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Pulse Oximetry for Predicting Clinical Deterioration in Sepsis

Sepsis is a life-threatening condition caused by a dysregulated response to infection, leading to organ dysfunction and high mortality—about 10% overall and over 40% in septic shock cases. Early detection of patients at risk of deterioration in the emergency department (ED) is critical for timely treatment and appropriate patient disposition. Existing tools like the National Early Warning Score (NEWS) are commonly used but have limited accuracy in predicting worsening outcomes in suspected sepsis cases.

Sepsis progression involves complex macro- and microvascular changes, including systemic vasodilation, endothelial dysfunction, and impaired microcirculation, which can lead to haemodynamic instability and shock. These vascular changes affect cardiac output and peripheral resistance.

A new study hypothesises that non-invasive photoplethysmography (PPG), a waveform obtained from pulse oximetry reflecting cardiovascular dynamics, can detect these early vascular and cardiac alterations. By analysing PPG waveforms within 20 minutes of ED arrival, the goal is to predict which patients with suspected sepsis will require ICU admission or may die within 48 hours, potentially improving early risk stratification beyond current scoring systems.

This study performed a secondary analysis of data from the Acutelines biobank, including 576 emergency department patients with early sepsis. Researchers collected clinical, demographic, vital signs, lab results, and PPG waveforms. Patients were grouped based on whether they met a composite endpoint of ICU admission and/or in-hospital death within 48 hours. The study calculated PPG features and compared them between these groups.

In the study, 9.7% of patients were admitted to the ICU or died within 48 hours of ED arrival. Within the first 20 minutes, those who deteriorated showed significantly lower PPG measures: systolic peak amplitude (1218 vs. 1490 AU), diastolic peak amplitude (462 vs. 621 AU), and shorter pulse intervals (0.540 vs. 0.609 seconds). The APG b/a ratio was also lower in this group. However, traditional blood pressure measures (systolic, diastolic, and mean arterial pressure) did not differ significantly between groups. Heart rate was higher in deteriorating patients (111 vs. 99 bpm) and strongly correlated with the PPG-derived pulse interval, both reflecting heartbeats' timing.

Patients with worse PPG features were also older with more cardiovascular comorbidities, which can influence arterial stiffness and vascular tone. Additionally, patients with lower SPA, DPA, and PI more often required vasopressors early after admission, indicating that PPG can detect haemodynamic deterioration and might help predict early vasopressor need, guiding personalised treatment.

While traditional clinical scores (qSOFA, NEWS) and elevated heart and respiratory rates also distinguished deteriorating patients, blood pressure measures did not differ significantly. PPG features captured distinct cardiovascular signals, such as arterial compliance and peripheral vascular tone, not reflected in standard vital signs or indices. This suggests that PPG may complement existing tools, providing novel physiological insights to improve early risk stratification.

PPG analysis within the first 20 minutes of emergency department arrival was identified as a valuable predictor of clinical deterioration in early sepsis patients. Significant differences in systolic and diastolic peak amplitudes, pulse interval, and APG b/a ratio distinguished patients who required ICU admission or died within 48 hours from those who did not. These results support the development of new tools for early risk identification, enabling personalised treatment and improved outcomes for sepsis patients in the ED.

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