

U. R. Bagal, P. C. Pandey, S. M. M. Naidu, and S. Hardas, Detection of opening and closing of the aortic valve using impedance cardiography and its validation by echocardiography, *Biomed. Physics Eng. Express*, 2017, published online, DOI 10.1088/2057-1976/aa8bf5)

Abstract: Impedance cardiography is a noninvasive technique for estimation of stroke volume, systolic time intervals, and some other cardiovascular indices. These estimations require error-free detection of the B, C, and X points of impedance cardiogram (ICG), as markers of aortic valve opening, peak aortic blood velocity, and aortic valve closure, respectively. Based on an empirical examination of the morphological variations in the ICG waveforms, a technique for automatic beat-to-beat detection of these points is developed. It uses wavelet-based denoising for suppression of respiratory artifacts to avoid restrictions on breathing during the recording. It uses R peaks of ECG as reference points to avoid inter-cycle smearing and multiple time-domain waveform features to reduce errors due to morphological variations. The technique is evaluated on simultaneously acquired and time-aligned ICG, ECG, and Doppler echocardiogram recordings from subjects with normal-health and subjects with cardiovascular disorders. Compared to the earlier techniques, the proposed technique detects the points with low bias and precision errors. The means of differences, as referred to the mean R-R interval, in the estimation of R-C, R-B, R-X, and B-X intervals with the corresponding measurements from Doppler echocardiograms as the reference were 0.5%, 0.3%, 0.5%, and 3.0% respectively. The corresponding standard deviations of differences were 1.3%, 1.3%, 5.8%, and 6.0%. The proposed technique may help in improving the acceptability of impedance cardiography for diagnosis of cardiovascular disorders.