Understanding Vital-Sign Abnormalities in Critical Care Patients

S Hugueny1, D Clifton3, L Tarassenko3, M Pinsky2, M Hravnak2
1Institute of Biomedical Engineering, University of Oxford, Oxford, UK
2University of Pittsburgh, Pittsburgh, PA, USA

Introduction

The number of avoidable cardiac arrests and unplanned admissions to ICU in step-down units (SDUs) remains too high. We have previously shown how a data fusion index, based on the integration of vital signs continuously monitored in SDUs, can identify the cardio-respiratory instability which often precedes these adverse events [1]. We show how the correlations between vital signs, captured in a data fusion index based on a probabilistic model of normality [2], change during times of cardio-respiratory instability.

Methods

An observational study was carried out in a 24-bed SDU, in which vital signs - heart rate (HR), respiratory rate (RR), \( \text{SpO}_2 \), and blood pressure - from 326 patients were continuously recorded [1]. The existing standard of care used single-channel Medical Emergency Team (MET) activation criteria to determine when individual vital signs became abnormal. Retrospective evaluation of the continuous vital sign data identified that MET criteria were exceeded on 401 occasions; of these, 238 were deemed to be non-artefactual by clinicians. 111 of the latter (from 59 patients) were indicative of sufficient cardio-respiratory instability that they should have required an MET call (“critical events”).

Vital-sign dynamics during these 111 events were compared with data from stable periods, using order statistics and covariance analysis.

Results

We found the probability distributions of the most extreme and the median data for each parameter over 1-minute intervals. The distributions of RR for those critical events characterised by abnormal RR (Fig 1, coloured lines) are significantly different to those of RR data from stable patients (Fig 1, shaded area). The same type of patterns were observed with the other vital signs. The bivariate Gaussian distributions of best-fit for data from critical events (abnormal RR or HR) show significant differences in covariance when compared with those calculated for data intervals from stable patients (see Fig 2, in which covariance is indicated by ellipse orientation). Under normal conditions (black ellipses), RR is correlated with HR. During critical events, tachycardia occurs with little or no variation in RR (red ellipses); tachypnoea occurs with little or no variation in HR (blue ellipses).

Conclusions

Dynamics and correlations that exist in vital signs during periods of stability change significantly during periods of abnormality. A statistical approach that integrates data vital sign in a way which captures correlations between these data will be sensitive to cardio-respiratory deterioration.
References

Figure 1:

Figure 2: