

Use of Continuous Noninvasive Arterial Pressure Cycle Duration to Predict Hypovolemia in Low Body Negative Pressure

Presenting Author: Anna-Maria Eid, MD, Yale New Haven Health

Co-Authors: Mohamed Elgamal, Mohamed Eid, Aymen Alian, MD, Kirk Shelley, MD, PhD, Yale New Haven Health

Introduction: Clinical signs of hypotension are considered late indicators of hypovolemic shock. Low Body Negative Pressure (LBNP) is an experimental model that mimics hypovolemia by pooling blood in the lower extremities. Continuous Noninvasive Arterial Pressure (CNAP, CNSystems, Austria) is currently being used as a blood pressure monitor. In this study, the duration of ejection time (EJ), an estimate of systole, and non-ejection time (NEJ), an estimate of diastole, were measured together with the ratio of these values to the Total Cycle Duration (TCD = EJ + NEJ). This study aims to see if the variations in cardiac cycle length provides a tool for early prediction of hypovolemia.

Methods: The data of 18 healthy volunteers subjected to a readily reversible LBNP protocol were used. This entailed 3-minute phases during which the pressure was progressively decreased by 15 mmHg. The study continued until the subject reached either 3 minutes at -75 mmHg or any phase in which symptoms consistent with significant hypovolemia occurred- light headedness, nausea, diaphoresis, blurred vision, tingling in extremities, or a measured systolic blood pressure less than 80 mmHg. Once an end-point was reached, pressure in the chamber was increased to -30 mmHg for 1 minute then to 0 for 3 minutes before concluding the study. Blood pressure tracings were recorded utilizing the CNAP double finger sensor. Subjects able to tolerate the entire negative pressure protocol without symptoms were designated as high tolerance (HT), while those with symptoms were designated low tolerance (LT). In the first part of the analysis, EJ and NEJ durations and ratios of the CNAP waveforms were identified using LabChart Pro 7. Data were then reported as average and SD, p-value <0.05 was considered significant.

Results: In the LT group, there was 23% and 32% reduction in the NEJ duration and ratio (NEJ/TCD) respectively between baseline and LBNP -45, while there was a 3.4% and 1.9% reduction respectively in the HT group. There was no significant difference when comparing the NEJ/TCD ratio between the LT and HT groups at baseline, LBNP -15 and -30, which correspond to no blood loss, 330 ml of blood loss, and 660 ml of blood loss, respectively. However, at LBNP -45, which corresponds to 1 liter of blood loss, there was a significant difference between HT and LT groups in the NEJ/TCD ratio (p-value=0.015). LT participants had an intercept of the EJ and NEJ duration curves (Graph 1.1) which is at least 4 minutes before the development of symptoms (nausea, lightheadedness...) were noted. In comparison, the percent change in Mean Arterial Pressure (MAP) amongst the HT group was 1.5% ($\bar{X}_{BL}= 86.2$ mmHg, $\bar{X}_{-45}= 87.5$ mmHg) and 3.9% in LT group ($\bar{X}_{BL}= 91.2$ mmHg, $\bar{X}_{-45}=87.6$ mmHg), respectively.

Conclusion: In progressive hypovolemia, heart rate is expected to increase commensurate to shortening of the diastolic phase, which corresponds to the NEJ duration. LT subjects had a significant change in their NEJ/TCD ratio at LBNP -45, approximately 3 minutes before becoming symptomatic. Conversely, the HT group did not have any significant changes in

their NEJ/TCD ratios. In face of stable MAP, changes in the NEJ/TCD ratio were more significant indicating that it may be a useful noninvasive measure of impending hypovolemia.

References: *Journal of clinical monitoring and computing*, 25(6), 377-385.
Anesthesia & Analgesia, 92(6), 1483-1486.
Journal of trauma and acute care surgery, 61(3), 629-634.
The American journal of surgery, 192(6), 727-731.

Graph 1.1-Non-ejection and Ejection Durations of LT and HT Groups at Progressive LBNP

