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A CARDIAC OUTPUT ESTIMATION MODEL BY THE NEURAL NETWORK TECHNIQUE TOWARD TOTAL ARTIFICIAL HEART CONTROL

Department of Artificial Organ, National Cardiovascular Center, Suita, Osaka, Japan
T. Masuzawa, Y. Taenaka, E. Tatsumi, M. Kinoshita, T. Nakatani, H. Akagi,
Y. Baba, K. Araki, M. Watari, Y.H. Park, K. Eya, K. Toda, and H. Takano

A modeling of the cardiovascular system is a useful way to develop a control algorithm of a total artificial heart. In this study, a computer neural network model to estimate cardiac output from other physiological data was developed and evaluated feasibility of the modeling technique. A treadmill exercise experience with a goat was performed to obtain the physiological data and to realize a cardiovascular system model during exercise. Blood pressure catheters and a blod flow probe were implanted in the chest and the exercise tests were performed nine times after two weeks of the operation. The exercise test contain five minutes walking with speed of 2 MPH(miles per hour) and five minutes resting after the walking. Left and right atrial pressure, arterial pressure, pulmonary arterial pressure, heart rate, pulmonary arterial flow, mixed venous saturation, and physical activity by an acceleration sensor were measured during the exercise and the average of these data for each ten seconds were digitized. The model to estimate cardiac output from heart rate, mean arterial pressure, mixed venous saturation and physical activity, which were good correlative data with cardiac output in the measured data, was constructed based on a neural network technique. A three-layer back-propagation neural network, which has the input layer with forty two cells, the hidden layer with thirty two cells and the output layer with ten cells, was used to organize the model on a micro-computer. Five hundred and forty six sets of data, which were obtained from eight times exercise tests, were used for learning process of the network. Seventy sets of the learning data and sixty six sets data which were not used for learning were used to evaluate the performance of the cardiac output estimation of the model. The correlation coefficient between the learning data and real cardiac output was 0.965 ($p<0.001$) and that for the non-learning data was 0.869 ($p<0.001$). The feasibility of the computer neural network technique to model the cardiovascular system regulation mechanism was confirmed in the study. We believe that the technique will be a useful tool for development of the total artificial heart control algorithm by further improvement.