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National Early Warning Score (NEWS) at ICU discharge can predict early clinical deterioration after ICU transfer

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ABSTRACT

Objective: This study aims to determine the ability of the National Early Warning Score at ICU discharge ($NEWS_{dc}$) to predict the development of clinical deterioration within 24 h.
Methods: A prospective observational study was conducted. The NEWS was immediately recorded before discharge ($NEWS_{dc}$). The development of early clinical deterioration was defined as acute respiratory failure or circulatory shock within 24 h of ICU discharge. The discrimination of $NEWS_{dc}$ and the best cut off value of $NEWS_{dc}$ to predict the early clinical deterioration was determined.
Results: Data were collected from 440 patients. The incidence of early clinical deterioration after ICU discharge was 14.8%. $NEWS_{dc}$ was an independent predictor for early clinical deterioration after ICU discharge (OR 2.54; 95% CI 1.98–3.26; $P < 0.001$). The AUROC of $NEWS_{dc}$ was 0.92 ± 0.01 (95% CI 0.89–0.94, $P < 0.001$). A $NEWS_{dc} > 7$ showed a sensitivity of 93.6% and a specificity of 82.2% to detect an early clinical deterioration after ICU discharge.
Conclusion: Among critically ill patients who were discharged from ICU, a $NEWS_{dc} > 7$ showed the best sensitivity and specificity to detect early clinical deterioration 24 h after ICU discharge.

1. Introduction

Because of limited resources and the consideration for optimal resource allocation, appropriate ICU admission and discharge criteria may increase the benefits of patient care as well as to improve patient safety. Although the ICU admission criteria are clearly stated [1], the decision of ICU discharge may be difficult to determine. In addition, premature discharge from the ICU results in early ICU readmission and increased ICU mortality [2-6]. Several indices and clinical criteria have been proposed to identify the most appropriate patient to prevent premature ICU discharge [7-14]. Unfortunately, there are several limitations to apply these sophisticated criteria in clinical practice.

The National Early Warning Score (NEWS) is a simple aggregated weighted score based on the measurement of six vital signs and inspired gas breathed by the patient at the time. A higher NEWS indicates a greater severity of illness and risk of adverse outcomes [15,16]. Unfortunately, the use of NEWS values to select the appropriate patients for ICU discharge has never been tested.

The medical ICU at Songklanagarind Hospital is a level I ICU, which has 12 beds to care for mixed medical critically ill patients including acute respiratory failure, acute circulatory failure, and multiple organ failure. Because of high ICU requirements, most of the clinically stable patients are selected for discharge from the unit in order to receive new acute deteriorated patients from the ward or emergency department. The current ICU discharge criteria depend on the decision of the intensivist in charge of the patient. The NEWS was adopted in our unit for a period of time to monitor clinical deterioration of critically ill patients. In this study, we aimed to use the NEWS immediately before ICU discharge to predict early clinical deterioration, including acute respiratory failure or circulatory shock, in patients discharged from the ICU.

2. Methods

2.1. Patients

A prospective observation study was conducted. The study protocol was approved by the ethics committee (EC) at the Faculty of Medicine, Prince of Songkla University (EC number: 57-278-157). The data of 500 critically ill patients who were discharged from the medical ICU between December 2015 and October 2016 were recorded and followed

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up. A waiver of consent was approved and the investigators assigned a confidentiality term.

2.2. Data collection

All demographic data including age, gender, causes of ICU admission, Acute Physiologic and Chronic Health Evaluation (APACHE) II score, and types of ICU discharge were collected. The NEWS at the time of ICU discharge was also calculated and recorded immediately before transfer of the patients to the destination ward. The clinical conditions 24 h after ICU discharge were also monitored and recorded by the researchers (S.U., J.K.). The primary outcome was the development of early clinical deterioration, defined as acute respiratory failure or circulatory shock within 24 h of ICU discharge.

