of the head and abdomen, and ISS were significantly higher, and GCS score was significantly lower in the group of patients who died as compared to those who survived. In addition, there were significant differences in the following variables: cause of trauma, circumstance of injury, and RR. The percentages of missing values varied between 0% and 33% (age, 0%; sex, 0%; CCI, 0%; cause of trauma, 0%; circumstances of injury, 1%; GCS score, 13%; RR, 33%; SI,

Table 1. Characteristics of hospital walk-in trauma patients

Variable	Survived	Died	*P*-value
Number of patients	9623	130	
Age (years), median (IQR)	75 (59–85)	83 (73–88)	<0.001
Age ≥55 years	7634 (79.3)	124 (95.4)	<0.001
Male sex	4296 (44.6)	73 (56.2)	0.011
Charlson Comorbidity Index			<0.001
0	4756 (49.4)	39 (30.0)	
1, 2	3641 (37.8)	52 (40.0)	
3, 4	962 (10.0)	26 (20.0)	
≥5	264 (2.7)	13 (10.0)	
Cause of trauma			0.028
Suicide attempt	68 (0.7)	3 (2.3)	
Accident	8972 (93.2)	124 (95.4)	
Assault	119 (1.2)	2 (1.5)	
Occupational injury	464 (4.8)	1 (0.8)	
Circumstances of injury			<0.001
Traffic accident	680 (7.1)	4 (3.1)	
Free fall	394 (4.1)	9 (7.0)	
Fall at ground level	6052 (63.3)	104 (80.6)	
Fall on stairs	1362 (14.3)	6 (4.7)	
Other	1066 (11.2)	6 (4.7)	
Trauma type			0.490
Blunt	9444 (98.1)	126 (96.9)	
Penetrating injury	179 (1.9)	4 (3.1)	
Vital signs on arrival at the hospital			
Glasgow Coma Scale			<0.001
3–8	29 (0.3)	7 (6.5)	
9–13	334 (4.0)	22 (20.4)	
14–15	8006 (95.7)	79 (73.1)	
Respiratory rate (breaths/min)			0.031
≤9	8 (0.1)	1 (1.1)	
10–29	6252 (97.1)	87 (94.6)	
≥30	178 (2.8)	4 (4.3)	
Shock Index, median (IQR)	0.57 (0.48–0.68)	0.63 (0.52–0.79)	<0.001
Shock Index ≥0.9	466 (5.3)	17 (14.3)	<0.001
Temperature (°C)			0.711
<36	709 (8.9)	12 (11.2)	
36–38	7090 (88.7)	94 (87.9)	
>38	198 (2.5)	1 (0.9)	
Maximum AIS score ≥3			
Head	1567 (16.3)	46 (35.4)	<0.001
Face	27 (0.3)	0 (0.0)	0.999
Neck	5 (0.1)	0 (0.0)	0.999
Thorax	1144 (11.9)	13 (10.0)	0.600
Abdomen/ pelvic contents	189 (2.0)	7 (5.4)	0.014
Spine	429 (4.5)	4 (3.1)	0.589
Upper extremities	674 (7.0)	3 (2.3)	0.055
Lower extremities	3970 (41.3)	60 (46.2)	0.300
External	0 (0.0)	0 (0.0)	N/A
ISS ≥15	1724 (18.2)	54 (42.2)	<0.001

Data are shown as *n* (%) unless otherwise indicated. AIS, Abbreviated Injury Scale; IQR, interquartile range; ISS, Injury Severity Score; N/A, not applicable.

9%; body temperature, 17%; maximum AIS score, 0%; ISS, 2%).

Tables 2 and 3 show the results of the multivariable analysis using the multiple imputation method. Logistic regression analysis identified the following factors as having a significant association with in-hospital mortality: age, male sex, CCI 3–4 and ≥5 with CCI = 0 as a reference, circumstances of injury (free fall and fall at ground level), GCS score, SI ≥ 0.9, severe injuries of the head, abdomen, and lower extremities, and ISS ≥ 15.

