

# Artificial Organs Engineering

## 1. Staff and Students (April 2010 through March 2011)

Professor	Setsuo Takatani	
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Graduate Students	Eiki Nagaoka,	Takashi Kitao,
	Naoyuki Yokoyama,	Taro Kimura

## 2. Purpose of Education

Artificial organ is an inter-disciplinary science aiming to treat patients who require therapy beyond treatments by internal medicine and/or surgical medicine. It requires knowledge from basic medical sciences to engineering technologies. Artificial organs assist or replace functions of failing organs till their recovery, bridge to transplantation, actively promote recovery by combining with other advanced treatment methodologies, or permanently support the organ function.

In surgical area, especially for treatment of profound heart failure patients, mission of our laboratory aims to educate students efficient methodologies for research and development of replacement and assist type mechanical circulatory support devices, for effective maintenance of circulation using artificial hearts, and for clinical applications of artificial hearts as well as research on next generation modalities for cardiovascular diseases.

## 3. Research Subjects

- 3.1 Research and Development of Advanced CardioVascular Devices:** Advanced mechanical circulatory support devices applicable from infants to adults, from extracorporeal to implantable systems will be researched and developed to treat end-stage heart failure patients. Through CAD/CAM design and precision machining, in vitro performance and durability testing, and ex vivo and in vivo biological performance studies, clinically applicable devices will be obtained.
- 3.2 Basic Research on Cell Biomechanics, Biorheology, and Thrombosis Studies:** The research focuses upon blood cells and device interaction, specifically mechanical effects of the cardiovascular devices upon blood cell elements including RBCs, WBCs and platelets, cell aggregation and adhesion phenomena, lysis and coagulation process on the artificial surface. The study will lead to understanding of mechanism leading to hemolysis, coagulation in the cardiovascular devices to attain biocompatible devices.
- 3.3 Research and Development of Sensors and Control Algorithm:** This study aims at development of sensors for cardiovascular dynamics measurement and possible application in controlling the artificial organs. The optical interaction with blood cells, tissues and organs will be investigated to develop an appropriate sensing technique and sensors. This study will be conducted in connection with the basic research of (2) to understand mechanical effects of blood pumps upon blood cell elements leading to hemolysis and arteriosclerosis process. In relation to understanding the recovery process of myocardium during ventricular unloading with the mechanical circulatory devices, a semiconductor micro-pressure sensor that can be used for prolonged duration in biological environment will be researched and developed.
- 3.4 Research and Development of Optimal Methods for Promoting Myocardial Recovery, Understanding of Recovery Process and Next Generation Devices:** Aiming at understanding recovery process of myocardium during mechanical unloading, this study constructs a global model of cardiovascular system covering from molecular level to organ level. Next generation optimal therapy by combining mechanical circulatory support device with regenerative medicine, cell transplantation and pharmaceutical regimens will be researched.

## 4. Clinical Services

We plan to contribute to treatment of acute as well as chronic heart failure patients through short or prolonged applications of pulsatile and/or continuous flow circulatory support devices.

## 5. Publications

### Original articles

1. Sakota D and Takatani S. Photon-Cell Interactive Monte Carlo "*pciMC*" model based on the geometric optics theory for photon migration in blood by incorporating both extra- and intra-cellular pathways. *J Biomed Optics*

2010 November/December; 15(6): 2010.

2. Ugaki S, Honjo O, Nakakura M, Douguchi T, Itagaki A, Yokoyama N, Ohuchi K, Takatani S, and Sano S. Transfusion-Free Neonatal Cardiopulmonary Bypass Using a TinyPump, *Annals of Thoracic Surgery* 2010; 90: 1615-21.
3. Yokoyama Y, Kawaguchi O, Shinshi T, Steinseifer U, Takatani S. A new Pulse Duplicator with a Passive Fill Ventricle for Analysis of Cardiac Dynamics. *J Artif Organs* (PMID:20878198 (8pp) 2010).
4. Yokoyama Y, Kawaguchi O, Kitao T, Kimura T, Steinseifer U, and Takatani S. Prediction of the external work of the native heart from the dynamic H-Q curves of the rotary blood pumps during left heart bypass. *Artif Organs* 2010; 34(9): 766-777.
5. Nagaoka E, Someya T, Kitao T, Kimura T, Ushiyama T, Hijikata W, Shinshi T, Arai H, Takatani S. Development of a disposable magnetically levitated centrifugal blood pump (MedTech Dispo) intended for bridge-to-bridge applications -Two-week in vivo evaluation. *Artif Organs* 2010; 34(9): 778-783.
6. Hijikata W, Sobajima H, Shinshi T, Nagamine Y, Wada S, Takatani S, and Shimokohbe A. Disposable MagLev Centrifugal Blood Pump Utilizing a Cone-Shaped Impeller. *Artif Organs* 2010; 34(8): 669-677.
7. Sakota D, Takatani S. Photon Cell Interactive Monte Carlo (pciMC) Model to describe both Intracellular and Extracellular optical pathways of biconcave red blood cells: Phase Function and Albedo. Proc. SPIE. 757316 (10pp), 2010

#### Review Articles

1. Yamane T, Kyo S, Matsuda H, Abe Y, Imachi K, Masuzawa T, Nakatani T, Sase K, Tabayashi K, Takatani S, Tatsumi E, Umezu M and Tsuchiya T, Japanese guidance for ventricular assist devices and total artificial hearts, *Artif Organs* 2010; 34(9): 699-702.