2.3. National Early Warning Score (NEWS)

The NEWS was introduced by the Royal College of Physicians of London (RCPL) in order to bring about a major change required in the assessment and response to acute illness. In this simple scoring system, a score is assigned according to the physiological measurements which are pragmatically recorded during hospitalization. There are seven parameters that comprise this scoring system: respiratory rate, oxygen saturation, oxygen requirement, body temperature, pulse rate, systolic blood pressure, and level of consciousness (Table 1). The higher scores indicate significant clinical deterioration and severity. The NEWS is categorized into 3 classes according to the composite score that includes low risk (NEWS 0–4), moderate risk (NEWS 5–6), and high risk (NEWS >6). Furthermore, the intensity of care was tailored regarding the level of the NEWS.

2.4. Definitions

In the current study, the causes of ICU admission were classified into septic shock, acute respiratory failure, acute renal failure, heart failure, cardiogenic shock, and post-cardiac arrest. The types of ICU discharge were categorized to planned ICU discharge, unplanned ICU discharge, and discharge for end-of-life care. The critically ill patients, who were fully evaluated by the intensivist in charge for the readiness of ICU discharge after daily morning ward rounds, were defined as planned ICU discharge. Unplanned ICU discharge was recorded if the patients were discharged for an immediate ICU bed requirement. Most of the unplanned ICU discharge patients were the most clinically stable patients which were decided by the intensivist in charge.

Early clinical deterioration in this study was defined as the development of acute respiratory failure or circulatory shock within 24 h after discharge from the ICU. Acute respiratory failure was defined as the need for intubation, invasive mechanical ventilation, non-invasive mechanical ventilation or high flow oxygen therapy. Hypotension that required vasopressors or inotropes was defined as circulatory shock. We did not record other types of organ system failure because a previous study showed that the major causes of ICU readmission were respiratory failure and a compromised circulatory system [17].

2.5. Statistical analysis

Continuous variables were expressed as mean ± standard deviation (SD) or median with a minimum and a maximum dependent on the distribution of data and discrete variables that were expressed in percentages. The clinical characteristics between early clinical deterioration and non-deterioration were compared by the chi-squared test, Fisher's exact test, Mann-Whitey test, and independent samples *t*-test as appropriate.

We then used simple univariate and multivariate logistic regression to evaluate the correlation between the potential variables and primary outcome. The variables with $P < 0.1$ in univariate analysis were introduced into the multivariate logistic regression model. Collinearity between variables was excluded before modeling. All variables, odds ratios (ORs) and their 95% confidence intervals (CIs) were used to identify the independent predictors of early clinical deterioration.

Afterwards, a receiver operating characteristic (ROC) curve and a calculated corresponding area under the ROC curve (AUROC) of $NEWS_{dc}$ were constructed. The Youden index was introduced to select the best cut off value of $NEWS_{dc}$ with the best sensitivity, specificity, positive likelihood ratio (LR+) and negative likelihood ratio (LR−) to predict the primary outcomes. A P value <0.05 indicated statistical significance. All statistical analyses were computed by MedCalc® Statistical Software version 17.1 (MedCalc Software bvba, Ostend, Belgium).

3. Results

3.1. Patient characteristics

Sixty cases of ICU discharge for end-of-life care were excluded. Of the remaining 440 cases that were then analyzed, the median age of the patients was 61 (20,96) years old and 219 (49.8%) were male. The median APACHE II score was 25.5 (13,37). The median of the $NEWS_{dc}$ was 3 (0,13). Septic shock and acute respiratory failure were among the major reasons for ICU admission (27.0%, 24.5%, respectively). Approximately 53.2% of the cases were planned ICU discharge and 46.8% were unplanned ICU discharged.

3.2. Clinical characteristics between early clinical deterioration and non-deterioration

Of 440 patients, 65 patients (14.8%) developed early clinical deterioration. The demographic data, including mean age, gender, and median APACHE II, were comparable between the early clinical deterioration and non-deterioration group. Causes of ICU admission, types of ICU discharge, and $NEWS_{dc}$ were significantly different between the groups (Table 2). Most of unplanned ICU discharged patients developed early clinical deterioration. The median $NEWS_{dc}$ was significantly higher in the early clinical deterioration group: 10 (5,13) vs 3 (0,12) ($P < 0.001$).

