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Daily surveillance with early warning scores help predict hospital mortality in medical wards

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Background/aim: To analyze the potency of a modified early warning score (EWS) to help predict hospital mortality when used for surveillance in nonacute medical wards.

Materials and methods: Patients in internal medicine wards were prospectively recruited. First, highest, and last scores; and mean daily score recordings and values were recorded. Nurses calculated scores for each patient upon admission and every 4 h. The last score was the score before death, discharge, or transfer to another ward. The highest scores in total and for each single parameter were used for analysis.

Results: Fifty-nine percent of 182 recruited patients had recordings eligible for data analysis. Patients admitted from the emergency room had higher mortality rates than patients admitted from outpatient clinics (15% vs. 1.5%; P = 0.01) as well as patients whose first (40% vs. 4.9%; P = 0.033) and highest scores (18.8% vs. 1.3%; P = 0.003) were equal to or more than 3. The first recorded EWS was not predictive for mortality while the maximum score during the admission period was.

Conclusion: This study underlines the fact that each physiological variable of EWS may not have the same weight in determining the outcome.

Key words: Acute, admission, early warning score, internal medicine

1. Introduction

Objective tools using physiological parameters to recognize deteriorating patients in wards have been gaining attention in recent years. It was noted that patients admitted to intensive care units from the wards had higher mortality rates when compared to those from emergency or operating rooms, and, as the length of stay in the wards increased, the mortality increased in parallel, indicating the importance of critical hours (1). Physiological parameters deviate from normal some time before arrest, leaving a window of opportunity to recognize the deteriorating patient (2). Early warning scores (EWSs) that rely on physiological parameters have been developed to foresee which patients have the potential to "get worse" and were originally used as a triage tool in the emergency rooms and acute medicine units. The number of abnormal parameters on admission and increasing scores correlate with in-hospital mortality; the odds ratio reaches 37 especially when the score is equal to or above three (3). Numerous scoring systems have been developed, but most of them have been validated only in emergency and acute medical care settings as initial recordings (4,5). Our first aim was to analyze whether the EWSs have a potential to foresee in-hospital mortality when used both as a screening and a surveillance tool. The second aim was to observe the compliance of nurses in a pilot study.

2. Materials and methods

2.1. The participants and study design

Patients who were admitted to an internal medicine ward of a university hospital were prospectively recruited. This ward had 32 beds with heterogeneous patients from different divisions of internal medicine. Most of the patients needed close follow up and most of them had complex comorbidities such as heart failure and cancer. Patients who were hospitalized for less than 24 h, had been transferred from the intensive care unit, or had a terminal illness were excluded. Comorbidities and certain drugs that can affect the vital signs (beta-blocker, calcium

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channel blockers, digoxin) were noted. Additionally, those who lacked a daily score calculation in more than 30% of their admission days were excluded from the final analysis, but the number of those patients was recorded to observe the compliance of the nurses with the protocol. A modified version of EWS was used (Table 1) (4,5). As the adult hospital is a Joint Commission International accredited hospital, vital signs were evaluated in accordance with the nursing protocols. Body temperature was measured with tympanic thermometers. Nurses were trained to calculate the EWS for each patient upon admission and every 4 h thereafter. They were told to take hourly scores if they found a score of equal to or more than 3. Each patient had an admission score, which was calculated right after admission to the ward. The last score was the score before death, discharge, or transfer to another ward. The highest scores in total and for each single parameter were used for analysis as well as the pertaining first and last scores. Patients were followed up by the ward attending physician and the residents. No clinical intervention such as admission to the intensive care unit was considered according to the EWS results. Ward physicians knew about the study but they did not know the scores of the individual patients. The study was approved by Hacettepe University Faculty of Medicine Hospital Ethics Committee (Number: FON 09/58-104).

2.2. Statistical analyses

Numeric variables were analyzed by Mann–Whitney test. The chi-square test was performed to test for the difference between categorical variables with continuity correction and Fisher's exact test when indicated. A P value less than 0.05 was accepted as significant. Receiver operator characteristics (ROC) curves were used to calculate the predictive power of the various parameters examined by the study in predicting mortality.

3. Results

A total of 182 patients were recruited during the study period. A threshold of 30% was accepted arbitrarily to exclude those patients who had score recordings lacking; data of 108 patients were eligible for analysis (59.3%). Median age of the patients was 59.5 years (25th–75th percentiles; 38–71). Fifty percent of the patients were males and the median follow-up period was 15.5 days (25th–75th percentile; 8–22). The in-hospital mortality was 6.5% overall. No difference was present with regard to underlying chronic conditions (diabetes, hypertension, chronic heart failure, coronary artery disease, chronic obstructive pulmonary disease, malignancy) or drug use (beta-blocker, calcium channel blocker, digoxin) between the patients who died and those who survived. However, patients who died had more chronic renal disease than those who survived (P = 0.011) (Table 2). A higher proportion of patients died if they were admitted from the emergency room when compared to elsewhere (85.7% vs. 33.7%, respectively, P = 0.01).

