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Monitoring Heart Rate Variability Using Blood Flow Sounds in the Blood Circuit

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Objectives : Several studies have attempted to analyze the heart rate variability (HRV) during dialysis using electrocardiography, to predict the risk of hypotension. We hypothesized that sounds reflecting heartbeats could also be captured from blood flow sounds in the blood circuit. Therefore, we explored the possibility of monitoring HRV during dialysis by analyzing blood flow sounds within the blood circuit as an aid in patient monitoring.
Methods : Using a prototype electronic stethoscope, we recorded the blood flow sounds in the blood circuit during dialysis and determined the cardiac cycles by calculating the interval between R-waves (R-R Interval, RRI). HRV during dialysis was evaluated using the Lorenz plot, with the n-th RRI plotted on the horizontal axis and the n+1-th RRI plotted on the vertical axis.
Results : In patients with stable HRV, the RR intervals remained stable at 1000 ms. The Lorenz plot also showed a high-density distribution in the upper right quadrant, indicative of a resting state. A patient with detectable arrhythmias exhibited a high-density distribution in the lower left quadrant on the Lorenz plot, indicating a tense state, and we confirmed the occurrence of premature contractions in the latter half of dialysis on the heartbeat record. Even though the blood pressure was maintained during dialysis, the patients with detectable tension showed a high-density distribution in the lower left quadrant on the Lorenz plot, suggesting that dialysis treatment imposed a burden on the patients.
Conclusions : Heartbeats can be detected from blood flow sounds in the blood circuit, and this method is considered less burdensome and more convenient for both the medical staff and the patient than use of electrocardiography. Moreover, observing the longitudinal changes in the HRV during dialysis using the Lorenz plot makes it easier to monitor the patient's condition.