3.3. Independent predictors of early clinical deterioration

Although unplanned ICU discharge was significantly higher in the early deterioration group, the univariate and multivariate analyses could not be determined due to the zero cell issue. In simple univariate

Table 1
National Early Warning Score.

Physiological parameters	3	2	1	0	1	2	3
Respiratory rate	≤8		9–11	12–20		21–24	≥25
Oxygen saturations	≤91	92–93	94–95	≥96			
Any oxygen supplement		Yes		No			
Temperature	≤35		35.1–36.0	36.1–38.0	38.1–39.0	≥39.1	
Systolic blood pressure	≤90	91–100	101–110	111–219			≥220
Heart rate	≤40		41–50	51–90	91–110	111–130	≥131
Level of consciousness[a]				A			V, P or U

[a] The AVPU scale for level of consciousness ="alertness, voice, pain, unresponsive".

Table 2
Clinical characteristics of 440 patients discharged from ICU between early clinical deterioration group and non-deterioration group.

Variables	Early deterioration ($N = 65$)	Non-deterioration ($N = 375$)	P
Mean age, y (SD)	60.77 (12.81)	60.13 (15.31)	0.68[a]
Male gender	29 (44.6)	190 (50.7)	0.36c
Median APACHE II (min,max)	27 (18,35)	25 (13,37)	0.45[b]
Causes of ICU admission			0.002[c]
• Sepsis/septic shock	22 (33.8)	97 (25.9)	
• Acute respiratory failure	15 (23.1)	93 (24.8)	
• Acute renal failure	3 (4.6)	68 (18.1)	
• Heart failure	14 (21.5)	69 (18.4)	
• Post-cardiac arrest	10 (15.4)	20 (5.3)	
• Cardiogenic shock	1 (1.5)	28 (7.5)	
Types of ICU discharge			<0.001[c]
• Planned discharge	0 (0.0)	234 (62.4)	
• Unplanned discharge	65 (100)	141 (37.6)	
Median NEWS at ICU discharge (min,max)	10 (5,13)	3 (0,12)	<0.001[b]

Data are presented as n (%) unless indicated otherwise.
APACHE II: Acute Physiologic and Chronic Health Evaluation II, ICU: intensive care unit, NEWS: National Early Warning Score.
[a] Independent sample *t*-test.
[b] Mann-Whitney test.
[c] Chi squared test.

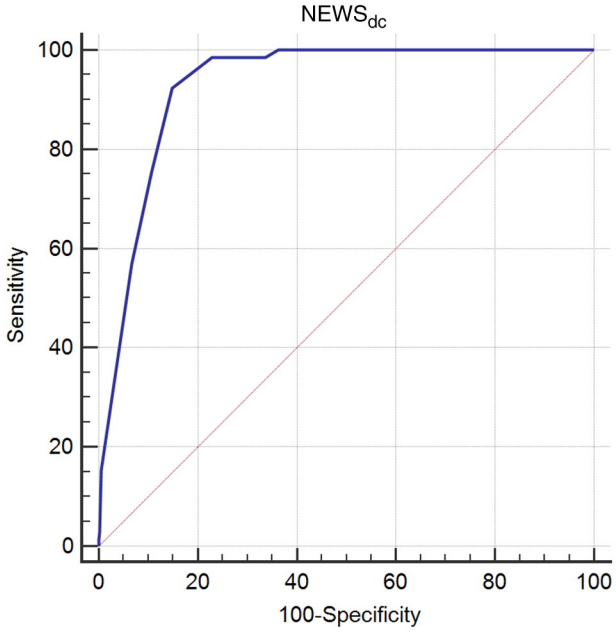

Fig. 1. Receiver operating characteristic (ROC) curve for NEWS$_{dc}$ for the early clinical deterioration after ICU discharge. Area under the receiver operating characteristic (AUROC) of NEWS$_{dc}$ is 0.92 ± 0.01 (95% CI 0.89–0.94, $p < 0.001$). A NEWSdc >7 show a sensitivity of 93.6% and a specificity of 82.2% to detect an early clinical deterioration after ICU discharge.

