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INVITED REVIEW

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Does earlier detection of critically ill patients on surgical wards lead to better outcomes?

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ABSTRACT

INTRODUCTION Patients at risk of catastrophic deterioration are often identified too late. Delayed identification of sick patients and delayed referral to intensive care units might be associated with poor outcomes. The goal of the review is to assess the potential impact of systems that enable early detection of critically ill surgical patients.

MATERIALS AND METHODS A Medline search was performed in September 2004. Other articles were identified using the bibliographies of papers found through Medline. All interventional trials reviewing the effect of Critical Care Outreach and Medical Emergency Teams were reviewed.

RESULTS There is evidence that simple algorithms based on bedside observations can identify a large proportion of sick patients on general wards. Non-randomised studies have shown mixed results on impact of these interventions on mortality, cardiopulmonary arrests and intensive care admissions. The majority of studies do not specifically address surgical patients. A ward-based randomised trial from the UK seems to suggest improved mortality following the introduction of a Critical Care Outreach service with an Early Warning Score.

DISCUSSION AND CONCLUSION The literature about Critical Care Outreach and Medical Emergency teams is characterised by methodological weaknesses. However there is a common suggestion that early detection might improve outcome of critically ill surgical patients.

KEYWORDS
Critical care/standards – Postoperative complication/prevention and control – Mortality – Risk assessment – Severity of illness index

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Delayed recognition of critically ill patients is a significant contributor to mortality and morbidity in patients on general surgical wards. Delayed recognition of critical illness in the peri-operative phase contributes to potentially avoidable intensive care admissions and preventable cardiopulmonary arrests.

In order to improve the recognition of patients at risk of catastrophic deterioration, a structured approach to evaluation of bedside observations of patients on general wards has been suggested.

Two hypotheses have contributed to this development:

1. *Critically ill patients have a better prognosis if appropriate treatment is commenced early on during the course of their illness.*
   - > Trauma patients treated according to Advanced Trauma Life Support guidelines have an improved chance of survival because the algorithms used allow the identification and treatment of life-threatening injuries within minutes of the event.[1,2]
   - > Elderly patients admitted with pneumonia have a 15% reduction in mortality if antibiotics are given within 8 h of hospital admission.[3]
   - > Patients with severe sepsis or septic shock have improved survival if their treatment is initiated within 4 h of hospital admission and follows protocols of fluid resuscitation and inotropic support.[4]
2. *Systematic reviews have shown, that the majority of cardiac arrests in hospital are preceded by significant physiological abnormalities.[11–13] These deranged parameters are usually documented but not acted upon. Resulting inappropriate and delayed treatment prior to intensive care admission leads to increased mortality. Deficiencies in medical staff training contribute to this problem.*

Table 1 Criteria for initiation of medical emergency team call

Staff member is worried about the patient
Acute changes in heart rate to <40 or >130 beats/min
Acute change in systolic blood pressure to <90 mmHg
Acute change in respiratory rate to <8 or >30 breaths/min
Acute change in pulse oximetry saturation to <90% despite oxygen administration
Acute change in conscious state
Acute change in urine output to <50 ml in 4 h

After Bellomo *et al.*[31]

The suggested systems of physiological assessments fall into two groups.

Medical Emergency Teams

In Australia, the concept of the Medical Emergency Teams (METs) has been developed.[5] The MET usually consists of a doctor and a senior nurse from intensive care, sometimes joined by a medical doctor. They respond to call-outs from any staff outside the intensive care unit. Call out is triggered mainly by abnormal physiological parameters (Table 1). Part of the MET intervention can be the reporting of medical errors.[6]

Critical Care Outreach

Partly as a response to the MET, in the UK the concept of Critical Care Outreach was introduced.[7] In most hospitals, the outreach service is performed by senior nurses from intensive care. To initiate a call-out bedside observations are scored using modifications of an Early Warning Score (EWS;, Table 2). The Early Warning Score is a weighted assessment based on the main bedside observations – blood pressure (usually systolic), pulse rate, respiratory rate, temperature and level of consciousness. Modifications have included relative drop in blood pressure from a predefined 'normal' pressure, oxygen saturations, urine output per hour, age and pain. While EWS can help to trigger an outreach team call-out, it can also be used to track a patient's deterioration or improvement in response to treatment. EWSs have been described as 'physiological track and trigger systems'.[8]

The goal of this review is to summarise the relevant literature in order to give practising surgeons an overview of available service models and their expected impact on perioperative care and clinical outcomes.

