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Evaluation of the efficacy of the National Early Warning Score in predicting in-hospital mortality via the risk stratification☆

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ABSTRACT

Purpose: To investigate the efficacy of the National Early Warning Score (NEWS) in predicting in-hospital mortality.
Materials and methods: This was a retrospective observational study and the electronic medical records of the patients were reviewed based on NEWS at the time of admission.
Results: The performance of NEWS was effective in predicting hospital mortality (area under the curve: 0.765; 95% confidence interval: 0.659–0.846). Based on the Kaplan Meier survival curves, the survival time of patients who are at high risk according to NEWS was significantly shorter than that of patients who are at low risk ($p < 0.001$). Results of the multivariate Cox proportional hazards regression analysis showed that the hazard ratios of patients who are at medium and high risk based on NEWS were 2.6 and 4.7, respectively ($p < 0.001$). In addition, our study showed that the combination model that used other factors, such as age and diagnosis, was more effective than NEWS alone in predicting hospital mortality (NEWS: 0.765; combination model: 0.861; $p < 0.005$).
Conclusions: NEWS is a simple and useful bedside tool for predicting in-hospital mortality. In addition, the rapid response team must consider other clinical factors as well as screening tools to improve clinical outcomes.

1. Introduction

Many types of patients can experience unexpected clinical deterioration during hospitalization, and this deterioration is associated with in-hospital mortality [1-4]. The primary aim of predicting in-hospital mortality is to improve patient prognosis. Currently, several scoring systems are used to predict in-hospital mortality [5-7]. The Acute Physiology and Chronic Health Evaluation (APACHE) and the Simplified Acute Physiology Score (SAPS) are representative prognostic models [5-7]. However, these scales are relatively complex, include several items, and cannot be used as a quick bedside tool. Recently, artificial intelligence was developed as part of a clinical decision support system to predict adverse events such as cardiac arrest several hours before its occurrence [8-11]. However, this system has not been used in critically ill patients.

Early warning systems for the early recognition of clinical deterioration in critically ill patients within 24 h can reduce the incidence of in-hospital cardiac arrest [12-14]. One such system, the standardized National Early Warning Score (NEWS) was established by the Royal College of Physicians of London and is currently used in several countries [12,15]. The NEWS has a good ability to discriminate acutely ill patients at risk of clinical deterioration within 24 h as well as events such as cardiac arrest, unexpected admission to an intensive care unit (ICU), and death. The NEWS is intended to provide reliable, timely, and effective indications of the clinical responses of acutely ill patients. By including seven simple physiological variables, the NEWS also provides a useful and rapid bedside tool [12,15-17]. For these reasons, it has been implemented in the afferent limb of the rapid response system [17,18]. However, the efficacy of the NEWS in identifying patients at risk of in-

Abbreviations: APACHE, The Acute Physiology and Chronic Health Evaluation; SAPS, The Simplified Acute Physiology Score; NEWS, National Early Warning Score; ICU, intensive care unit; RRT, rapid response team; EMR, electronic medical record; AUC, area under the curve; HR, hazard ratio; CI, confidence interval; AUC, the area under the curve; AVPU, Alert, Voice, Pain, Unresponsive.

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hospital mortality at the time of admission has not been validated because the risk stratification of NEWS was developed to predict clinical deterioration within 24 h, which is a short-term outcome.

We hypothesized that the NEWS would be useful for predicting in-hospital mortality in screened patients when other factors used for predicting prognosis are considered. This study aimed to assess the efficacy of the NEWS at the time of admission for predicting in-hospital mortality and to identify clinical factors that may improve the predictive performance of the NEWS.

2. Material and methods

2.1. Study setting

This was a retrospective observational study of patients admitted between December 2013 and March 2014 at Chungnam National University Hospital, a 1200-bed tertiary academic hospital, in South Korea. In this hospital, the electronic medical record (EMR)-based NEWS system was established in November 2013 and is used for adult patients admitted to the general ward. The vital signs of admitted patients are checked regularly by registered nurses. Based on their decision-making, the nurses enter seven physiological variables into the NEWS, and the NEWS data are stored in the EMRs. After a 6-month trial, the rapid response team (RRT) introduced a track-and-trigger system in May 2014. This study included patients older than 20 years and those whose first NEWS was recorded within 48 h after admission. We included only the first serial NEWS for analysis. We excluded patients with any missing variables, patients who were discharged within 72 h of a scheduled examination or treatment (e.g., endoscopy, scheduled chemotherapy), and patients whose first NEWS was not recorded within 48 h after admission. Demographic and clinical data and survival status were obtained from the EMRs. The primary outcome among critically ill patients was in-hospital mortality.

