Development of an external aortic circulatory assist device using the shape memory alloy fibers.

（書式１８）課程博士

学　位　論　文　要　約

博士論文題目　Development of an external aortic circulatory assist device using the shape memory alloy fibers

（形状記憶合金線維を応用した大動脈拍動補助装置の開発研究）

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Objectives: The aim of this study was to develop a new sophisticated extra aortic pulsation circulatory assist device using shape memory alloy (SMA) fibers as an actuator. We employed 150 μm (BioMetal Toki Corporation) Ni-Ti anisotropic SMA fiber for the device. The fibers contract by Joule heating with an electric current supply and relax passively at the frequency of 2-3 Hz. The special feature of the new device were as follows: an extra aortic pulsation function synchronizing with the native heart, a wrapping mechanical structure for the aorta that allow the device to function in a similar mechanism as the Aortomyoplasty and extra aortic balloon pump.

Methods: The device consisted of rubber silicone wall plates as structural backbone frame. These plates are serially connected by circumferential position on the aortic vessel for radial displacement. We examined the contractile function of the device in a systemic mock circulatory system with a pneumatically driven silicone left ventricle model. Also we conducted a numerous in-vitro studies, and we examined the contractile effects of the device and evaluated its hemodynamic effect. Pressure and flow waveforms were digitally recorded as well as its driving condition of contraction, phase width and delay. Furthermore, we evaluated its clinical feasibility in the thoracic cavity of acute goat animal experiment.

Results: Hemodynamic was affected by the contraction and relaxation speed of SMA fibers. The systolic or diastolic pressure increased to 116/77 mmHg with 200 ms phase delay, and to 106/77 mmHg with 600 ms phase delay, where's the control condition was 105/72 mmHg. Meanwhile mean flow increased 8% ($p < 0.05$) with co-pulsation and 4% during counter-pulsation mode with significant augmentation in the peak diastolic pressure. Complete implantation of the device and its actuator system inside the goat thoracic cavity could be accomplished without the minor aortic branches dissection. A significant hemodynamic change was achieved in synchronization with animal native heart.

Conclusions: We successfully developed a new extra aortic pulsation circulatory assist device using SMA fibers. The results of the mock experiment and the animal feasibility studies indicated its promising alternative extra aortic approach for non-blood contacting cardiovascular circulatory support.