

## Augmented Index of Finger Pulse Oximeter During Mild Hypovolemia

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**Introduction:** Lower Body Negative Pressure (LBNP) is a known method for simulating hypovolemia. The forehead is relatively immune to the sympathetically mediated vasoconstriction, while the finger has rich sympathetic supply. The position of the dicrotic notch of the arterial waveform is a sensitive indicator of vascular tone.<sup>1</sup> We herein calculate the augmentation index (AI) of the plethysmographic (PPG) waveform, defined as the ratio between PPG peak height after dicrotic notch (“DNP”)/ PPG pulse amplitude (“Pulse”)(figure 1A). LBNP on the order of  $-15$  mmHg seems to be equivalent to blood loss of 333 ml, while LBNP of  $-30$  mmHg equivalent to blood loss of 666 ml, LBNP of  $45$  mmHg seems to be equivalent to blood loss of 1000 mL.<sup>2</sup> During hypovolemia, the increase in sympathetic tone is usually expressed by changes in heart rate (HR) and heart rate variability (HRV). LF represents sympathetic tone, HF represents parasympathetic tone, while LF/HF represents sympatho-vagal balance.<sup>3</sup> The present study compares the PPG AI of the forehead and finger, together with changes in HR and HRV during LBNP.

**Methods:** With IRB approval, 17 healthy volunteers age 23-39 underwent a LBNP protocol consisting of a 3 min baseline and successive 5 min intervals at  $-30$ ,  $-60$  and  $-75$ mmHg. Heart rate and PPG signals were recorded at finger and forehead at 100 Hz. Heart rate variability (HRV) was calculated using AHA definitions (LF 0.04-0.15 Hz; HF 0.15-0.4Hz) with commercially available software (Chart 5.5.5, ADInstruments). During each phase of LBNP, ratio of DNP/Pulse (=AI) was determined for 20 successive PPG beats. Average percentage change was calculated from baseline:  $=100 \times (\text{post-baseline}) / \text{baseline}$ . Comparisons were made with ANOVA and data was expressed as median (1<sup>st</sup> quartile to 3<sup>rd</sup> quartile). P value  $<0.008$  was considered significant (Bonferroni correction).

**Results:** As summarized in figure 1B, both HR and AI increased with progression of LBNP. At  $-30$  mmHg ( $\approx 666$  mL of blood loss  $\approx 10\%$  of blood volume), the relative increases in HR, HRV (LF, HF, LF/HF) were 7%(2% to 9%), 2%(-8% to 12%), -8%(-31% to 26%), 10%(-22% to 61%)( $p=0.0005$  for HR,  $p=0.44$  for LF,  $p=0.50$  for HF and  $p=0.43$  for LF/HF). Whereas the percent changes of finger AI and forehead AI were 43%(30% to 90%), 24%(13% to 31%), respectively ( $p<0.002$  for interparameter difference).

**Conclusion:** The data show that AI clearly distinguished between the responses of the Finger and Forehead to progressive hypovolemia. Finger PPG AI is preceding in changes in HR and HRV during mild to moderate hypovolemia (-30 mmHg). With the progress of LBNP to -60, the HRV changes in the same direction as in the finger PPG AI. Thus PPG AI is a useful tool to detect mild to moderate hypovolemia.

- References:** 1. Am Heart J 138 (3 Pt 2), 220-224. 9 1999  
 2. J Appl Physiol 116: 406–415, 2014  
 3. Science 1981 Jul 10;213(4504):220-2