This study was approved by the institutional review board of Chungnam National University Hospital in the Republic of Korea (No. 2015-08-040). The need for informed consent was waived because the study design was retrospective and the data were retrieved by reviewing the EMRs.

2.2. NEWS

The NEWS dataset comprises seven physiological variables: systolic blood pressure, heart rate, respiratory rate, body temperature, oxygen saturation, use of any supplemental oxygen, and level of consciousness [15]. The score for each of the seven parameters (0–3 points) is summed to calculate the NEWS. The triggering thresholds based on the NEWS were classified as low risk (1–4), medium risk (5–6 or red score), and high clinical risk (≥7). The red score was defined as an extreme variation in a single parameter (Fig. 1) [15].

2.3. Statistical analysis

Descriptive data are presented as mean ± standard deviation or as number and percentage. An independent *t*-test was used to analyze categorical data, and a chi-square test was used to analyze continuous data. Survival was calculated according to the trigger thresholds for the NEWS using Kaplan–Meier analysis and compared using the log-rank test. Cox proportional-hazards regression analysis was performed using backward elimination to identify the independent risk factors for in-hospital mortality. Statistically significant variables in the univariate analysis were subsequently included in the multivariate analysis. In the present study, we investigated the best model that included risk factors that can be used for the accurate prediction of in-hospital mortality. The discriminatory power of each model was assessed using Harrell's C-index and an analysis of the area under the curve (AUC), and results were evaluated and compared using the Bootstrap method [19]. A p value <0.05 was considered to be significant, and the results are presented as the hazard ratio (HR) and 95% confidence interval (CI). All statistical analyses were performed using the R statistical package (version 2.13.1; R Foundation, Vienna, Austria; www.R-project.org) and IBM SPSS Statistics (version 20.0; IBM Corp., Armonk, NY, USA).

3. Results

3.1. Baseline characteristics of the study population

During the study period, a total of 10,038 people were screened. We excluded from the analysis patients who were discharged from hospital within 72 h after admission because they underwent a simple examination or treatment (e.g., endoscopy, scheduled chemotherapy) (n = 4346), patients with missing variables such as oxygen saturation or consciousness level because these were not checked at the time of admission (n = 3897), and patients whose first NEWS was recorded after 48 h at the time of admission (n = 495). The remaining 1300 patients were included in the analysis.

The baseline characteristics of the patients are shown in Table 1. Of the 1300 patients included in this analysis, 43 (3.3%) died during hospitalization. These patients were older and more likely to be men. Most of the nonsurvivors had cancer and had been admitted for medical as opposed to surgical reasons. One-third of the nonsurvivors were at high risk based on the trigger thresholds for the NEWS. The hospital stay

PHYSIOLOGICAL PARAMETERS	3	2	1	0	1	2	3
Respiratory Rate (breaths/min)	≤8		9 - 11	12 - 20		21 - 24	≥25
Oxygen Saturations (%)	≤91	92 - 93	94 - 95	≥96			
Any Supplemental Oxygen		Yes		No			
Temperature (°C)	≤35.0		35.1 – 36.0	36.1 – 38.0	38.1 – 39.0	≥39.1	
Systolic BP (mmHg)	≤90	91 - 100	101 - 110	111 - 219			≥220
Heart Rate (beats/min)	≤40		41 - 50	51 - 90	91 - 110	111 - 130	≥131
Level of Consciousness				A			V, P, or U

A, Alert; V, Voice; P, Pain; U, Unresponsive

Fig. 1. National Early Warning Score (NEWS). The score for each of the seven parameters (0–3 points) is summed up to calculate the NEWS. The triggering thresholds based on the NEWS were classified as low risk (1–4), medium risk (5–6 or red score), and high clinical risk (7 or more). The red score was defined as an extreme variation in a single parameter. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)