Table 4 shows the summary of comorbidities in patients who died while in the hospital; most of these were due to lifestyle-related diseases, such as hypertension and diabetes, followed by dementia, heart failure, and malignant tumors.

Table 5 shows the diagnoses of injuries with an AIS of ≥3. There were 158 injuries with AIS ≥3 in the 130 patients who died while in the hospital, of which 72 were head injuries, the largest number.

DISCUSSION

THE ANALYSIS REVEALED several risk factors for mortality among self-ambulatory trauma patients

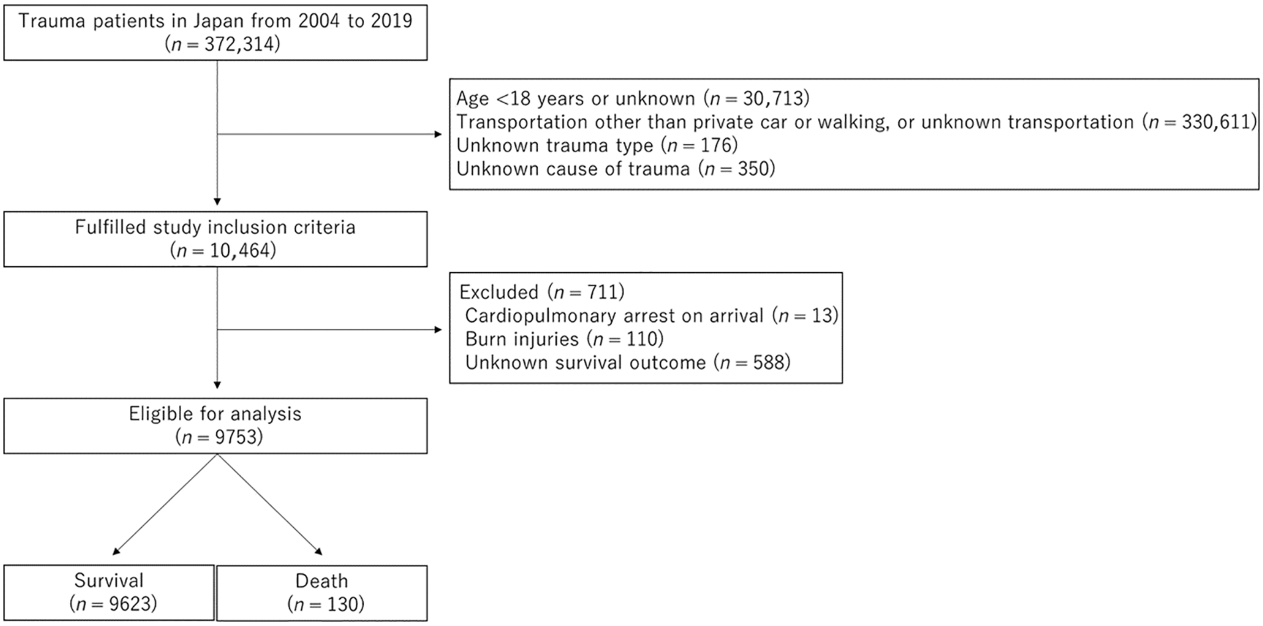

Fig. 1. Diagrammatic representation of the study enrollment process of trauma patients visiting the emergency department alone.

Table 2. Results of multivariable logistic regression analysis with mortality as an outcome amonghospital walk-in trauma patients: variables with odds ratios (model 1)

Variable	Odds ratio (95% CI)	*P*-value
Age	4.49 (1.83–11.02)	0.001
Male sex	1.81 (1.24–2.65)	0.002
Charlson Comorbidity Index		
0	Reference	
1, 2	1.25 (0.81–1.95)	0.314
3, 4	1.97 (1.16–3.36)	0.012
≥5	3.57 (1.81–7.03)	<0.001
Circumstances of injury		
Traffic accident	1.87 (0.52–6.73)	0.339
Free fall	5.45 (1.88–15.81)	0.002
Fall at ground level	3.76 (1.62–8.71)	0.002
Fall on stairs	Reference	
Others	1.94 (0.60–6.28)	0.269
Glasgow Coma Scale		
3–8	18.74 (7.67–45.76)	<0.001
9–13	4.43 (2.70–7.27)	<0.001
14–15	Reference	
Shock Index ≥0.9	2.29 (1.32–4.00)	0.003
ISS ≥15	2.41 (1.64–3.54)	<0.001

