

# *8<sup>th</sup> International Conference on Pediatric Mechanical Circulatory Support Systems & Pediatric Cardiopulmonary Perfusion*

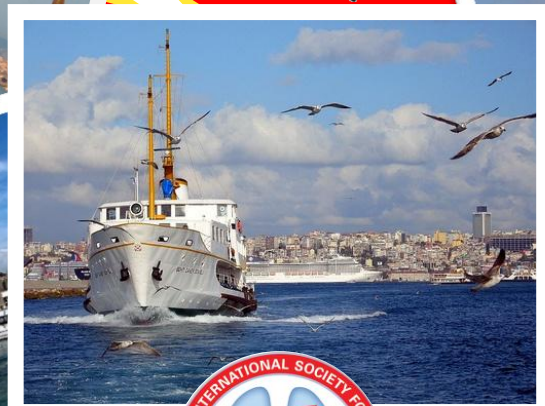
**JUNE 13-16, 2012, GALATASARAY UNIVERSITY, ISTANBUL, TURKEY**

<http://pennstatehershey.org/web/pedscpb/home>

*8<sup>th</sup> INTERNATIONAL CONFERENCE IS DEDICATED TO HONOR  
PROF. DR. AYDIN AYTAÇ FOR HIS LIFE-LONG CONTRIBUTIONS  
AS A PIONEERING SURGEON AND EDUCATOR OF THE  
DEVELOPMENT OF PEDIATRIC CARDIAC SURGERY IN TURKEY*



*Türkiye*



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Research Center  
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## *Graduate Student Oath*

*I* have entered the serious pursuit of new knowledge as a member of the community of graduate students at Penn State College of Medicine. I will strive to uphold the values of integrity, professionalism, and scholarship.

### **INTEGRITY**

I will uphold academic and scientific honesty.

I will conduct research objectively, using my knowledge responsibly.

I will not allow financial gain, competition, or personal ambition to cloud my judgment in the conduct of ethical research and scholarship.

### **PROFESSIONALISM**

I will share knowledge and resources resulting from my research, within the limits of intellectual property agreements.

I will contribute to the public understanding of the scientific process and the impact of my results.

I will minimize the adverse effects of my research on people, animals and the natural world.

### **SCHOLARSHIP**

I will report my results accurately regardless of the expectations set forth by myself, the scientific community, or funding sources.

I will recognize the limits of my knowledge and will pursue life-long learning.

I will fulfill my responsibility to mentor and instruct the next generation of scientists.

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## Welcome to the Eighth Annual Event

### Welcome to the 8<sup>th</sup> International Conference on Pediatric Mechanical Circulatory Support Systems & Pediatric Cardiopulmonary Perfusion

Akif Ündar, PhD, USA, Atıf Akçevin, MD, Turkey, Tijen Alkan-Bozkaya, MD, Turkey, İhsan Bakır, MD, Turkey, Yves Durandy, MD, France, Huriyet Ersayın-Kantas, FCCP, UK, Colleen E. Gruenwald, PhD, Canada, Giovanni Battista Luciani, MD, Italy, David Palanzo, CCP, USA, Linda B. Pauliks, MD, MPH, USA, Chitra Ravishankar, MD, USA, Eugen Sandica, MD, Germany, Shunji Sano, MD, PhD, Japan, Kyung Sun, MD, PhD, MBA, Korea, Rıza Türköz, MD, Turkey, Bonnie Weaver, RN, CCRN, USA, and John L. Myers, MD, USA

On behalf of the organizing committee, we are pleased to welcome you to the 8<sup>th</sup> International Conference on Pediatric Mechanical Circulatory Support Systems & Pediatric Cardiopulmonary Perfusion at the GALATASARAY UNIVERSITY, ISTANBUL, TURKEY. Atıf Akçevin, MD, Chief of Cardiovascular Surgery at the American Hospital in Istanbul will be the Local Conference Chair. The scientific co-chairs of this unique event will be Tijen Alkan-Bozkaya, MD, Turkey, İhsan Bakır, MD, Turkey, Yves Durandy, MD, France, Huriyet Ersayın-Kantas, FCCP, UK, Colleen E. Gruenwald, PhD, Canada, Giovanni Battista Luciani,

MD, Italy, John L. Myers, MD, USA, David Palanzo, CCP, USA, Linda B. Pauliks, MD, MPH, USA, Chitra Ravishankar, MD, USA, Eugen Sandica, MD, Germany, Shunji Sano, MD, PhD, Japan, Kyung Sun, MD, PhD, MBA, Korea, Rıza Türköz, MD, Turkey, and Bonnie Weaver, RN, CCRN, USA.

The eighth international conference is dedicated to honor Prof. Dr. Aydın Aytaç for his life-long contributions as a pioneering surgeon and educator of the development of pediatric cardiac surgery in Turkey (Figure 1).

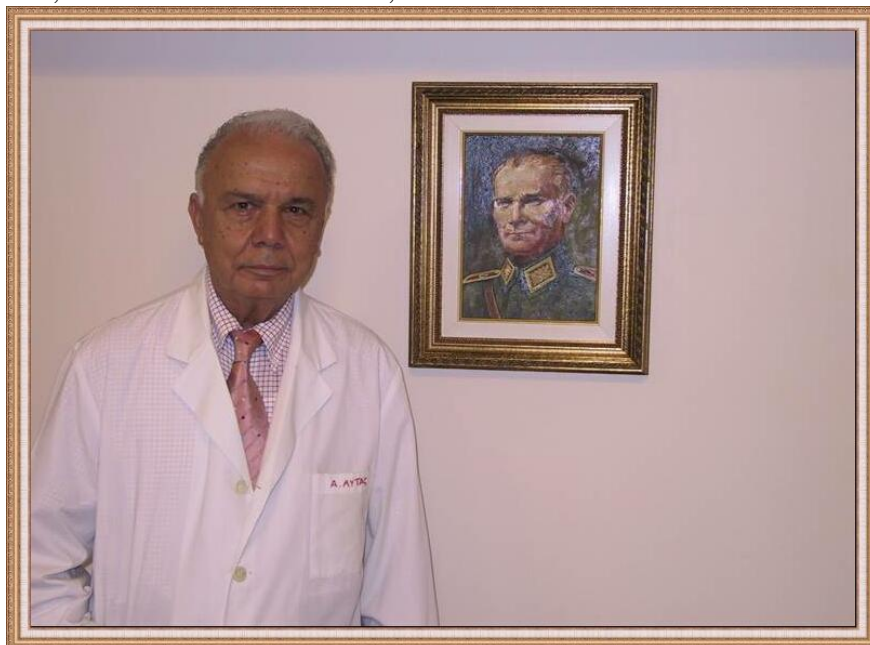


Figure 1. Prof. Dr. Aydın Aytaç.

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This year, we were fortunate enough to organize our event at the historic Galatasaray University and its magnificent facilities located in Istanbul which is the only city in the world built on two continents, Asia and Europe. The university was first established in 1481 and was called the Galata Palace ('Galata Saray') as an "Enderun-u Hümayunu" (Galata Palace Imperial School). All of the magnificent past of this university can be found at the following link: <http://gsu.edu.tr/en/universite/tarihce>. We hope that all of the participants will enjoy the event in this historic setting and incredible view of the Bosphorus.

Plenary sessions, mini-symposiums and regular slide and poster presentations will start on Thursday morning, June 14, and continue through 5 pm on Saturday, June 16th. The topic of the first plenary session will be "Managing the single ventricle patient from fetus to definite treatment", followed by a key note lecture. This year's participants will also have the distinct pleasure of having Professor of Emeritus, William S. Pierce, MD, from Penn State Hershey College of Medicine, as the key note lecturer. His lecture is entitled "A 40-YEAR ODYSSEY IN MECHANICAL CIRCULATORY SUPPORT". The second Plenary panel will focus on "Pediatric mechanical circulatory support (MCS) devices and outcomes" including a special lecture entitled "Pediatric MCS and Pediatric Heart Transplantation in Japan" by Shunji Sano, MD. The first day's scientific program will end with a mini-symposium entitled "Bioengineering approaches in pediatric cardiovascular medicine".

Second and third days of the event will also cover the most important neonatal/pediatric cutting-edge topics and all new results on extracorporeal life support systems including multi-disciplinary team approach to solve the complex problems in neonatal and pediatric cardiac surgery; cardiopulmonary perfusion; myocardial protection; neonatal and pediatric anesthesia; neuromonitoring; and pediatric MCS and CPB around the globe. In addition, there will be dozens of slide and poster presentations from young investigators. The last day of the event will bring several wet-labs including ECLS circuits; VADs; Ultrafiltration; Pulsatile perfusion; Neonatal/Pediatric CPB Circuit - step-by-step circuit set-up; Neuromonitoring; Near-infrared

spectroscopy (NIRS); and Neonatal/Pediatric oxygenators with integrated arterial filters. These wet labs will be organized by moderators Huriyet Ersayin-Kantas, FCCP, UK, and David Palanzo, CCP, USA.

### Conference awards

The program committee members have decided to add two new young investigator awards for the Istanbul meeting because of their life-long contributions to the Artificial Organs: The Yukihiro Nosé, MD, PhD, Young Investigator Award and The Peer M. Portner, PhD, Young Investigator Award. In addition to six earlier awards, all eight awards will be given to young investigators based on their full manuscript and original research. All details regarding awards can be accessed via conference web site. <http://pennstatehershey.org/web/pedscpb/home>.

### Artificial Organs

If an abstract is accepted either for oral or poster presentation, then the presenters are required to submit original manuscripts. As usual, the January 2013 issue of Artificial Organs is dedicated to our conference manuscripts, in addition to May 2012 issue for accepted abstracts. Special thanks to Angela T. Hadsell, Executive Editor, and Paul Malchesky, D. Eng, Editor-in-Chief, for making this issue possible and for their continued support year after year.

### Financial support

We thank the Penn State Hershey Pediatric Cardiovascular Research Center, the Penn State Hershey Children's Hospital, and the International Society for Pediatric Mechanical Circulation Support for providing financial support to this event. In addition, we received funds from the following companies (as of April 18, 2012):

#### Platinum Level:

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### **Third annual meeting of the international society for pediatric mechanical cardiopulmonary support**

Third annual meeting of the Society will be held at the Galatasaray University, Aydin Doğan Conference Room, from noon to 1 pm on June 15, 2012, during the 8th International Conference on Pediatric Mechanical Circulatory Support Systems & Pediatric Cardiopulmonary Perfusion. This meeting will be for Society members only. All society details, including: mission, membership registration, and sponsorship applications can be found at the Society and Conference web site. <http://pennstatehershey.org/web/pedscpb/home>

Our society has not only made significant contributions to education and training for participants at the 7th event in 2011, but has also reached out to Istanbul by organizing three additional symposiums and wet-labs resulting in training of over 312 participants from 50 centers all around the Republic of Turkey (1-9). These special one day symposiums called "Istanbul Symposiums" will be continued with different topics in 2012 as well. Based on the outcomes of these symposiums, we have already seen remarkable changes in particular for neonatal CPB and ECLS around the Republic of Turkey (3-4). In addition, members of these symposiums have direct communication with the officials at the health ministry in Turkey.

### **Future goals of the society and the conference**

During the past seven years, we have generated over 350 high quality publications in all aspects of pediatric CPB and MCS on this underserved area of research (5). Our goal is to reach 500 publications by the end of the 10th conference. In addition, we have trained and educated hundreds of participants each year (over 1,850 participants to date). Again, for the next three conferences, we would like to do the same, and educate on average 250-300 participants each year.

Several senior members of the society raised concerns regarding corporate membership. In response, we had to remove just a few members who had significant conflict of interest (COI) or intentionally mislead us regarding their disclosures. We can assure each

member of the society (and future members as well) that there was not, is not, and will not be any influence from Industry on our society. All members have to fill out the Disclosure forms annually, and any applicant who has any financial gain from a relevant industry will not be accepted as a member of the society. Our goal remains to be 100% free from commercial bias. Therefore, we will only accept and elect board members who have no financial or scientific conflicts of interest with the aims of our society. During the third society meeting, each member will receive a full report for the year of 2011 as well as future society goals and elections of several committees.

As we have written several times before, our motto continues to be "If the course of just one child's life is improved as a result of this event, we have reached our goal."

### **Acknowledgments:**

Special thanks go to Heather Stokes and Jennifer Stokes, RN, from the Pediatric Clinical Research Office of the Penn State Hershey Milton S. Medical Center for their assistance in the coordination and management of this event. Parts of this editorial were extracted from authors' earlier publication in Artificial Organs (10).

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## International Faculty

### *Conference Founder*

Akif Ündar, PhD

### *Honorary Co-Chairs*

Aydın Aytaç, MD, Istanbul, Turkey  
John A. Waldhausen, MD, Hershey, USA  
William S. Pierce, MD, Hershey, USA

### *Local Conference Chair*

Atıf Akçevin, MD, Istanbul, Turkey

### *Local Honorary Co-Chairs*

Sait Aşlamacı, MD, Ankara, Turkey  
Tayyar Sarioğlu, MD, Istanbul, Turkey

### *Planning/Scientific Committee:*

Tijen Alkan-Bozkaya, MD, Turkey  
İhsan Bakır, MD, Turkey  
Yves Durandy, MD, France  
Huriyet Ersayın-Kantas, FCCP, UK  
Colleen E. Gruenwald, PhD, Canada  
Giovanni Battista Luciani, MD, Italy  
John L. Myers, MD, USA  
David Palanzo, CCP, USA  
Linda B. Pauliks, MD, MPH, USA  
Chitra Ravishankar, MD, USA  
Eugen Sandica, MD, Germany  
Shunji Sano, MD, PhD, Japan  
Kyung Sun, MD, PhD, MBA, Korea  
Rıza Türköz, MD, Turkey  
Bonnie Weaver, RN, CCRN, USA

### *Social Program Chair:*

Tijen Alkan-Bozkaya, MD, Turkey

### *International & Local Members, Moderators & Wet Lab Instructors*

Hashim Abdul-Khaliq, MD, Germany  
David Anderson, MD, UK  
Luca Barozzi, MD, Italy  
Emre Belli, MD, France  
Dietmar Boethig, MD, Germany  
Christos Calaritis, CCP, Canada  
Jean-Yves Chevalier, MD, France  
Chris Chin, MD, UK  
Nigel Cross, FCCP, UK  
Yves Durandy, MD, France  
Huriyet Ersayın-Kantas, FCCP, UK  
Colleen E. Gruenwald, PhD, Canada  
Giovanni Battista Luciani, MD, Italy  
Hideshi Itoh, CCP, Japan  
Thomas Markmann, Germany  
John L. Myers, MD, USA  
David Palanzo, CCP, USA  
Linda B. Pauliks, MD, MPH, USA  
Kerem Pekkan, PhD, USA  
Feng Qiu, MD, China  
Chitra Ravishankar, MD, USA  
Adela Rohnean, MD, France  
Marina Rubatti, MD, France  
Eugen Sandica, MD, Germany  
Shunji Sano, MD, PhD, Japan  
Kyung Sun, MD, PhD, MBA, Korea  
Serdar Ural, MD, USA  
Michael Van Driel, Ing. Switzerland  
Bonnie Weaver, RN, CCRN, USA  
Wei Wang, MD, China  
Sung Yang, PhD, Korea  
Jeffrey D. Zahn, PhD, USA

