The spectral analysis of photoplethysmography to evaluate an independent cardiovascular risk factor

Pratiksha G Gandhi[1], Gundu Hr Rao[2]
2014 Dec 9;7:539-47. https://pubmed.ncbi.nlm.nih.gov/25525382/

Abstract

Background: In this study, we evaluate homeostatic markers correlated to autonomic nervous and endothelial functions in a population of coronary artery disease (CAD) patients versus a control group. Since CAD is the highest risk marker for sudden cardiac death, the study objective is to determine whether an independent cardiovascular risk score based on these markers can be used alongside known conventional cardiovascular risk markers to strengthen the understanding of a patient's vascular state.

Materials and methods: Sixty-five subjects (13 women) with a mean age of 62.9 years (range 40-80 years) who were diagnosed with CAD using coronary angiography (group 1) and seventy-two subjects (29 women) with a mean age of 45.1 years (range 18-85 years) who claimed they were healthy (group 2) were included in the study. These subjects underwent examination with the TM-Oxi and SudoPath systems at IPC Heart Care Centers in Mumbai, India. The TM-Oxi system takes measurements from a blood pressure device and a pulse oximeter. The SudoPath measures galvanic skin response to assess the sudomotor pathway function. Spectral analysis of the photoplethysmograph (PTG) waveform and electrochemical galvanic skin response allow the TM-Oxi and SudoPath systems to calculate several homeostatic markers, such as the PTG index (PTGi), PTG very low frequency index (PTGVLFi), and PTG ratio (PTGr). The focus of this study was to evaluate these markers (PTGi, PTGVLFi, and PTGr) in CAD patients against a control group, and to calculate an independent cardiovascular risk factor score: the PTG cardiovascular disease risk score (PTG CVD), calculated solely from these markers. We compared PTGi, PTGVLFi, PTGr, and PTG CVD scores between the CAD patient group and the healthy control group. Statistical analyses were performed using receiver operating characteristic curves to determine the specificity and sensitivity of the markers to detect CAD at optimal cutoff values for PTGi, PTGVLFi, PTGr, and PTG CVD. In addition, correlation analyses between these markers and conventional autonomic nervous system and endothelial function markers were performed to understand the possible underlying physiological sources of the differences observed in marker values between CAD patients and healthy control patients. Additionally, t-tests were performed between two subgroups of the CAD patient group to determine whether diabetic or coronary artery bypass grafting (CABG) patients have significantly different PTGi marker values.

Results: Each spectral analysis PTG marker yielded a high specificity and sensitivity to detect CAD. Most notably, the PTG CVD score had a sensitivity of 82.5% and specificity of 96.8%, at a cutoff of 2, when used to detect CAD (P=0.0001; area under the receiver operating characteristic curve =0.967). The PTG spectral analysis markers were well-correlated to other autonomic nervous system and endothelial function markers. CAD diabetic patients (n=27) had a lower PTGi value compared with the CAD non-diabetic patients (n=38): and patients that underwent CABG (n=18) had a higher PTGi value compared with the CAD without CABG surgery patients (n=47).

Conclusion: The spectral analysis of the photoplethysmography method is noninvasive, fast, operator-independent, and cost-effective, as only an oximeter and galvanic skin response device are required in order to assess in a single testing the autonomic nervous system and endothelial function. The spectral analysis techniques used on the photoplethysmogram, as outlined in this study, could be useful when used alongside conventional known cardiovascular disease risk markers.

Keywords: PTG CVD score; PTG spectral analysis; PTGVLFi; PTGi; PTGr; coronary artery disease.