ORIGINAL ARTICLE

Association between pre-hospital National Early Warning Score and in-hospital mortality in patients with traumatic brain injury

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ABSTRACT

BACKGROUND: This study aimed to examine the association between the outcome of traumatic brain injury (TBI) and pre-hospital National Early Warning Score (NEWS), Injury Severity Score (ISS), and Revised Trauma Score (RTS).

METHODS: This retrospective and observational study included adult patients with TBI admitted to the pre-hospital emergency medical services system between January 2019 and December 2020. TBI was considered when the abbreviated injury scale score was 3 or higher. The primary outcome was in-hospital mortality.

RESULTS: Among 248 patients included in the study, in-hospital mortality was 18.5% (n=46). In the multivariate analysis for predicting in-hospital mortality, pre-hospital NEWS (Odds ratio [OR], 1.198; 95% Confidence interval [CI], 1.042–1.378) and RTS (OR, 0.568; 95% CI, 0.422–0.766) were independently associated with in-hospital mortality. The area under the curves (AUCs) for ISS, RTS, and pre-hospital NEWS were 0.731 (95% CI, 0.672–0.786), 0.853 (95% CI, 0.802–0.894), and 0.843 (95% CI, 0.791–0.886), respectively. The AUC of pre-hospital NEWS was significantly different from that of ISS but not from that of RTS.

CONCLUSION: Pre-hospital NEWS could contribute to improving prognosis by aiding in the rapid classification of patients with TBI in the field and their transportation to appropriate hospitals.

Keywords: Mortality; prognosis; scoring; trauma.

INTRODUCTION

Traumatic brain injury (TBI) is a public health problem responsible for morbidity and mortality worldwide. As TBI has a high incidence rate and often has many sequelae, it is associated with heavy expenditure on health care each year.[1,2] Mortality from TBI depends on the severity of an injury, time to treatment, and transport to an appropriate care center.[3] Thus, an appropriate trauma scoring system that can be applied in the field is required to reduce TBI-associated mortality.

Several effective trauma scoring systems have been developed that allow rapid assessment of the severity of injury and predict prognosis. The injury severity score (ISS) and revised trauma score (RTS) are commonly used tools in trauma, including TBI.[4,5] These tools were helpful in determining the extent of damage and predicting prognosis in several studies involving TBI.[6,7] However, it is difficult to use the ISS at the pre-hospital level because it is calculated based on the results of imaging or surgical findings of the anatomical site.[5] In addition, because it is difficult to measure the accurate Glasgow coma scale (GCS) score using the AVPU scoring system mainly at the pre-hospital level, the RTS may not be accurate.[8] In contrast, the pre-hospital national early warning score (NEWS) was associated with outcome and severity in critical ill patients.[9] However, the relationship between pre-hospital NEWS and TBI outcome is unknown. Therefore, we examined the association of TBI outcome with pre-hospital NEWS, RTS, and ISS.

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MATERIALS AND METHODS

Study Design and Population

We performed this retrospective and observational study of patients with TBI admitted through the pre-hospital emergency medical services (EMS) system at Chonnam National University Hospital between January 2019 and December 2020. TBI was considered when the abbreviated injury scale (AIS) score was ≥3.[10] The following exclusion criteria were applied: age <18 years; cardiac arrest following trauma before emergency department visit; transfer from other hospitals; specific trauma mechanisms, such as drowning or hanging; and missing data. Our hospital's Institutional review board approved the study. Informed consent was waived because this was a retrospective study.

Data Collection

Data on the following variables were obtained from each patient: Age; sex; mechanism of trauma; systolic blood pressure (SBP, mmHg), respiratory rate, pulse rate, body temperature (BT, °C), and oxygen saturation on admission; initial GCS score; and in-hospital mortality. We collected pre-hospital data, including SBP, respiratory rate, pulse rate, BT, oxygen saturation, and mental status of each patient at the time of arrival of the EMS at the scene from electronic medical records (EMRs).