Eighty-five percent of patients who died had a maximum score equal to or more than 3, whereas 25.7% of patients who survived had a maximum score equal to or more than 3 (P = 0.001). Additionally, 28% of patients who died had a first score equal to or more than 3, whereas 3% of patients who survived had a first score equal to or more than 3 (P = 0.002). Six of the seven patients who died had scores ≥5 and were admitted from the emergency room. The only patient who had a score below 3 (the highest score was 1) and died was a 65-year-old woman who was admitted from the outpatient clinic for joint pain and who developed bacteremia. The highest score (P = 0.001) but not the first score was associated with mortality for patients admitted from the emergency room. ROC analysis revealed that first score was not predictive for mortality but the highest score, specifically as a single parameter the highest neurologic score during the inpatient period, predicted mortality (Figure).

4. Discussion

EWSs, originally intended to guide triage in the emergency room, have been promising tools to foresee the prognosis

Table 1. Early warning score chart.

Score	3	2	1	0	1	2	3
Heart rate (/min)		≤44	45–54	55–100	101–110	111–130	130
Systolic blood pressure (mmHg)	<70	71–80	81–100	101–199		≥200	
Respiratory rate (/min)		≤8	9–12	12–20	20–24	24–29	30
Temperature (°C)			<36	36–37.4	37.5–37.9	≥38	
Neurological status				A	V	P	U

A, alert; V, responds to voice; P, responds to pain; U, unresponsive

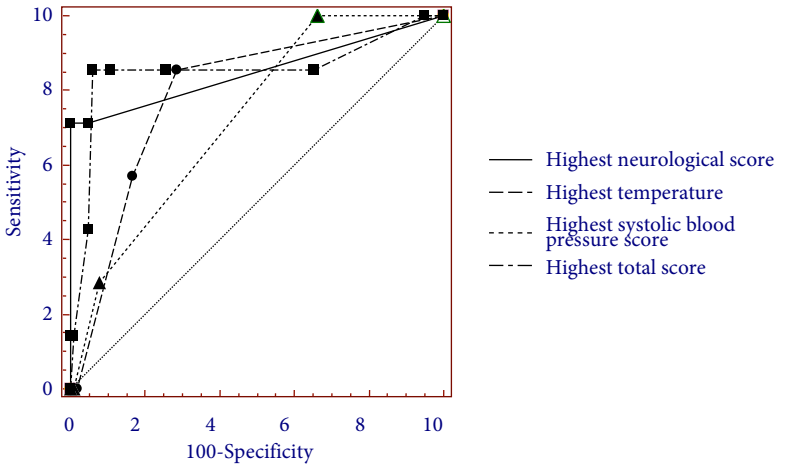
Table 2. Characteristics of patients and data about score recordings.

Variable	Patients who were discharged (n = 101)	Patients who died (n = 7)	P
Median age (25th–75th percentiles)	59 (36.5–71)	65 (53–83)	0.153
Female (number, (%))	49 (48.5)	5 (71.4)	0.437
Comorbidities* (number, (%))			
Hypertension	44 (43.6)	3 (42.9)	0.643
Diabetes	26 (25.7)	2 (28.6)	0.584
Heart failure and/or coronary artery disease	28 (27.7)	2 (28.6)	0.629
Chronic renal disease	13 (12.9)	4 (57.1)	0.011
Malignancy	19 (18.8)	0	0.349
Chronic obstructive pulmonary disease	9 (8.9)	0	0.534
Drugs			
Beta blockers	28 (27.7)	2 (28.6)	1.000
Calcium channel blockers	22 (21.8)	3 (42.9)	0.349
Digoxin	13 (12.9)	1 (14.3)	1.000
Rate of admission from the emergency room	34 (33.7)	6 (85.7)	0.010
Data about score recordings			
Mean number of score recordings per patient per day	4.5 (0.88–10.2)	6.7 (4.1–14)	0.039
Total number of score recordings per patient throughout inpatient period	76.1 (9–322)	56.5 (13–99)	0.458
Highest score	2 (0–7)	5 (1–7)	0.001
Total score	33.9 (0–205)	54.2 (14–91)	0.047
First score	0.59 (0–6)	1.86 (0–6)	0.395
Last score	0.25 (0–2)	3.29 (0–7)	<0.001

*One patient may have more than one condition.

and decrease morbidity and mortality of inpatients. The original EWS was not intended to foresee prognosis since the potential events during the admission period can influence the outcome. Modified EWSs have been the most frequently used validated system (6). Another new validated system, Worthing physiological scoring system, could predict mortality, length of stay, and admission to coronary and medical intensive care units. Most recently, the Vitalpac Early Warning Score (ViEWS) system has demonstrated an area under the curve of 0.888 (95% CI, 0.880–0.895), which is higher than that of the other 33 systems analyzed, and has been validated on thousands of patients' data (7).