Materials and Methods

Literature was reviewed in September 2004 using Medline, intensive care journals and abstract collections from meetings relevant for intensive care medicine.

The following terms were used for the Medline search alone or in combinations: patient care team, critical care, severity of illness index, heart arrest, risk assessment and critical illness. All articles reporting interventional trials of critical care outreach, Early Warning Scores or Medical Emergency Teams were reviewed. All interventional studies were examined for information on outcomes of surgical patients.

No formal meta-analysis was performed on the articles identified because of heterogeneity of patient groups examined, interventions and measured outcomes.

Results

Evidence for predictive value of physiological abnormalities

CARDIAC ARRESTS

The literature suggests that the majority of cardiac arrests are preceded by significant and recorded physiological abnormalities. The majority of cardiac arrests follow

Table 2 Chart to calculate a 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 (beats/min)		≤ 40	41–50	51–100	101–110	111–129	≥ 130
Respiratory rate (breaths/min)		≤ 9		9–14	15–20	21–29	≥ 30
Temperature (°C)		≤ 35		35–38.4		≥ 38.5	
AVPU score				Alert	Reacting to Voice	Reacting to Pain	Unresponsive

After Subbe C *et al.*[20]

changes in blood pressure, pulse rate but more importantly respiratory and mental function. This seems to be true for data from British,[9] Australian[10] and American studies.[11–13]

INTENSIVE CARE

While abnormalities of physiology preceding admission to intensive care have not been described to the same extent, there seems to be agreement in the literature that delay in the recognition of severe illness affects patients' outcome.[14,15]

Surgical patients referred to a British intensive care unit (ICU) had significant physiological abnormalities that would have triggered an Early Warning Score for a mean of 12 h (range, 2–23 h) prior to being referred to medical staff. Physiological abnormalities were documented for a mean of 27 h (range, 1–368 h) prior to referral to the intensive care team.[16]

McQuillan *et al.*[14] analysed records of 100 medical and surgical patients admitted to two ICUs. In cases where two reviewers agreed that care prior to admission to ICU had been suboptimal, mortality to hospital discharge was nearly doubled.[14]

Stenhouse *et al.*[17] analysed data on medical and surgical patients from the British Intensive Care data base, ICNARC. They found that patients with similar pathology and pathophysiology who were admitted later in the course of their hospital admission had worse outcomes then those who were admitted within 24 h of admission.

The outcome of patients who fit objective ICU admission criteria but are hospitalised in regular wards has been assessed in a study of patients from five acute care Israeli hospitals. Admission to intensive care was associated with a survival advantage only for the first 3 days of admission after adjusting for age and severity of illness using amongst other parameters the Acute Physiology Score (APS).[18]

Validation of track and trigger systems

EARLY WARNING SCORES

Early Warning Scores were first published by Morgan *et al.*[19] as a means to identify deteriorating patients on surgical wards (personal communication). The system resulted from the review of notes of patients admitted to intensive care. Subsequently, a modified Early Warning Score has been validated as a means to quantify the relative risk of patients suffering cardiac arrests, death or admission to critical care areas in acute medical admissions.[20]

Similar data in surgical patients have been published in abstract form.[21] Scoring models based on bed-side observations achieve high sensitivity and specificity for identification of at-risk patients.

MET criteria

The authors are not aware of any study quantifying the sensitivity and specificity of MET criteria for identification of patients requiring admission to ICU or suffering from cardiopulmonary arrests.