### *Local Members – Türkiye*

Mehmet A. Ağırbaşı, MD  
Alp Alayunt, MD  
Tijen Alkan-Bozkaya, MD  
Numan Ali Aydemir, MD  
İhsan Bakır, MD  
Hakan Ceyran, MD  
Sertaç Çiçek, MD  
Ali İhsan Dokucu, MD  
Ersin Erek, MD  
Sertaç Haydın, MD  
Ali Rıza Karacı, MD  
Ender Ödemiş, MD  
İsmihan Selen Onan, MD  
Tufan Paker, MD  
Ahmet Şaşmaz, MD  
Halil Türkoğlu, MD  
Ayda Türköz, MD  
Rıza Türköz, MD  
Yusuf K. Yalçınbaş, MD  
Tahir Yağdı, MD

### *Conference Coordinator:*

Heather Stokes

## Conference Supporters

### Educational Grants:

Penn State Hershey Pediatric Cardiovascular Research Center, Hershey, PA  
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International Society For Pediatric Mechanical Cardiopulmonary Support



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## Final Scientific Program

### Wednesday, June 13, 2012

1:00pm – 5:00pm Registration

### Thursday, June 14, 2012

7:00am – 8:00am Registration

8:00am – 8:20am WELCOME - Atif Akçevin, MD, Turkey & Akif Ündar, PhD, USA

8:20am-10:00am **PLENARY SESSION #1: Managing the Single Ventricle Patient from Fetus to Definite Treatment (20 min. each)**

Moderators: David Anderson, MD, UK & John L. Myers, MD, USA and Shunji Sano, MD, PhD, Japan

1. HLHS- Surgical approach (John L. Myers, MD, USA)
2. The HYBRID Operation in High-Risk cases of HLHS and Critical Aortic Stenosis / Borderline Left Ventricle (David Anderson, MD, UK)
3. Heart Transplantation in Neonates and Infants (Chitra Ravishankar, MD, USA)
4. Echocardiographic Assessment of Single Ventricle Heart (Linda B. Pauliks, MD, MPH, USA)

Discussion – 20 minutes

10:00am – 11:00am Break / Posters / Exhibitions / Wet-labs

11:00am – 11:45am **KEY NOTE LECTURE: A 40-YEAR ODYSSEY IN MECHANICAL CIRCULATORY SUPPORT**  
(WILLIAM S. PIERCE, MD, HERSEY, PA, USA)

Introduction: John L. Myers, MD, USA

11:45am – Noon Presentation of Young Investigators' Awards

Noon – 1:00pm Lunch

1:00pm – 3:00pm **PLENARY SESSION #2: Pediatric MCS – Devices & Outcomes (20 min. each)**  
Moderators: William S. Pierce, MD, USA & Kyung Sun, MD, PhD, MBA, Korea

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**SPECIAL LECTURE: Pediatric Mechanical Circulatory Support and Pediatric Heart Transplantation in Japan (Shunji Sano, MD, PhD, Japan) (30 min)**

1. Pediatric MCS: Bad Oeynhausen Experience. (Eugen Sandica, MD, Germany)
2. Characteristics of a Non-Occlusive Pressure-Regulated Blood Roller-Pump (Yves Durandy, MD, France)
3. CARDIOHELP – The Multi-Use ECLS Platform (Thomas Markmann, Germany)
4. First Use of a New Diagonal Pump in Extracorporeal Support Systems for Children and Infants (Dietmar Boethig, MD, Germany)

Discussion – 10 minutes

3:00pm – 3:45pm Break / Posters / Exhibitions / Wet-labs

3:45pm – 5:45pm **MINI-SYMPOSIUM #1: Bioengineering Approaches in Pediatric Cardiovascular Medicine (20 min. each)**

Moderator: Akif Ündar, PhD, USA and Jeffrey D. Zahn, PhD, USA

1. Advances in Neonatal and Pediatric Bioengineering Using Computational Fluid Dynamics (Kerem Pekkan, PhD, USA)
2. Development of a Microanalytical Monitor for Tracking Systemic Inflammation during Extracorporeal Circulatory Support (Jeffrey D. Zahn, PhD, USA)
3. Recent Progress in Measurement of Blood Physical Properties under Microfluidic Environments. (Sung Yang, PhD, Korea)
4. Circuit Components' Selection during Neonatal / Pediatric CPB: An Engineering Approach (Akif Ündar, PhD, USA)
5. The Relation of Manufacturing Techniques and Cannula Choice in Pediatric Extracorporeal Circulation (Ing. Michael Van Driel, Switzerland)

Discussion – 15 minutes

8:00am – 5:45pm **Poster Presentation #1:**

Co-Chairs: Tijen Alkan-Bozkaya, MD, Turkey and Ahmet Şaşmaz, MD, Turkey

**P1. The Effect of Different Modified Ultrafiltration Durations on Early Postoperative Pulmonary Functions and Hemodynamics in Newborn and infants Following Arterial Switch Operation**

Ayda Türköz, MD, Ezgi Tunçay, MD, Şule Turgut Balcı, MD, Hülya Gönen, MD, Emre Ozker, MD, Halim Ulugöl, MD, Can Vuran, MD, Bülent Sarıtaş, MD, Rıza Türköz, MD, Gülnaz Arslan, MD.

*Departments of Anesthesiology and Cardiovascular Surgery, Baskent University  
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**P2. Evaluation of Three Hollow-Fiber Membrane Oxygenators without Integrated Arterial Filters for Neonatal Cardiopulmonary Bypass**

NM Dogal,<sup>1</sup> RK Mathis,<sup>1</sup> J Lin,<sup>1</sup> F Qiu,<sup>1</sup> A Kunselman<sup>2</sup> and Akif Ündar<sup>1,3,4</sup>

<sup>1</sup>Penn State Hershey Pediatric Cardiovascular Research Center, Department of Pediatrics; <sup>2</sup>Public Health and Sciences; <sup>3</sup>Department of Surgery; <sup>4</sup>Department of Bioengineering, Penn State Milton S. Hershey Medical Center, Penn State Hershey College of Medicine, Penn State Hershey Children's Hospital, Hershey, Pennsylvania, USA

**P3. The Protective Effect of St. Thomas' Cardioplegia Enriched with Zacopride on Rat Isolated Hearts**

Bei Wu MD, Cun Long, MD, Feilong Hei, MD, Shilei Wang, MS.

Department of Extracorporeal Circulation, Fuwai Hospital and Cardiovascular Institute, Chinese Academy of Medical Science, Peking Union Medical College, Beijing, China

**P4. The Hepatic Morphology after Heart Surgery in Neonates: The Effects of Cardiopulmonary Bypass and Hypothermia**

Theodor Tirilomis,<sup>1</sup> MD, PhD, Julia M. Zwiehoff,<sup>1</sup> MD, Regina Waldmann-Beushausen,<sup>1</sup> Simon Schneider,<sup>2</sup> MD, Friedrich A. Schoendube,<sup>1</sup> MD, PhD

<sup>1</sup>Dept. for Thoracic, Cardiac, and Vascular Surgery and <sup>2</sup>Dept. for Medical Statistics, University of Goettingen, Goettingen, Germany

**P5. Selective Cerebral Perfusion with Aortic Cannulation and Short Hypothermic Circulatory Arrest in Aortic Reconstruction**

Rıza Türköz, MD, Bülent Sarıtaş, MD, Emre Özker, MD, Can Vuran, MD, Uygar Yörüker, MD, Şule Balcı, MD Ayda Türköz, MD

Departments of Cardiovascular Surgery, Department of Anesthesia, Baskent University, Istanbul Teaching and Medical Research Center, Istanbul, Turkey

**P6. Cardiectomy, Circulation Splitting, Damus Interruption: Complex Scenarios in Paediatric Mechanical Circulatory Support with Berlin Heart Excor.**

Massimo Griselli, MD, MS, FRCS (CTh), Phil Botha, PhD, MRCS, Jane Cassidy, MRCP, Asif Hasan, FRCS (CTh)

Departments of Paediatric Cardiothoracic Surgery, Freeman Hospital, Newcastle upon Tyne, UK

**P7. Reduction of Driveline Infections through Doubled Driveline Tunneling of Left Ventricular Assist Devices (LVAD)**

Felix Fleissner, MD, Murat Avsar, MD, Doris Malehsa, MD, Petra Weißhaeuptl-Karstens, Martin Strueber MD, Axel Haverich MD, Jan D. Schmitto, MD

Department of Cardiac-, Thoracic-, Transplantation- and Vascular Surgery

Hannover Medical School, Germany

**P8. Clinical Outcomes and Experience of 13 Pediatric Patients after Arterial Switch Operation Managed with Extracorporeal Membrane Oxygenation**

Yuan Yuan, MD, Long Cun, MD, Liu Jinping, MD, Feng Zhengyi, MD, Zhao Ju, MD, Cui Yongli MD

*Department of Extracorporeal Circulation, Fuwai Hospital and Cardiovascular Institute, Chinese Academy of Medical Science, Peking Union Medical College, Beijing, China*

**P9. The NeonatOx: An Update on Design, In-Vitro, and In-Vivo Testing**

Jutta Arens<sup>1‡</sup>; Mark Schoberer<sup>2‡</sup>; Aileen Erben<sup>2</sup>; Thorsten Orlikowsky<sup>2</sup>; Daan Ophelders<sup>3</sup>; Reint K. Jellema<sup>3</sup>; Boris W. Kramer<sup>3</sup>; Petra De Brouwer<sup>1</sup>; Thomas Schmitz-Rode<sup>1</sup>; Ulrich Steinseifer<sup>1</sup>

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**P10. Miniaturisation: The Clue to Clinical Application of the Artificial Placenta**

Mark Schoberer<sup>1‡</sup>; Jutta Arens<sup>2‡</sup>; Aileen Erben<sup>1</sup>; Petra De Brouwer<sup>2</sup>; Thomas Schmitz-Rode<sup>2</sup>; Ulrich Steinseifer<sup>2</sup>; Daan Ophelders<sup>3</sup>; Reint K. Jellema<sup>3</sup>; Boris W. Kramer<sup>3</sup>; Thorsten Orlikowsky<sup>1</sup>

<sup>1</sup> Section Neonatology of the Department of Paediatric and Adolescent Medicine, University Hospital, RWTH Aachen University, Aachen, Germany; <sup>2</sup> Department of Cardiovascular Engineering, Institute of Applied Medical Engineering, Helmholtz Institute, RWTH Aachen University, Aachen, Germany; <sup>3</sup> Department of Paediatrics, School of Mental Health and Neuroscience; School of Oncology and Developmental Biology; Maastricht University Medical Center, Maastricht, Netherlands; <sup>‡</sup> Both Authors contributed equally to this manuscript

**Friday, June 15, 2012**

**7:00am – 8:00am Registration**

**8:00am – 10:00am PLENARY SESSION #3: Extracorporeal Life Support (20 min. each)**

**Moderators: Chitra Ravishankar, MD, USA & Bonnie Weaver, RN, CCRN, USA**

**1. The Use of ECMO Utilizing the Rotaflow Pump in Pediatric Patients  
(Colleen E. Gruenwald, PhD, Canada)**

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2. Pediatric Single Cannula Veno-Venous Extracorporeal Membrane Oxygenation: A Twenty-year Clinical Experience (Jean-Yves Chevalier, MD, France & Pierre-Louis Leger, MD, France)
3. Unfractionated Heparin Monitoring Strategies for ECLS (Christos Calaritis, CCP, Canada)
4. Pediatric Extracorporeal Life Support Nursing Education: 2012 Update (Bonnie Weaver, RN, CCRN, USA)
5. Translational Research on Neonatal/Pediatric ECLS: 2012 Update (Akif Ündar, PhD, USA)

Discussion – 20 minutes

10:00am – 10:45am Break / Posters / Exhibitions / Wet-labs

10:45am – Noon MINI-SYMPOSIUM #2: Multi-Disciplinary Team Approach to Solve the Complex Problems in Neonatal and Pediatric Cardiac Surgery (20 min. each)  
Moderators: İhsan Bakır, MD Turkey and Tayyar Sarioğlu, MD, Turkey

1. Congenital Heart Disease: From Computational Fluid Dynamics to Surgery (Luca Barozzi, MD, Italy and Giovanni Battista Luciani, MD, Italy)
2. Nonsurgical Management of Pulmonary Atresia with Intact Ventricular Septum in Neonates (Ender Ödemiş, MD, Turkey)
3. Application of Hemodynamic Energy to Cardiovascular Research at Korea Artificial Organ Center (Kyung Sun, MD, PhD, MBA, Korea)

Discussion (15 minutes)

Noon – 1:00pm LUNCH  
**3<sup>rd</sup> ISPMCS ANNUAL MEETING – Members ONLY – Aydın Doğan Conference Room**

1:00pm – 3:00pm PLENARY SESSION #4: Cardiopulmonary Perfusion (17 min. each)  
Moderators Colleen E. Gruenwald, PhD, Canada and David Palanzo, CCP, USA

1. The Use of Blood and Strategies of Blood Conservation in Infant Cardiac Surgery Using Cardiopulmonary Bypass (Colleen E. Gruenwald, PhD, Canada)
2. Biomarker Response to CPB in Pediatric Population (Mehmet A. Ağırbaşı, MD)
3. Importance of Complete MUF in Pediatric Cardiac Surgery Patients (David Palanzo, CCP, USA)
4. Pediatric Perfusion in Japan: 2010 Practice Survey (Hideshi Itoh, CCP, Japan)
5. Evaluation of neonatal oxygenators with or without integrated arterial filters (Feng Qiu, MD, China)

6. Pediatric / Neonatal MCS & CPB in Guys & St Thomas' Hospital NHS Foundation Trust (Huriyet Ersayin-Kantas, FCCP, UK)

7. Multi Year Clinical Experience with Affinity Pixietm Oxygenation System in Pediatric and Infant Patients (Nigel Cross, FCCP, UK)

3:00pm – 3:45pm Break / Posters / Exhibitions / Wet-labs

3:45pm – 5:15pm MINI-SYMPOSIUM #3: Myocardial Protection during CPB (15 min. each)  
Moderator: Atif Akçevin, MD, Istanbul, Turkey and Emre Belli, MD, France

**SPECIAL LECTURE: Arterial Switch Operation: Technical details influencing outcome.**  
Marie Lannelongue experience based on 2000 procedures (Emre Belli, MD, France)  
(30 min)

