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Outcomes/Predictions

A risk scoring model based on vital signs and laboratory data predicting transfer to the intensive care unit of patients admitted to gastroenterology wards

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ABSTRACT

Purpose: To compare the ability of a score based on vital signs and laboratory data with that of the modified early warning score (MEWS) to predict ICU transfer of patients with gastrointestinal disorders.
Materials and methods: Consecutive events triggering medical emergency team activation in adult patients admitted to the gastroenterology wards of the Asan Medical Center were reviewed. Binary logistic regression was used to identify factors predicting transfer to the ICU. Gastrointestinal early warning score (EWS-GI) was calculated as the sum of simplified regression weights (SRW).
Results: Of the 1219 included patients, 468 (38%) were transferred to the ICU. Multivariate analysis identified heart rate ≥ 105 bpm (SRW 1), respiratory rate ≥ 26 bpm (SRW 2), ACDU (Alert, Confused, Drowsy, Unresponsive) score ≥ 1 (SRW 2), SpO_2/FiO_2 ratio < 240 (SRW 2), creatinine ≥2.0 mg/dL (SRW 2), total bilirubin ≥9.0 mg/dL (SRW 2), prothrombin time/international normalized ratio (INR) ≥1.5 (SRW 2), and lactate ≥3.0 mmol/L (SRW 2) for inclusion in EWS-GI. The area under the receiver operating characteristic curve of the EWS-GI was larger than that of MEWS (0.76 vs. 0.64; $P < 0.001$).
Conclusions: EWS-GI may predict ICU transfer among patients admitted to gastroenterology wards. The EWS-GI should be prospectively validated.

1. Introduction

Medical emergencies, including upper (variceal and non-variceal) and lower gastrointestinal bleeding, acute liver failure, severe sepsis/septic shock, and respiratory insufficiency, occur frequently in patients admitted to gastroenterology wards [1-5]. Several risk assessment and scoring systems have been developed for upper gastrointestinal bleeding [1,2,6] and advanced liver disease [7]. However, to our knowledge, overall assessment scores for the risk of transfer to intensive care units (ICUs) have not been developed for patients with gastrointestinal disorders.

Early warning scores (EWS) are bedside evaluation tools based on physiologic measurements (e.g., blood pressure, heart rate, respiratory rate) obtained at admission or by monitoring during hospitalization. EWS provide a simple method for categorizing a patient's condition and indicating when a patient may require additional attention [8-10]. Despite the potential ability of EWS to identify physical deterioration in acute care settings, improvements are needed [11]. In addition, most EWS are disease-nonspecific that do not consider the characteristics of patients with certain diseases [10]. For example, physiologic characteristics may differ in critically ill patients with and without gastrointestinal disorders [12], and traditional EWS may perform differently in these groups of patients. These factors indicate a need for EWS tailored to different patient groups.

The number of patients who can be monitored and treated in ICUs is restricted owing to resource limitations. Early identification of patients at risk of deterioration and the selection of those who might benefit from ICU care can be crucial. This study was therefore designed (i) to develop a risk screening tool, the gastrointestinal EWS (EWS-GI), using

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vital signs and laboratory data for patients admitted to gastroenterology wards; and (ii) to compare the ability of the EWS-GI and the previously described modified EWS (MEWS) [8] to predict ICU transfer of these patients.

2. Material and methods

2.1. Study design and study subjects

This retrospective cohort study was conducted at the Asan Medical Center, a 2680-bed university-affiliated hospital in Seoul, Korea. Consecutive events triggering medical emergency team (MET) activation in adult patients admitted to the gastroenterology wards of Asan Medical Center between March 2008 and December 2015 were reviewed. The MET at Asan Medical Center has been described [13]. The MET was automatically activated when a patient was identified by 24 h electronic medical record (EMR)-based monitoring as reaching a threshold for a relevant vital sign or laboratory measurement, based on the medical alert system criteria used at Asan Medical Center. The MET was also activated when it was telephoned or paged by a general ward (GW) nurse or resident, or when a cardiopulmonary resuscitation code blue was announced anywhere in the hospital. For patients with multiple MET activations, only the first activation was included. Events were excluded if a do not resuscitate order had been issued within 24 h of MET activation, if they involved cardiopulmonary resuscitation, or if the MET had been activated for simple procedural assistance or to educate healthcare providers. The primary study outcome was ICU transfer. The study protocol was approved by the institutional review board of Asan Medical Center (no. 2015-1101), which waived the requirement for informed consent because the study was retrospective, and the patient records were anonymized and de-identified prior to analysis.

2.2. Data collection and definitions

Data collected for all MET activations included demographic factors; comorbidities; causes of activation; vital signs; ACDU (Alert, Confused, Drowsy, Unresponsive) score; SpO_2/FiO_2 (SF) ratio; outcome of the MET intervention; and mortality after MET activation. The vital signs and ACDU score were used to calculate the MEWS [8]. We used SF ratio instead of PaO_2/FiO_2 ratio because arterial blood gas sampling was not available for every patient, but SF ratio was rapidly and easily measured by using the pulse oximetry. Moreover, previous studies found that the SF ratio, being highly correlated with PaO_2/FiO_2 ratio, could be a useful tool for assessment of hypoxia in the setting of acute respiratory distress [14,15]. Laboratory data, including blood chemistry, coagulation profile, and serum lactate, were also collected on the day of MET activation.