Risk assessment should start when the patient is first admitted to the emergency room or the ward, but as it can never be enough it should continue with surveillance. Our study demonstrated that while only a small proportion of patients had a score more than 2 at admission, one third of them had one during follow up. The main finding of this study was that patients admitted from the emergency room had higher mortality rates, yet the admission scores were not different among those who died and those who survived. On the other hand, the highest scores and the last recorded scores were significantly different between the two groups. It seems that patients admitted from the emergency room might be more prone to deteriorate throughout the course of their inpatient period, although they are hemodynamically stable at the time of admission to the wards. Goldhill et al. (3) also showed that patients who died were often inpatients staying for days or weeks,



Scores	AUC	Sensitivity (%)	Specificity (%)	NPV (%)	PPV (%)
Highest neurological score (cut-off: >0)	0.850	71.4	100	98.1	100
Highest temperature score (cut-off: >1)	0.789	85.7	71.2	98.6	17.1
Highest systolic blood pressure score (cut-off: >0)	0.722	100	33.6	100	9.5
Highest total score (cut-off: >4)	0.853	85.7	94.06	99	50

AUC: area under the curve, NPV: negative predictive value, PPV: positive predictive value

Figure. ROC analysis for individual variables.

allowing time for clinicians to intervene and potentially change outcome. A study by Bleyer et al. (8) from the United States demonstrated similar results on 1.15 million individual vital sign recordings taking advantage of an electronic vital sign database. The mortality rate increased dramatically when there were 3 or more critical vital signs, which was more likely to occur early in the hospital admission, but could occur after 5 days of hospitalization. They also validated the modified EWS and ViEWS, showing that these scores are predictive not only at the time of admission but also during the inpatient period.

Our study demonstrated that each physiological variable may not have the same weight to affect the outcome, although combined scoring systems have been shown to demonstrate a higher specificity compared to single parameter scores (9). Highest total score showed an area under the curve of 0.853 (95% CI, 0.772–0.914) with a cut off >4. In addition, neurological score showed an area under the curve of 0.850 (95% CI, 0.769–0.911) with a cut off >1 (Figure). Temperature and neurological status were most predictive of hospital mortality especially when used for surveillance. Heart rate was not predictive for mortality as also demonstrated by Moon et al. (10).

The patients in this study cohort were mostly nonacute patients, which may be the reason why the initial admission scores were not predictive of in-hospital mortality. Indeed, studies are very heterogeneous with different patient populations and different outcome analyses, but most of them report positive effects of using EWS to predict the prognosis and to decrease arrests and hospital mortality in different hospital settings. The modified EWS had moderate ability to predict the need for higher level of care in the emergency department (11). Preoperative EWS and the changes in a patient's EWS correlated with mortality postoperatively and with critical care requirements (12). Ghanem-Zoubi et al. (13) demonstrated that simple clinical score and rapid emergency medicine score were the most accurate to predict the mortality of septic patients in general internal medicine wards. Implementation of a modified version of EWS in orthopedics and trauma wards have led to a decrease in mortality in 4 years, but this was not a statistically significant decrease (14). As this study also demonstrated, any EWS system may perform acceptably in the local environments for which they were developed, but their universal applicability is debatable. For the time being, the ViEWS score is the most promising predictor of early in-hospital mortality with an area under the ROC curve of 88% for 24 h mortality even in its abbreviated form (7). We preferred to use a modified version of EWS because of its simplicity and since VIEWS had not been published when we designed the present study.

EWS-based systems might have certain caveats. Especially paper-based EWSs might lead to errors and omissions (15). Additionally, as the scoring system gets complicated, the risk of errors increases (16). Scoring errors tend to cause underscoring as demonstrated by Smith et al. during an epidemic of Legionnaire's disease (17). Particularly in those patients seemingly 'well', erroneous recordings may increase, especially when nurses refrain from manually counting the respiratory rate (16). This 'well-patient bias' might lead to underscoring and skipping of the deteriorating patient, which might also be the case with the single patient who died but did not have a high score recording; she was admitted as an elective case from the outpatient clinic because of joint pain. Moreover, a recent study by Kim et al. showed that 45.3% of the patients who experienced a cardiac arrest in the general wards had MEWS values ≤2 even 8 h before the incident (18).

One of the limitations of the study was it only observed the relation between the scores and the outcome, but did not examine the effect of an outreach service. It is well known that the meaningful use of an EWS should trigger a procedure that will call a critical care outreach service to evaluate a need for a higher level of care. Another limitation was the low adherence of nurses to EWS recordings: only 59% of the recruited patients had 70% admission days with complete EWS recordings although vital signs were assessed regularly as the hospital required. The study by Ludikhuize has also shown that adherence of the nurses was low and the action flow chart was not implemented fully (19). Lastly, this was a pilot study involving only one floor of medical wards in a single center and there were only seven mortalities, and so results might not be projected to a larger patient population with only these findings.

In conclusion, our study demonstrated that the highest recordings of a modified EWS could predict the hospital mortality of medical patients in this cohort. Mortality was associated with the highest score but not the first score even for patients admitted from the emergency room. Hence, the use of an EWS initially solely on admission might not predict worse outcomes, but continuing surveillance is mandatory during the inpatient period. Dynamic track and trigger systems and readily available critical care beds would be needed to influence the outcomes.

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