1. Myocardial protection during Neonatal/Pediatric CPB  
(Rıza Türköz, MD, Istanbul, Turkey)
2. Is There Any Rationale for the Choice of a Time Interval between Cardioplegia Injections? (Yves Durandy, MD, France)
3. Relation between Warm Ischemic Time and Peak Level of Troponin Following Cardiopulmonary Bypass (Marina Rubatti, MD, France)

Discussion – 15 minutes

5:15pm – 7:00pm INVITED LECTURE: Protective Effects of Limb Ischemic Preconditioning Pretreatment to the Brain after Cerebral Ischemic Injury (Wei Wang, MD, China) (20 min)

Regular Slide Presentations #1: (Selected from abstracts)  
10 slide presentations (10 min. each)

**Co-Chairs:** Eugen Sandica, MD, Germany, Luca Barozzi, MD, Italy, Kerem Pekkan, PhD

**Moderator:** Eugen Sandica, MD, Germany

**S1. Size of Berlin Heart Excor Influences Outcome in Children**

Oliver Miera<sup>1</sup>, MD, Stanislav Ovroutski<sup>1</sup>, MD, Michael Hübler<sup>2</sup>, MD, Björn Peters<sup>1</sup>, MD, Vladimir Alexi-Meskishvili<sup>2</sup>, PhD, Yuguo Weng<sup>2</sup>, PhD, Felix Berger<sup>1</sup>, PhD, Roland Hetzer<sup>2</sup>, PhD

<sup>1</sup> *Deutsches Herzzentrum Berlin, Dept. of Congenital Heart Disease / Pediatric Cardiology*

<sup>2</sup> *Deutsches Herzzentrum Berlin, Dept. of Cardiothoracic and Vascular Surgery, Berlin, Germany*

**S2. Left Atrial Decompression during Extracorporeal Membrane Oxygenation in Patients with Biventricular Physiology: Current Strategy and Clinical Outcomes**

Yasuhiro Kotani, MD<sup>1</sup>, Devin Chetan, HBA<sup>1</sup>, Warren Rodrigues, MD<sup>2</sup>, Ben Sivarajan, MD<sup>2</sup>,

Colleen Gruenwald, PhD<sup>3</sup>, Anne-Marie Guerguerian, MD<sup>2</sup>, Glen Van Arsdell, MD<sup>1</sup>, Osami Honjo, MD<sup>1</sup>

*Cardiovascular Surgery<sup>1</sup>, Critical Care Medicine<sup>2</sup>, Cardiovascular Perfusion<sup>3</sup>, Labatt Family Heart Centre, the Hospital for Sick Children, Toronto, Ontario, CANADA*

**S3. Dosage of Vasoactive-inotropic Agents: a Powerful Predictor of Acute Kidney Injury in Pediatric Patients with Extracorporeal Life Support**

Cui Yongli, MD, Liu Jinping, MD, Feng Zhengyi, MD, Zhao Ju, MD, Long Cun, MD, Wang Wei, MD

*Department of Extracorporeal Circulation, Fuwai Hospital, CAMS & PUMC, Beijing, China*

**Moderator: Luca Barozzi, MD, Italy**

**S4. Methylprednisolone in Neonatal Open Heart Surgery**

Juho Keski-Nisula, MD, Eero Pesonen, PhD, Kaija Peltola, PhD, Netta Tuominen, MD, Heikki Sairanen, PhD, Pertti Neuvonen, PhD, Klaus Olkkola, PhD, Sture Andersson, PhD, Pertti Suominen, PhD.

*Department of Anesthesia and Intensive Care, Children's Hospital, Helsinki University Central Hospital, P.O. B. 281, Stenbäckinkatu 11, FIN-00029 HUCS, Helsinki, Finland*

**S5. Tranexamic Acid in Pediatric Cardiac Heart Surgery**

R Couturier<sup>\*</sup> MD, M Rubatti<sup>\*</sup> MD, C Credico<sup>\*</sup> MD V Anelkian MD<sup>\*</sup>. V Louvain MD<sup>\*\*</sup> S Grassin Delye<sup>\*\*\*</sup>

*<sup>\*</sup>Department of Anesthesia, <sup>\*\*</sup>Laboratory of Hemostasis, Marie Lannelongue Hospital Le Plessis Robinson. <sup>\*\*\*</sup>Grassin Delye S Raymond Pointcarré Hospital Laboratory of Pharmacology Garches, France*

**S6. Should Peritoneal Dialysis Catheter Be Routinely Implanted In TGA Cases?**

Emre Özker, MD, Bülent Saritaş, MD, Can Vuran, MD, Uygur Yörüker, MD, Şule Balcı, MD, Özlem Sarısoy, MD, Rıza Türköz, MD

*Department of Cardiovascular Surgery, Department of Anesthesia, Department of Pediatric Cardiology, Baskent University, Istanbul Teaching and Medical Research Center, Istanbul, Turkey*

**Moderator: Kerem Pekkan, PhD, USA**



**S7. Randomized Comparison between Mild and Moderate Hypothermic Cardiopulmonary Bypass for Neonatal Arterial Switch Operation**

<sup>1</sup>Numan Ali Aydemir, <sup>1</sup>Bugra Harmandar, <sup>1</sup>Ali Riza Karaci, <sup>2</sup>Abdullah Erdem, <sup>1</sup>Ahmet Sasmazel, <sup>1</sup>Ibrahim Yekeler

<sup>1</sup>Department of Pediatric Cardiac Surgery, <sup>2</sup>Department of Pediatric Cardiology, ISTANBUL, TURKEY, Dr.Siyami Ersek Thoracic and Cardiovascular Training and Research Hospital

**S8. Angiotensin II Type 1 (AT1) Receptor Antagonist Not Cardioplegia Temperature Regulates Activation of Pro-Inflammatory Signal Transducers and Activators of Transcription (STAT) Proteins in Neonatal Rat Myocytes.**

Gianluca Lucchese, MD, PhD, Giulia Elisa Cambi, ScD, Fabrizio De Rita, MD, Mauro Franzoi, CP, Giuseppe Faggian, MD, Alessandro Mazzucco, MD, Pietro Amedeo Modesti, MD, PhD, Giovanni Battista Luciani, MD.

Division of Cardiac Surgery, University of Verona, Verona, Italy; Department of Medical and Surgical Critical Care, University of Florence, Italy

**S9. A Microfluidic Device to Continuously Measure Inflammation Biomarkers in Circulating Blood during Mechanical Circulatory Support Procedures**

Lawrence A. Sasso<sup>1</sup>, Ian H. Johnston<sup>1</sup>, Mihgde Zheng<sup>1</sup>, Rohit K. Gupte<sup>1</sup>, Akif Ündar<sup>2</sup>, Jeffrey D. Zahn<sup>1</sup>

<sup>1</sup>BioMEMS Laboratory, Department of Biomedical Engineering, Rutgers University, Piscataway, NJ; <sup>2</sup>Pediatric Cardiovascular Research Center, Departments of Surgery, Pediatrics, and Bioengineering, Penn State College of Medicine, Penn State Children's Hospital, Hershey, Pennsylvania, USA

**S10. Pre-Surgical Evaluation of Fontan Connection Options for Patients with Apicocaval Juxtaposition, using Computational Fluid Dynamics**

Prahlad G.Menon<sup>1</sup>, MS, Masahiro Yoshida<sup>2</sup>, MD, PhD, Kerem Pekkan<sup>1</sup>, PhD

<sup>1</sup> Department of Biomedical Engineering, Carnegie Mellon University, Pittsburgh, PA, USA; <sup>2</sup> Department of Cardiothoracic Surgery, Children's Hospital of Pittsburgh, Pittsburgh, PA, USA

8:00am – 7:00pm

**Poster Presentation #2:**

Co-Chairs: Ali Riza Karaci, MD, Turkey and Ayda Türköz, MD, Turkey

**P11. Results of Pediatric Mechanical Assist for Postcardiotomy Ventricular Failure and Cardiac Arrest in Intensive Care Unit: Choice of Device and Modality of Support**

\*Tayyar Sarioglu, MD, \*\*Yusuf Yalcinbas, MD, \*\*Yasemin Turkecul, MD, \*\*Ahmet Arnaz, MD, \*\*\*Bilge Narin, MD, \*\*\*Ayse Ulukol, MD, \*\*\*\*Arda Saygili, MD, \*\*Murat Boz, CCP, \*\*Zekeriya Telli, CCP, \*\*\*\*Ayşe Sarioglu, MD

\*Acibadem University, Department of Cardiovascular Surgery, Istanbul, Turkey

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*\*\*Acibadem Bakirkoy Hospital, Department of Cardiovascular Surgery, Istanbul, Turkey*

*\*\*\* Acibadem Bakirkoy Hospital, Department of Anesthesiology, Istanbul, Turkey*

*\*\*\*\*Acibadem Bakirkoy Hospital, Department of Pediatric Cardiology, Istanbul, Turkey*

**P12. A Novel Fontan Fenestration with Desirable Flow Characteristics - In Vitro Analysis and Lumped Parameter Modeling**

Priti G. Albal<sup>1</sup>, Riza Turkoz<sup>2</sup>, Akif Ündar<sup>3</sup>, Kerem Pekkan<sup>1</sup>

<sup>1</sup>Biomedical Engineering Department, Carnegie Mellon University, USA

<sup>2</sup>Cardio-thoracic Surgery Department, Baskent University, Istanbul

<sup>3</sup>Penn State Children's Hospital and Bioengineering, Pennsylvania State University, USA

**P13. Carotid Doppler Flow after Cardiopulmonary Bypass and Mild Hypothermia in Neonatal Piglets**

Theodor Tirilomis<sup>1</sup>, MD, PhD, Stella Malliarou<sup>2</sup>, MD, PhD, Marc Bensch<sup>1</sup>, MD, PhD, K. Oguz Coskun<sup>1</sup>, MD, Aron-Frederik Popov<sup>1</sup>, MD, PhD, Friedrich A. Schoendube<sup>1</sup>, MD, PhD

<sup>1</sup>Dept. for Thoracic, Cardiac, and Vascular Surgery, University of Goettingen, and

<sup>2</sup>Dept. for Neurology and Neurological Rehabilitation, Asklepios Clinics Schildautal, Seesen, Germany

**P14. Evaluation Of Quadrox-I and Capiiox FX Neonatal Oxygenators with Integrated Arterial Filters in Eliminating Gaseous Microemboli and Retaining Hemodynamic Properties during Simulated Cardiopulmonary Bypass**

J Lin<sup>1</sup>, NM Dogal<sup>1</sup>, RK Mathis<sup>1</sup>, F Qiu<sup>1</sup>, A Kunselman<sup>2</sup> and Akif Ündar<sup>1,3,4</sup>

<sup>1</sup>Penn State Hershey Pediatric Cardiovascular Research Center, Department of Pediatrics; <sup>2</sup>Public Health and Sciences; <sup>3</sup>Department of Surgery; <sup>4</sup>Department of Bioengineering, Penn State Milton S. Hershey Medical Center, Penn State Hershey College of Medicine, Penn State Hershey Children's Hospital, Hershey, Pennsylvania, USA

**P15. Vision-guided Tracking of Multiple Surgical Instruments in Robot-assisted Surgery**

Jiwon Ryu<sup>1</sup>, Jaesoon Choi<sup>2</sup>, PhD, Hee Chan Kim, PhD<sup>3</sup>

<sup>1</sup>Interdisciplinary Program, Bioengineering Major, Graduate School, Seoul National University, Seoul, Korea, <sup>2</sup>Brain Korea 21 Program for Biomedical Science, College of Medicine, Korea Artificial Organ Center, Korea University, Seoul 136-705, Korea,

<sup>3</sup>Department of Biomedical Engineering, College of Medicine and Institute of Medical and Biological Engineering, Medical Research Center, Seoul National University, Seoul, Korea

**P16. Hemodynamic Energy Could Change Depends on Position of Patients during Extracorporeal Circulation**

<sup>1</sup>Chi Bum Ahn, PhD, <sup>3</sup>Kuk Hui Son, MD, <sup>1,2</sup>Ho Sung Son, MD, <sup>1,2</sup>Jae Seung Jung, MD, <sup>1,2</sup>Kyung Sun, MD.

<sup>1</sup>.Korea Artificial Organ Center, <sup>2</sup>.Department of Thoracic and Cardiovascular Surgery, College of Medicine, Korea University, Seoul, Korea. <sup>3</sup>.Division of Cardiovascular and Rare Disease, Korea National Institute of Health

**P17. Change of the Hemodynamic Energy Depends on Artificial Grafts.**

<sup>1</sup>Chi Bum Ahn, PhD, <sup>1,2</sup>Ho Sung Son, MD, <sup>1,2</sup>Jae Seung Jung, MD, <sup>3</sup>Kuk Hui Son, MD, <sup>1</sup>Jung Joo Lee, PhD, <sup>1</sup>Jeasoon Choi, PhD, <sup>1</sup>Seung Joon Song, PhD, <sup>1,2</sup>Kyung Sun, MD.

<sup>1</sup> Korea Artificial Organ Center,

<sup>2</sup> Department of Thoracic and Cardiovascular Surgery, College of Medicine, Korea University, Seoul, Korea

<sup>3</sup> Division of Cardiovascular and Rare Disease, Korea National Institute of Health

**P18. Cardiopulmonary bypass in neonatal piglets: can survival be predicted?**

Theodor Tirilomis, MD, PhD, Marc Bensch, MD, Lars Nolte, MD, Katja Steinke, MD, Friedrich A. Schoendube, MD, PhD

Dept. for Thoracic, Cardiac, and Vascular Surgery, University of Goettingen, Goettingen, Germany

**P19. Postoperative Prophylactic Peritoneal Dialysis in Neonates and Infants after Complex Congenital Cardiac Surgery**

Akçevin A<sup>\*</sup>, Alkan-Bozkaya T, Türkoğlu H, Paker T<sup>\*</sup>, Aytaç A<sup>\*</sup>.

Istanbul Bilim University, Dept. of Cardiovascular Surgery and V.K.V. American Hospital, Cardiovascular Surgery, Istanbul, TURKEY<sup>\*</sup>

**P20. Aorticopulmonary Window w/wo Interrupted Aortic Arch: Surgical Correction Of In Neonatal Period and Results**

Alkan-Bozkaya T., Akçevin A<sup>\*</sup>, Türkoğlu H., Paker T<sup>\*</sup>, Bayer V., Ersoy C<sup>\*</sup>, Ündar A<sup>\*\*</sup>.

