Identifying Patient Deterioration in the Emergency Department using Data Fusion Systems

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The Problem
UK NHS hospitals are required to use “track and trigger” (T&T) systems in which vital-sign observations are collected periodically from patients and scored. If the scores exceed a pre-defined threshold, care of the patient is escalated. T&T systems are typically used in wards where observations are relatively infrequent (4-8 hours).

In the Emergency Department (ED), observations are taken more frequently (<1 hour), and there is additional pressure to diagnose and treat patients within a 4-hour limit, as per national guidance.

The additional workload results in low levels of correctly completed T&T scores. Furthermore, the busyness of a typical ED means that it is likely that deterioration may be missed between observations.

Intervention
To determine if the percentage correctly completed T&T scores could be increased, and whether deterioration could be detected between observations, bed-side vital-sign monitors were connected to more unwell patients in the ED at JR hospital. Each monitor was linked to an intelligent data-fusion system, which generates alerts based on abnormal patient physiology.

During this phase of research, the data-fusion system was operated in “blinded” mode, so that alerts were not auditable to staff, and recorded for retrospective analysis. In addition, paper observation charts were collected and transcribed to a database. Adult patients were selected at random for inclusion in the study, and consent was gained to use their data for analysis. The efficacy of the data fusion system and perfect (retrospective) T&T was assessed using “gold standard” labels of actual escalations for each patient, provided by a panel of ED clinicians who reviewed all the patient notes independently.

Outcome Measures:
Number of patients who had:
1. physiological escalations post-arrival correctly identified by T&T and data fusion (true positives)
2. Number of patients with no escalations, that had no alerts generated by T&T and data fusion (true negatives)

Continuous Data Fusion
The alarm rate from continuous vital sign monitors in acute wards is high, and many alerts are false (e.g. Tsien and Fachler reported that 86% of ICU alerts were unwarranted). In addition, current vital sign monitors examine each vital sign independently, and are therefore insensitive to certain types of early patient deterioration where small deviations from normality in more than one vital sign may be a precursor to further deterioration.

The system introduced at the John Radcliffe Hospital ED deals with both of these issues by generating a Patient Status Index (PSI), which is a continuous variable that summarises the physiological condition of a patient. It is derived from the probability of a single set of observations with respect to a previously described cohort (Figure 2). An alert if the PSI exceeds 3.0 for 4 out of 5 consecutive minutes (for continuous variables) is generated. A downward trend in the PSI indicates deteriorating patient status, whereas an upward trend indicates improving patient status.

Results
The outcomes are shown in Figure 4. An event was “true positive” only if a PSI or T&T alert was generated within 15 minutes of the documented escalation. “True negatives” only occurred when no alerts were generated for the patients with no documented escalations. The combined system detected 39/51 in total, and 34/37 for which there was full continuous data. In comparison, manual T&T detected 14/51 escalations.

Figure 4 shows an example patient who is likely to have benefited from the combined system if alerts had been audible to staff.

Future Work
The combination of automatic T&T score calculation and continuous data fusion is being used for active interventions in a 10,000 patient RCT-style study that will commence in Summer 2011 at the John Radcliffe Hospital, Oxford. During this period, nursing staff will be reminded when observations are due for each patient. Furthermore, they will be asked to respond alerts generated by the data fusion system by recording an additional observation. Our study will enable us to deduce whether computer-assisted T&T scoring alongside continuous monitoring can reduce short-term patient mortality and hospital length of stay.

Acknowledgements
The work described here has been funded by the National Institute for Health Research Biomedical Research Centre, Oxford.

References
Tsien C, Fachler P. Floor progress for existing monitors in the intensive care unit. Crit Care Med 2007; 35: A40A