#### Conference Presentations

##### Overseas

##### Invited Lectures

1. Takatani S, Rotary blood pumps for pediatric and adult extracorporeal circulation, **18<sup>th</sup> Congress of the International Society for Rotary Blood Pumps (ISRBP) 2009**, Berlin, Germany, October 14-16, 2010.
2. Kitao T, Ando Y, Yoshikawa M, Kobayashi M, Kimura T, Osawa H, Machida S, Yokoyama N, Konno T, Ishihara K, Takatani S. In Vivo Evaluation of TinyPump for Pediatric Mechanical Circulatory Support. **6<sup>th</sup> World Congress on Biomechanics 2010**, Singapore, August 1-8, 2010.

##### General Presentations

1. Yokoyama Y, Kimura T, Nagaoka E, Shinshi T, Arai H, Takatani S. Assessment of hemodynamic as well as thrombogenic performances of a magnetically levitated centrifugal blood pump based on the Fast Fourier Transform analysis of impeller dynamics, **18<sup>th</sup> Congress of the International Society for Rotary Blood Pumps ISRBP**, Berlin Germany, October 14-16, 2010.
2. Kimura T, Yokoyama Y, Sakota D, Nagaoka E, Takakuda K, Takatani S. Evaluation of platelet aggregation in calves during centrifugal blood pump support. **18<sup>th</sup> Congress of the International Society for Rotary Blood Pumps ISRBP**, Berlin Germany, October 14-16, 2010.
3. Ando Y, Kitao T, Nagaoka E, Kimura T, Yokoyama N, Sakota D, Yokoyama Y, Yoshikawa M, Tomonaga R, Takatani S. In vivo biocompatibility assessment of the pediatric TinyPump: Results of the 6<sup>th</sup> version. **18<sup>th</sup> Congress of the International Society for Rotary Blood Pumps ISRBP**, Berlin Germany, October 14-16, 2010.
4. Yokoyama N, Sakota D, Nagaoka E, Takatani S. In vivo validation of selective destruction of aged RBCs by a rotary blood pump. **18<sup>th</sup> Congress of the International Society for Rotary Blood Pumps ISRBP**, Berlin Germany, October 14-16, 2010.
5. Nagaoka E, Someya T, Hijikata W, Ando Y, Yokoyama Y, Shinshi T, Arai H, Takatani S. MedTech Dispa, a disposable mag-lev centrifugal blood pump: Two-month in vivo evaluation of biocompatibility in LVADcondition. **18<sup>th</sup> Congress of the International Society for Rotary Blood Pumps ISRBP**, Berlin Germany, October 14-16, 2010.
6. Sakota D and Takatani S. A Novel Photon Propagation Model for Non-invasive and Continuous Diagnosis of Blood during Extracorporeal Circulation with Rotary Blood Pumps. **18<sup>th</sup> Congress of the International Society for Rotary Blood Pumps ISRBP**, Berlin Germany, October 14-16, 2010.
7. Hijikata W, Mamiya T, Shinshi T, Takatani S, Development of a maglev centrifugal blood pump employing a

- magnet-less disposable pump head, **18<sup>th</sup> Congress of the International Society for Rotary Blood Pumps ISRBP**, Berlin Germany, October 14-16, 2010.
8. Suzuki Y, Kita K, Hamazaki S, Hisamatsu A, Fujita H, Takatani S, Performance improvement of an axial flow pump using forced whirling motion effect, **18<sup>th</sup> Congress of the International Society for Rotary Blood Pumps ISRBP**, Berlin Germany, October 14-16, 2010.
  9. Hamazaki S, Suzuki Y, Fujita H, Takatani S, Development of a mixed flow pediatric blood pump, **18<sup>th</sup> Congress of the International Society for Rotary Blood Pumps ISRBP**, Berlin Germany, October 14-16, 2010.
  10. Yokoyama N, Sakota D, Yasuda T and Takatani S. Age Dependent deformability changes of RBCs evaluated using a cyclically reversing shear flow generator. **54<sup>th</sup> Annual Meeting for Biophysical Society**, San Francisco, California, USA, February 20-24, 2010
  11. Sakota D and Takatani S, Photon-Cell Interactive Monte Carlo (pciMC) Model to describe both Intracellular and Extracellular Optical Pathways for Biconcave Red Blood Cells: Phase Function and Albedo. **SPIE Photonics West 2010**, San Francisco, California, USA, Jan.23-28, 2010.