Istanbul Bilim University, Dept. of Cardiovascular Surgery and V.K.V. American Hospital, Cardiovascular Surgery, Istanbul, TURKEY<sup>\*</sup> and Penn State University, Children's Hospital, Hershey, PA, USA<sup>\*\*</sup>

**Saturday, June 16, 2012**

**7:00am – 8:00am Registration**

**8:00am – 10:00am PLENARY SESSION #5: Neonatal and Pediatric Anesthesia & Neuromonitoring (20 min. each)**

**Moderator: Chris Chin, MD, UK and Yves Durandy, MD, France**

- 1. ABCs of Neonatal Cardiac Anaesthesia (Chris Chin, MD, UK)**
- 2. NIRS (Yves Durandy, MD, France)**
- 3. Neonatal/Pediatric Neuro-Imaging - MRI (Adela Rohnean MD, France)**
- 4. Cerebral Expression of Neuroglobin and Cytoglobin after Deep Hypothermic Circulatory Arrest in Neonatal Piglets (Hashim Abdul-Khaliq, MD, Germany)**
- 5. Brain Protection during Pediatric Cardiac Surgery: A Multi-Disciplinary Team Approach at Penn State Hershey (Akif Ündar, PhD, USA)**

**Discussion – 20 minutes**

**10:00am – 10:45am Break / Posters / Exhibitions / Wet-labs**

**10:45am – Noon Parallel Sessions:**

**10:45am – Noon MINI-SYMPOSIUM #4: Pediatric CPB & MCS & Heart Transplantation in Turkey: Current practices and outcomes (20 min. each)**

**Moderators: Alp Alayunt, MD, Turkey and Sait Aşlamaci, MD, Turkey**

- 1. Pediatric/Neonatal CPB Procedures: Current outcomes (Hakan Ceyran, MD, Turkey)**
- 2. Pediatric/Neonatal ECLS Systems (Sertaç Çiçek, MD, Turkey)**
- 3. Pediatric/Neonatal MCS & Heart Transplantation in Turkey (Tahir Yağdı, MD, Turkey)**

**Discussion – 15 minutes**

**Parallel Sessions:**

**Wet-labs:**

**Instructors/Moderators: Huriyet Ersayin-Kantas, FCCP, UK, and David Palanzo, CCP, USA**

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**Neuromonitoring; Near-infrared spectroscopy (NIRS)  
ECLS circuits; VAD's; Ultrafiltration; Pulsatile perfusion  
Neonatal/Pediatric CPB Circuit - step-by-step circuit set-up  
Neonatal/Pediatric oxygenators with integrated arterial filters**

Noon – 1:00pm LUNCH

1:00pm – 3:00pm **Regular Slide Presentations #2: (Selected from abstracts)**  
12 slide presentations (10 min. each)

**Co-Chairs:** Tufan Paker, MD, Hakan Ceyran, MD, Theodor Tirilomis, MD, PhD,  
**Moderator:** Tufan Paker, MD

**S11. Routine Fenestration during Fontan Procedure**

Bülent Saritas, MD, Emre Ozker, MD, Can Vuran, MD, Uygar Yoruker, MD, Canan Ayabakan, MD, Rıza Türköz, MD.

*Departments of Cardiovascular Surgery, Department of Pediatric Cardiology, Baskent University, Istanbul Teaching and Medical Research Center, Istanbul, Turkey*

**S12. Midterm Results after Arterial Switch Operation for Transposition of the Great Arteries: A Single Centre Experience**

Aron Frederik Popov<sup>1</sup>, MD, Michael Giesler<sup>1</sup>, MD, Kasim Oguz Coskun<sup>1</sup>, MD, Gerd Gunnar Hanekop<sup>2</sup>, MD, Jose Hinz<sup>2</sup>, PhD, MD, Theodor Tirilomis<sup>1</sup>, PhD, MD, Verena Gravenhorst<sup>3</sup>, MD, Thomas Paul<sup>3</sup>, PhD, MD, Wolfgang Ruschewski<sup>1</sup>, PhD, MD,

<sup>1</sup> *Department of Thoracic Cardiovascular Surgery, University of Göttingen, Germany;*

<sup>2</sup> *Department of Anesthesiology and Intensive Care Medicine, University of Göttingen, Germany;* <sup>3</sup> *Department of Pediatric Cardiology and Intensive Care Medicine, University of Goettingen*

**S13. Aortic Surgery after Previous Procedure of Congenital Aortic Stenosis**

Theodor Tirilomis, MD, PhD, K. Oguz Coskun, MD, Aron-Frederik Popov, MD, PhD, Wolfgang Ruschewski, MD, PhD

*Dept. for Thoracic, Cardiac, and Vascular Surgery, University of Goettingen, Goettingen, Germany*

**S14. The Comparison of the Effects of Bretschneider HTK and Conventional Crystalloid Cardioplegia on Myocardium at Tissue Level**

Oktay Korun, MD, Murat Özkan, MD, Ayşen Terzi, MD, Atilla Sezgin, MD, Sait Aşlamacı, MD

*Baskent University Hospital, Departments of Cardiac Surgery and Pathology  
Baskent University, Faculty of Medicine, Ankara, Turkey*

**JUNE 13-16, 2012, GALATASARAY UNIVERSITY, ISTANBUL, TURKEY**

**Moderator: Hakan Ceyran, MD**

**S15. Cerebral Perfusion during Pediatric Cardiopulmonary Bypass: Correlations between Near Infrared Spectroscopy and Temperature, Lactate, Pump Flow and Blood Flow**

Sertac Haydin, MD<sup>1</sup>, Burak Onan, MD<sup>1</sup>, Ismihan Selen Onan, MD<sup>1</sup>, Erkut Ozturk, MD<sup>2</sup>, Muzeyyen Iyigun, MD<sup>3</sup>, Mehmet Yeniterzi, MD<sup>1</sup>, Ihsan Bakir, MD<sup>1</sup>

<sup>1</sup>Department of Cardiovascular Surgery, Pediatric Cardiac Surgery Division;

<sup>2</sup>Department of Pediatric Cardiology; <sup>3</sup>Department of Anesthesiology, Istanbul Mehmet Akif Ersoy Thoracic and Cardiovascular Surgery Education and Research Hospital, Istanbul, Turkey

**S16. The Effects of Different Ventilator Modes on Cerebral Tissue Oxygen Saturation in Patients with Bidirectional Superior Cavapulmonary Connection**

Ayda Türköz, MD Şule Turgut Balcı, MD, Hülya Gönen, MD, Emre Ozker, MD, Bilgiser Esen, MD, Rıza Türköz, MD.

Departments of Anesthesiology and Cardiovascular Surgery, Baskent University Istanbul Teaching and Medical Research Center, İstanbul, TURKEY

**S17. The Effects of Antegrade Cerebral Perfusion on Prognosis and Outcome in Neonatal and Infant Aortic Arch Repair Concomitant with Intracardiac Surgery**

Sasmazel Ahmet, Karaci Ali Riza, Numan Aydemir, Harmandar Bugra, Yekeler Ibrahim Staff Cardiothoracic Surgeon, Cardiovascular Surgery Clinic, Dr. Siyami Ersek Thoracic and Cardiovascular Surgery Training and Research Hospital, Haydarpaşa, İstanbul, TURKEY

**S18. Comparison between D901 Lilliput 1 and Kids D100 Neonatal Oxygenators: Towards Bypass Circuit Miniaturization.**

Fabrizio De Rita, MD, Diego Marchi, CP, Gianluca Lucchese, MD, PhD, Luca Barozzi, MD, Tiziano Menon, MS, Giuseppe Faggian, MD, Alessandro Mazzucco, MD, Giovanni Battista Luciani, MD

Division of Cardiac Surgery, University of Verona, Verona, Italy

**Moderator: Theodor Tirilomis, MD, PhD,**

**S19. Pumpless Extracorporeal Lung Assist as a Rescue Therapy in an Adolescent with Cystic Fibrosis**

N Yalindag-Ozturk<sup>1</sup>, C Vuran<sup>2</sup>, B Keles<sup>1</sup>, F Karakoç<sup>3</sup>, R Ersu<sup>3</sup>

<sup>1</sup> Division of Pediatric Critical Care, Department of Pediatrics, Marmara University Hospital, İstanbul, Turkey. <sup>2</sup> Department of Cardiovascular Surgery, Başkent University Medical Research and Treatment Center in İstanbul, Turkey. <sup>3</sup> Division of Pediatric

*Pulmonology, Department of Pediatrics, Marmara University Hospital, İstanbul, Turkey.*

## **S20. Experience with Extracorporeal Life Support in Pediatric Patients after Cardiac Surgery**

SHU-CHIEN HUANG, YIH-SHARNG CHEN, CHUNG-I CHANG, ING-SH CHIU, WEN-JE KO, SHOEI-SHEN WANG

*Departments of Surgery, National Taiwan University Hospital, Taipei, Taiwan*

## **S21. Development of Nobel Pulsatile Flow ECMO System**

Hideshi Itoh<sup>\*†</sup>, Shingo Ichiba<sup>†</sup>, Yoshihito Ujike<sup>†</sup>, Hideaki Obata<sup>§</sup>, Shunji Sano<sup>\*</sup>

<sup>\*</sup> *Department of Cardiovascular Surgery, Okayama University Hospital, JAPAN*

<sup>†</sup> *Department of Emergency and Critical Care Medicine, Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences, JAPAN*

<sup>§</sup> *Department of Biomedical Engineering, Okayama University of Science, JAPAN*

## **S22. Two Jarvik Child Pumps as Bi-Ventricular Assist Device (BVAD) in an Ovine Animal Model**

Jan D. Schmitt, Stuart McConchie, Murat Avsar, Felix Fleissner, Heinz Haberer, Petra Ziehme, Gwen Büchler, Robert Jarvik, Axel Haverich, Martin Strueber

*Department of Cardiac-, Thoracic-, Transplantation- and Vascular Surgery, Hannover Medical School, Germany*

**3:00pm – 3:45pm**      **Break / Posters / Exhibitions / Wet-labs**

**3:45pm – 5:00pm**      **Regular Slide Presentations #3: (Selected from abstracts)**  
**7 slide presentations (10 min. each)**

**Co-Chairs: Rıza Türköz, MD and Yusuf K. Yalçınbaş, MD**

**Moderator: Rıza Türköz, MD**

## **S23. Implementing a Haptic Augmented Reality Surgeon Console Framework for Enhanced Safety in Robot Assist Minimally Invasive Surgery**

<sup>1</sup>SeungWook Choi, MS, <sup>2</sup>Jaesoon Choi, PhD, <sup>2</sup>Seung Joon Song, MS, <sup>2</sup>Jun Woo Park, PhD, <sup>4</sup>Hee Chan Kim, PhD, <sup>1</sup>Heung Sik Kang, MD, PhD, <sup>2,3</sup>Kyung Sun, MD, PhD, MBA

<sup>1</sup>*Department of Radiology, College of Medicine, Seoul National University, <sup>2</sup>Korea Artificial Organ Center, <sup>3</sup>Department of Thoracic and Cardiovascular Surgery, College of Medicine, Korea University, <sup>4</sup>Department of Biomedical Engineering, College of Medicine and Institute of Medical and Biological Engineering, Medical Research Center, Seoul National University, Seoul, Korea*

**S24. Initial Clinical Experience with Spectrum Medical M3 Monitor in Pediatric Cardiac Surgery: Gaseous Emboli Monitoring for Capiox RX05 Oxygenator and Capiox FX05 Oxygenator**

Yusuf Yalcinbas, MD, \*Serdar Gunaydin, MD, Murat Boz, CCP, Zekeriya Telli, CCP, \*\*Tayyar Sarioglu, MD

*Acibadem Bakirkoy Hospital, Department of Cardiovascular Surgery, Istanbul, Turkey*

*\*Kırıkkale University, Department of Cardiovascular Surgery, Kırıkkale, Turkey*

*\*\*Acibadem University, Department of Cardiovascular Surgery, Istanbul, Turkey*

**S25. Extracorporeal Life Support (ECLS) Experiences of a New Congenital Heart Center in Turkey**

E.Erek<sup>1</sup>, S.Haydin<sup>1</sup>, B.Onan<sup>1</sup>, S.Onan<sup>1</sup>, P.Yazıcı<sup>1</sup>, O.Kocyigit<sup>2</sup>, C.Tanidir<sup>3</sup>, P.Yivli<sup>4</sup>, E.Odemis<sup>3</sup>, M.Yeniterzi<sup>1</sup>, I.Bakir<sup>1</sup>

*Istanbul Mehmet Akif Ersoy Thoracic and Cardiovascular Surgery Training and Research Hospital; Istanbul, Turkey; <sup>1</sup>Cardiovascular Surgery Department;*

*<sup>2</sup>Anesthesiology; <sup>3</sup>Pediatric Cardiology; <sup>4</sup>Perfusionist*

**S26. Comparison of Gluteraldehyde Fixed Autologous Pericardial Patch with Dacron Patch for VSD Closure**

Uygar Yoruker, MD, Can Vuran, MD, Bülent Saritas, MD, Emre Ozker, MD, Canan Ayabakan, MD, Özlem Sarisoy, MD, Ersin Ögüş, PhD, Rıza Türköz, MD.

*Departments of Cardiovascular Surgery, Department of Pediatric Cardiology, Baskent University, Istanbul, Turkey*

**Moderator: Yusuf K. Yalçınbaş, MD**

**S27. Impact of Pulsatile Perfusion in Neonates and Infants with Complex Pathologies: Results**

Alkan-Bozkaya T., Akçevin A., Türkoğlu H., Paker T., Ündar A \*\*

*Istanbul Bilim University, Dept. of Cardiovascular Surgery and V.K.V. American Hospital, Cardiovascular Surgery, Istanbul, TURKEY\* and Penn State University, Children's Hospital, Hershey, PA, USA\*\**

**S28. Intraoperative Flow Study in VSD, Pulmonary Atresia and MAPCA**

Murat Basaran, Nihat Cine, Eylem Tuncer, Fusun Guzelmeric, Ayse Yildirim, Cevat Naci Oner, Hacı Aslan, Hakan Ceyran

*Istanbul Kosuyolu Yuksek Ihtisas Egitim Arastırma Hastanesi, Turkey*

**S29. Perfusion Practices and Education of Perfusionists for Open Heart Surgery in Turkey**



Ismihan Selen Onan<sup>1</sup>, MD, Perihan Yivli<sup>1</sup>, Halime Erkan<sup>1</sup>, Atif Akçevin<sup>2</sup>, MD, Akif Ündar<sup>3</sup>, PhD, Ihsan Bakir<sup>1</sup>, MD

<sup>1</sup> Department of Cardiovascular Surgery, Istanbul Mehmet Akif Ersoy Thoracic and Cardiovascular Surgery Training and Education Hospital, Istanbul, Turkey

<sup>2</sup> Department of Cardiovascular Surgery, American Hospital, Istanbul, Turkey

<sup>3</sup> Penn State Hershey Pediatric Cardiovascular Research Center, Penn State Hershey Children's Hospital, Hershey, Pennsylvania, USA

8:00am – 6:45pm

**Poster Presentation #3:**

**Co-Chairs: Ismihan Selen Onan, MD & Larwence A. Sasso, PhD**

**P21. Evaluation of Four Pediatric Cardiopulmonary Bypass Circuits In Terms of Perfusion Quality and Capturing Gaseous Microemboli**

Ryan K. Mathis, BS, \* Judith Lin, BS, \* Natalie M. Dogal, BS, \* Feng Qiu, MD, \* Allen Kunselman, MA, # Shigang Wang, MD, \* Akif Ündar, PhD<sup>††</sup>

*Penn State Hershey Pediatric Cardiovascular Research Center, Department of Pediatrics<sup>\*</sup>, Surgery<sup>†</sup>, Bioengineering<sup>‡</sup>, Public Health and Sciences#. Penn State Milton S. Hershey Medical Center, Penn State Hershey College of Medicine, Penn State Hershey Children's Hospital, Hershey, PA, USA*

**P22. Surgical Approach to “Swiss Cheese” VSDs and Our Results**

Türkoğlu H., Alkan-Bozkaya T., Akcevin A., Paker T., Ersoy C., Bayer V., Aytac A.