CI, confidence interval; ISS, Injury Severity Score.

visiting the emergency unit, including older age, male sex, higher CCI, circumstances of injury (free fall and fall at ground level), lower GCS score, higher SI, and the presence of severe head, abdomen, and lower extremity injuries. Few studies have focused on the risk factors for mortality among patients with trauma who visit the emergency department on their own; to our knowledge, this is the largest relevant analysis to date.

Trauma from free fall usually presents multiple injuries, the most common of which are fractures of the extremities.[13] The suicide attempt group had more fractures of the ribs, pelvis, and lower extremities and a higher mortality rate than the accidental fall group.[14] Variables such as height of fall, impact surface, and site of prior contact could be related to mortality.[15] Falls at ground level are the most common mechanism of injury, and the morbidity and mortality from them are known to increase with advancing age.[16] Head trauma is a known risk factor for mortality in falls at ground level.[17] Early mortality is associated with the severity of the trauma itself, while late mortality is correlated with chronic health conditions, such as patient comorbidities.[18]

As previously reported, head injuries are the most common type of trauma in deceased patients.[19] Head trauma as a predictive factor of death after trauma in patients who visited the emergency department might be explained by the concept of "talk and deteriorate." This is a subset of patients with head trauma whose condition deteriorates despite being

Table 3. Results of multivariable logistic regression analysis with mortality as an outcome among hospital walk-in trauma patients: variables with the odds ratios (model 2)

Variables	Odds ratio (95% CI)	*P*-value
Age	4.47 (1.79–11.19)	0.001
Male sex	2.03 (1.38–3.00)	<0.001
Charlson Comorbidity Index		
0	Reference	
1, 2	1.17 (0.75–1.81)	0.497
3, 4	1.75 (1.03–2.99)	0.039
≥5	3.19 (1.62–6.28)	<0.001
Circumstances of injury		
Traffic accident	1.79 (0.49–6.53)	0.377
Free fall	5.14 (1.73–15.21)	0.003
Fall at ground level	3.37 (1.43–7.93)	0.006
Fall on stairs	Reference	
Others	1.89 (0.58–6.21)	0.292
Glasgow Coma Scale		
3–8	20.21 (8.20–49.81)	<0.001
9–13	4.31 (2.62–7.08)	<0.001
14–15	Reference	
Shock Index ≥0.9	2.10 (1.19–3.71)	0.011
Maximum AIS score ≥3		
Head	3.94 (2.03–7.67)	<0.001
Face	0.00	0.981
Neck	0.00	0.993
Thorax	1.99 (0.94–4.21)	0.073
Abdomen/pelvic contents	9.12 (3.56–23.39)	<0.001
Spine	1.48 (0.48–4.53)	0.494
Upper extremities	1.22 (0.35–4.30)	0.754
Lower extremities	2.78 (1.43–5.42)	0.003
External	Reference	

AIS, Abbreviated Injury Scale; CI, confidence interval.

able to talk immediately after an injury.[20] In this group, the primary injury is not severe enough to disrupt high cognitive function but eventually results in death due to secondary brain injury and other potentially preventable factors. Previous studies have reported that "talk and deteriorate" was strongly associated with a subdural hematoma and cerebral contusion, and the current results are consistent with those of previous studies.[21]

Severe injuries of the abdomen included small intestinal and mesenteric injuries that do not cause specific symptoms and are often overlooked in imaging assessments of sonography or computed tomography.[22–24] In some cases, patients with minor intestinal or mesenteric injuries have subtle symptoms at the time of their visit to the emergency department and progressively deteriorate. Given the characteristics of these injuries, the results of this study showing abdominal pelvic organ injuries as independent risk factors of death are clinically plausible, although definitive conclusions cannot be drawn as to the actual mechanism leading to death.

