

Utilization of HRV to Detect Impending Shock

Presenting Author: Mohamed Elgamal, Yale Medical School.

Co-authors: Anna-Maria Eid, Ahmad Ibrahim, Kim Tran, Aymen Alian, M.D., Kirk Shelley, M.D., Ph.D., Yale Medical school.

Background/Introduction:

Trauma remains the leading cause of mortality worldwide, with half of the deaths attributed to hemorrhage (1).

In trauma patients, heart rate (HR) and blood pressure (BP) are late clinical indicators of hypovolemia that are masked by compensatory changes in vascular tone that is controlled by the autonomic nervous system until the point of cardiovascular collapse. Detection of autonomic nervous system effects on the body during hypovolemia induced lower body negative pressure (LBNP) can be crucial in understanding how the body behaves during blood loss and can be also a tool in early detection of impending shock. The electrocardiogram (EKG), has the potential to be used as a non-invasive clinical tool for analyzing the autonomic nervous system effects on the body during hypovolemia induced LBNP. Using LBNP simulated hypovolemia, we examined the morphological changes in the EKG using Heart Rate Variability (HRV) which is the beat to beat variation in heart rate or the duration of the R-R interval and is believed to be a measure of the cardiac autonomic nervous system (2). The aim of the study is to use HRV in understanding the changes in the autonomic nervous system during progressive hypovolemia and to detect if it can be an effective tool to predict the magnitude of hypovolemia before the onset of hemorrhagic shock.

Methods: With IRB approval, 31 healthy subjects ages 18-40 underwent progressive LBNP (baseline, -15, -30, -45, and -60 mmHg or until the subject became symptomatic). Subjects that completed the LBNP protocol without symptoms were designated as high-tolerance (HT) and symptomatic subjects were designated as low-tolerance (LT). EKG waveforms were monitored using Datex Omida. All data was digitized and continuously recorded to a laptop using LabChart (ADInstruments). LabChart Heart rate variability (HRV) was analyzed in the frequency domain wherein we distinguished between high frequency, HRV-HF (0.15–0.4 Hz) and low frequency, HRV-LF, (0.04–0.15 Hz) during each stage of the LBNP protocol. We expanded our analysis of EKG waveforms to the following frequencies; low frequency (0.04–0.15 Hz) (marker of sympathetic modulation), high frequency (0.15–0.4 Hz) (marker of Efferent vagal activity). Friedman ANOVA and Wilcoxon tests were used to identify changes in the EKG variables, p-value <0.017 was considered statistically significant after Bonferroni adjustment.

Results: With progressive LBNP, there were significant reduction in HF in the presymptomatic and symptomatic phases in the LT subjects and only during the -60 in the HT subjects. There were no significant changes in the LF in both the HT and LT subjects in any of the phases during progressive LBNP (Table B, Fig 2). In the LT subjects there was a significant fall in the average HF of (87.7%) in the presymptomatic phase compared with a non-significant (0.84%) fall in the -45 mmHg phase in the HT subjects (Table A, Fig 1). In the LT subjects there was a significant fall in the average HF of (85.8%) in the symptomatic phase compared with a significant (79.4%) fall in the -60 mmHg phase in the HT subjects (Table A, Fig 1).

Conclusion:

During HRV the HF can be considered as a tool to predict impending shock by at least 3 to 5 minutes before the appearance of symptoms.

Table A

LT & HT HF EKG	% change compared to baseline									
	Baseline	-15	-30	-45/Presym	-60/Sym	-15	-30	-45 / Presym	-60/Sym	
LT HF (0.15-0.4 Hz)	1164.89	814.39	522.91	143.41	165.18	-30.09	-55.11	-87.69	-85.82	
HT HF (0.15-0.4 Hz)	563.52	682.50	513.77	558.81	116.31	21.11	-8.83	-0.84	-79.36	

Table B

LT & HT LF EKG	% change compared to baseline									
	Baseline	-15	-30	-45/Presym	-60/Sym	-15	-30	-45 / Presym	-60/Sym	
LT LF(0.04-0.15 Hz)	988.84	1018.00	799.45	455.87	282.05	2.95	-19.15	-53.90	-71.48	
HT LF(0.04-0.15 Hz)	722.57	993.50	638.96	816.07	510.19	37.50	-11.57	12.94	-29.39	

Fig 1

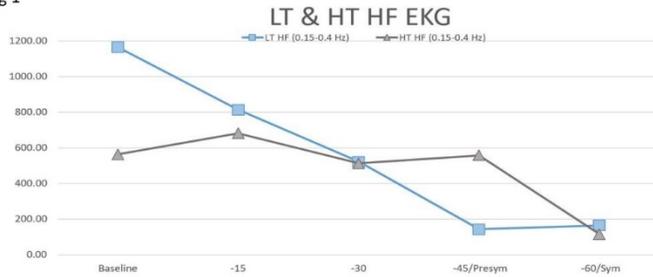
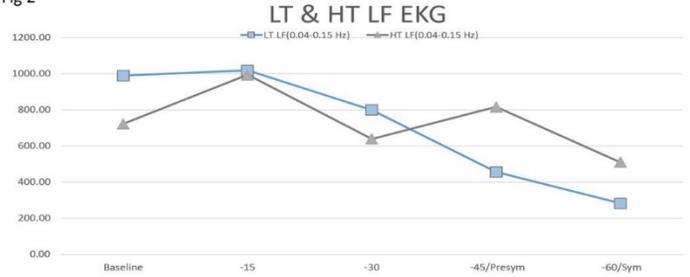


Fig 2



(Table A, B): They show the change in power and % change to baseline from baseline to -60 or symptomatic phase in HT and LT subjects in HF and LF respectively.

(Fig 1,2): They track the change in power from baseline to -60 or symptomatic phase in HT and LT subjects in HF and LF respectively.

References:

1. Transfusion, 59: 1423-1428. doi:10.1111/trf.15161
2. Frontiers in physiology, 6, 55. doi:10.3389/fphys.2015.00055