*İstanbul Bilim Üniversitesi ve Amerikan Hastanesi, Kalp ve Damar Cerrahisi Dept. İstanbul, TÜRKİYE*

**P23. Congenital Heart Surgery Cases Accompanied with Genetic Syndromes**

Alkan-Bozkaya T, Akcevin A \*, Ercelen N \*\*, Türkoglu H, Paker T \*, Aytac A \*.

*Istanbul Bilim University, Dept. of Cardiovascular Surgery and V.K.V. American Hospital, Dept. of Cardiovascular Surgery\* and Dept. of Genetics \*\*, Istanbul, TURKEY*

**P24. In Vitro Effect of Clinical Propofol Concentrations on Platelet Aggregation**

Hye Gyo Chung BS, Ho Sung Son MD, , Yun Hee Kim MD, Chang Kyu Lee MD, Choon Hak Lim MD, Sun K MD, PhD

*Department of Medicine, School of Medicine, Department of Anaesthesiology and Pain Medicine, Cardiovascular Surgery, and Laboratory Medicine, College of Medicine, Korea University, Seoul, Republic of Korea*

**P25. Role of Negative-Pressure Wound Therapy in Deep Sternal Wound Infection in Open Heart Surgery**

Halil Başel\*, Rahmi Zeybek\*, Bekir İnan\*, Cemalettin Aydın\*, Melike Teker\*, Hüseyin Tanuğur\*, Süleyman Yazıcı\*\*

*\*Bezmi Alem Vakıf Üniversitesi Tıp Fakültesi Kalp Damar Cerrahisi Kliniği*

*\*\* Dicle Üniversitesi Tıp Fakültesi Kalp Damar Cerrahisi Kliniği*

**P26. Is the Devega Reliable Method for Functional Tricuspid Valve Regurgitation Associated with Left-Sided Valvular Disease?**

Halil Başel<sup>\*</sup>, Rahmi Zeybek<sup>\*</sup>, Bekir İnan<sup>\*</sup>, Cemalettin Aydın<sup>\*</sup>, Melike Teker<sup>\*</sup>, Hüseyin Tanuğur<sup>\*</sup>, Süleyman Yazıcı<sup>\*\*</sup>

*\* Bezmi Alem Vakıf Üniversitesi Tıp Fakültesi Kalp Damar Cerrahisi Kliniği*

*\*\* Dicle Üniversitesi Tıp Fakültesi Kalp Damar Cerrahisi Kliniği*

**P27. Is the HbA1C Level a Risk Marker in Coronary Artery Bypass Surgery?**

Halil Başel<sup>\*</sup>, Rahmi Zeybek<sup>\*</sup>, Bekir İnan<sup>\*</sup>, Cemalettin Aydın<sup>\*</sup>, Melike Teker<sup>\*</sup>, Hüseyin Tanuğur<sup>\*</sup>, Süleyman Yazıcı<sup>\*\*</sup>

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*\*\* Dicle Üniversitesi Tıp Fakültesi Kalp Damar Cerrahisi Kliniği*

**P28. The Use of Ventricular Assist Devices in Pediatric Heart Transplantation**

Jian-Ming Chen, Yih-Sharng Chen, Shu-Chein Huang, Shoei-Shen Wang, Shu-Hsun Chu, Nai-Kuan Chou

*Department of Surgery, National Taiwan University Hospital. Taipei, Taiwan*

**P29. Microfluidic-Based System for Continuous Blood Protein Extraction during In-Vivo Piglet Model of Extracorporeal Life Support**

Kiana Aran, Larwence A. Sasso, Mercedes Morales, Jean Lo, Feng Qui, Akif Ündar and Jeffrey D. Zahn

*Rutgers University, Department of Biomedical Engineering, Piscataway, New Jersey, USA*

*Penn State College of Medicine, Penn State Children's Hospital, Hershey, Pennsylvania, USA*

**P30. Evaluation of Two Types of Neonatal Oxygenators in Reducing Gaseous Microemboli and Maintaining Optimal Hemodynamic Stability an A Simulated Pediatric CPB Circuit**

Neelima Marupudi, BS,<sup>\*</sup> Shigang Wang, MD,<sup>\*</sup> Akif Ündar, PhD<sup>\*,#</sup>

*Penn State Hershey Pediatric Cardiovascular Research Center, Department of Pediatrics<sup>\*</sup>, Surgery and Bioengineering<sup>#</sup>. Penn State Milton S. Hershey Medical Center, Penn State Hershey College of Medicine, Penn State Hershey Children's Hospital, Hershey, PA, USA*

**P31. A Non-occlusive, Inexpensive Pediatric Pulsatile Roller Pump for CPB, ECLS and LVAS/RVAS**

Shigang Wang, MD<sup>\*</sup>, Yves Durandy, MD<sup>#</sup>, Akif Ündar, PhD<sup>\*,†</sup>

*Penn State Hershey Pediatric Cardiovascular Research Center, Department of Pediatrics\*, Surgery and Bioengineering†. Penn State Milton S. Hershey Medical Center, Penn State Hershey College of Medicine, Penn State Hershey Children's Hospital, Hershey, PA, USA*

*# Institut Cardiovasculaire Paris-Sud, Ave du Noyer Lambert, FR 91300 Massy, France*

5:00 pm

**CLOSING REMARKS**

JUNE 13-16, 2012, GALATASARAY UNIVERSITY, ISTANBUL, TURKEY

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## Fetal Cardiac Ultrasonography; Learning and Development of Experience at a Teaching University

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Serdar H. Ural, MD, Linda Pauliks, MD, Akif Undar, PhD  
Department of Obstetrics & Gynecology  
The Pennsylvania University College of Medicine, Hershey, Pennsylvania, U.S.A.

### Background:

Obstetrical ultrasonography has one of the steepest learning curves in practice. This is due to the fact the fetus is a moving body and its position constantly varies. Within fetal ultrasound, cardiac assessment is even more difficult as there is an organ, the heart, that also is constantly moving. This makes the heart anatomy assessment during pregnancy one of the more difficult and significant examinations in ultrasonography. Cardiac anomalies are associated with increased risk for chromosomal aneuploidy of about 30%, therefore correct detection and diagnosis is essential in order to be able to counsel the pregnant women during pregnancy.

### Methods:

A routine fetal anatomy ultrasound screen assessing the heart and other organs in general takes place between 18 and 22 weeks of gestation as the organ size is the most optimal for analysis by the operator. Usually a single exam is sufficient. In a teaching institution the need for repeat ultrasound examinations for accurate assessment are expected to be higher due to this learning curve. Our study analyzed the ultrasound repeat rate (URR) percentage specifically for the fetal heart.

### Results:

A routine fetal anatomy ultrasound screen assessing the heart and other organs in general takes place between 18 and 22 weeks of gestation as the organ size is the most optimal for analysis by the operator. Usually a single exam is sufficient. In a teaching institution the need for repeat ultrasound examinations for accurate assessment are expected to be higher due to this learning curve. Our study analyzed the ultrasound repeat rate (URR) percentage specifically for the fetal heart.

### Conclusions:

To date there have been no studies specifically providing data on URR for fetal cardiac ultrasound screening. Our unique investigation clearly reveals that in a teaching university setting, a single exam may not suffice.



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## The HYBRID Operation in High-Risk cases of HLHS and Critical Aortic Stenosis/Borderline Left Ventricle

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David R Anderson\*, B M Austin\*, C Salih\*, T Krassmen®, E Rosenthal®, S A Qureshi®;  
Dept of Paediatric Cardiology® and Surgery\*, Evelina Children's Hospital, Guy's & St Thomas  
NHS Foundation Trust, LONDON, UK

### Background:

In the past decade stage 1 palliation of HLHS has advanced to achieve relatively low operative mortality (<20%) in most major centres. However a subset of patients continues to present an increased operative risk for stage1 palliation. These are:

- (a) Low birth weight (<2.5Kg)
- (b) Highly restrictive or intact inter-atrial septum
- (c) Post-natal collapse with multi-organ failure.

Also in cases of Critical Aortic Stenosis with borderline LV function and or size it can be difficult to decide at birth if a biventricular circulation is feasible.

Faced with high stage 1 operative mortality(>80%) in low birth weight infants we adopted the Hybrid approach for those infants. In addition we decided to include the other categories of higher risk HLHS and cases of critical aortic stenosis/borderline LV. Our program was approved by our Hospital Clinical Governance Committee and commenced in December 2005.

### Methods:

Since then 40 cases have been treated, 24 with higher risk HLHS and 11 with Critical AS/borderline LV. There were 5 cases of Aortic atresia with non-committed VSD in low birth weight babies which are analysed as HLHS making 29 cases

The operation is performed in the catheter laboratory via median sternotomy placing bilateral pulmonary artery bands and stenting the arterial duct under x-ray guidance. Some cases of critical aortic stenosis had prior balloon valvuloplasty or had ballooning in the catheter laboratory at the same time via the sternotomy. Atrial septostomy was usually performed later if indicated sometimes with implantation of an atrial stent. Four cases of very restrictive atrial septum had open septectomy on bypass prior to banding and stenting.

### Results:

Initially 30-day mortality was high especially for HLHS cases (9 of 29) but has reduced over time with increasing experience. HLHS mortality overall has been (17of 29) which is lower than our earlier experience with these cases. For low birth weight HLHS babies, (14 cases) 30-day mortality was 3(22%) with 5 late deaths either at later surgery or interstage making an overall mortality for this group (57%). 6 babies have gone on to completion Fontan with 4 pending.

Of 11 cases with critical aortic stenosis/borderline LV there have been 2 early deaths and one late death. 3 cases

### Conclusions:

Our use of the Hybrid operation has been evolving in the light of our own experience and that of other centres. We believe that it represents a viable treatment alternative for certain cases of severe Left Heart disease but that the most appropriate application is yet to be determined.

## Heart Transplantation in Neonates and Infants

Chitra Ravishankar, MD  
Division of Pediatric Cardiology, The Children's Hospital of Philadelphia, Philadelphia,  
Pennsylvania, USA

### Background:

The first pediatric heart transplantation was performed in 1968. Older children occasionally underwent transplants during the 1970s and early 1980s (pre-cyclosporine era). Successful routine cardiac transplantation began after the introduction of cyclosporine. Its successful application to infant recipients, particularly those with hypoplastic left heart syndrome began with the pioneering efforts of Dr. Leonard Bailey and his team at Loma Linda University Children's Hospital in 1985. Since 2000, infants have comprised 23% of pediatric cardiac transplant recipients.

### Indications:

The most common indication for transplant during infancy is congenital heart disease/CHD (58%), followed by cardiomyopathy/CM (39%); this has changed very little in the past 10 years.

### Outcomes:

Survival after infant transplantation has been superior compared to older children. According to the most recent Pediatric report of the International Society of Heart and Lung Transplantation, the median survival, or half-life (the time at which 50% of recipients remain alive) was 18.4 years for those who underwent transplant during infancy. Risk factors predictive of 1-year mortality included the following pre-transplant factors: need for extracorporeal membrane oxygenation, renal failure and mechanical ventilation prior to transplantation, and diagnosis of CHD.

In addition to survival, long-term neurologic outcome and quality of life will also be discussed in this talk.

### ABO Incompatible transplantation:

The immunologic immaturity of the infant has been exploited to the advantage of pediatric heart recipients. Since the first report of the use of ABO incompatible heart transplantation in infants was published in 2001, its success has been corroborated by other reports. It is now a widely used practice in the North America and the rest of the world.

### Reference:

1. Bailey LL. Origins of neonatal heart transplantation: an historical perspective. Semin Thorac Cardiovasc Surg Pediatr Card Surg Annu. 2011; 14(1):98-100.
2. Richard Kirk, MA, FRCP, FRCPCH, Leah B. Edwards, Anna Y. Kucheryavaya, MS, Christian Benden, MD, Jason D. Christie, MD, MS, Fabienne Dobbels, PhD, Axel O. Rahmel, MD, Josef Stehlik, MD, MPH, and Marshall I. Hertz, MD. The Registry of the International Society for Heart and Lung Transplantation: Fourteenth Pediatric Heart Transplantation Report—2011. J Heart Lung Transplant. 2011 Oct; 30(10):1095-103.
3. Guleserian KJ, Schechtman KB, Zheng J, Edens RE, Jacobs JP, Mahle WT, Emerson SL, Naftel DC, Kirklin JK, Blume ED, Canter CE. Outcomes after listing for primary transplantation for infants with unoperated-on non-hypoplastic left heart syndrome congenital heart disease: a multi-institutional study. J Heart Lung Transplant. 2011 Sep; 30(9):1023-32.
4. West LJ. ABO-incompatible hearts for infant transplantation. Curr Opin Organ Transplant. 2011 Oct; 16(5):548-54.
5. Chinnock RE, Freier MC, Ashwal S, Pivonka-Jones J, Shankel T, Cutler D, Bailey L. Developmental outcomes after pediatric heart transplantation. J Heart Lung Transplant. 2008 Oct; 27(10):1079-84.