regression analysis, the patients with acute renal failure, post-cardiac arrest, and NEW$_{dc}$ were among the significant parameters correlated to early clinical deterioration after ICU discharge. After the multivariate regression analysis, patients with the admission diagnosis of acute renal failure and the NEWS$_{dc}$ were the only independent predictors of early clinical deterioration (Table 3). The NEWS$_{dc}$ was the only scoring tool that significantly predicted early clinical deterioration (OR 2.54; 95% CI, 1.98–3.26; $P < 0.001$). The ROC and AUROC of the NEWS$_{dc}$ to predict early clinical deterioration was then constructed (Fig. 1). The AUROC of the NEWS$_{dc}$ was 0.93 ± 0.01 (95% CI 0.90–0.95, $P < 0.001$). Regarding the Youden index determination, a NEWS$_{dc}$ > 7 gave the best sensitivity (92.31%), specificity (85.07%), LR+ (6.18) and LR- (0.09) to predict early clinical deterioration.

4. Discussion

In the present study, we found that the NEWS immediately before ICU discharge was an independent predictor of clinical deterioration within 24 h after transfer. A NEWS$_{dc}$ >7 could significantly predict post-ICU clinical deterioration with the sensitivity of 92.31% and specificity of 85.07%.

Although the Society of Critical Care Medicine has launched a guideline for admission, triage, and discharge for the ICU, the evidence in this guideline is very weak [1,13]. Therefore, the decision for ICU discharge still depends on the decision of the intensivist. Several studies showed that the decision for ICU discharge was influenced by workload pressure and bed demand [18-20]. As a result, a premature ICU discharge could happen.

Several previous studies reported a premature ICU discharge associated with clinical deterioration, ICU readmission and mortality [5,21,22]. The ICU readmission rate within 24 to 48 h is considered a quality of the ICU and a major performance indicator of the ICU. Age, causes of ICU admission, co-morbidities, number of organ failures, high acute physiologic scores on admission, ICU discharge during the night shift, and ICU length of stay were among the risk factors of clinical deterioration that resulted in readmission [2,20,23-28]. In our cohort, unplanned ICU discharge was 46.8% and most of the cases developed early clinical deterioration. A high percentage of unplanned ICU discharge in our findings indicated high ICU workload and high ICU bed pressure. This issue was evidently correlated to early clinical deterioration.

The RCPL introduced the NEWS for monitoring clinical deterioration and to adjust the intensity of patient care [15]. The NEWS has currently been found to predict the risk of sudden cardiac arrest and ICU admission [15,29]. Our study selected the NEWS to determine the predictive power of clinical deterioration within 24 h of ICU discharge because this score is composed of very simple physiologic parameters derived from current vital signs and neurological signs. In the present study, the NEWS upon ICU discharge was an independent predictor for early clinical deterioration within 24 h of ICU discharge and a NEWS$_{dc}$ demonstrated an AUROC of 0.93 ± 0.01 (95% CI 0.90–0.95, $P < 0.001$). Furthermore, a NEWS$_{dc}$ > 7 had significant sensitivity, specificity, LR+ and LR− to predict early clinical deterioration after ICU discharge.

According to a suggestion by the RCPL, the patient who has a NEWS of 5–6 should have an urgent review for acute physiologic deterioration and NEWS values >6 need to be considered for ICU admission [15]. Our unit practice is currently unaligned to that suggestion; the median

Table 3
Univariate and multivariate logistic regression models of predictors associated with early clinical deterioration.

Variables	Univariate			Multivariate		
	OR	95% CI	P	Adjusted OR	95% CI	P
Causes of ICU admission						
• Sepsis/septic shock	Reference		NA	–		
• Acute respiratory failure	0.71	0.35–1.45	0.35	–		
• Acute renal failure	0.24	0.07–0.80	0.02	0.18	0.05–0.65	0.009
• Heart failure	0.89	0.43–1.87	0.77	–		
• Post-cardiac arrest	2.75	1.22–6.23	0.01	2.08	0.85–5.09	0.11
• Cardiogenic shock	0.16	0.22–1.22	0.08	0.14	0.02–1.14	0.07
Unplanned ICU discharge[a]	undetermined			–		
NEWS at ICU discharge, per point	2.26	1.84–2.79	<0.001	2.54	1.98–3.26	<0.001

OR: odds ratio; CI: confidence interval; NA: not available; NEWS: National Early Warning Score; ICU: intensive care unit.
[a] Undetermined because of zero cell issue.

