

Risk factors for mortality of severe trauma based on 3 years' data at a single Korean institution

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Purpose: This study aimed to determine the mortality rate in patients with severe trauma and the risk factors for trauma mortality based on 3 years' data in a regional trauma center in Korea.

Methods: We reviewed the medical records of severe trauma patients admitted to Ajou University Hospital with an Injury Severity Score (ISS) > 15 between January 2010 and December 2012. Pearson chi-square tests and Student t-tests were conducted to examine the differences between the survived and deceased groups. To identify factors associated with mortality after severe trauma, multivariate logistic regression was performed.

Results: There were 915 (743 survived and 172 deceased) enrolled patients with overall mortality of 18.8%. Age, blunt trauma, systolic blood pressure (SBP) at admission, Glasgow Coma Scale (GCS) at admission, head or neck Abbreviated Injury Scale (AIS) score, and ISS were significantly different between the groups. Age by point increase (odds ratio [OR], 1.016; P = 0.001), SBP ≤ 90 mmHg (OR, 2.570; P < 0.001), GCS score ≤ 8 (OR, 6.229; P < 0.001), head or neck AIS score ≥ 4 (OR, 1.912; P = 0.003), and ISS by point increase (OR, 1.042; P < 0.001) were significant risk factors.

Conclusion: In severe trauma patients, age, initial SBP, GCS score, head or neck AIS score, and ISS were associated with mortality.

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Key Words: Wounds and injuries, Injury Severity Score, Glasgow Coma Scale, Abbreviated Injury Scale, Risk factors

INTRODUCTION

Recent improvements in trauma and critical care systems have decreased the global mortality rate of patients with multiple traumas [1,2]. However, the national trauma system in Korea was only recently implemented in 2012, and the nationwide trauma registry is still in its infancy [3,4]. In the national trauma system in Korea, the highest level of trauma center appointed by the government is the regional trauma center, of which there are currently 11 hospitals, with 17 hospitals in total expected to receive this designation by 2017 [5].

For policy development, long-term data are needed, but there

have been few short-term reports regarding preventable trauma mortality in Korea since 1997 [3,4]. Thus, there are growing demands for domestic trauma data that include not only the rates of mortality but also the factors that contribute to post-traumatic mortality. Previous studies [6-16] have indicated that age, prehospital care, whole body computed tomography, blood transfusion, and scales such as the Abbreviated Injury Scale (AIS) and Injury Severity Score (ISS) are significant factors for trauma-related mortality.

This study aimed to determine the mortality rate in patients with severe multiple traumas and the risk factors for trauma mortality based on 3 years' data in a regional trauma center in Korea.

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METHODS

Study population and institution

Data sets of trauma patients who visited Ajou University Hospital in Korea, with ISS > 15, between January 2010 and December 2012 were collected from the institutional trauma registry and analyzed. Patients were placed in the survived or deceased groups. Ajou University Hospital is a leading tertiary hospital in Korea with 16,000 trauma patients visiting its emergency room every year.

Definitions and measures

The AIS is an anatomical based, consensus derived, global severity scoring system that classifies each injury by body region (head, neck, face, thorax, abdomen, spine, upper extremity, lower extremity, and external and other regions) according to its relative importance on a 6-point ordinal scale [17]. The ISS is an aggregate score for patients with multiple injuries and is calculated as the sum of the squares of the three highest AIS scores for three most severely injured areas of the body [18]. The ISS allows for direct comparison between multiple trauma patients with injuries of varying severities in different body regions (head or neck, face, chest, abdominal or pelvic contents, extremities or pelvic girdle, and external) and has been shown to be a good predictor of survival [18]. Severe trauma is generally defined as an ISS > 15 [19].

In this study, AIS scores were coded by two nurse practitioners who were responsible for AIS coding. Three general surgeons, a neurosurgeon, and an orthopedic surgeon collaborating in the trauma service team confirmed the AIS scores

for each body region.

Statistical analysis

To identify independent risk factors for mortality after severe trauma, we selected potential predictors based on previous studies and the clinical experience of our research group. These variables were age, sex, severity of injury, and early physiology. Severity of injury was evaluated with the Glasgow Coma Scale (GCS), ISS, and AIS score of each body region. Early physiology was evaluated using initial systolic blood pressure (SBP) measured in the emergency department at the time of arrival.

Comparisons of continuous variables between the survived and deceased groups were conducted using t-tests. Chi-square tests were used to analyze categorical variables such as the mechanism of trauma and sex.

A multivariate logistic regression analysis was performed using a stepwise model, with mortality as the dependent variable. For this analysis, several continuous variables that have an accepted normal range or gradual orders in a limited range, such as SBP, GCS score, and AIS score, were converted to categorical variables. Initial SBP was categorized into two groups with 90 mmHg as the cutoff value, which is a datum value for diagnosis of shock, and GCS score was categorized with 8 points as the cutoff value, which is the value for initial intubation in Advanced Trauma Life Support guidelines and that would be more likely to indicate a loss of consciousness [20]. Variables with continuous values from one to the highest value, such as age and ISS, were included as continuous variables in the logistic regression.