## Echocardiographic Assessment of the Single Ventricle Heart

Linda B Pauliks<sup>1</sup>, MD, MPH, John L. Myers<sup>2</sup>, MD, J. Brian Clark<sup>2</sup>, MD, Akif Ündar<sup>3</sup>, PhD  
Pediatric Cardiovascular Research Center, Departments of <sup>1</sup>Pediatrics, <sup>2</sup>Surgery and <sup>3</sup>Bioengineering,  
Penn State College of Medicine, Penn State Children's Hospital, Hershey, Pennsylvania, USA

### Background:

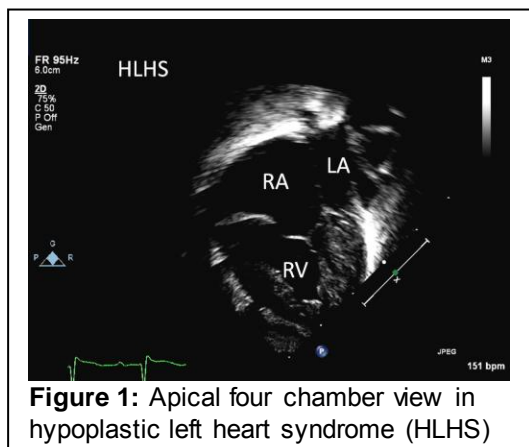
Echocardiographic guidance plays an important role in the management of single ventricle hearts from fetal life through adulthood. Figure 1 shows a case of hypoplastic left heart syndrome (Figure 1). Echocardiography is excellent with regards to providing anatomical detail. In contrast, functional assessment of the single ventricle heart remains challenging and still largely rests on qualitative criteria. Recent advances in quantitation of myocardial function will be discussed as they apply to the single ventricle heart.

### Methods:

This is a retrospective case series. The potential of three-dimensional echocardiography will be discussed using concrete examples of hypoplastic left heart syndrome, tricuspid atresia and double inlet left ventricle. In addition, we present data on a case series of 15 children (13 boys) with Fontan palliation of single ventricle hearts and 30 age-matched normal controls. All patients underwent stress echocardiography according to the Bruce treadmill exercise protocol. Echocardiographic images including digital color tissue Doppler clips were acquired before and right after exercise from standard views (Vivid 7, GE, Madison, WI). During off-line analysis, mitral and tricuspid ring velocities were determined if applicable (Echopac, GE, Madison, WI).

### Results:

Representative cases of patients with single ventricle physiology will be shown to illustrate key points of the echocardiographic assessment. Tissue Doppler and stress echocardiographic data will be discussed using typical cases.



**Figure 1:** Apical four chamber view in hypoplastic left heart syndrome (HLHS)

### Conclusions:

Echocardiography is an excellent tool to guide clinical management of patients with single ventricle hearts. Its greatest strength is to provide detailed anatomical information about the heart itself although it should be recognized that the ability to detect thrombus in the Fontan tunnel maybe limited. In contrast to anatomical information, quantitative assessment of myocardial function remains challenging in single ventricle hearts. Tissue Doppler stress echocardiography allows us to determine the contractile reserve of univentricular hearts in a quantitative manner but the interpretation may be difficult.

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## **An Odyssey in Mechanical Circulatory Support**

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William S. Pierce, M.D., Evan Pugh Professor Emeritus of Surgery  
The Pennsylvania State University, College of Medicine  
Department of Surgery, Division of Artificial Organs,  
Hershey, PA, USA

During the past decade, mechanical circulatory support has become a universally accepted effective method of supporting the failing heart – first as a “bridge” to cardiac transplantation and also as destination therapy – i.e. permanent circulatory support.

Our group at Penn State began work in this field in 1970 where we develop what is now known as the Thoratec Pneumatic Ventricular Assist device (PVAD). That device provides flow up to 6 l/min and provides a pulse that appears identical to that of the natural heart. To date, over 4000 clinical applications of this pump have been reported – the youngest patients being teenagers. The device allows patients to be ambulatory and to improve their overall health prior to transplantation. Smaller, implantable electric motor driven rotary devices have been easier to implant and have largely supplanted the pulsatile pumps.

It is clear that ventricular assist pumps will play an important role in supporting the circulation in patients who are not transplant candidates. We developed a pulsatile implantable blood pump having no tubes or wires crossing the body wall. Electrical energy was supplied by inductive coupling while an intrathoracic compliance chamber negated the need for a “vent” tube. The system is referred to as the Arrow Lionheart. The system was used in 30 patients with considerable success. Hopefully, the type of energy transfer will soon be used in implantable rotary pumps to eliminate the problems associated with wire crossing the body wall – infection and wire fracture.

The availability of donor hearts is far less than the need and with attention to safety in automobiles and the industrial workplace; donor heart availability will be more limited in the future. Our group has focused on a mechanical heart, electrically driven and contained within the pericardial sac. The two valved pumps are alternately actuated by a DC motor and roll-screw positioned between the pumps. A sophisticated control system balances the output of the two pumps and maintains left atrial pressure within the normal range. The pumps have been implanted in 70 kg calves with survival of over one year. An industrial partner has been identified but the economic climate is not felt to be optimal at this time for commercial success. While improvements are and will be made, clearly, at present, a clinically useful mechanical heart is available.



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## Pediatric MCS: Bad Oeynhausen Experience

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Eugen Sandica, MD

Department of Surgery for Congenital Heart Defects, Center for Congenital Heart Defects,  
Heart and Diabetes Center NRW, Bad Oeynhausen, Germany

### Background:

Mechanical circulatory support in pediatric patients remains a challenging issue. We reviewed the use of ECMO (extracorporeal membrane oxygenation) and VAD (ventricular assist device) in pediatric population at our institution.

### Methods:

Hospital records of children who required ECMO and VAD at our institution were reviewed. Patients' demographics, diagnosis, surgical procedure and mechanical circulatory support details were analyzed.

### Results:

Between 1992 and 2011, 63 ECMO systems have been implanted in 59 pediatric patients and another 54 patients received a VAD. ECMO system was required for failure to separate from cardiopulmonary bypass (33.3%), for low cardiac output state (15.9%) or during cardiopulmonary resuscitation or short thereafter (36.5%). 14.3% from ECMO systems were non-cardiac ECMO. Twenty-two patients (37.3%) in ECMO group were discharged alive. Different ventricular assist devices have been implanted in pediatric population at our institution: EXCOR Berlin Heart (13 patients), Medos (11 patients), Thoratec (19 patients), HeartWare (5 patients), Novacor (2 patients), CorAide (2 patients), Heart Mate II (1 patient), Cardiowest (1 patient). Twenty-nine patients (53.7%) have been successfully bridged to cardiac transplantation, weaning was possible in 6 patients (11.1%). There have been 15 deaths (27.8%). Four patients (7.4%) are still on support. In Excor Berlin Heart group, the survival was 92.3%, the median weight was 14.2 kg (range 4.2 – 51.6 kg) and median age was 4.1 years (range 0.25 – 11.8 years).

### Conclusion:

ECMO has a valuable role in pediatric patients with or without congenital heart disease. In our experience, more than one third of these patients, including neonates, infants, older children, patients with functionally univentricular heart, or those requiring rescue ECMO can be salvaged. Survival rate in patients with ventricular assist device was 72.8 %. The ventricular assist device (VAD) Berlin Heart EXCOR Pediatrics provides an effective means of bridging children of almost all ages and sizes to cardiac transplantation or myocardial recovery with a low rate of major complications.

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## Characteristics of a Non-Occlusive Pressure-Regulated Blood Roller-Pump

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Yves Durandy M.D.

Department of Perfusion and Intensive Care, Institut Hospitalier J. Cartier – Massy, France

### Background:

The pumps used for extracorporeal life support (ECLS) were developed for conventional cardiopulmonary bypass, consequently the ideal pump for ECLS remains to be designed. However, an original non-occlusive pressure-regulated roller-pump is probably the best answer to the specific issues related to ECLS.

The Rhône-Poulenc pump was designed in the 70s. It is composed of a rotor with three rollers and without stator; the rotor tubing is stretched on the rollers. The rotational speed varies from one to 50 rpm. The pump follows the Starling law. The tubing is flat when empty, ovoid when preload increases and round when afterload is excessive.

When preload increases the volume of the tubing increases from zero to its maximal value and the flow increases for a constant rotor speed. When the afterload is excessive the chamber becomes round and the flow reverts to zero.

The advantages of this pump for long-term support are numerous:

Blood trauma and hemolysis are decreased thanks to the quality of the silicon tubing, non-occlusivity and low rotor speed.

There is no risk of high suction and cavitation in case of poor drainage and no risk of disconnection or rupture in case of occlusion downstream the pump. This advantage is used to generate pulsatile flow. Furthermore, in case of accidental presence of air bubbles in the circuit, this pump in vertical position acts as a bubble trap.

This pump is probably superior to classical occlusive roller-pump or centrifugal pump used for ECLS.

The pediatric program of single cannula veno-venous bypass which we developed in the 80s is still ongoing today. [1-2]

### References:

1. Single-cannula venovenous bypass for respiratory membrane lung support. J Thorac Cardiovasc Surg. 1990; 99: 404-409
2. Preliminary report: extracorporeal lung support for neonatal acute respiratory failure. Lancet. 1990; 335: 1364-1366

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## CARDIOHELP – The Multi-Use ECLS Platform

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Thomas Markmann, MAQUET Cardiopulmonary AG, Rastatt, Germany

Since the launch in August 2010 more than 2.000 adult patients have been treated with CARDIOHELP. With these patients CARDIOHELP was used mainly for veno-venous or veno-arterial ECLS and for MECC procedures in the OR as minimally-invasive perfusion system for on-pump CABG surgery

MAQUET now introduces the 30 day approved ROTASSIST – a smart-system centrifugal pump which is designed to be a bridge to decision to buy valuable time for clinicians to choose an appropriate treatment option for their patients. ROTASSIST is available in two versions, one for adult use and one specially intended for children.



ROTASSIST fills in the gap to make CARDIOHELP suitable for all indications where cardiac support and/or respiratory assistance is needed.

## First Use of a New Diagonal Pump in Extracorporeal Support Systems for Children and Infants

J. Optenhoefel, S. Tiedge, Th. Breymann, M. Ono, H. Koeditz\*, D. Boethig\*  
Department for Cardiac, Thoracic, Transplantation and Vascular Surgery; \*Department for Paediatric Cardiology and Intensive Care Medicine, Hannover Medical School, Hannover, Germany

### Background:

Diagonal pumps for extracorporeal membrane oxygenation in small patients combine the advantages of being small, requiring a low priming volume and causing only few hemolysis. DP3 (Medos, Germany) is a new diagonal pump allowing pulsatile perfusion that was shown to be beneficial.

### Methods:

Between 7/2007 and 03/2012 we supported 53 ECMO patients aged from 1 day to 16.9 years (mean 3.1, median 0.3 years) using 14 Centrimag (Cen), 28 Rotaflow (Rot) and 41 DP3 pump heads. Mean and range of pump run time were Cen: 181 (65-537), Rot: 193 (1-857), DP3: 221 (12-1404) hours. Kaplan-Meier evaluations considered freedom from isolated pump change (IPC), assuming simultaneous change including other components as not pump induced. We stratified by pump type, ECMO indication, and patient age group.

### Results:

Group	Cardiac < 1 year			Cardiac > 1 year			Pulmonary < 1 year			Pulmonary > 1 year		
Pump	Cen	Rot	DP3	Cen	Rot	DP3	Cen	Rot	DP3	Cen	Rot	DP3
Pump heads	5	7	22	2	4	3	6	9	4	4	8	11
Freedom from IPC [%]	100	66.7	73.8	100	100	100	80	100	100	100	100	90
Mean support [weeks]	0.9	0.6	1.1	1.5	1.4	0.9	0.8	1.5	0.9	1.6	1.1	2.0
Max. support [weeks]	1.7	1.0	8.4	1.9	3.5	2.0	1.7	5.1	1.6	3.2	1.9	5.1
p (log rank)	0.49			n.a.			0.37			0.58		

2 DP3 patients had pulsatile perfusion (14 and 58 days).

### Conclusions:

According to our preliminary experience, we consider DP3 a competitive diagonal pump capable of pulsatile perfusion.

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## Advances in Neonatal and Pediatric Bioengineering Using Computational Fluid Dynamics

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Kerem Pekkan, PhD

Pediatric Cardiovascular Fluid Mechanics Laboratory

Biomedical Engineering Department, Carnegie Mellon University, Pittsburgh, Pennsylvania, USA

### Introduction:

Neonatal and pediatric cardiovascular fluid mechanics is an emerging biomedical engineering research field studying normal, diseased and surgically palliated hemodynamics during early development. In this talk recent bioengineering applications from our research group are reviewed emphasizing, clinical and surgical impact. These projects include the effects of patient specific flow waveforms (caval pulsatility) on single-ventricle hemodynamics, three-dimensional flow dynamics of novel Fontan templates intended for adult conversion and apicocaval juxtaposition. Significance of using proper bioengineering metrics (our time-integral approach) to evaluate the Fontan caval flow pulsatility and patient-to-patient variation are demonstrated. Stagnant regions calculated using computational fluid dynamics (CFD) from selected conduit anatomies are illustrated using the residence time approach. Pediatric and neonatal devices that feature complex flow instability and unsteadiness related to neonatal cardiopulmonary by-pass, systemic-to-pulmonary shunt, septal-defect occluders and patient-specific venous confluence models are also reviewed. Patient-specific CFD simulations of combined right-ventricle and outflow track (RVOT) will be used to estimate the velocity profile and its relation to the RVOT valve dynamics. We will also demonstrate the use of CFD particle tracking to evaluate the relative effect of 'flow-split' and 'caval cross-flow mixing' on hepatic flow distribution. Based on this information, surgeon can precisely evaluate the degree of improvement with 'creating a smaller offset' on hepatic flow distribution. Likewise, if the hepatic flow distribution is already balanced due to patient-specific flow split, surgeon may prefer to use a larger (closer to one-diameter-offset offset) to minimize the power loss. Additional applications of our optimization based virtual surgical planning studies applied to aortic dissection and prediction of stent dislocation will be presented. These studies are critical for Pediatric Cardiology and Surgery, providing hemodynamic understanding of pediatric pulmonary/venous function, hepatic growth factor mixing and adult "failed" physiology, impacting patients having heart defects.



## Development of a Microanalytical Monitor for Tracking Systemic Inflammation during Extracorporeal Circulatory Support

Jeffrey D. Zahn, PhD

BioMEMS Laboratory, Department of Biomedical Engineering, Rutgers University, Piscataway, New Jersey, USA

### Background:

Recent advances in the development of microdiagnostic platforms have allowed point of care or near-patient monitoring. Batch fabricated microfluidic platforms that can mimic conventional sample preparation techniques performed in laboratories hold great potential to enable both research and healthcare advances. These miniaturized diagnostic devices have been termed micro total analysis systems ( $\mu$ TAS) or biochips and combine sensing mechanisms (physical, optical, electrical or chemical) with microfluidics. While microfluidics promises to have an impact in many research fields, one of the more attractive applications has been towards biomedical and life science diagnostics. There is a growing market for point of care diagnostic devices for surgical, bedside and outpatient monitoring.

Such microdiagnostics are being developed to miniaturize cell separation methods to fractionate non-homogeneous cell suspensions such as blood, or to miniaturize specific laboratory tests such as immunoassays for tracking plasma protein components. A microdiagnostic system is being developed consisting of a microfiltration platform which can continuously separate plasma proteins from solid blood components (Fig. 1). This system can continuously sample blood from an extracorporeal circulatory loops through a sampling manifold connected to the arterial port of the membrane oxygenator on the heart-lung machine and measure biomarker concentrations through an automated immunoassay performed within the device (Fig. 2).