RTS was calculated based on vital signs and GCS scores at admission.[4] Pre-hospital NEWS was calculated based on pre-hospital data.[9] The AIS score and ISS were evaluated based on data from the EMRs. The primary outcome was in-hospital mortality.

Statistical Analysis

Continuous variables that did not satisfy the normality test are presented as median values with interquartile ranges. Categorical variables are presented as frequencies and percentages. Differences between the two groups were assessed using a Mann–Whitney U-test for continuous variables. Fisher exact test or Chi-square test was used to compare categorical variables, as appropriate. Furthermore, we conducted a multivariate analysis using logistic regression of relevant covariates to predict in-hospital mortality. Variables with $p<0.20$ in the univariate analysis were included in the multivariate regression model. We used a backward stepwise approach and sequentially eliminated variables with $p>0.10$ to build a final adjusted regression model. We presented logistic regression analysis results as odds ratios (ORs) and 95% confidence intervals (CIs). Receiver operating characteristics (ROC) curve analysis was performed to examine the prognostic performance of ISS, RTS, and pre-hospital NEWS for in-hospital mortality. The comparison of dependent ROC curves was performed using the DeLong method.[11] All analyses were performed using the PASW/SPSS™ software, version 18 (IBM Inc., Chicago, IL, USA) and MedCalc version 19.0 (MedCalc Software, bvba, Ostend, Belgium). A two-sided significance level of 0.05 was defined as a statistically significant value.

RESULTS

Patient Selection and Characteristics

In total, 262 patients with severe trauma were identified to meet the inclusion criteria during the study period. After excluding patients based on the exclusion criteria, 248 patients were finally included in this study (Fig. 1). There were 191 men (77.0%), and the median age of the patients was 64.0 (53.0–74.8) years. The in-hospital mortality rate was 18.5% (n=46).

Comparison of Baseline and Clinical Characteristics between Survivors and Non-Survivors

Table 1 shows the baseline and clinical characteristics of survivors and non-survivors. According to pre-hospital data, non-survivors had a greater proportion of GCS scores ≤12 and lower SBP and oxygen saturation than survivors. According to hospital data, non-survivors had a greater proportion of GCS scores ≤12; lower SBP, BT, and oxygen saturation; and higher respiratory rates than survivors. Non-survivors had higher pre-hospital NEWS and ISS and lower RTS than survivors.

Multivariate Analysis using Logistic Regression for Predicting in-hospital Mortality

Table 2 shows the results of the multivariate analysis for predicting in-hospital mortality. After adjusting for confounders, pre-hospital NEWS (OR, 1.198; 95% CI, 1.042–1.378) and RTS (OR, 0.568; 95% CI, 0.422–0.766) were independently associated with in-hospital mortality.

Prognostic Performance of ISS, RTS, and Pre-hospital NEWS for in-hospital Mortality

The area under curves (AUCs) of ISS, RTS, and NEWS for predicting in-hospital mortality were 0.731 (95% CI, 0.672–0.786), 0.853 (95% CI, 0.802–0.894), and 0.843 (95% CI, 0.791–0.886), respectively. The AUC of pre-hospital NEWS

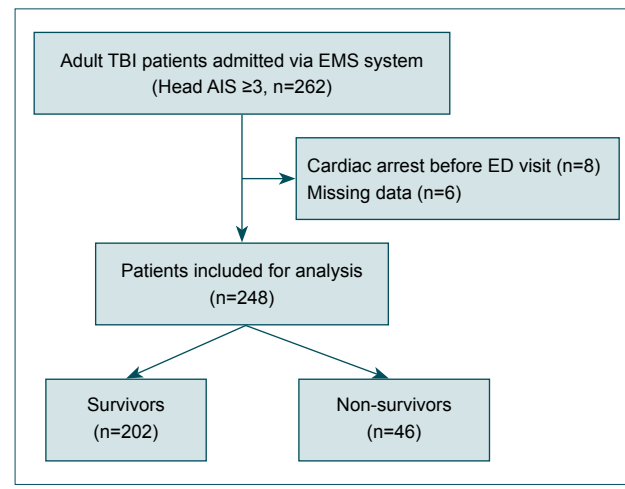

Figure 1. Schematic diagram showing the number of patients with TBI included in the present study.

