Nasal Pulse Oximeter: New Site for Monitoring Central Blood Volume During LBNP Induced Hypovolemia

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Background/Introduction:

- The photo plethysmograph (PPG) waveform, while widely used today as a monitor for arterial oxygen saturation, has the potential to be used as a non-invasive clinical tool for monitoring changes in blood volume.[1]
- Clinical indicators of hypovolemia (namely Hypotension and tachycardia) are late signs and usually masked by compensatory changes in vascular tone until the point of cardiovascular collapse.[2] Early detection of hypovolemia is therefore crucial to increasing survival outcomes in trauma patients.
- Using lower body negative pressure (LBNP) simulated hypovolemia, we examined morphological changes in the PPG waveform (amplitude and area) at the nose with changes in stroke volume (SV) and mean arterial pressure (MAP).
- Nose supplied by internal carotid artery branches which we think is more immune to sympathetic changes compared to more commonly used sites for pulse oximeter (finger). was used to monitor amplitude and area of waves in LBNP.

Methods:

- With IRB approval, 18 healthy subjects ages 18-40 underwent progressive LBNP (baseline, -15, -30, -45, and -60 mmHg or until the subject became symptomatic).
- Subjects that completed the LBNP protocol without symptoms were designated as high-tolerance (HT) and symptomatic subjects were designated as low-tolerance (LT).
- Subjects were monitored with a 5-lead EKG and continuous non-invasive blood pressure (CNAP). PPG waveforms were monitored using nasal (Xhale) and finger (Nellcor) pulse oximeter probes. Stroke volume (SV) was measured non-invasively using NICOM (Cheetah). All data was digitized and continuously recorded to a laptop using LabChart (ADInstruments).
- LabChart peak analysis was used to measure the average nasal PPG amplitude, area during each stage of the LBNP protocol together with SV and MAP.
- Correlation was used to identify changes in hemodynamic, stroke volume and PPG variables.

Results:

- In HT subjects, there was a strong correlation between nasal PPG amplitude and area with stroke volume (SV) ($r = 0.99$), while the LT subjects demonstrated strong correlation ($r = 0.97$ and $r = 0.98$) respectively.
- With progressive LBNP, stroke volume was significantly reduced (i.e. reduction in SV >10%) in both HT and LT subjects with no significant changes in MAP.

- Nasal PPG amplitude and area declined >50% and 69% in LT subjects, while in HT nasal PPG amplitude and area declined to 37% and > 52% respectively

Discussion:

- Stroke volume declined with progressive hypovolemia while MAP remained relatively constant demonstrating compensatory changes in vascular tone.
- Changes in nasal PPG amplitude and area were strongly correlated with changes in stroke volume suggesting that the nasal site is relatively immune to vasoconstriction and more representative of central blood volume.

Conclusion:

- Nasal pulse oximeter is an important site to track changes in central blood volume and stroke volume during LBNP induced hypovolemia.