Validation of a Modified Early Warning Score (MEWS) in emergency department observation ward patients

驗証「早期預警修正計分法」對急症室觀察病房病者使用的正確性

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Objective: The Modified Early Warning Score (MEWS) is a simple physiological scoring system, which can easily be applied at the bedside. The ability of MEWS to identify patients at risk of deterioration in a busy ward was investigated. *Method:* In a prospective cohort study, we applied MEWS to patients admitted to the 16-bed emergency department observation ward (EDOW) of a tertiary teaching hospital. *Results:* Data on 427 consecutive EDOW admissions were collected from 7 June to 4 July 2004. Main outcome measures were death, intensive care unit (ICU) admission and inpatient hospital admission. Scores of > 4 were associated with increased risk of death (OR 54.4, 95% CI = 4.7–633.7), ICU admission (OR 12.7, 95% CI = 1.1–147.3) and hospital admission (OR 9.5, 95% CI = 3.3–27.9). *Conclusion:* MEWS is suitable for bedside application in an EDOW setting and may help identify patients at risk of deterioration who require increased levels of care as hospital inpatients and in ICU. Where experienced staff is not available to closely monitor patients in an EDOW, the use of the MEWS system may aid close monitoring and identification of high-risk patients. (*Hong Kong j.emerg.med.* 2006;13:24-30)

目的：「早期預警修正計分法」是一個可容易地應用於臨床上，簡單的生理計分系統；旨在調查研究其對識別在繁忙病房內，有潛在病情惡化風險病者的能力。**方法：**這是前瞻、列隊性的研究，我們在一所高等教學醫院 16 張病床的急症室觀察病房內，對病者應用早期預警修正計分法。**結果：**由 2004 年 6 月 7 日至 7 月 4 日期間共收集得 427 份連續留駐急症室觀察病房的資料；主要結果量度包括死亡率、深切治療住院率及醫院住院率。得分 4 分以上的與下列各項均有關聯：增加死亡風險（機會率 54.4，95% 置信區間 4.7–633.7），入住深切治療部（機會率 12.7，95% 置信區間 1.1–147.3）及住院（機會率 9.5，95% 置信區間 3.3–27.9）。**總結：**早期預警修正計分法是適合臨床應用於急症室觀察病房的環境，它有助識別有病情惡化潛在風險而需要增加護理程度（例如住院或入住深切治療部）的病者。當急症室觀察病房缺乏資深職員密切監控觀察病者時，早期預警修正計分系統的使用可助緊密監察及識別高危病者。

Keywords: Hospital emergency service, observation, physiologic monitoring

關鍵詞：醫院急症服務、觀察、生理監控

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Introduction

The emergency department (ED) observation ward is the interface between ED care and hospital inpatient or intensive care unit (ICU) management in hospitals in Hong Kong. Because of resource limitations, the number of patients that can be monitored and treated in the ICU and as hospital inpatients is restricted. The identification of patients who might benefit from critical care is therefore crucial.

The Early Warning Score (EWS)[1] is a tool for bedside evaluation based on five physiological parameters: systolic blood pressure, pulse rate, respiratory rate, temperature and AVPU score (A for 'alert', V for 'responsive to verbal stimulation', P for 'responsive to painful stimulation', U for 'unresponsive').[2] The ability of a modified EWS, including relative deviation from patients' normal blood pressure and urine output, to identify surgical patients who would potentially benefit from intensive care, was demonstrated in 2000.[3] The Modified Early Warning Score (MEWS) was validated in medical admissions in 2001.[4] An increasing MEWS score was shown to be associated with worse outcome across a range of specialties, including medicine, surgery and orthopaedics.[5] However, MEWS has not been validated in a heterogeneous group of patients admitted to an ED observation ward (EDOW).

The aims of this study were: (i) to evaluate the ability of MEWS (Appendix) to identify patients at risk; and (ii) to examine the feasibility of MEWS as a screening tool to trigger early assessment and inpatient admission to the hospital or ICU.

Methods

This single-centre, prospective cohort study was conducted in the 16-bed EDOW of a university teaching hospital in the New Territories of Hong Kong from 7 June to 4 July 2004.

