

Non-invasive, Quantitative, Measurements of Autonomic Nervous System Activity Levels: II. Critical Care Approaches

Joseph Colombo, Ph.D.¹; William C. Shoemaker, MD²; Rohit R Arora, MD, FACC³;

Ramesh K Adiraju, MD, FACC⁴

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ABSTRACT

Introduction: Over the last decade classical-heart rate variability (HRV) has been used to facilitate monitoring the autonomic nervous system (ANS). One form of classical-HRV is spectral or frequency analysis of instantaneous HR as standardized in the 1996 Task Force article [Circulation. 93:1043-65]. From the standard, the frequency analysis of choice is the short-term fast Fourier transform (stFT). What seems to have been missing from that standard was a concurrent analysis of respiratory activity (RA). Spectral analysis of HR and RA (real-time HRV – rtHRV) and has been shown to independently measure both ANS branches, simultaneously and non-invasively. This article finds that the stFT version of rtHRV is best applied in the critical care and trauma arenas. The stFT-based solution is used in unchallenged situations where the patient is supine and at rest. It can be used in continuous monitoring mode or in intermittent monitoring mode. The intermittent monitoring mode includes three or four (or more) five to ten minute monitoring periods per day (like BP and HR in the hospital) to acquire trending information on the progress of the patient.

Methods: 204 severely injured patients were non-invasively monitored beginning shortly after admission to the emergency department (ED) in a level-1, university-run, trauma service. We studied and compared the temporal ANS and hemodynamic patterns. RTHR was measured by stFT spectral analysis to evaluate the low frequency area (LFa), which is the area under the spectral analysis curve within the frequency range of 0.04 to 0.10 Hz. The respiratory frequency area (RFa) of variability is a 0.12 Hz-wide frequency range centered around the fundamental respiratory frequency (FRF) defined by the peak mode of the RA power spectrum and is indicative of Vagal or parasympathetic (PSNS) activity. HRV was studied concurrently with noninvasive hemodynamic monitoring consisting of: a) cardiac output bioimpedance, HR, and mean arterial pressure to reflect cardiac function. Pulse oximetry to reflect changes in pulmonary function, and c) transcutaneous oxygen (PtcO₂) indexed to the FiO₂ as a marker of tissue perfusion. The pulmonary and tissue perfusion data will be presented in a separate article.

Results: Our team observed that ANS dysfunction, particularly parasympathetic abnormality, could be a primary abnormality or a secondary physiologic manifestation. It was also observed that ANS dysfunction could be an early indicator of more serious clinical conditions. The authors have found that modifying and resetting ANS dysfunction can be achieved using conventional ER and OR drugs and non-pharmaceutical therapies known to effect the sympathetic and parasympathetic nervous systems (*e.g.*, central adrenergic or cholinergic antagonists and hemodynamic hyperperfusion). Resetting ANS to normalcy or close to normalcy not only resulted in resolution or avoidance of clinical symptomatology but has lead to, in our experience, improvements in the primary disease manifestations and better responses to treatment.

Discussion: The data suggest that poor ANS results can lead to poor outcomes, and that favorable ANS results can lead to favorable outcomes. This in general is accepted. However, our data also provides preliminary evidence that the modification of poor ANS results to favorable ANS results can improve outcomes. This evidence is encouraging and indicates the need for future prospective studies. The data also suggest that measured parasympathetic activity may also play a critical role in patient care: 1) Excesses in parasympathetic (RFa) levels can be a marker for proper tissue and organ perfusion and therefore another marker for outcomes, 2) Parasympathetic excess may drive the sympathetics via hemodynamic instability and predispose to malignant arrhythmias airway instability in critically ill patients and acute situations.

Conclusion: Clinically, the stFT method has been found to help differentiate hemodynamic trends that support survival in Critical Care Medicine. Preliminary evidence in this study suggests that improving ANS results can lead to improved outcomes. Our efforts in this area continue.