Table 1. Comparison of baseline characteristics of patients with TBI according to in-hospital mortality

Variables	Patients with TBI (n=248)	Survivors (n=202)	Non-survivors (n=46)	p-value
Age, years	64.0 (53.0–74.8)	64.0 (53.0–75.0)	61.0 (51.8–69.3)	0.227
Male, n (%)	191 (77.0)	153 (75.7)	38 (82.6)	0.421
Mechanism of trauma				1.000
Blunt	244 (98.4)	199 (98.5)	45 (97.8)	
Penetrating	4 (1.6)	3 (1.5)	1 (2.2)	
Prehospital score				
GCS score ≤12, n (%)	114 (46.0)	75 (37.1)	39 (84.8)	<0.001
Systolic BP, mmHg	129 (103–150)	130 (110–150)	110 (98–140)	0.016
Respiratory rate, /min	18 (16–20)	18 (16–20)	18 (16–22)	0.324
Pulse rate, /min	82 (73–95)	81 (74–94)	86 (68–101)	0.380
Body temperature, °C	36.5 (36.3–36.9)	36.5 (36.4–36.9)	36.5 (36.1–36.8)	0.471
Oxygen saturation, %	97 (93–98)	97 (95–98)	92 (83–96)	<0.001
Prehospital NEWS	5 (3–8)	5 (3–6)	10 (7–11)	<0.001
Hospital score				
Revised Trauma Score	7.84 (5.97–7.84)	7.84 (6.38–7.84)	4.09 (4.09–5.97)	<0.001
GCS ≤12, n (%)	112 (45.2)	72 (35.6)	40 (87.0)	<0.001
Systolic BP, mmHg	130 (100–140)	130 (110–140)	100 (80–152)	0.005
Respiratory rate, /min	20 (20–22)	20 (20–20)	22 (20–24)	<0.001
Pulse rate, /min	84 (72–98)	82 (74–94)	90 (70–110)	0.208
Body temperature, °C	36.3 (36.0–36.6)	36.4 (36.1–36.7)	36.1 (36.0–36.4)	0.006
Oxygen saturation, %	97 (95–98)	97 (96–98)	96 (92–98)	0.003
Injury Severity Score	22 (16–25)	19 (14–25)	25 (22–32)	<0.001

TBI: Traumatic brain injury; GCS: Glasgow Coma Scale; BP: Blood pressure; NEWS: National Early Warning Score.

Table 2. Multivariate logistic regression analysis for predicting in-hospital mortality in patients with TBI

	Adjusted OR (95% CI)	p-value
Prehospital NEWS	1.198 (1.042–1.378)	0.011
Hospital score		
Revised Trauma Score	0.568 (0.422–0.766)	<0.001
Body temperature, °C	0.487 (0.220–1.080)	0.077
Oxygen saturation, %	0.953 (0.886–1.026)	0.205
Injury Severity Score	1.048 (0.998–1.101)	0.063

OR: Odds ratio; CI: Confidence interval; NEWS: National Early Warning Score.

was significantly different from that of ISS but not from that of RTS for predicting in-hospital mortality (Fig. 2).

DISCUSSION

In the present study, pre-hospital NEWS was associated with in-hospital mortality in patients with TBI. Furthermore, pre-hospital NEWS showed a similar performance as RTS in predicting in-hospital mortality. In the present study, NEWS evaluated by paramedics at the scene was as effective for predicting in-hospital mortality as RTS evaluated by medical staff in the triage room after hospitalization.