After appropriate training, nursing staff collected data while performing routine duties. The following physiological parameters were recorded on admission: systolic blood pressure, pulse rate, temperature, respiratory rate and either AVPU score or Glasgow Coma Scale (GCS).[6] Blood pressure and pulse rate were measured electronically (Press-mate BP 8800, Colin Electronics, Japan) and checked manually where appropriate. The tympanic temperature was recorded (ThermoScan, Type 6014, Braun, Germany). The respiratory rate was counted over a full minute. AVPU or GCS scores were recorded according to the best response at the time of blood pressure measurement. Nursing staff collected the physiological parameters four times daily (7 am, 11 am, 3 pm and 7 pm) on a dedicated data collection sheet. Completeness of data was checked daily at the bedside by the authors.

The collected data were used to calculate the Modified Early Warning Score (MEWS). A 'critical score' was defined as a MEWS > 4. The highest score reached during EDOW admission was defined as 'ScoreMax'. Primary endpoints were hospital admission to an inpatient ward, ICU admission and death at 30 days. Hospital admission and ICU admission were at the discretion of specialist emergency physicians in the EDOW, who were unaware of the MEWS of the patients.

Statistical analysis was performed using StatView and MedCalc software. The patients eventually admitted to the hospital were compared to those not admitted with regard to their initial physiological parameters by t-tests. We regarded $p < 0.05$ as statistically significant. Receiver operating characteristic (ROC) curves were generated to identify the performance of each MEWS criterion.

Results

In total, 427 patients were admitted consecutively to the EDOW during the study period. Two patients with incomplete epidemiological or discharge data were excluded, leaving 425 (mean age 59 years; SD = 20; range, 15–95; 55% female). Table 1 shows that a heterogeneous group of patients was admitted during the observation period but over 60% had primarily cardiac or gastrointestinal symptoms, or dizziness.

Subsequently 94 patients, already admitted to the EDOW, were assessed by specialist emergency physicians as 'high risk', and were therefore admitted formally to inpatient wards. The specialists had no knowledge of the MEWS at the time. Of these 94 patients, 91 were admitted to the medical ward as 'inpatients' (of whom two died), and three patients were admitted to ICU. MEWS scores in patients admitted to the EDOW ranged from 0–5, median of 1 (Figure 1). Eleven patients had critical scores (> 4) on initial admission while another six patients developed critical scores after admission to the EDOW (Figure 2).

Table 1. Summary of the patients

Variables	n = 425
Age	59 ± 20 years
Sex	Male: 191 (45%); Female: 234 (55%)
System (emergency department diagnosis or complaints)	
Allergic reaction (Angioedema and anaphylaxis)	14 (3%)
Cardiac (Chest pain, palpitation, atrial fibrillation, supraventricular tachycardia and congestive heart failure)	98 (23%)
Dizziness	78 (18%)
Gastrointestinal (Gastroenteritis, abdominal pain, hepatitis and gastrointestinal bleeding)	87 (20%)
Hyper/hypoglycaemia	11 (3%)
Hypertension	13 (3%)
Neurological (Headache, convulsion and stroke)	19 (5%)
Others (Gout, cellulitis, hypokalemia, heat exhaustion and snake bite)	38 (9%)
Respiratory (Asthma, chronic obstructive pulmonary disease and hyperventilation)	34 (8%)
Trauma (Head injury, sprained back and other minor blunt injuries)	33 (8%)
Observation:	
Systolic blood pressure (mmHg)	132 ± 26
Heart rate (bpm)	75 ± 15
Respiratory rate (bpm)	18 ± 2
Temperature (°C)	36.6 ± 0.6
Glasgow Coma Scale score	15 ± 0
Overall ScoreMax	2.3 ± 1.0

