

## Non-Invasive Techniques to Track Stroke Volume during Simulated Uncontrolled Hemorrhage

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Battlefield medics and civilian first-responders have limited tools to assess the magnitude of blood loss in traumatically-injured patients. Accurate measures of stroke volume would provide important quantitative values for blood volume reductions, but battlefield medics and civilian first-responders do not have access to standard laboratory methods to measure stroke volume. They may have access to arterial pulse wave detectors (for example, SPO<sub>2</sub> monitors), but the usefulness of pulse wave detectors for determining stroke volume during hemorrhage has not been determined.

**PURPOSE:** To compare stroke volumes estimated with a standard laboratory rebreathing (RB) method to stroke volumes estimated from finger pulse waves using pulse contour (PC) analysis during simulated hemorrhage with lower body negative pressure (LBNP). **METHODS:** We studied nine healthy volunteers (5 female and 4 male; 24±2 yrs; 170±4 cm; 67±4 kg). ECG, beat-by-beat finger arterial pressure (Finometer), respiratory rate (pneumobelt), and cardiac output (RB and PC methods) were measured every two minutes during progressive LBNP at a decompression rate of 3 mmHg/min to -60 mmHg. Slopes relating changes of stroke volume were compared using linear regression. **RESULTS:** At baseline, stroke volumes were higher ( $P=0.003$ ) for RB (116 ± 6.5 ml) than PC (91 ± 4.3 ml). Compared with baseline, stroke volumes were lower ( $P = 0.001$ ) by minute four of LBNP for RB but not for PC. Slopes relating changes of stroke volumes during LBNP calculated from the RB method (-1.3 ± 0.1 ml/mmHg) were significantly steeper ( $P = 0.001$ ) than those calculated for the PC method (-0.63 ml/mmHg). **CONCLUSIONS:** Stroke volumes measured with PC underestimate stroke volumes measured with RB at rest, and are less sensitive in detecting early changes during simulated hemorrhage. Blunted slopes recorded for PC compared with RB suggest that estimates of stroke volume based on pulse contour analysis of arterial pressure waveforms may be inaccurate for tracking reductions of blood volume during hemorrhage.