2.3. Statistical analysis

Continuous variables are reported as medians and interquartile ranges and were compared by the Mann–Whitney *U* test, whereas categorical variables are reported as percentages and were compared by the Chi-square or Fisher's exact test, as appropriate. The cutoff values of potential predictors of ICU transfer were selected using locally weighted scatterplot smoothing curves [16]. Multivariate regression analysis using stepwise backward selection was performed to identify factors predicting ICU transfer. The weights derived from multiple logistic regressions were simplified as natural numbers >0, and the EWS-GI was calculated as the sum of these simplified weights. The areas under the receiver operating characteristic (ROC) curve for the EWS-GI and MEWS predicting ICU transfer were compared by DeLong's test, as described [17]. The optimal cutoff values for the EWS-GI and MEWS were identified by ROC analysis. Kaplan–Meier survival estimates were stratified by EWS-GI and MEWS to compare their ability to predict mortality. All tests of significance were two tailed, and *P* values <0.05 were considered significant. All analyses were performed using SPSS version 18.0 for Windows (SPSS Inc., Chicago, IL, USA) and MedCalc Statistical Software version 16.8.4 (MedCalc Software bvba, Ostend, Belgium).

3. Results

During the study period, the MET was activated for 2172 patients admitted to the gastroenterology wards. Our gastroenterology department cares for approximately 19800 admissions (adult patients) per year, so there were 14.2 MET activations/1000 admissions. Of these, 953 were excluded from analysis. Of the remaining 1219 patients, 751 (62%) were treated in the GWs and 468 (38%) were transferred to the ICU (see Supplementary material for details).

The baseline characteristics and clinical outcomes of the study patients are shown in Table 1. The percentage of patients with liver cirrhosis was significantly higher in the ICU than in the GW group. MET activation was triggered automatically using only EMR-based screening criteria for 57% in the GW group and 39% in the ICU group ($P < 0.001$). Regarding activation cause, patients in the ICU group were more likely

Table 1
Clinical characteristics of the study patients[a].

	Total (n = 1219)	General ward (n = 751)	ICU (n = 468)	*P*
Age	61 (50–70)	62 (52–71)	58 (47–68)	<0.001
Male gender	795 (65)	488 (65)	307 (66)	0.83
Comorbidity				
Diabetes	244 (20)	147 (20)	97 (21)	0.63
Chronic heart disease	296 (24)	190 (25)	106 (23)	0.29
Liver cirrhosis	541 (44)	297 (40)	244 (52)	<0.001
Chronic kidney disease	30 (3)	18 (2)	12 (3)	0.86
Malignancy	492 (40)	348 (46)	144 (31)	<0.001
Activation type				<0.001
EMR triggered	610 (50)	429 (57)	181 (39)	
Call triggered	609 (50)	322 (43)	287 (61)	
Activation cause				
Acute liver failure	183 (15)	45 (6)	138 (30)	<0.001
Severe sepsis/septic shock	414 (34)	285 (38)	129 (28)	<0.001
Hypovolemic shock	164 (14)	98 (13)	66 (14)	0.60
Respiratory insufficiency	329 (27)	171 (23)	158 (34)	<0.001
Vital signs				
Systolic blood pressure, mm Hg	108 (85–130)	105 (85–128)	115 (87–136)	<0.001
Heart rate, bpm	102 (85–120)	99 (82–116)	107 (91–123)	<0.001
Respiratory rate, bpm	22 (18–28)	20 (18–26)	24 (20–30)	<0.001
Temperature, °C	36.8 (36.4–37.7)	36.8 (36.5–37.8)	36.8 (36.4–37.5)	0.05
ACDU score	0 (0–2)	0 (0–0)	1 (0–3)	<0.001
SpO_2/FiO_2 ratio	338 (222–462)	400 (260–467)	314 (188–452)	<0.001
Modified early warning score	4 (3–5)	3 (2–5)	5 (3–6)	<0.001
Laboratory data				
Creatinine, mg/dL	1.0 (0.7–1.9)	0.9 (0.7–1.6)	1.3 (0.8–2.4)	<0.001
Total bilirubin, mg/dL	3.7 (1.5–11.1)	2.8 (1.1–7.5)	6.3 (2.1–22.0)	<0.001
Prothrombin time, INR	1.6 (1.3–2.1)	1.4 (1.2–1.8)	1.9 (1.4–2.6)	<0.001
Lactate, mmol/L	2.5 (1.6–4.6)	2.1 (1.4–3.6)	3.5 (1.9–6.1)	<0.001
Mortality				
14 day	217 (18)	58 (8)	159 (34)	<0.001
28 day	322 (26)	118 (16)	204 (44)	<0.001
60 day	431 (35)	185 (25)	246 (53)	<0.001

ICU = intensive care unit, EMR = electronic medical record, ACDU = alert/confused/drowsy/unresponsive, SpO_2 = peripheral oxygen saturation, FiO_2 = fraction of inspired oxygen, INR = international normalized ratio.

[a] Data are presented as median (interquartile range) or number (percentage) of patients.