Data presented as mean ± SD

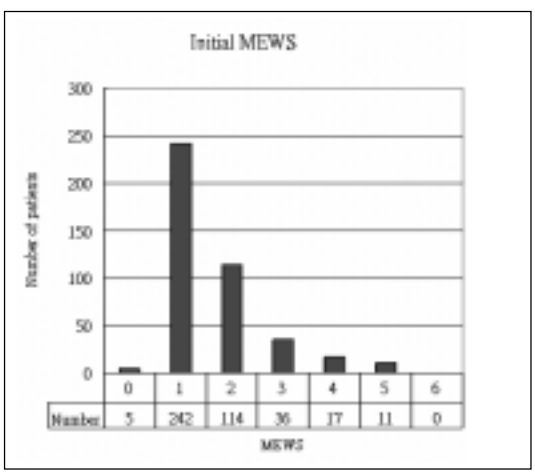

Figure 1. Distribution of initial Modified Early Warning Score (MEWS).

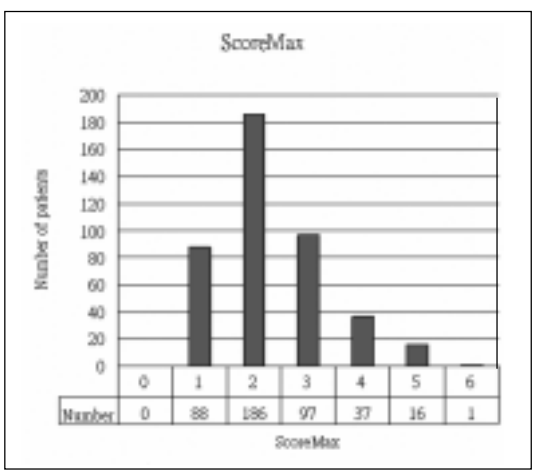

Figure 2. Distribution of maximum scores (ScoreMax).

A ScoreMax > 4 was associated with an increased risk of death (OR 54.4, 95% CI = 4.7–633.7), ICU admission (OR 12.7, 95% CI = 1.1–147.3) and inpatient hospital admission (OR 9.5, 95% CI 3.3–27.9).

Patients admitted formally to inpatient wards were older and had a higher respiratory rate (Table 2). There were no significant differences with respect to systolic blood pressure, heart rate and temperature.

ROC curves of different physiological parameters and ScoreMax were compared for predicting serious outcome defined as 'death and/or ICU admission' (Figure 3). The area under the curve was highest for ScoreMax with a value of 0.96 (Table 3). ROC curves were also compared for hospital admission (Figure 4). The area under the curve was highest for respiratory rate with a value of 0.77 (Table 3).

The sensitivity and specificity of ScoreMax for death or ICU admission were calculated using a ROC curve of ScoreMax and serious outcome (death/ICU). Criteria > 3 performed best, yielding a sensitivity of 100% (95% CI = 48–100%) and a specificity of 88% (95% CI = 85–91%). Using criteria of > 4 yielded a sensitivity of 60% (95% CI = 15–94%) and specificity of 97% (95% CI = 95–98%).

Discussion

The Modified Early Warning Score is best regarded as a defined judgement on routinely recorded physiological data. Using previously published scoring criteria,[1,3,4] this study has demonstrated that a raised MEWS was associated with increased mortality in a group of EDOW admissions. Calculation of the MEWS for EDOW admissions might be useful to

Table 2. Physiological parameters on admission of patients requiring or not requiring admission to hospital

	No admission	Admission	p-value
Number	331	94	
Age (years)	57 ± 20	64 ± 18	0.005
Systolic BP (mmHg)	139 ± 28	140 ± 28	0.76
Pulse rate (bpm)	81 ± 17	83 ± 18	0.32
Respiratory rate (bpm)	18 ± 2	20 ± 3	< 0.0001
Temperature (Celsius)	36.6 ± 0.6	36.8 ± 0.9	0.12

Data presented as mean ± SD, p-value for independent samples t-test

Table 3. Area under ROC curve of each parameter

Parameter	Serious outcome	Admission
ScoreMax	0.96	0.73
Respiratory rate	0.91	0.77
Heart rate	0.89	0.55
Temperature	0.79	0.51
Systolic blood pressure	0.61	0.51
Glasgow Coma Scale	0.50	0.50

