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Validation of a modified Early Warning Score in medical admissions

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Summary

The Early Warning Score (EWS) is a simple physiological scoring system suitable for bedside application. The ability of a modified Early Warning Score (MEWS) to identify medical patients at risk of catastrophic deterioration in a busy clinical area was investigated. In a prospective cohort study, we applied MEWS to patients admitted to the 56-bed acute Medical Admissions Unit (MAU) of a District General Hospital (DGH). Data on 709 medical emergency admissions were collected during March 2000. Main outcome measures were death, intensive care unit (ICU) admission, high dependency unit (HDU) admission, cardiac arrest, survival and hospital discharge at 60 days. Scores of 5 or more were associated with increased risk of death (OR 5.4, 95%CI 2.8–10.7), ICU admission (OR 10.9, 95%CI 2.2–55.6) and HDU admission (OR 3.3, 95%CI 1.2–9.2). MEWS can be applied easily in a DGH medical admission unit, and identifies patients at risk of deterioration who require increased levels of care in the HDU or ICU. A clinical pathway could be created, using nurse practitioners and/or critical care physicians, to respond to high scores and intervene with appropriate changes in clinical management.

Introduction

Catastrophic deterioration of patients in hospital is frequently preceded by documented deterioration of physiological parameters.[1,2] Failure of clinical staff to respond to deterioration of respiratory or cerebral function and increase levels of medical intervention will put patients at risk of cardiorespiratory arrest.[3,4] Inappropriate action in response to observed abnormal physiological and biochemical variables might lead to avoidable death.[5] Suboptimal care prior to admission to a critical care unit can lead to increased mortality.[6]

Because of resource limitations, the number of patients that can be monitored and treated in intensive care units (ICUs) and high dependency units (HDUs) is restricted. The selection of patients who might benefit from critical care is therefore crucial. Identifying medical in-patients at risk of deterioration at an early stage by means of simple protocols based on physiological parameters may reduce the number of pre-ICU resuscitations.[7]

The Early Warning Score (EWS)[8] is a tool for bedside evaluation based on five physiological parameters: systolic blood pressure, pulse rate, respiratory rate, temperature and AVPU score. The ability of a modified EWS, including relative deviation from patients normal blood pressure and

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urine output, to identify surgical patients who would potentially benefit from intensive care has been recently demonstrated.[9] None of the existing physiological scoring systems has been validated in patients admitted on an unselected medical take.

The aims of this study were: (i) to evaluate the ability of a modified EWS (MEWS, Table 1) to identify medical patients at risk; and (ii) to examine the feasibility of MEWS as a screening tool to trigger early assessment and admission to an HDU or ICU.

Methods

Data were collected for all medical emergency admissions admitted to the Medical Admissions Unit (MAU) of a District General Hospital (DGH) during March 2000. Patients admitted directly to Coronary Care, Medical HDU or ICU, and patients re-admitted during the observation period were not included in this study.

After appropriate training, nursing staff collected data while performing routine duties. Demographic details, systolic blood pressure, pulse rate, temperature, respiratory rate and AVPU score (A for 'alert', V for 'reacting to vocal stimuli', P for 'reacting to pain', U for 'unconscious') were recorded on admission. Blood pressure and pulse rate were measured electronically (DINAMAP, Critikon) and checked manually where appropriate. The temperature was taken orally (Temp-PlusII, IVAC). The respiratory rate was counted over a full minute. AVPU scores were scored according to best response at time of blood pressure measurement. Nursing staff collected physiological parameters twice daily (once am and once pm) on a dedicated data collection sheet for up to 5 days. Completeness of data was checked daily at the bedside by two of the investigators (MK, CS).

The collected data were used to calculate a modified Early Warning Score (MEWS) (Table 1). It was decided from previous experience to define a MEWS of five or more as a 'critical score'. The highest score reached during admission was labelled 'ScoreMax'.

Primary endpoints were HDU admission, ICU admission, attendance of the cardiac arrest team at a cardiorespiratory emergency and death at 60 days.

HDU and ICU admission were at the discretion of the attending physicians, who were unaware of the MEWS of the patient.

Statistics were generated using SPSS (version 10.0). Relative risk ratios were calculated by using cross-tabulation of results. We regarded $p<0.05$ as statistically significant.

Results

During the observation period, data were collected from 709 admissions. Patients with incomplete epidemiological or discharge data were excluded. At least one complete set of physiological data during the first 24 h of admission, epidemiological data and discharge dates were available for 673 admissions. These were analysed further.