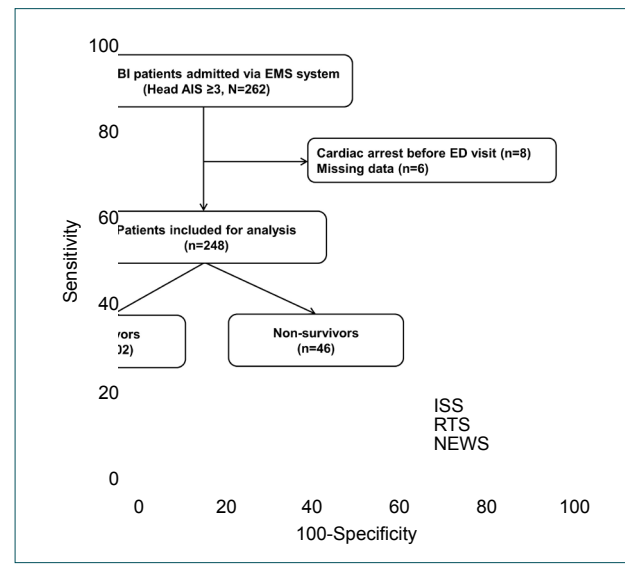

Figure 2. Receiver operating characteristic curve analyses of ISS, RTS, and pre-hospital NEWS, the area under the curves (AUCs) of ISS, RTS, and NEWS for predicting in-hospital mortality were 0.731 (95% CI, 0.672–0.786), 0.853 (95% CI, 0.802–0.894), and 0.843 (95% CI, 0.791–0.886), respectively. The AUC of pre-hospital NEWS was significantly different from that of ISS but not from that of RTS. ISS: Injury severity score, RTS: Revised trauma score, NEWS: National early warning score, AUC: Area under the curve, CI: Confidence interval

Several studies have demonstrated that the GCS score is associated with mortality in patients with TBI.[12,13] In a study by Han et al.,[13] GCS scores ≤5 were associated with mortality owing to TBI, which is consistent with the results of our study as the GCS score of non-survivors was 4 (3–9). However, the determination of the GCS score at the pre-hospital level may be difficult and inaccurate, unlike that at the hospital level.[8] Thus, the simple AVPU scale can be preferred over the GCS to examine the status of consciousness at the pre-hospital level. For pediatric patients, the AVPU scale score had a good correlation with the standard GCS score in the pre-hospital setting.[14] In patients with TBI <15 years old, there was a clear correlation between the pre-hospital AVPU scale and GCS scores.[15] In the present study, according to the pre-hospital AVPU scale, 114 patients (46.0%) responded to pain and/or were unresponsive. This correlated with the 112 patients (45.2%) with GCS scores ≤12 at the hospital level. This correlation would contribute to showing similar performances for the prognosis of TBI by pre-hospital NEWS and RTS at the hospital level.

TBI consists of two temporal pathological stages spanning an initial traumatic shock and multiple secondary cascades, resulting in progressive tissue degeneration and neurological damage. In an experimental study by Yan et al.,[16] rats with traumatic axonal injury showed an obvious decrease in sensorimotor function, significant edema, and enlargement of the cerebral ventricle on radiological examination. In addition, hypoxia induced additional brain damage, resulting in aggravated behavioral impairment. Various clinical observation studies have also shown that hypoxia can induce brain injury.[17] In the present study, oxygen saturation in the group of patients with TBI was 97%, which was higher in survivors than in non-survivors. Although there is no clear mechanism for neurologic deficits caused by post-traumatic hypoxia, increased neuroinflammation and prolonged metabolic dysfunction may have contributed.[16]

At present, it is recommended to maintain an SBP ≥110 mmHg in patients with TBI,[18] which was consistent with the SBP of non-survivors that was below 110 mmHg at both the pre-hospital and hospital levels in the present study. Hypotension was associated with prognosis in patients with overall trauma, including patients with TBI. In the statewide analysis of TBI, pre-hospital hypotension was associated with mortality. Furthermore, when hypotension was accompanied by hypoxia, the adjusted odds of death were more than double compared to that of hypotension alone.[19] In a study of TBI occurring in mountain areas, patients with TBI having hypotension had more severe coagulation disorders, lower hemoglobin levels, and base excess levels.[20] In this study, hypotension at the pre-hospital and hospital levels were associated with mortality.[20]