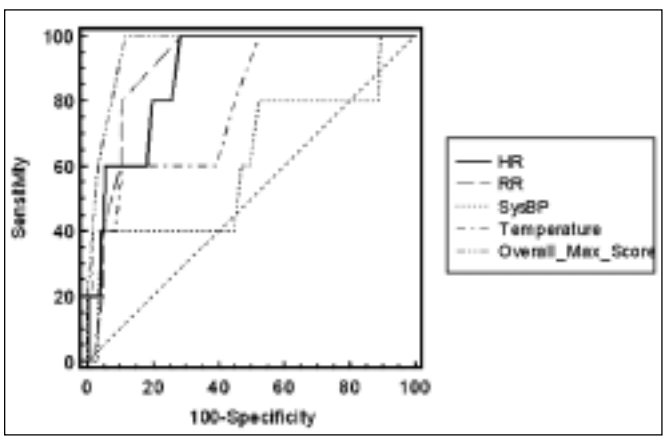

Figure 3. ROC curves for serious outcome (death/ICU admission).

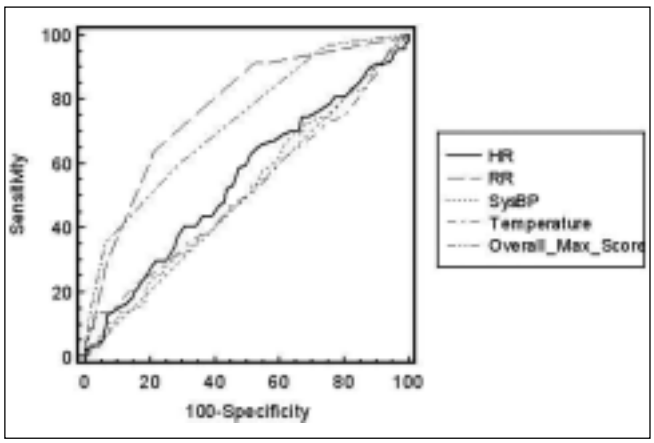

Figure 4. ROC curves for hospital admission.

identify patients at highest risk of deterioration. Appropriate interventions could then be targeted upon a small number of at-risk patients among the 10-20 daily EDOW admissions.

Subbe suggested that case mix might be one important factor.[4] Application of MEWS in the EDOW demonstrated that it was useful in a heterogeneous group of patients.

To prioritise scarce hospital resources, it would be valuable to identify patients who would benefit from inpatient hospital or ICU admission, as well as those whose inpatient or ICU admission could be prevented by changes of management in the EDOW. 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 in a hospital ward or ICU rather than in an EDOW.

By comparing MEWS to predict inpatient hospital admission and death or ICU admission, it was found that MEWS was more sensitive and specific in predicting death or ICU admission over hospital ward admission. MEWS is thus more useful with serious patients.

Previous work showed no benefit of introducing a MEWS system on clinical outcomes, cardiopulmonary arrests and ICU utilisation in acute medical admissions.[7] It may be useful to devise a protocol in the EDOW with standardised response to abnormal values, and investigate the effect afterwards. Although we had used a critical score > 4 in this study to calculate odds ratios, we demonstrated that scores > 3 were more sensitive in predicting serious outcome. This exploratory study sought to identify the trigger score for adverse outcomes, which was found to be MEWS > 3. This criterion should be the trigger score for immediate specialist emergency physician review when MEWS is clinically implemented. Future studies may help to identify and confirm the most appropriate cut-off score for different at-risk populations.

Respiratory rate was demonstrated to be the best discriminating physiological parameter to predict serious outcome (death or ICU admission). Respiratory rate is less commonly documented compared to blood pressure, heart rate, GCS and temperature during routine observation. Although taking the respiratory rate is more labour-intensive than the automated techniques of measuring blood pressure, heart rate and temperature, it is a recommended parameter for routine observations. The long-term beneficial effect of introducing the MEWS system on respiratory rate recording in general wards has recently been demonstrated.[8]

Unlike previous studies, GCS was not a predictor in our study. This was most likely due to the fact that patients with decreased GCS would not be admitted to our EDOW. Unlike some Western societies where excessive alcohol ingestion is a major problem, such alcohol consumption is rare in our setting, and the few patients who present with alcohol-related decreased GCS are observed close to the resuscitation room rather than the EDOW.