### Conclusions:

The long term goal will be to use the information generated from diagnostic devices during surgery as a clinical monitor. Continuous monitoring of systemic inflammatory responses in patients undergoing extracorporeal circulatory support procedures will aid physicians in developing clinical applications for the treatment and prevention of inflammation during cardiac surgery in pediatric patients. Such a, novel device may be used for monitoring all CPB patients (>400,000 adult and pediatric patients) in addition to thousands of pediatric and adult sepsis and extracorporeal life support patients around the globe.

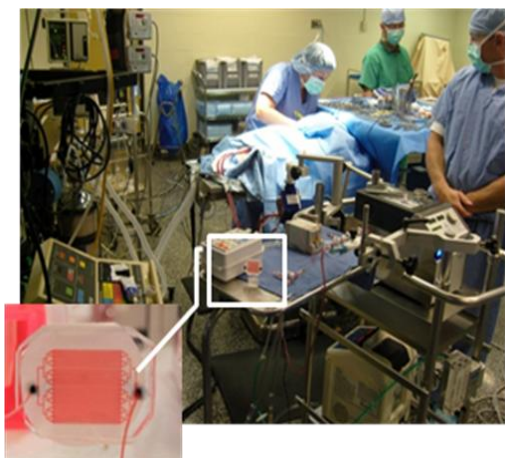


Figure 1: A microfiltration device being perfused with blood from an ECLS loop

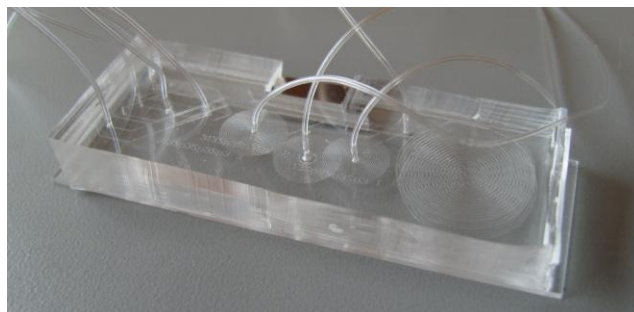


Figure 2: A microimmunoassay which can autonomously conduct serial immunoassay cytometric bead incubation steps

## Recent Progress in Measurement of Blood Physical Properties under Microfluidic Environments

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### Background:

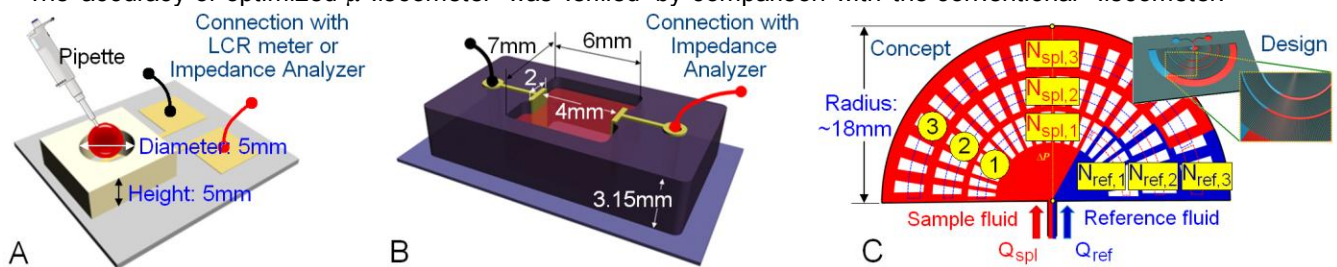
Measurement of physical properties of human blood is crucial in clinical practice for diagnosis and treatment purposes. The electrical conductivity, impedance and dielectric constant of blood are strongly correlated with the aggregation and sedimentation of red blood cells (RBCs), and blood hematocrit (HCT). The blood viscosity has significant influence on the erythrocyte sedimentation rate and closely relates with the physiological condition of the patient. In the area of automation and miniaturization is possible to develop accurate microfluidic methods for rapid testing of the biophysical parameters of blood.

### Methods:

(A) For recording the changes in the blood conductivity during the aggregation and sedimentation, blood samples are collected in a miniature container with two planar electrodes on the bottom (Figure 1A). (B) To measure the electrical impedance of blood, we devised the measurement cell with two plane-parallel gold electrodes on its side walls (Figure 1B). The blood samples were introduced into the electrical measurement cells using a pipette. (C) The concept of  $\mu$ -viscometer that can have various shear rates with fixed flow rate condition is shown in Figure 1C. In  $\mu$ -viscometer experiments, the blood and phosphate buffer saline were precisely infused to the device by using a commercial syringe pump.

### Results:

(A) Recorded blood conductivity (Figure A) slightly increases during the first minute of observation and then decreases for a long time to small value. Using the dielectric theory we explained the increase in blood conductivity by aggregation of RBCs. We analytically described the decrease in the conductivity during sedimentation and estimated the initial velocity and acceleration of RBCs. (B) We proposed an electrical method (Figure B) to measure HCT based on a new HCT estimation parameter  $100 R_p / (R_i + R_p)$ , which represents the HCT using a combination of the resistances of the plasma,  $R_p$  and the cytoplasm,  $R_i$ . (C) The viscosity values at different shear rates can be estimated by comparing the number of channels occupied by each fluid at each array (Figure C):  $\mu_{rel,n} \approx (N_{spl,n} / N_{ref,n})(Q_{ref} / Q_{spl})$ . The accuracy of optimized  $\mu$ -viscometer was verified by comparison with the conventional viscometer.



### Conclusions:

Three novel microfluidic devices have been developed and tested in order to measure aggregation and sedimentation of RBCs, HCT, and blood viscosity. We believe that our study is an important step towards the creation of new methods for measuring physical properties of blood and their introduction into clinical practice.

### Acknowledgement:

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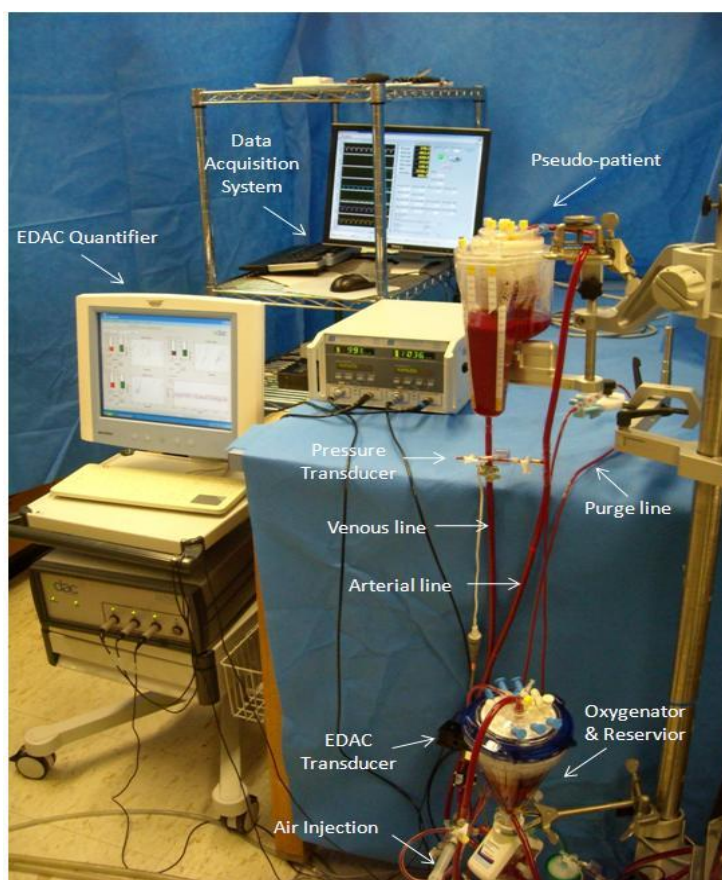
## Circuit Components' Selection during Neonatal / Pediatric CPB: An Engineering Approach

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Cardiovascular centers around the globe consider many factors when selecting components of the cardiopulmonary bypass (CPB) circuitry. Ideally, they should have access to scientific data to guide evidence based choices, in order to optimize patient safety and minimize bypass related morbidity. Translational research is rarely done to evaluate different pump systems (roller vs. centrifugal), oxygenators, and cannulae. Three of the major focuses of Penn State Hershey Pediatric Cardiovascular Research Center are 1) to do translational research for selecting the best combination of pumps, oxygenators, cannulae, and tubing length on clinical ELCS and CPB circuitry, 2) to train clinicians (including clinicians from other centers) with our newest circuits in-vitro-and in-vivo, and 3) to share our clinical protocols with other pediatric centers around the globe (1).

During the past half century, impressive improvements have been achieved in terms of the devices and protocols. However, it has been well documented that cardiopulmonary bypass evokes an acute systemic inflammatory response syndrome (SIRS) due to its non-physiological inherency, and hemodilution and microemboli issues. In high-risk cases, this inflammatory reaction may become further exaggerated and lead to the development of severe postoperative complications. In the evaluations of the CPB devices, we focus on the hemodynamic performances, as well as their microemboli capturing abilities (2-3). Using custom-made data acquisition system and software, we were able to evaluate several new components of the circuitry with novel emboli classification and detection system (Figure 1).

The rapid development of neonatal / pediatric CPB technology will continue. As a pre-clinical evaluating tool, translational research will provide more useful information for the selection of devices, encourage further development of the technology, and ultimately benefit the patients. With the goal of minimizing the adverse effects of neonatal/pediatric pediatric CPB procedures, we are eager to conduct more translational research when new products become available, and we will continue our education and training program to the clinicians, technicians, and nurses for the newest technology in neonatal/pediatric CPB components and techniques.



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## The Relation of Manufacturing Techniques and Cannula Choice in Pediatric Extracorporeal Circulation

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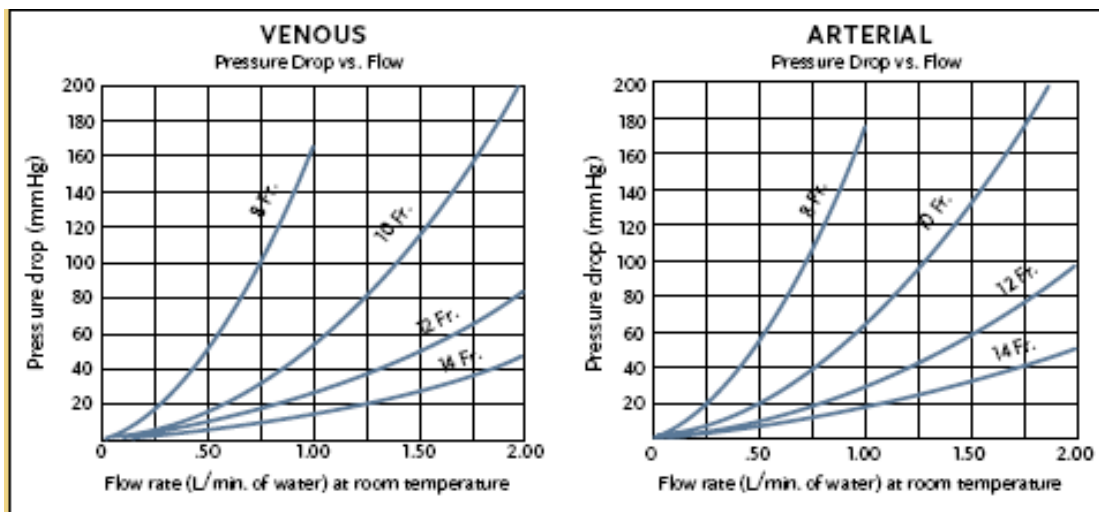
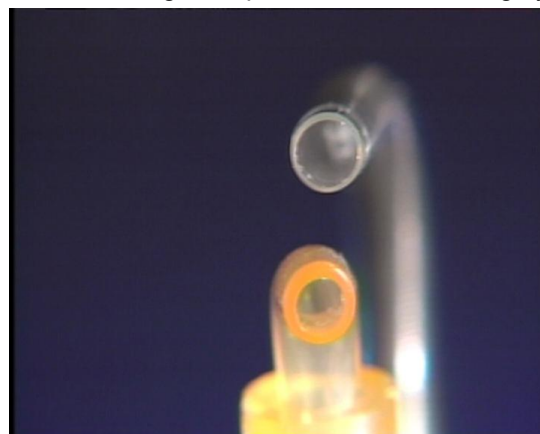
### Abstract:

The use of any ECC (Extra Corporeal Circuit) always includes the usage of cannulae. The choice of the right cannula is a key decision in the successful management of blood flow either in routine use or in a mini-bypass or minimally invasive intervention application. This is even more critical for the right cannula choice in pediatric cardiac surgery. Furthermore, the cannula often represents the smallest cross sectional area in the circuit and therefore plays an important role in the optimal blood handling capabilities of any ECC.

Controlling shear stress, velocities, pressures and flow patterns are essential for avoiding mechanical hemolysis when using CPB (Cardiopulmonary Bypass) or any other support system (ECMO, VAD, etc...). As clinicians are getting more and more aware of the importance of circuit design and the right choice of the various components in order to offer better patient outcome, choosing the optimal cannula can highly contribute to this effort.

It is our aim to demonstrate and discuss the various consequences of the use of a specific type of cannula for a specific application. Both theory and lab-work will be presented in order to demonstrate the flow characteristics of various cannula designs and types, as well as the relation of flow and blood velocity to blood shear and cannula performance, relating Poiseuille's law to cannula performance.

$$Q = \frac{\Delta p \times R^4 \times \pi}{L \times \eta \times 8}$$





## The Effect of Different Modified Ultrafiltration Durations on Early Postoperative Pulmonary Functions and Hemodynamics in Newborn and infants Following Arterial Switch Operation

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### Background:

Modified ultrafiltration (MUF) is used to ameliorate the deleterious effects of cardiopulmonary bypass in pediatric cardiac surgery patients. The ideal duration for MUF has not been established yet. In our prospective, randomized study, we investigated the effects prolonging the duration of MUF on pulmonary functions and hemodynamics in the early postoperative term in newborn and infant patients who underwent operation for transposition of great arteries (TGA).

### Methods:

After obtaining the approval from the Ethics Committee, 56 newborn and infant patients who had undergone TGA operation between 2009 - 2011 were included in the study and divided into three groups. MUF was applied to all patients following the termination of cardiopulmonary bypass (10, 15 and 20 minutes in group 1, 2 and 3, respectively).

