

Impact of Surgical Stimulation and Vasodilators on Pulse Oximetry-Derived Left Ventricular Function Data Sets

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Introduction: Pulse oximeter (PPG) amplitude modulation (mod) is related to stroke volume variability, while baseline PPG respiratory modulation reflects changes in blood volume (preload)^{1,2}, as evidenced by changes with assumption of beach chair position and during lower body negative pressure interventions. Ventricular function sets express cardiac work as a function of preload. The classic left ventricular stroke work (LVSW) per beat formula consists of mean systemic arterial blood pressure minus mean left atrial pressure*body surface area indexed stroke volume*K.³ This work measurement (pressure gradient*volume*K) can be shortened to mean systemic blood pressure*stroke volume. Accordingly, mean systemic arterial blood pressure*PPG AC mod as a function of PPG DC mod should provide the data required to evaluate Starling curve left ventricular function. This premise was tested by evaluating the impact of vasodilators on mean systemic arterial blood pressure*PPG AC mod as a function of PPG DC mod.

Methods: A pheochromocytoma patient was studied in depth during laparoscopic resection of the tumor. Vasodilators (phentolamine, nitroglycerin, sodium nitroprusside and hydralazine) were administered to normalize blood pressure during the course of the procedure. Systemic arterial blood pressure and pulse oximetry data were measured pre-vasodilator and post-vasodilator (33 data sets). The study was approved by the Institutional Review Board. Frequency analysis of the PPG waveforms was used to determine amplitude modulation of PPG (PPG AC) and baseline modulation (PPG DC).

Results: It is proposed that increases in AC mod represent decreases in stroke volume. LVSW was expressed by the following equation: $LVSW = MAP - (15 - PPG\ AC\ modulation)$. It is also hypothesized that increases in DC mod represent decreases in preload. DC mod values were normalized by inverting the numeric scale (X axis values). Vasodilator administration was associated with preserved ventricular function. The directional changes in the data were consistent with established cardiac physiology principles. Relationships are presented in figure (1-A), while during sympathetic surge associated with surgical stimulation the directional change in the Starling curve data reversed as shown in figure (1-B).

Conclusion: A series of left ventricular function data sets were constructed from systemic arterial blood pressure and PPG AC mod and PPG DC mod measurements. Findings infer that the combination of PPG AC, PPG DC modulation and systemic arterial blood pressure measurements may provide the data required to construct a non-invasive ventricular function Starling curve. The precise numeric impact of changed PPG modulation as a result of changes in the caliber of the microvasculature requires further study.

References: 1. JCMC 2014; 28,(6): 591-596, 2. JCMC 2011;25 (6); 387-396, 3. Circulation 1964; 29: 739-749