Interventional studies

BRITISH STUDIES

A range of studies has evaluated the impact of introducing early warning scores. The studies tend to evaluate Early Warning Scores as part of a care package including the introduction of critical care outreach with senior staff from intensive care reviewing patients flagged up by scoring models.

Leary *et al.*[22] found no changes in re-admission rates or length of stay on general wards after introducing a critical care outreach team on medical and surgical wards. The study compared two 12-month periods before and after introduction of an outreach service.

Ball *et al.*[23] found a reduction in re-admissions to ICU and mortality following admission to ICU after introduction of a critical care outreach team on medical and surgical wards. They used criteria similar to the MET criteria. The study design was a pragmatic before- and after-study of medical and surgical patients with no adjustment for severity of illness. The intervention group had a lower predicted mortality, contained less medical patients and stayed on average longer in ICU than the control group.

Pittard[24] found a reduction of emergency admission to ICU following the introduction of a modified EWS on two surgical wards with reduced mortality in these patients from 28.6% to 23.5%. The intervention included a system of escalation for call-out of medical staff: if the most junior member of the patients team did not respond within a predefined time-frame, the next more senior member could be alerted and so on up to consultant level. Depending on the severity of the initial physiological abnormality of patients, more or less senior members of the medical team were to be alerted as first responders.

Subbe *et al.*[25] found no change in mortality, cardiopulmonary arrests and intensive care admissions after introducing a modified EWS on a medical admissions unit.

The most detailed study to date is a ward-randomised trial of phased introduction of critical care outreach in a district general hospital.[26] Mortality and length of stay for patients admitted to these wards was compared with outcomes before and after introduction of outreach and with outcomes in matched wards at the same time. Mortality was 159 of 3269 (4.9%) patients in the outreach intervention group and 204 of 2963 (6.9%) patients in the control group. After adjusting severity of illness by using the Simplified Acute Physiology Score II (SAPS II)[27] death probability estimate, overall in-hospital mortality was significantly reduced in the outreach group (two-level odds ratio, 0.52; 95% CI, 0.32–0.85). Surgical and medical patients were analysed together.

Abstracts have suggested lower APACHE II scores for ICU admissions of surgical patients from wards using a modified EWS.[15]

AUSTRALIAN STUDIES

There are several interventional studies examining the effects of introducing a MET.

A study by Bristow *et al.*[28] compared adverse events in two hospitals without a MET with one hospital with a MET. Adverse events were ICU and High Dependency Unit (ICU/HDU) unanticipated admission, cardiac arrest, death, and deaths without a prior 'do not resuscitate' (DNR) order. The study used ICD-9 codes to adjust for diagnostic categories. While hospital mortality was similar in all hospitals, the rate of unanticipated intensive care admissions in the hospital with a MET was lower then in the two other hospitals.

The study by Buist *et al.*[29] compared the incidence of, and mortality from, cardiopulmonary arrests before and after introduction of a MET in a tertiary referral teaching hospital. The authors found a significant reduction in the incidence of cardiopulmonary arrests from 3.77 to 2.05 per 1000 admissions. This study has been criticised because the reduction in cardiopulmonary arrests seemed to proceed the introduction of the MET in a graphic published as part of the paper.

A group from Melbourne reported results of the introduction of MET on surgical and medical wards in a tertiary referral hospital, in two separate papers.[30,31] Excluding a 2-month training period, two 4-month periods before and after MET were compared. In medical patients, a reduction of the number of cardiopulmonary arrests during the 4-month periods from 63 to 22 was observed . The number of bed-days in ICU taken up by post-arrest patients was also reduced from 166 to 33 days. Overall mortality in the whole patient group was reduced by 26% (302 of 21,090 patients before intervention versus 222 of 20921 patients after intervention). In surgical patients, a more detailed analysis showed a dramatic reduction of adverse events after introduction of a MET. The authors examined patients with major surgery. For the purpose of this study, major surgery was defined as surgery requiring more then 48 h of hospital stay. The list of adverse outcomes included acute myocardial infarction, pulmonary embolism, acute pulmonary oedema, respiratory failure, stroke, severe sepsis, acute renal failure, emergency admission to ICU, and death. The 4-month control period was compared with the 4-month intervention period. A reduction from 301 adverse outcomes to 127 adverse outcomes per 1000 surgical admissions was observed. Emergency ICU admissions were reduced from 89 to 48 (*i.e.* by 44%). The number of in-patient deaths was reduced from 73 to 45 deaths. Mean duration of hospital stay was reduced from 23.8 to 19.8 days. Results were, however, not adjusted for severity of illness or seasonal variations.