Figure 3 shows that although respiratory rate was the best individual predictor among the parameters measured, the MEWS performed best overall. In addition, although the difference in mean respiratory rate was statistically significant, clinically the difference

was not as great (20 vs. 18 bpm) and therefore respiratory rate might not be suitable as a sole indicator of serious illness.

Our study was limited by several factors. It was a single-centre study on a limited number of patients in a specific local setting. The majority of patients who were admitted as inpatients to the hospital or ICU, or those who died, would have had improvements and deteriorations following transfer out of the EDOW. MEWS-type data leading up to those events would probably give additional information regarding physiology prior to catastrophic events. Moreover, around one-third of the EDOW daily admissions occurred between 7 pm and 7 am (n = 5) and this group was at higher risk of unnoticed deterioration if MEWS was not calculated during that period. If MEWS were to be implemented generally in clinical practice, further observation would need to be done at 11 pm and 3 am to ensure patient monitoring was optimal.

The implementation of MEWS was acceptable to the nursing staff, although thought to be more labour intensive and complex than recording simple observations. Some nursing staff members were not convinced that MEWS was an improvement on their clinical judgement and experience. As patients in the study were not randomised to two groups – those evaluated by MEWS and those evaluated by clinical judgement alone – it is not possible to say to what extent implementing MEWS will improve patient surveillance and decision-making.

Future studies may include oxygen saturation (SpO_2) as one of the physiological parameters to see if it behaves similar to respiratory rate as a potential discriminator to identify patients at risk. It may also be useful to evaluate MEWS for patients in the emergency department 'majors' area which has a distinct population from that observed in the EDOW.

Conclusion

The MEWS is able to identify patients at risk and is feasible as a screening tool in the setting of unselected EDOW admissions to trigger early assessment and inpatient admission to the hospital or ICU.

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Appendix. Modified Early Warning Score

MEWS	+3	+2	+1	0	+1	+2	+3
Systolic blood pressure	< 70	70–80	81–100	101–199		≥ 200	
Heart rate		< 40	41–50	51–100	101–110	111–130	> 130
Respiratory rate		< 9		9–14	15–20	21–29	≥ 30
Temperature		< 35	35.1–36	36.1–38	38.1–38.5	>38.5	
AVPU/GCS score	< 9	9–13	14	A/15	V/Confused	P	U

The score is calculated by measuring the five parameters as above and adding together the assigned score for each physiological value.

AVPU = Alert, Verbal, Pain, Unresponsive; GCS = Glasgow Coma Scale

References

1. Morgan RJM, Williams F, Wright MM. An Early Warning Scoring System for detecting developing critical illness. Clin Intens Care 1997;8:100.
2. American College of Surgeons Committee on Trauma. Advanced Trauma Life Support Course for Physicians. Chicago, IL: American College of Surgeons; 1993.
3. Stenhouse C, Coates S, Tivey M, Allsop P, Parker T. Prospective evaluation of a modified Early Warning Score to aid detection of patients developing critical illness on a surgical ward. Br J Anaesth 2000;84:663.
4. Subbe CP, Kruger M, Rutherford P, Gemmel L. Validation of a modified Early Warning Score in medical admissions. QJM 2001;94:521–6.
5. Quarterman CP, Thomas AN, McKenna M, McNamee R. Use of a patient information system to audit the introduction of modified early warning scoring. J Eval Clin Pract 2005;11(2):133–8.
6. Teasdale G, Jennett B. Assessment of coma and impaired consciousness. A practical scale. Lancet 1974;2:81–4.
7. Subbe CP, Davies RG, Williams E, Rutherford P, Gemmel L. Effect of introducing the Modified Early Warning Score on clinical outcomes, cardio-pulmonary arrests and intensive care utilisation in acute medical admissions. Anaesthesia 2003,58(8):797–802.
8. McBride J, Knight D, Piper J, Smith GB. Long-term effect of introducing an early warning score on respiratory rate charting on general wards. Resuscitation 2005;65:41–4.