Overall, 45% of patients were male, and 55% were female. The mean age of patients was 63 years (SD 20, range 16–100).

During follow-up, seven patients were admitted to ICU, 23 to HDU, four were resuscitated by the cardiopulmonary arrest team and 56 patients died.

Physiological parameters on admission

Mean values for measured parameters on admission were as follows: blood pressure (systolic) 139 mmHg (SD 27 mmHg), pulse rate 86 bpm (SD 20 bpm), respiratory rate 20 bpm (SD 5 bpm), temperature 36.6 °C (SD 0.9 °C).

The majority of patients scored 0 on admission for blood pressure (91%), pulse rate (78%), temperature (95%) and AVPU score (92%). Median score for respiratory rate was 1 (55% of admissions).

Admission scores ranged from 0 to 9 (median of 1). The number of patients with critical scores

Table 1 Modified Early Warning Score

	3	2	1	0	1	2	3
Systolic Blood pressure (mmHg)	<70	71–80	81–100	101–199		⩾200	
Heart rate (bpm)		<40	41–50	51–100	101–110	111–129	⩾130
Respiratory rate (bpm)		<9		9–14	15–20	21–29	⩾30
Temperature (°C)		<35		35–38.4		⩾38.5	
AVPU score				**A**lert	Reacting to **V**oice	Reacting to **P**ain	**U**nresponsive

(>4) was greatest on the day of admission and gradually decreased over the period of stay from 7.1% on admission to 4.8% on Day 1, 3.9% on Day 2 and 1.8% on Day 3. In the 81 patients that stayed in the MAU for a minimum of 3 days, scores stayed unchanged for 42, deteriorated in 12 and improved in 28 patients. During the observation period the mean of the highest score reached was 2.29 (SD 1.51) (Figure 1).

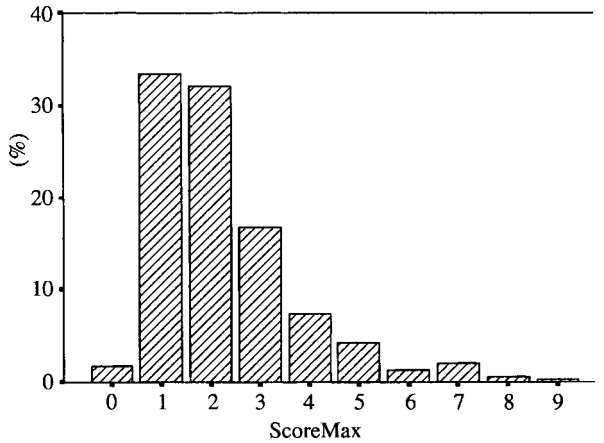

Figure 1. Distribution of maximum scores (ScoreMax) expressed as percentage of all ScoreMax.

Outcome

A ScoreMax of 5 or more was associated with an increased risk of death (OR 5.4, 95%CI 2.8–10.7), ICU admission (OR 10.9, 95%CI 2.2–55.6) and HDU admission (OR 3.3, 95%CI 1.2–9.2). Endpoints happened at a median of 4 days (0–45 days) after transfer from the MAU; 22 of the endpoints were reached while patients were in the MAU.

Endpoints were reached by 7.9% of patients with ScoreMax of 0–2, 12.7% of patients with a ScoreMax of 3–4 and 30% of patients with a ScoreMax of 5–9. Figure 2 shows the frequency of endpoints according to EWS on admission. Patients who reached predefined endpoints were significantly older and on admission had lower systolic blood pressure, higher pulse rate and a higher respiratory rate (Table 2).

Observations on admission and relative risk of reaching predefined endpoints

Whereas high EWS were associated with increased risk to reach endpoints, increased scores for single parameters did not always translate into an increased overall risk. Table 3 shows relative risk

