Evaluation Method for Heart Failure using RR Sequence Normalized Histogram

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As an early noninvasive detection method of studying the potential risk of cardiovascular diseases, heart rate variability (HRV), has been widely applied in clinical medicine. Histogram and scatter plot are important graphical indices for HRV. However, they are difficult to quantify the complexity for HRV and have little specificity to some cardiovascular diseases. This paper proposed a new graphical method for HRV analysis, which was named as RR sequence normalized histogram. The general construction procedure for normalized histogram is summarized as follows. Given a RR sequence, the all element RRi (i=1, 2, , N) are separated into seven kinds based on the element value. Then the percentage pi of element distribution in each kind is calculated. Three quantitative indices are defined by analyzing the percentage pi: center-edge ratio (CER), cumulative energy (CE) and range information entropy (RIEn). CER characterizes the fluctuation of the sequence element apart from the mean. CE indicates the equilibrium of the percentage pi in all seven kinds. RIEn reflects the distribution complexity of the elements in the normalized histogram. To verify the validity of the new method, a total of 120 subjects (60 heart failure subjects and 60 healthy control subjects) were enrolled. The test results showed that: 1) the normalized histograms between heart failure and healthy control subjects are significantly different; 2) the mean values of CER and CE in heart failure group are higher than that in healthy control group; 3) A Wilcoxon rank sum test showed that CER ($p = 0.232$) and CE ($p = 0.417$) had no statistical differences between two groups while RIEn ($p = 0.027$) had. This indicated that the new method had a potential application in evaluating the heart failure and the index RIEn had a better effectiveness than the other two indices.