The present study had several limitations. First, it was a retrospective study performed at a single center; thus, its findings are not immediately generalizable to the overall population. Further multicenter studies with larger samples and prospective designs are necessary to substantiate our findings. Second, the measurement of the respiratory rate could not be accurate at the pre-hospital and hospital levels, which was pointed out by the previous studies.[21,22] Third, since most information of patients were provided by the caregiver and not the patient, it was not reflected in this study because there was insufficient investigation into the history of medications such as beta-blockers and underlying diseases. Finally, we did not analyze the effects of essential procedures (such as interventions, operations, and transfusions) on in-hospital mortality. These procedures are closely related to the prognosis of TBI. For this reason, a prospective multicenter study should be conducted in the future.

Conclusion

Prehospital NEWS showed a similar performance as RTS in predicting in-hospital mortality in patients with TBI. Pre-hospital NEWS will contribute to improving prognosis by aiding in the rapid classification of patients with TBI in the field and their transportation to an appropriate hospital.

Ethics Committee Approval: This study approved by the Chonnam National University Hospital Institutional Review Board (Date: 22.03.2022; CNUH-2022-075).

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Authorship Contributions: Concept: D.H.L.; Design: J.L., D.H.L.; Supervision: B.K.L.; Resource: J.L.; Materials: J.L., E.N.; Data: J.L., E.N.; Analysis: D.H.L., B.K.L.; Literature search: E.N.; Writing: J.L., D.H.L.; Critical revision: D.H.L., B.K.L.

Conflict of Interest: None declared.

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ORİJİNAL ÇALIŞMA - *ÖZ*

Travmatik beyin hasarı olan hastalarda hastane öncesi Ulusal Erken Uyarı Skoru ile hastane içi mortalite arasındaki ilişki

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AMAÇ: Bu çalışma, travmatik beyin hasarı (TBH) sonuçları ile hastane öncesi Ulusal Erken Uyarı Skoru (NEWS), Yaralanma Şiddet Skoru (ISS) ve Revize Travma Skoru (RTS) arasındaki ilişkiyi incelemeyi amaçlamıştır.
GEREÇ VE YÖNTEM: Bu geriye dönük gözlemsel çalışma, Ocak 2019 ile Aralık 2020 arasında hastane öncesi acil sağlık hizmetleri sistemine başvuran TBH'li yetişkin hastaları içermektedir. Kısaltılmış Yaralanma Skalası Puanı 3 veya daha yüksek olduğunda TBH kabul edildi. Primer sonuç, hastane içi mortalite idi.
BULGULAR: Çalışmaya alınan 248 hasta arasında hastane içi mortalite %18.5 (n=46) olarak bulundu. Hastane içi mortaliteyi öngörmeye yönelik çok değişkenli analizde, hastane öncesi NEWS (Odss ratio, 1.198; %95 güven aralığı [CI], 1.042–1.378) ve RTS (OR, 0.568; %95 CI, 0.422–0.766) hastane içi mortaliteyle bağımsız olarak ilişkiliydi. ISS, RTS ve hastane öncesi NEWS için eğrinin altındaki alan (AUC'ler) sırasıyla 0.731 (%95 CI, 0.672–0.786), 0,853 (%95 CI, 0.802–0.894) ve 0.843 (%95 CI, 0.791–0.886) idi. Hastane öncesi NEWS'in AUC'si, ISS'ninkinden önemli oranda farklıydı, ancak RTS'ninkinden farklı değildi.
TARTIŞMA: Hastane öncesi NEWS, sahada TBH'li hastaların hızlı bir şekilde sınıflandırılmasına ve uygun hastanelere nakledilmesine yardımcı olarak prognozun iyileştirilmesine katkıda bulunabilir.
Anahtar sözcükler: Mortalite; prognoz; skorlama; travma.

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