A more recent study[32] examined adverse events in surgical patients following ICU. The patients had major vascular, orthopaedic or colorectal surgery. During the intervention phase, a specialist nurse reviewed patients for 3 days following their discharge from ICU on weekdays only. The study showed a reduction of serious adverse events in the first 3 days following ICU from 19 to 11 events per 100 patients. Sepsis, new significant renal impairment and the need to return to operating theatre decreased during the intervention phase, use of troponin I and detection of acute myocardial infarctions increased. While the reduction in adverse events was statistically significant, the mechanism for the reduction in some of the events is not clear and the study was not powered to detect differences in mortality. Interestingly, the results were achieved despite the established presence of a medical emergency team in the same hospital, which received an increased number of call-outs during the intervention phase (25 versus 17 per 100 patients).[32]

The Medical Early Response Intervention and Therapy Study (MERIT) randomised 23 hospitals to MET versus no MET and examined the incidence of unanticipated ICU admissions, cardiac arrests and deaths. Preliminary analysis suggests no significant result with a trend towards favourable outcomes in the MET hospitals, especially in those performing poorly prior to the intervention. The negative outcome seems to be explained by poor compliance with MET call-out criteria (Intensive Care Society State of the Art Meeting 2004, communication Prof. Hillman). Formal publication of the results is awaited.[33]

AMERICAN STUDIES

One interventional study[34] using the MET teams has been published by a team from Pittsburgh. Over a 6.8-year period (5 years pre-MET and 1.8 year post-MET), a reduction of cardiac arrests per 1000 admissions from 6.5 to 5.4 was observed. This result was statistically significant and coincided with a gradual increase in the number of MET responses from 13.7 to 25.8 per 1000 admissions.[34]

Discussion

Evidence for predictive value of physiological abnormalities

There appears to be good evidence for the predictive value of physiological abnormalities. It is of particular concern that respiratory distress and disturbed mental function seem to be of particular importance, as these are often not routinely assessed (or recorded).

Validation of track and trigger systems

Whilst the MET criteria identify a significant number of patients at risk, they have two disadvantages. They do not acknowledge that the majority of patients develop mild abnormalities in several parameters before reaching the threshold for a single parameter. Furthermore, they do not allow monitoring ('tracking') of the deterioration and feedback the improvement in response to treatment.

Published data on Early Warning Scores used different scoring models and there is, to date, little data to compare

Table 3 Sensitivity and specificity of different scoring models in acute medical admissions

MET/outreach triggered on admission	MET criteria	MEWS	ASSIST
Sensitivity	21%	20%	28%
Specificity	95%	94%	92%
Accuracy	86%	85%	84%

Unpublished data. MEWS, modified Early Warning Score;[20] ASSIST, Assessment Score for Sick Patients Identification and Step-up in Treatment.[37]

the sensitivity and specificity of different systems over a broad range of medical and surgical specialties (Table 3). Most hospitals would consider the introduction of a single system across all specialities. This could potentially lead to considerable differences of sensitivity and specificity across different specialties and, depending on the scoring system used, to very different call-out rates to emergencies in medical or surgical wards.

Interventional studies

Unfortunately, some of the studies reviewed did not focus exclusively on surgical patients (Table 4). This limits the conclusions that can be drawn.

Two studies have examined the effect of METs on cardiopulmonary arrests in detail.[29,30] In both studies, there was little evidence that improvement resulted from early identification of critically ill patients. It is possible that improved identification of patients at-risk led to a more pro-active discussion of 'Do-Not-Attempt-Resuscitation' orders.

