Investigating respiratory variation in the plethysmograph to identify obstructive sleep apnea

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Introduction: Our team has been developing an automated remote triage system for emergency response incidents based on the START triage protocol\(^1\). In patients who are unable to walk and unresponsive, remote sensing of airway, breathing, and circulation status is required to execute the triage. The photoplethysmogram is a portable, inexpensive, and readily available sensor that has potential for this application. This study explores the features of the photoplethysmograph signal that are predictive of obstructive events.

Method: Patients were recruited by the Dartmouth Hitchcock Medical Center Sleep Disorders Laboratory. Polysomonograph (gold standard for diagnosing sleep apnea\(^2\)) and photoplethysmograph recordings from a forehead pulse oximeter were made for each patient during the overnight sleep study. The photoplethysmograph signals corresponding to obstructive sleep apnea (OSA) and normal events were analyzed by investigating the average pulse height and respiratory waveform variation defined by pulse height variability, average change in baseline\(^3\), and average change in pulse peak over a respiratory cycle.

Results: Preliminary results from 3 patients indicate that there is an overall increase in pulse height when an OSA event occurs. Respiratory waveform variation was completely undetectable from changes in pulse peaks and also did not seem to be detectable from fluctuations in pulse height. The baseline of the plethysmogram was the only feature of the signal that indicated that respiratory variation might noticeably change for an OSA event. For instance, during 2 non-event periods and 3 OSA event periods within the same patient, the average pulse height increased from 17.3 ± 6.5 for non-event periods to 21.7 ± 9.9 for OSA events. The average change in pulse height (non-event: 12.8 ± 4.6; OSA: 15 ± 7.7) did not appear significantly different so respiratory waveform variation between OSA and normal events seems undetectable while the change in baseline from inspiration to expiration over a respiratory cycle had the most noticeable variation for an OSA event (non-event: 6.2 ± 1.6; OSA: 3.6 ± 1.9).

Discussion: These preliminary results suggest that there are some features of the plethysmograph that may be extracted to identify OSA events. Additional study is needed to incorporate data from a larger set of patients. If successful, the algorithms used to analyze the plethysmograph in this study will be incorporated into the automated remote triage system.

Figures 1 and 2: Plots of a non-event and an OSA event for the same sample patient showing the plethysmograph (PPG), pulse heights (Δ Pulse), baseline signal (Δ Base), and abdominal effort (AB).

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