Normalizing PPG Signals to the AC Component – Applications for Monitoring Volume Loss

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Background/Introduction: We previously have shown that photoplethysmographic (PPG) monitoring at a site relatively devoid of vasoconstrictive activity (e.g., forehead and ear) reveals relative degrees of pulsatile and nonpulsatile blood volume similar to the relationship between stroke volume (SV) and venous volume systemically; and that, since it is not influenced by background, AC height can be related to SV. The AC@rest voltage corresponds to the portion of SV delivered to the given site under resting conditions. We herein determine whether consistency of AC measurements under baseline conditions is comparable to the consistency of echocardiographically measured SV under resting conditions and then express changes in DC in $AC_{@rest}$Mults to determine if the PPG can delineate changes in venous volume.

Methods: All assessments were performed with IRB approval, utilizing infrared reflectance PPG sensors interfaced via bridge amplifier to Power Lab data acquisition system (ADInstruments) applied to the forehead and ear (because they are relatively immune to vasoconstrictive stimuli). In part 1, AC height was determined during a total 48 sessions performed 3 to 72 hours apart in three volunteers. Intersession variability was compared to that reported in the literature for SV variability obtained echocardiographically.[1,2] In 12 healthy volunteers, we then sought to determine if declines in AC and DC in response to 75mmHg lower body negative pressure (LBNP) corresponded, respectively, to declines in SV and overall volume reported for comparable degrees of LBNP in the literature with invasive monitoring.[3]

Results: For repeated measures of AC height, coefficient of variation (CofV) for intersession variability in our subjects was 17.3%; this was greater than the 9.2% CofV for echocardiographic SV assessments on successive days.1 Alternatively, 2x standard error (2xSE) in our subjects averaged 8% of mean vs. 11% in the literature.[2] Moreover, our intra-session 2xSE/Mean averaged only 3%.

During LBNP, the 73.3 ± 12% ↓in AC was similar to the reported 65% ↓in SV. The decline in DC was 5.4 ± 2.4 AC_{rest}Mults, corresponding to 675ml (5.4 x baseline SV of 125ml measured echocardiographically in our subjects): This was within the 500 to 1000ml range of simulated loss reported in the literature for comparable degrees of LBNP.

Conclusion: The findings suggest that, by normalizing to $AC_{@rest}$, AC and DC measurements can be monitored and compared during myriad clinical and investigative settings. The relative individual changes and their relationships were consistent with changes in systemic arterial and venous volume reported in the literature.

References:

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