All studies have been criticised for methodological flaws and detailed analysis of a randomised controlled trial

Table 4 Interventional studies of critical care outreach and medical emergency team

Authors	Control group (*n*)	Intervention group (*n*)	Outcomes	Results	Significance
Buist *et al.*[29]	19,317	22,847	Cardiac arrests Unplanned ICU admissions	–50% +58%	P <0.001 NA
Subbe *et al.*[20]	659	1695	Cardiac arrests ICU admissions Death	+1% +1% +2%	NS NS NS
Pittard[24]	NA	NA	Unplanned ICU admissions	–26%	*P* <0.05
Leary & Ridley[22]	NA	NA	ICU re-admissions	+4%	NS
Ball *et al.*[23]	NA	NA	ICU re-admissions Hospital mortality of ICU patients	–6% –7%	NA NA
Bellomo *et al.*[30]	21,090	20,921	Cardiac arrests Mortality	–65% –26%	*P* <0.001 *P* <0.004
Bellomo *et al.*[31]	1116	1067	Adverse outcomes Postoperative death Length of hospital stay	–58% –37% –8%	*P* <0.0001 *P* <0.0178 *P* <0.0092
Priestley *et al.*[26]	3090	3269	In-hospital mortality Hospital length of stay	–52% 0*	NA NA
DeVita *et al.*[34]	143,776	55,248	Cardiac arrests per 1000 patients	–17%	*P* <0.0001

NA, not available; NS, not significant.

n relates to the group of patients relevant for the intervention (*i.e.* patients on the wards, not in ICU).

Results compares outcomes pre-outreach to outcomes post-outreach: [(pre-outreach – post-outreach)/pre-outreach] x 100.

[a]Several analysis of length of stay in this study showed different results. The impact on length of hospital stay was thought to be inconclusive.

(MERIT study) is currently awaited. The impact of Early Warning Scores (and outreach teams responding to abnormal Early Warning Scores) has been examined in single-centre studies only. The majority focused on intensive care admissions rather then the overall care given to critically ill patients on surgical wards. The absence of documented benefit in some of the studies is due to the small number of patients and partly due to the nature of critical illness. Whilst the majority of patients deteriorate over a period of time, 20–40% will deteriorate suddenly and without sufficient advance warning (authors' unpublished data). Patients with acute coronary syndrome causing sudden arrhythmias will deteriorate very rapidly and outside the time-frame of routine observations.

An unspecified number of patients identified by EWS will also suffer from conditions not correctable by treatment. However, early identification might allow open discussion with patients and relatives regarding end-of-life decisions. This would enable these patients to spend their last hours amongst friends and family rather than with the inappropriate call-out of the cardiac arrest team.

Financial aspects of care

The majority of studies did not explicitly review the cost of care before and after intervention. Funding for Critical Care Outreach or MET teams has to be offset against a reduction of ICU bed utilisation, reduction in length of hospital stay and potential increases in patient turn-over in ICUs and on the wards.

Conclusions

Studies contributing to this review have come from the US, Australia and the UK. This suggests that the underlying problems do not depend on the system of health care delivery or the level of funding but on more basic problems of organisation and training.

Physiological data seem to suggest that deterioration of patients on general wards is predictable on the basis of a structured analysis of physiological bed-side observations.

The translation of the benefits of early detection into early intervention and improved prognosis of surgical patients is less clear. They depend on a consistent response to abnormal parameters. Considering that it is often the most junior member of the team that is called to assess patients with significant abnormalities, training of junior doctors will have to be central for the success of any track and trigger system. Several courses aimed at junior doctors address this issue: ALERT (Acute Life threatening Events Recognition and Treatment) is a 1-day course aimed at junior doctors and nurses dealing with emergencies on the wards. CCRISP (Care of the Critically Ill Surgical Patient) is a 2-day course aimed at surgical senior house officers.

Isolated introduction of a physiological scoring system may only yield minor improvements. It is only in a package with improved and timely interventions which target deteriorating patients that a palpable improvement in outcomes of these surgical patients can be expected.

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