For all statistical analyses, a probability of <0.05 was

Table 1. Basic demographic and clinical characteristics at admission of patients with severe trauma and compared between those that survived and were deceased

Characteristic	All patients (n = 915)	Survived (n = 743, 81.2%)	Deceased (n = 172, 18.8%)	P-value
Age (yr)	45.4 ± 20.1	44.4 ± 19.9	49.6 ± 20.7	0.003
Male sex	709 (77.5)	582 (78.3)	127 (73.8)	0.204
Blunt trauma	898 (98.1)	726 (97.7)	172 (100)	0.045
SBP at ED admission (mmHg)	118.7 ± 34.7	120.3 ± 31.0	111.8 ± 47.1	0.025
Respiratory rate at ED admission (breaths/min)	19.8 ± 7.1	19.6 ± 6.8	20.6 ± 8.3	0.113
GCS score at ED admission	11.8 ± 4.3	12.8 ± 3.6	7.5 ± 4.4	<0.001
Head or Neck AIS score	2.6 ± 2.0	2.4 ± 2.1	3.5 ± 2.0	<0.001
Face AIS score	0.4 ± 0.9	0.4 ± 0.9	0.4 ± 0.9	0.572
Chest AIS score	1.6 ± 1.6	1.7 ± 1.6	1.5 ± 1.7	0.300
Abdominal or pelvic contents AIS score	1.3 ± 1.7	1.3 ± 1.7	1.2 ± 1.7	0.507
Extremities or pelvic girdle AIS score	1.3 ± 1.6	1.4 ± 1.52	1.1 ± 1.6	0.057
External AIS score	0.0 ± 0.2	0.0 ± 0.2	0.0 ± 0.1	0.173
ISS	25.1 ± 8.4	24.0 ± 7.8	29.6 ± 9.4	<0.001

Values are presented as mean ± standard deviation or number (%).

Comparisons were conducted between the survived and deceased groups using t-tests or chi-square tests.

SBP, systolic blood pressure; ED, Emergency Department; GCS, Glasgow Coma Score; AIS, Abbreviated Injury Score; ISS, Injury Severity Score.

Table 2. Risk factors for mortality from severe trauma, derived from a multivariate logistic regression analysis using a stepwise model with forward variable selection

Variable	Regression coefficient β	Adjusted OR, e^{β} (95% CI)	P-value
Age (yr)	0.016	1.016 (1.007–1.026)	0.001
SBP \leq 90 mmHg	0.944	2.570 (1.584–4.172)	<0.001
GCS score \leq 8	1.829	6.229 (4.181–9.282)	<0.001
Head or neck AIS score \geq 4	0.648	1.912 (1.248–2.928)	0.003
ISS (point)	0.041	1.042 (1.019–1.065)	<0.001
Constant	-4.584	-	-

OR, odds ratio; CI, confidence interval; SBP, systolic blood pressure; GCS, Glasgow Coma Scale; AIS, Abbreviated Injury Scale; ISS, Injury Severity Score.

considered to be statistically significant. All data were analyzed using IBM SPSS Statistics ver. 21.0 (IBM Co., Armonk, NY, USA).

Ethics statement

This study was approved by the Institutional Review Board (IRB) of Ajou University Hospital (IRB No. MED-OBS-14-446). The requirement for informed consent was waived by the IRB because of the observational nature of this study.

RESULTS

Of the 915 patients (709 men, 77.5%) that were identified, 743 patients (81.2%) survived (survived group), and 172 patients (18.8%) passed away (deceased group). The mean age of the entire sample was 45.4 (\pm 20.11) years. The deceased group was significantly older (49.6 \pm 20.7 years) than the survived group (44.4 \pm 19.9 years) (P = 0.003). Blunt trauma was the cause of injury in 898 patients (98.1%) and was the cause of injury in 726 patients (97.7%) in the survived group and 172 patients (100%) in the deceased group (P = 0.045) (Table 1). Initial SBP was significantly higher in the survived group (120.3 \pm 31.0 mmHg) than in the Deceased group (111.8 \pm 47.1 mmHg, P = 0.025). The mean GCS scores, head or neck AIS scores, and ISS were also significantly different between the survived and deceased groups (12.8 \pm 3.6 vs. 7.5 \pm 4.4, 2.4 \pm 2.1 vs. 3.5 \pm 2.0, and 24.0 \pm 7.8 vs. 29.6 \pm 9.4, respectively; all P < 0.001).

Therefore, the significant factors included in the multivariate analysis were age, blunt trauma, initial SBP, GCS score, head or neck AIS score, and ISS. All of the variables resulted in significant odds ratios (ORs) (Table 2). The greatest OR (6.229; 95% confidence interval [CI], 1.007–1.026) was observed with GCS scores \leq 8.

