1

NEW APPROACHES FOR LONG-TERM RESPIRATORY SUPPORT

National Cardiovascular Center, Suita, Osaka, Japan
Tatsumi E, Takano H, Taenaka Y, Nakatani T, Akagi H, and Masuzawa T

Continuous efforts have been made in our institute towards establishing the way of long-term respiratory support. Presented in this paper is: first a new method of long-term extracorporeal membrane oxygenation (ECMO), and secondly a novel integrated artificial heart-lung device (IAHLD) for prolonged cardiopulmonary support.

A new method of long-term ECMO was designed and evaluated in chronic animal experiments for up to 2 weeks. A pneumatic diaphragm-type ventricular assist device was implanted between the right atrium and the pulmonary artery in 4 goats and ECMO was conducted by interposing a newly-developed compact oxygenator in the return cannula. Regional anticoagulation within the circuit was undertaken by continuous infusion of FUT-175, a short acting protease inhibitor, from the inflow cannula of the circuit. Around 2-4 L/min of bypass flow, 100-130 ml/min of O_2 transfer and 60-90 ml/min of CO_2 removal were obtained in this system. Serum leakage in the oxygenator was completely eliminated with a novel gas-exchange membrane in which micropores became blind at the blood-contacting surface. Activated clotting time of the circuit blood (>300sec) was significantly longer than that of the body blood at low bypass rates, whereas those were almost equivalent (around 200 sec) at high bypass flow rates. This ECMO method solved several problems in conventional ECMO, and showed suitable performance for long-term respiratory assistance.

Realizing from accumulated data of ECMO experiments, however, that optimizing flow pattern in the device is of great importance, we undertook to develop an IAHLD as a long-term cardiopulmonary support system. The IAHLD consists of an artificial lung component (LC) and two blood pumps. The LC is made with a special composite hollow fiber membrane(surface area : 0.8 m^2) in which serum leakage is prevented with a thin polyurethane layer. The fibers are arranged as piled-up lattices and potted in a cylindrical housing. The blood pump (stroke volume : 60 ml) with a single inlet or outlet port is a pneumatic pusher-plate type and a Bjork-Shiley valve is mounted in the port. The LC is sandwiched by the inlet and outlet pumps and all components are integrated. This special scheme of the device contributed to maximizing gas-exchange efficiency, eliminating flow channeling and stagnation, as well as to reducing its blood-contacting surface. The prototype IAHLD demonstrated up to 170 ml/min of O_2 transfer and 150 ml/min of CO_2 removal rates, and up to 5.5 L/min of pump output. A flow visualization analysis revealed that the flow distribution within the device was uniform without any stasis. We concluded that the IAHLD is promising for long-term cardiopulmonary support, with a potential for non-heparin use if adequate thrombo-resistant surface modification is introduced.