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Hydrodynamic Performance and Hemolysis Tests Comparing Different Impeller Angles of a Centrifugal Blood Pump to be Used as Bridge to Decision or Recovery

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Study: Department of Bioengineering at Institute Dante Pazzanese of Cardiology has been developing and evaluating a new model of centrifugal blood pump for bridge to decision or recovery. This pump can be used extracorporealy with or without membrane oxygenator. Device design is based on centrifugal pumping principle associated to the usage of ceramic bearing to actieve durability up to 30 days. Rapid prototyping technology has been used for prototypes production with three different impeller angles: with four straight blades, with four 90º curved blades and with four 180º curved blades.
Methods: Hydrodynamic performance tests were conducted with those prototypes, using a mock loop system composed by Tygon® tubes, 500 ml flexible reservoir, digital flow meter, pressure monitor, electronic driver and adjustable clamp for flow control, filled with water/glycerin/alcool solution, simulating blood viscosity and density. Flow versus pressure curves were obtained for rotational speed of 1000, 1500, 2000 and 2500 rpm. Hemolysis tests were conducted with same prototypes and same closed circuit, however, free of air and flow fixed at 5 L/min against total pressure head of 100 mmHg, filled whit bovine blood.
Results: Results showed that rotor with straight blades, 90º and 180º curved blades provided similar hydrodynamic permance for lower rpm, but pump with straight blades showed better hydrodynamic performance for higher rpm. Hemolysis tests showed best results for 180º curved blades, with normalized index of hemolysis of 0,004±0,003g/100L.

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Development of The Calon Minivad™- A Novel Lvad With Potential for a Lower Cost and Reduced Complications

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Study: The MiniVAD™ is a new LVAD that utilises a novel layout to potentially improve implantability, manufacturability and haemocompatibility. It is hoped that this will lead to commensurate improvements to the device cost and complication rate, improving the overall health-economic proposition.
Methods: The performance of the MiniVAD has been evaluated in-vitro against a series of well-established metrics and also against novel assays developed by our group to gain better insight into haemocompatibility.
Results: Current results indicate that the MiniVAD performs competitively against all key performance and haemocompatibility metrics currently tested: Power: <1W/l/m @ 100mmHg Hydraulic characteristic: 0 - 8L/m average flow range with 'flat' HQ curve, low shut of pressure and good pre-load / afterload sensitivity. Physical size: <100g weight; 15mm depth x 35mm diameter package (outside of heart); 30mm length x 22mm diameter inflow cannula (implanted into ventricle). The MiniVAD can be implanted inside pericardium with convenient siting of outflow cannula (centrifugal outflow) and is suitable for less invasive techniques such as a mini thoracotomy. Haemolysis: <0.002 g/100L NIH, bovine blood, 6h loop test, 500ml loop, 5l/m Platelet activation: 11% compared to 9% in CentriMag and 6% in static (BAQ125, bovine blood, at 6h). Leukocyte damage: 8% compared to 5% in CentriMag and 6% in static (7AAD, bovine blood, at 6h). The haemocompatibility of the small, implantable MiniVAD is comparable with good, and substantially larger, extra-corporeal blood pumps such as the CentriMag and the Rotaflow. Further in-vitro evaluations are ongoing and in-vivo evaluations are planned for quarter four 2014.

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In-Vitro Shear Stress-Induced platelet activation: Differences between Species: Human, Ovine, and Porcine

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Study: Platelet activation caused by mechanical forces plays an important role in physiological hemostasis and pathological thrombosis in patients treated with blood contacting artificial organs. In vitro and in-vivo animal tests are commonly performed to evaluate the hemocompatibility of these devices before they are used clinically in humans.
Methods: The purpose of this study was to investigate the sensitivity and dependency of shear-induced platelet activation on shear stress in the three species. The experiments were carried out using two flow-through Couette-type blood-shearing devices. Two commonly used markers (surface expressed P-Selectin (CD62p) and soluble P-selectin) were used to indicate the shear-induced platelet activation and were quantified at a matrix of exposure time (0.039 to 1.48 s) and shear stress (50 to 320 Pa). Fresh human, ovine and porcine ACD-A coagulated blood were used for the experiments.
Results: The results showed that the level of surface expressed P-selectin increased appreciably in human and porcine blood after exposed to shear stress above 75 Pa. Surface P-selectin was a less sensitive marker for shear-induced platelet activation for ovine blood. The level of surface P-selectin in ovine blood did not increase as high as that in human and porcine blood. Relatively, soluble P-selectin in blood increased in the three species after being exposed to shear stress level above 75 Pa for duration longer than 0.5 sec. The data from these in-vitro experiments indicated that human blood is more susceptible to shear-induced platelet activation than porcine and ovine, the surface and soluble P-selectin response of porcine blood to shear stress is similar to the human blood. The differences in platelet activation markers between human, ovine and porcine platelets suggest that porcine blood might be the best species to evaluate biocompatibility related platelet activation of human.

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Importance of a Rotational Speed Control System for Implantable Centrifugal Blood Pumps

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Study: An Implantable Centrifugal Blood Pump (ICBP) has been developed in our institution to be used as Left Ventricle Assist Device (LVAD) in Bridged to Transplant (BTT). Actually the pump electronic control strategy is being studied used a Hybrid Cardiovascular Simulator (HCS) a tool that allows the physical connection of the ICBP under evaluation. Also, HCS allows to change some cardiovascular parameters in order to simulate specific heart diseases. This study shows different modes of ICBP actuation and its consequences for left ventricle and for cardiovascular system.
Methods: Controller adjusts the rotational speed depending on the heart rate. Tests were performed using HCS on specified heart rate and simulating failing heart. These test parameters were based on the patient natural activity.
Results: The results of controller action showed important for application, increasing rotational speed to avoid backflow and decreasing rotational speed to avoid aortic valve dysfunction. Future studies are in progress to improve the sensing and control algorithm.