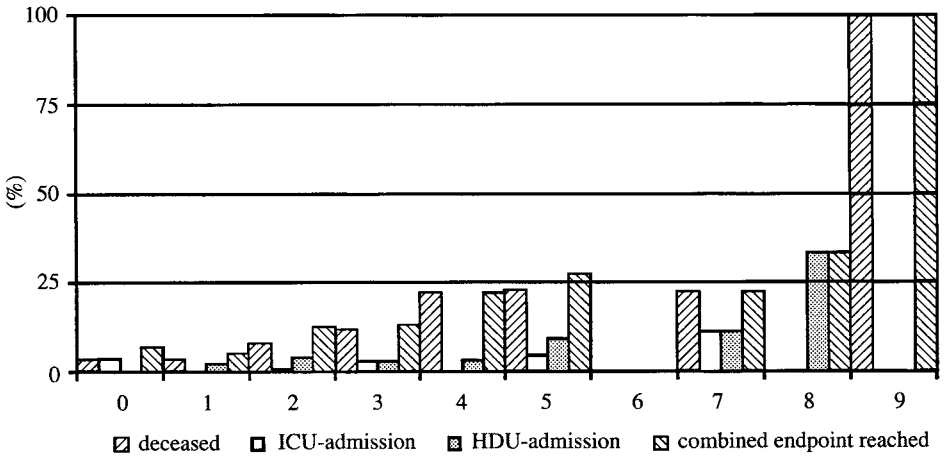

Figure 2. Frequency distribution of admission EWS (0-9) and clinical outcomes and combined outcome which aggregates death, cardiopulmonary resuscitation, HDU admission and ICU admission.

Table 2 Physiological parameters on admission of patients reaching or not reaching endpoints

	Endpoint not reached	Endpoint reached	*p*
n	598	75	
Age (years)	62 +/−20	74 +/−14	<0.0001
Systolic blood pressure (mmHg)	140 +/−30	127 +/−127	⩽0.0001
Pulse Rate (bpm)	86 +/−19	92 +/−23	⩽0.03
Respiratory Rate (bpm)	20 +/−4	23 +/−7	<0.002
Temperature (°C)	36.7 +/−0.9	36.5 +/−1	0.06

Data presented as means ± SD, *p* value for independent sample t-test.

Table 3 Relative risk ratios (RR) for patients with scores of 1,2 and 3 on admission, compared to patients with a score of 0

	3	2	1	0	1	2	3
Systolic blood pressure	<70	71–80	81–100	101–199		⩾200	
RR (95%CI)	8.6 (0.5–139)	5.7 (0.9–35)	2.1 (0.8–5.5)			0.5 (0.7–4.1)	
Heart rate		<40	41–50	51–100	101–110	111–129	⩾130
RR (95%CI)		NA	NA		1.6 (0.7–3.2)	1.5 (0.7–3.4)	3.0 (0.9– 9.5)
Respiratory rate		<9		9–14	15–20	21–29	⩾30
RR (95%CI)		NA			1.6 (0.4–7.2)	4.4 (1.0–19)	7.9 (1.5–42)
Temperature		<35		35–38.4	⩾38.5		
RR (95%CI)		5.9 (1.8–19)			0.9 (0.2–3.8)		
AVPU score				**A**lert	Reacting to **V**oice	Reacting to **P**ain	**U**nresponsive
RR (95%CI)					2.0 (0.9–4.8)	5.2 (1.5–18.1)	NA

NA, not applicable for scores with insufficient data.

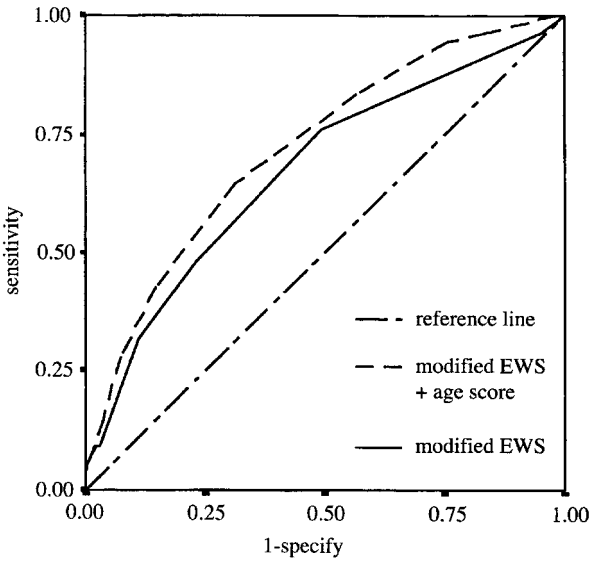

Figure 3. Receiver Operator Characteristic curves for modified EWS and modified EWS with age score (0 points for <50 years old, 2 points for 50–70 years old and 3 points for >70 years old).

ratios of increased scores, compared with a score of 0.

