Low-Cost Early Detection of Cardiovascular Disease in Chronic Kidney Disease Patients Based on Hybrid Heterogeneous ECG Features Including T-wave Altemans and Heart Rate Variability

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Objectives: According to Taiwan Society of Nephrology, there were more than 1,100,000 chronic kidney disease (CKD) patients in Taiwan. United States Renal Data System revealed that Taiwan had the highest incidence of end stage renal disease worldwide. Accumulating evidence shows that cardiovascular disease (CVD) contributes substantial burden to dialysis patients, accounting for almost 50 percent of mortality in both Chinese and Caucasian dialysis population. Traditional clinical risk factors include such as hypertension, dyslipidemia, hyperglycemia, and smoking. Unfortunately, the above factors may not totally explain and predict CVD high mortality. Hence, the research conbines heterogeneous ECG features as predictors, including T-wave altemans and heart rate variability for a low-cost prescreening tool within CKD patients. Methods: Fifty CKD hemodialysis patients were recruited and monitored over three years under IRB regulation at Tzu-Chi General hospital, Taiwan. Cardiologists categorized the population into two groups: 27 and 23 patients with and without CVD, respectively. Their ECG signals have been recorded for 5 minutes at supine for every 6 months. Potential features extracted from TWA and HRV in both frequency and time domains. For frequency analysis, basic Fourier transformation and Welch method were applied. Then, statistic analysis was followed to observe potential predictors, and then the decision-based neural network (DBNN) is used to fuse heterogeneous features. Results: Patients induced into CVD (n=23) had greater TWA magnitude (Valt: 0.24 ± 0.24 vs 0.09 ± 0.06 microvolt; P=.008) and cumulative alternans voltage (CAV: 24.21 ± 24.41 vs 9.04 ± 6.46 microvolt; P=.008) than those who has no CVD (n=27). The chi-square test showed significance between TWA and CVD (Alternans ratio$>$2.5, P=.028). The LF and LF/HF are significant smaller but the HF is higher in CVD group. The DBNN model with selected features provides 70.6% accuracy. Conclusions: Hybrid TWA and HRV successfully provide risk indicators for early CVD warning within dialysis patients for very low cost.