Table 4. Comorbidities among hospital walk-in trauma patients

Comorbidity	Number
Hypertension	41
Diabetes mellitus	22
Dementia	18
Heart failure	17
Malignant tumor	15
Ischemic heart disease	15
Stroke	14
Chronic renal failure	13
Cirrhosis	7
Blood disease	7
Under antithrombotic treatment	6
Chronic lung disease	5
Under steroid treatment	4
Bronchial asthma	4
Stomach ulcer	4
Psychiatric disorders	3
Chronic hepatitis	3
Chronic obstructive pulmonary disease	2
Inflammatory bowel disease	1
Others	25

Hip fractures, such as femoral intertrochanteric and neck fractures, account for most cases of severe trauma to the lower extremities. Previous studies have shown that hip fractures increase the risk of mortality due to complications, such as cardiovascular disease and pneumonia, and the results of this study are consistent with those of previous reports.[25] Moreover, it was shown that delayed time to surgery was associated with increased mortality among patients with hip fractures.[26]

The results of this study highlight the importance of a systematic approach in the assessment of patients with trauma. Physicians in the emergency department should be aware of the risk factors and be cautious even in patients with suspected local minor injuries. Early identification of patients with risk factors and careful monitoring might lower the death rate among self-ambulatory trauma patients walking into the emergency department.

Limitations

This study had several limitations. First, the retrospective study was prone to various biases due to unmeasured

Table 5. Diagnosis of injuries among hospital walk-in trauma patients with Abbreviated Injury Score ≥3

Diagnosis	Number
Head	72
Subdural hematoma	37
Brain contusion	15
Subarachnoid hemorrhage	13
Epidural hematoma	2
Others	5
Thorax	13
Rib fracture	9
Pulmonary contusion	3
Aortic injury	1
Abdomen	7
Mesenteric injury	2
Splenic injury	2
Small intestinal injury	1
Liver injury	1
Renal injury	1
Spine	4
Cervical fracture	2
Lumbar fracture	2
Upper extremity	2
Humerus fracture	1
Radial fracture	1
Lower extremity	60
Femoral intertrochanteric fracture	28
Femoral neck fracture	25
Femoral fracture (others)	4
Pelvic fracture	3

confounding factors; for instance, the JTDB does not include information on the patient's pre-injury activities of daily living, the amount of blood loss, or wound contamination. Second, JTDB only includes data of patients in Japan; therefore, our results need to be externally validated in other clinical settings. Third, most JTDB participating facilities were tertiary emergency medical centers. This could have resulted in a selection bias because the patients' characteristics in this study differed from those in other emergency room settings. Fourth, the data provided by JTDB are limited to inpatients and cannot be used for the analysis of all patients who visit the emergency department by themselves. Finally, the actual cause of death of the patients was not identified. It is not clear whether the deaths were from the trauma itself, complications, or withdrawal of treatment. It was assumed that patients with severe injuries at each site often died due to the following different mechanisms: head injuries because of trauma, abdominal injuries because of missed diagnosis, and lower extremity injuries because of complications. However, this hypothesis could not be tested because the cause of death remained unknown.

CONCLUSIONS

THIS STUDY IDENTIFIED several risk factors associated with death in trauma patients who visited the emergency department by themselves. Early identification of patients with these risk factors and appropriate interventions are important to reduce the risk of mortality posttrauma.

DISCLOSURE

Approval of the research protocol with approval no. and committee name: The study was approved by the Institutional Review Board of Tokyo Metropolitan Bokutoh Hospital (approval number: 02–170), which waived the requirement for informed consent due to the retrospective nature of the study.
Informed consent: N/A.
Registry and the Registration No. of the study/Trial: N/A.
Animal studies: N/A.
Conflict of interest: None.

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DATA AVAILABILITY

AUTHORS ARE NOT permitted to distribute the datasets generated and/or analyzed during the current study; however, these are available from the Japanese Association for the Surgery of Trauma (Trauma Registry Committee) and the Japanese Association for Acute Medicine (Committee for Clinical Care Evaluations) on reasonable request.

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