Systolic blood pressure scores were not associated with significantly increased risk to reach endpoints (Table 3). If the model for generating blood pressure scores was altered, endpoints were more frequently reached in patients with a systolic blood pressure of <100 mmHg than with 100–140 mmHg (OR 0.38, 95%CI 0.17–0.87). Incidents were even less frequent in patients with a systolic blood pressure of >140 mmHg (OR 0.49, 95%CI 0.28–0.86). Similarly, high scores related to raised temperature were not associated with increased risk but those related to low temperature were significant (Table 3).

Patients aged >70 years were significantly more at risk to reach endpoints than patients aged <50 years (OR 6.5, 95%CI 2.5–16.7). It is possible to analyse the effect of adding an age score to EWS by using Receiver Operator Characteristic curves. By adding an age score, the area under the curve increased from 0.67 to 0.72 for scores on admission and combined endpoints (Figure 3).

Discussion

The Modified Early Warning Score is best regarded as a defined judgement on routinely recorded physiological data. Using previously published scoring criteria,[8,9] this study has demonstrated that raised MEWS scores are associated with increased mortality in a group of medical emergency admissions. Calculation of the MEWS for emergency admissions might be useful in triage, to identify patients of highest risk of deterioration. Appropriate interventions could then be targeted upon a small number of patients among the 30–40 daily admissions within the unselected medical take.

Our study is limited by several factors. It is a single-centre study on a limited number of patients in a specific local setting. For technical reasons, we were unable to collect data for longer then 5 days. The majority of patients who were admitted to critical care areas or died will have had improvements and deteriorations following transfer out of the MAU. Physiological data leading up to those events would probably give additional information of the physiology prior to catastrophic events.

There are few previous data concerning other scoring systems and patients admitted via a general medical 'take'. The Acute Physiology and Chronic Health Evaluation (APACHE) II Score[10] and Mortality Prediction Model (MDM)[11] have only

been tested for subgroups of medical patients with acute renal and congestive heart failure.[12,13] The Simplified Acute Physiology Score (SAPS) was introduced in 1984 to estimate the risk of death for patients in intensive care,[14] and has since been improved[15] and tested in patients with myocardial infarction.[16–19] A reduced version (SAPS.R) has been shown to predict outcome accurately in ICU patients but has not been applied to general medical patients.[20]

None of the available scoring systems appears to be suitable for bedside assessment of ward patients in a routine fashion. MEWS is likely to present a more versatile tool in this context, since it simply collates the results of routinely collected variables.

Stenhouse[9] suggests use of a blood pressure score comparing actual blood pressure with previously measured pressures judged to be 'normal' for the patient. We felt that in the emergency situation, previous recordings would often not be available and that the calculation of the score would lose simplicity. Oxygen saturation is often recorded at the bedside, but can be misleading if reviewed outside the context of inspiratory oxygen concentration.

High scores were more likely to occur early during admission and falling MEWSs in most patients over time suggests beneficial effects of treatment. MEWS could therefore act as another method of assessing the efficiency of medical interventions.

We did not exclude patients with 'Do not attempt resuscitation' orders from the study, as we believe that a sensible discussion of possible outcomes with the patient and relatives should be part of the management of critically ill patients. MEWS might be helpful in identifying some of the patients in whom this discussion would be indicated.

Examination of the admission data demonstrates that the banding of values for each parameter as described from previous studies on surgical patients may not be generalizable to the patients admitted on an unselected reception. While the MEWS used in this study did identify some of the patients at increased risk, alterations in the scoring table (e.g. different blood pressure values, respiratory rate) might improve the fit of the score to clinical outcomes.

Case mix may be one important factor, and the score may be more predictive if different banding criteria are used for broad ranges of conditions e.g. respiratory disease, cardiac disease. Integration of the diagnosis into a scoring system might diminish the utility of the score by making it too complex.

To prioritize often scarce ICU resources, it would be valuable to identify patients who would benefit from ICU admission, as well as those whose ICU admission could be prevented by changes in management on the ward. As patients with critical scores (>4) in this study were at increased risk of catastrophic deterioration, MEWS might be a helpful screening tool to triage patients for intensified treatment on the ward or in HDU or ICU.

It remains to be seen whether identification of critically ill patients, selection of a higher level of care and consecutive changes in management affect outcome in this patient group.

In conclusion, the MEWS is a simple bedside tool that can be calculated by nursing staff in a busy clinical area. In the setting of the unselected medical 'take', it might help to identify some of those patients at risk of deterioration and need for more active intervention. A prospective multicentre study, expanding the case-mix in more detail, is needed to evaluate the effects of increased medical intervention in patients with a high MEWS.

Acknowledgements

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