DISCUSSION

In the present study, the overall mortality of patients with multiple traumas was 18.8%, which is similar to the findings of previous studies in which the mortality of patients with

multiple traumas was 18.7%–22.8% [1,11,13,21]. Comparatively, in patients with trauma in one body region, global mortality is reportedly 0.5%–6% [22]; these results collectively indicate higher mortality in patients with multiple traumas.

Multiple traumas indicate greater injury intensity, which is often the result of a high-energy blunt trauma [18]. Therefore, patients with multiple traumas are more likely to receive more severe injury and require greater medical resources and higher levels of medical care from the initial scene. The establishment of trauma systems and data collection is required to help allocate the necessary resources for patients with multiple traumas.

With validated predictors of mortality, patients with severe trauma can be triaged at the initial scene and transported to a higher-level trauma center. Several studies have demonstrated that age contributes to increased mortality risk among trauma patients [6-8], and several studies have developed appropriate scoring systems for triage including the Mechanism, Glasgow Coma Scale, Age, and Arterial Pressure (MGAP) score [8], Emergency Trauma Scores [11], and Trauma and Injury Severity Score [14]. These physiologic factors and scoring systems underpinned the design of the present study.

MGAP is a triage score to predict mortality that was reported in 2010 [8] and based on physical variables obtained during the initial prehospital phase. The OR for penetrating trauma was 4.11 (95% CI, 2.24–7.73), and the mechanism for trauma was blunt trauma in 87% and penetrating trauma in 13% of the deceased patients, while 92% of the living patients received a blunt trauma. In the present study, blunt trauma occurred more often, in 98% of the total sample of patients, with a significant difference between the deceased and survived groups (100% and 97.7%, respectively). In the study of MGAP, the OR for GCS, for a 1-point increase, was 0.71 (95% CI, 0.68–0.75) [8]. However, we dichotomized GCS based on a threshold of 8 points because of a lack of a visible difference by individual points. As a result, GCS scores \leq 8 resulted in an OR of 6.229. Age, for each 1-year increase, had the next highest odds (OR, 1.03) for mortality in the MGAP study [8]. Similarly, age resulted in an OR of 1.016 (P = 0.001) in the present study. Finally, the OR for arterial

pressure, by 1-mmHg increase, was 0.98 [8]. In our study, we converted SBP to categories based on 90 mmHg as the cutoff in order to distinguish patients with shock; this threshold value is included in the recent recommendations [8].

In addition to MGAP, other risk factors for posttraumatic mortality have been investigated in recent studies, including computed tomography [12], blood transfusion [10], and ISS [13]. Diagnostic whole-body CT was associated with a significant reduction in 30-day mortality among patients with severe blunt trauma [12], while ≥ 2 units of transfused blood was related to increased mortality [10]. However, AIS or ISS scores alone were not sufficient to predict traumatic mortality in several studies [13].

Of the regional AIS scores, our study showed that the head or neck AIS score was the only score to be significantly associated with mortality, with an AIS score > 4 resulting in an OR of 1.912. Of the few studies that have evaluated the predictive ability of head AIS scores for mortality, that of Baitello et al. [23] showed that a significantly higher number of patients who lost consciousness (33.9%–35.0%) died compared to those who did not lose consciousness (3.5%–9.0%, $P < 0.0001$) [23]. It is possible that more intensive head injuries are reflected in the head AIS score.

Although the ISS alone was not sufficient to predict mortality in a previous study [13], the ISS by point increase was a significant factor in the present study, which included severely injured trauma patients with ISS > 15 ; furthermore, the deceased group had a significantly higher ISS (29.6 points) than the survived group (24.0 points).

The present study had certain limitations. First, it focused on the severity of trauma during the initial evaluation stage only.

Other important factors such as medical and family history were not included in the analysis of mortality. Because the basic data at the time of initial evaluation of trauma patients were not sufficient, we aimed to determine the initial characteristics of the trauma patients who required more medical attention. Second, pediatric trauma patients were almost not included in our study. There was one infant included in the analysis, and the authors decided not to exclude the infant's data because it was unlikely that the result of 915 patients could be affected due to one. However, the result was based on adults mostly, so the risk factors of mortality may not have same significance when applied to neonates or pediatric patients. Further study for pediatric trauma patients would be necessary.

With the initial introduction of a national trauma care system in Korea, the mortality of patients with severe trauma managed in a leading trauma center was similar to that of level-1 centers in other countries with established trauma care systems. However, continuous efforts to reduce preventable mortality should be reflected in improvements in the trauma care system. In our rudimentary study, age, initial SBP, GCS score, head or neck AIS score, and ISS were associated with mortality in severe trauma patients. Despite these risk factors are already well-known, these had not been verified in domestic trauma patients before. With implementation of national trauma registry, multicenter based further study in domestic setting would be planned in the future.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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