Validation of Sympathetic Activity Index from Heart Rate Variability series: A Preliminary Muscle Sympathetic Nerve Activity Study

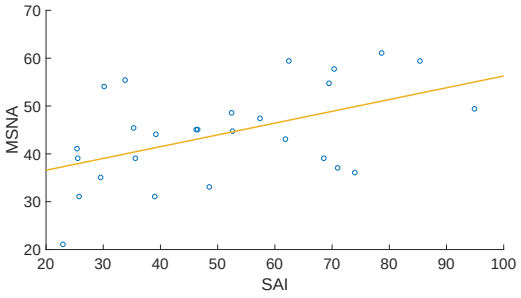
G Valenza[1,*], F Faita[2], L Citi[3], P J. Saul[4], RM Bruno[5], R Barbieri[6]

[1] Research Center E. Piaggio & Dept. of Information Engineering, University of Pisa, Pisa, Italy.
[2] Institute of Clinical Physiology, Italian National Research Council, Pisa, Italy.
[3] School of Computer Science and Electronic Engineering, University of Essex, Colchester, UK.
[4] West Virginia University School of Medicine, USA.
[5] INSERM Paris Cardiovascular Research Centre - University Paris Descartes, Sorbonne Paris Cite, France.
[6] Department of Electronics, Informatics and Bioengineering, Politecnico di Milano, Milano, Italy.

Introduction: We recently proposed a Sympathetic Activity Index (SAI) based on an orthonormal Laguerre expansion of linear RR-interval autoregressive kernels. The resulting heart rate variability (HRV) series analysis may be used for the effective estimation of cardiac sympathetic outflow because the underlying model is independent from the overlapping dynamics of the sympathetic and vagus nerves in the low frequency (LF) band (0.04-0.15Hz). Thus far, SAI has been proven effective in real heartbeat data gathered from healthy subjects undergoing different autonomic manoeuvres, as well as data from patients with Congestive Heart Failure (CHF). In this study, we perform a preliminary validation of the HRV-based SAI performance through concurrent estimates from efferent muscle sympathetic nerve activity (MSNA) recordings.

Methods: Electrocardiogram (ECG) and multiunit efferent postganglionic MSNA were simultaneously recorded in 12 hypertensive patients in the supine position during a 10min resting state and up to 30min sodium nitroprusside (SNP; 0.4 μg/kg per minute) administration. SNP is a direct vasodilating agent, thus expected to increase MSNA. The SAI index is estimated from the R-waves from ECG using a set of disentangling coefficients from a previous autonomic blockade study [1]. Group-wise comparisons between sessions were performed through Wilcoxon non-parametric tests for paired data, and a combined SAI-MSNA correlation analysis was performed through Spearman coefficient.

Results: Results show a characteristic increase of the MSNA during SNP intake with respect to the resting state (MSNA-Rest: 39 ± 4.5, MSNA-SNP: 54.3 ± 5 bursts per 100 heartbeats; $p < 0.001$). While SAI was associated with a significant SAI increase during SNP (SAI-Rest: 39.07 ± 13.46; SAI-SNP: 52.66 ± 17.76; $p < 0.001$), LF power did not show significant changes between sessions (SAI-Rest: 61.9 ± 36.24 [ms^2]; LF-SNP: 63.45 ± 49.62 [ms^2]; $p<0.05$). Spearman analysis highlights a significant correlation between SAI and MSNA ($r=0.475$; $p<0.02$) – see scatter plot in the figure on the right panel – and a non-significant correlation between LF power and MSNA ($r=-0.089$; $p>0.05$).



Conclusions: The presented results provide a further validation step of a novel non-invasive technique for estimating autonomic cardiovascular control dynamics, and they support the use of HRV-based SAI metrics as a reliable proxy of cardiac sympathetic outflow dynamics.

[1] Valenza G, Citi L, Saul JP, Barbieri R. "Measures of Sympathetic and Parasympathetic Autonomic Outflow from Heartbeat Dynamics", *Journal of Applied Physiology*, vol. 125, num 1, pp. 19-39, 2018.

*Corresponding Author Email: g.valenza@ieee.org