$NEWS_{dc}$ of the overall population and in the early clinical deterioration group was 3 (0,13) and 10 (5,13), respectively. Therefore, these patients possibly had physiological derangement before discharge and were possibly unfit for discharge. Regarding our findings, a patient with $NEWS_{dc}$ > 7 was considered as a high-risk patient to develop clinical deterioration after ICU discharge. This issue raised the concern for patient safety by our critical care team before deciding to discharge the patient from the ICU. This finding indicated that our unit requires more resources and more beds, and needs to modify the current practice in order to improve the safety of ICU discharge. Postponement of ICU discharge should be considered in the high-risk patient. However, if we need to discharge this high-risk patient from our ICU, the transfer to a step down unit or intermediate care unit with the optimal patient information handed over must be required. Transfer to a general ward should be accompanied with a critical care outreach team or rapid response team as another measure to monitor the high-risk patient for development of early clinical deterioration [13]. In addition, we also need several evidence-based interventions to prevent clinical deterioration and readmission after ICU discharge to include a transfer phone call, charted care summary, and a discharge physical re-examination by the discharging intensivist [30]. Although our results can not fit all units worldwide, our findings are directly related to our discharge patient safety issue. Moreover, the units that share a similar context with us could adopt the $NEWS_{dc}$ into the decision making for ICU discharge to improve their quality of care. Perhaps, the units should construct their own ICU discharge policy by integrating the clinical decision-making and the resource allocation policy with some acute physiologic scores in order to achieve patient safety outcomes.

There are several limitations in our study. The number of cases in this study was lower than in previous studies of acute physiologic scoring systems and the incidence of early clinical deterioration (14.8%) was essentially higher than previous studies from the USA [31] and Australia [32]. Given the high percentage of unplanned ICU discharge (46.8%), our unit has a high workload and high bed pressure, which may be different from other units worldwide. Therefore, the application of our findings needs to be considered. Subsequently, we collected only the total NEWS values rather than those of the component parameters; therefore, it may be difficult to identify which organ system had not recovered before ICU discharge. Although, the NEWS is a physiologic scoring tool to stratify the risk of clinical deterioration, this score is unable to discriminate between identical scores that have different composite values. Due to the way a NEWS value is constructed, not all NEWS values equal to 7 will have the same degree of underlying derangements or associated risks. A NEWS value of 7 indicates derangement of a minimum of two or three different major NEWS parameters and possibly some minor derangements. Therefore, a discharge policy based on NEWS values <7 may be associated with different risks for different patients with the same NEWS values. In our opinion, the application of the NEWS or other physiologic scoring tools to aid clinical decision making before ICU discharge might improve the safety of ICU discharge outcomes, such as the prevention of post-ICU clinical deterioration and the reduction of ICU readmission rate and mortality. Further research is required to test this hypothesis for further development and validation of acute physiologic scores to predict ICU readmission, post-ICU clinical deterioration, and post-ICU mortality. Moreover, the clinical outcomes of transferring high-risk ICU patients to a step-down unit, intermediate care or the general ward with a critical care outreach team need to be evaluated and compared to extended ICU care.

5. Conclusion

The incidence of early clinical deterioration in our study was very high. A NEWS score > 7 at the time of ICU discharge was a strong independent predictor and demonstrated significant sensitivity, specificity, LR+ and LR− to predict clinical deterioration within 24 h of ICU discharge. However, the clinical implications of this physiologic score need to be confirmed.

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Authors' contributions

SU, RB, JB contributed to the conception and design of the study. SU, JK performed the acquisition of data. RB contributed to the analysis and interpretation of data and drafted the manuscript. All authors approved the final manuscript.

Competing interests

No conflict of interest declared by all authors.

Consent for publication

Not applicable.

Ethical approval and consent to participate

The study protocol was approved by the ethics committee (EC) at Faculty of Medicine, Prince of Songkla University (EC number: 58-166-15-7). A waiver of consent was approved and the investigators assigned a confidentiality term.

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