### Results:

56 patients were enrolled in this study [Group 1 (n=18), Group 2 (n=18), Group 3 (n=20)]. Demographic and operative data were comparable in all groups. The amount of fluid removed by MUF in groups 2 and 3 were larger than the MUF in group 1 ( $190 \pm 101$  vs.  $196 \pm 122$  vs.  $113 \pm 463$  ml respectively,  $p < 0.01$ ). Hematocrit levels significantly increased at the end of MUF in groups 2 and 3 when compared to group 1 ( $41 \pm 4\%$  vs.  $41 \pm 6\%$  vs.  $36 \pm 5\%$  respectively  $p < 0.01$ ). Blood pressure significantly increased at the end of MUF in group 3 when compared to group 1 and 2 ( $66 \pm 12$  vs.  $62 \pm 10$  vs.  $60 \pm 8$  mmHg, ( $p < 0.05$ )). Red blood cell transfused after cardiopulmonary bypass after MUF was significantly less in group 2 and 3 than in the group 1 ( $73 \pm 35$  vs.  $70 \pm 28$  vs.  $91 \pm 43$  ml respectively,  $p < 0.05$ ). Pulmonary functions, hemodynamic parameters including oxygen index, respiratory index and ventilation index were similar in all three groups, postoperatively.

### Conclusions:

MUF improved in hematocrit levels and blood pressure. Prolonging the duration of MUF did not have a significant impact on extubation and ICU stay times.

## Evaluation of Three Hollow-Fiber Membrane Oxygenators without Integrated Arterial Filters for Neonatal Cardiopulmonary Bypass

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### Background:

The cardiopulmonary bypass (CPB) procedure has been shown to be a potential cause of postoperative neurological morbidity as a result of various factors, which include: large amounts of gaseous microemboli (GME) reaching the patient and hypoperfusion of the patient due to "stolen" blood flow.

### Methods:

This study used a simulated CPB circuit identical to that in a clinical setting to examine three different hollow-fiber membrane oxygenators without integrated arterial filters – the Capiiox RX 05, the Quadrox-i neonatal, and the KIDS D100 – to determine their ability to reduce the number of GME delivered to the neonatal patient and their hemodynamic properties in response to varying flow rates, normothermic vs. hypothermic conditions, and open vs. closed purge line. The circuit was first primed with Ringer's Lactate and then human blood with a hematocrit of 30%. Injections of 5cc boluses of air were injected into the venous line proximal to the venous reservoir over a thirty-second interval. Six injections were done for each oxygenator at each of the eight different experimental conditions for a total of 64 experiments per oxygenator (192 total injections). A flow probe, pressure transducer, and Emboli Detection and Classification (EDAC) quantifier transducer were positioned both upstream and downstream of the oxygenator to measure differences in each parameter.

### Results:

Results demonstrated that the Capiiox RX05 is the most effective oxygenator at reducing the number of microemboli that potentially can be delivered to the neonatal patient (Table 1). In regards to the hemodynamic properties, the Quadrox-i has the most favorable results, with the lowest mean pressure drop and the best energy retention across the oxygenator.

Table 1. Gaseous microemboli count at 35°C and 700 ml/min

Purge Line Status	Oxygenator	Pre-oxygenator				Post-oxygenator				Arterial line			
		Total emboli	0-20 µm	20-40 µm	>40 µm	Total emboli	0-20 µm	20-40 µm	>40 µm	Total emboli	0-20 µm	20-40 µm	>40 µm
Closed	RX05	202 ± 18	167 ± 17	34 ± 6	1 ± 2	12 ± 4	11 ± 4	1 ± 1	0 ± 0	1 ± 2	1 ± 2	0 ± 0	0 ± 0
	Quadrox-i Neo	743 ± 132	574 ± 77	152 ± 52	18 ± 8	155 ± 62	108 ± 34	40 ± 22	6 ± 7	40 ± 24	31 ± 17	9 ± 7	0 ± 0
	KIDS D100	2656 ± 678	1708 ± 433	864 ± 229	84 ± 23	1088 ± 298	709 ± 196	368 ± 100	11 ± 4	334 ± 79	310 ± 69	23 ± 9	1 ± 1
Open	RX05	179 ± 39	137 ± 64	28 ± 11	2 ± 1	10 ± 2	9 ± 2	1 ± 1	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
	Quadrox-i Neo	3708 ± 559	3450 ± 538	250 ± 36	8 ± 2	66 ± 32	55 ± 26	10 ± 5	2 ± 3	8 ± 4	7 ± 4	1 ± 1	0 ± 0
	KIDS D100	599 ± 79	392 ± 53	187 ± 27	21 ± 6	273 ± 46	182 ± 38	85 ± 15	6 ± 6	55 ± 11	50 ± 8	4 ± 3	0 ± 0

When the purge line is closed,  $p < 0.01$ , KIDS vs. the other two oxygenators at pre-oxygenator and post-oxygenator sites; RX05 vs. Quadrox-i at pre-oxygenator site;

When the purge line is open,  $p < 0.01$ , RX05 vs. Quadrox-i & KIDS at the pre-oxygenator site; Quadrox-i vs. KIDS at the pre-oxygenator site.

When switching the purge line status,  $p < 0.01$ , KIDS with open purge line vs. closed purge line at the pre- and post-oxygenator sites; Quadrox-i with open purge line vs. closed purge line at the pre-oxygenator site.

### Conclusions:

This study showed that the Capiiox RX05 is the most effective oxygenator at reducing the number and size of microemboli. In regards to hemodynamic properties, the Quadrox-i Neonatal has the most favorable results, with the lowest pre-oxygenator mean pressure, lowest mean pressure drop across the oxygenator, and the best energy retention across the oxygenator as shown by the THEpre and THEpost values. (Supported by PSH-PCRFC)

## The Protective Effect of St. Thomas' Cardioplegia Enriched with Zacopride on Rat Isolated Hearts

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### Background:

Cardioplegia still remains the key role of myocardium preservation in open heart surgery. Activation of inward rectifier potassium channel (IK1) can reduce the damage of myocardial cells caused by hypoxia. Zacopride is a selective IK1 channel agonist and suppresses triggered arrhythmias in rat hearts. The purpose of this investigation is to study the effects of St. Thomas (ST) cardioplegia enriched with Zacopride on a rat isolated heart model.

### Methods:

Sprague-Dawley rat hearts were harvested and perfused for 20 minutes with Krebs-Henseleit (KH) buffer followed by 15 minutes perfusion with calcium-free KH buffer in Con group (Con, n=8), ST solution in ST group (ST, n=8) and ST solution with Zacopride in STZ group (STZ, n=8). After 45 minutes of arresting, all hearts were reperfused with 37°C KH buffer for 60 minutes. Hemodynamic indexes, content of cTnI and superoxide dismutase (SOD) in coronary outflow fluid, tissue dry-wet ratio and infarct size were measured.

### Results:

STZ group arrests faster than Con and ST groups ( $9.25 \pm 2.38s$  vs.  $72.25 \pm 8.1s$ ,  $p < 0.01$ ,  $12.75 \pm 2.87s$ ,  $p > 0.05$ ) and needs less time from the initial of reperfusion to rebeat ( $41.63 \pm 4.63s$  vs.  $53.63 \pm 2.77s$ ,  $52.25 \pm 4.46s$ ,  $p < 0.05$ ). Compared with Con and ST groups, STZ group showed significant decreases in maximum cTnI level ( $20.28 \pm 1.95pg/ml$  vs.  $42.62 \pm 6.08pg/ml$ ,  $p < 0.01$ ,  $30.93 \pm 2.52pg/ml$ ,  $p < 0.05$ ), dry/wet ratio ( $0.09 \pm 0.02$  vs.  $0.11 \pm 0.01$ ,  $0.11 \pm 0.03$ ,  $p < 0.05$ ) and infarct size ( $22.98 \pm 2.07\%$  vs.  $43.8 \pm 3.79\%$ ,  $39.55 \pm 1.58\%$ ,  $p < 0.05$ ). SOD in STZ group is higher than Con and ST groups ( $82 \pm 11.6 \times 10^{-3} U/ml$  vs.  $13.2 \pm 1.92 \times 10^{-3} U/ml$ ,  $p < 0.01$ ,  $28.6 \pm 5.55 \times 10^{-3} U/ml$ ,  $p < 0.05$ ). Figure 1 summarized the hemodynamic indexes of each group.

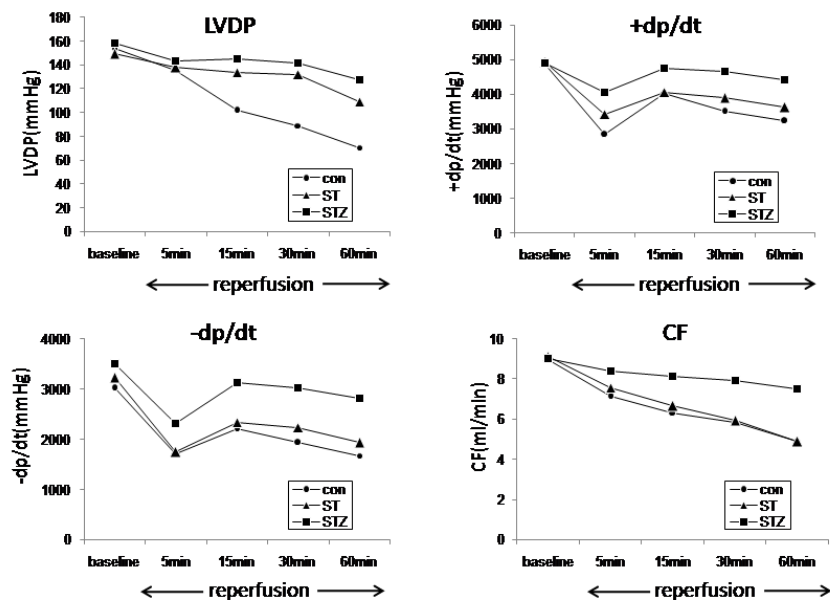


Figure 1. The hemodynamic indexes of each group.

### Conclusions:

St. Thomas cardioplegia enriched with Zacopride may have beneficial effects against ischemia-reperfusion injury in this rat isolated-heart model. The further investigation is warranted for studying the protective effects relating different doses of Zacopride in St. Thomas cardioplegia.

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## The Hepatic Morphology after Heart Surgery in Neonates: The Effects of Cardiopulmonary Bypass and Hypothermia

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### Background:

Little is known about the effects of cardiopulmonary bypass (CPB) and systemic hypothermia on neonatal hepatic tissue. In this study, we examined the effect of CPB and deep hypothermic circulatory arrest (DHCA) in neonatal hepatic tissue.

### Methods:

Liver biopsies of neonatal piglets after CPB (n=4), DHCA (n=5), and surgery without CPB (non-CPB; n=3) were evaluated and with those of control piglets (n=9) compared. The liver specimens were fixed and stained with H&E using standard histological techniques and were scored regarding hepatocellular swelling and edema, inflammation, and apoptosis.

### Results:

Swelling and edema was significantly more evident after DHCA (score  $2.0 \pm 0.4$  vs.  $0.2 \pm 0.3$  in control and  $0.6 \pm 0.5$  after CPB;  $p < 0.001$  and  $p < 0.05$  respectively). Regarding inflammation the score of treated groups was high than in control; CPB  $2.5 \pm 0.5$ , DHCA  $1.6 \pm 0.4$ , non-CPB  $1.2 \pm 0.6$ , control  $0.4 \pm 0.3$  ( $p < 0.001$  CPB and DHCA vs. control;  $p < 0.05$  non-CPB vs. control). The highest apoptotic cell count was in non-CPB group ( $22 \pm 4$  vs.  $11 \pm 3$  in control and  $9 \pm 4$  after CPB;  $p < 0.05$ ).

### Conclusions:

The major findings of the present study include: (1) surgical trauma increases hepatocellular apoptosis; (2) CPB activates hepatic inflammation; and (3) DHCA results in hepatocellular swelling and edema.

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## Selective Cerebral Perfusion with Aortic Cannulation and Short Hypothermic Circulatory Arrest in Aortic Reconstruction

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### Background:

Deep hypothermic circulatory arrest (DHCA) technique has been used in aortic arch and isthmus hypoplasia for many years. However with the demonstration of the deleterious effects of prolonged DHCA, selective cerebral perfusion (SCP) was started to be used in aortic arch repair. For SCP, perfusion via innominate artery route is generally preferred (either direct innominate artery cannulation or re-routing of the cannula in the aorta is used). Herein we present our selective cerebral and myocardial perfusion (SCMP) and short DHCA technique where we use aortic cannulation in order to avoid the technical difficulties of innominate artery cannulation.

### Methods:

34 cases with aortic arch and isthmus hypoplasia accompanying cardiac defects were operated with SCMP and short DHSA in Baskent University Istanbul Research and Training Hospital between January 2007 and May 2012. There were 16 cases with VSD-coarctation with aortic arch hypoplasia (CoAAH), 4 TGA-VSD-CoAAH, 4 Taussing Bing Anomaly, 2 CAVSD-CoAAH, 3 single ventricle-CoAAH, 2 type A interruption-VSD, 1 subvalvular aortic stenosis-CoAAH and 2 isolated CoAAH. Aorta was cannulated in the middle of the ascending aorta in all cases. The cross-clamp was applied to the aortic arch at distal to either innominate artery or left carotid artery. In addition, side biting clamp was applied to the descending aorta. The aorta between these two clamps was reconstructed with gluteraldehyde treated autogeneous pericardium using SCMP. The proximal arch and distal ascending aorta reconstruction were carried out under short DHCA.

### Results:

The mean age of the patients was  $3.8 \pm 8$  months. The mean cardiopulmonary bypass and cross-clamp times were  $161 \pm 71$  and  $57.8 \pm 39$  minutes, respectively. The mean SCMP and descending aorta ischemia time were  $24.6 \pm 8$  and  $28 \pm 8.1$  minutes, respectively. Mean DHCA time was  $7.6 \pm 2.16$  minutes (min: 4, max 10 min). The mean in-hospital stay time was  $15 \pm 12$  days. The mortality rate was 2.9% (1 patient).

### Conclusions:

SCMP with aortic cannulation and short DHSA (under 10 minutes) in aortic reconstruction are safe and advantageous in this high-risk patient group.



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## **Cardiectomy, Circulation Splitting, Damus Interruption: Complex Scenarios in Paediatric Mechanical Circulatory Support with Berlin Heart Excor.**

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### **Background:**

We report three applications of Berlin Heart Excor (BHE) in children with complicated physiology requiring additional surgical procedures to provide adequate mechanical support.

### **Methods:**

Case 1: Child with severe aortic regurgitation post VA-ECMO, not improving on standard BIVAD support, due to chronic compression of left lung by severe cardiomegaly. The ventricular mass was removed and the atria closed with bovine pericardial patches. BHE inflow cannulae were inserted into the patches and the great arteries closed off proximal to the BHE outflow cannulae. Case 2: Child with single ventricle physiology, Damus anastomosis and BT shunt. Severe pulmonary valve regurgitation and ventricular failure necessitated single LVAD insertion with closure of the pulmonary artery arm of the Damus. Case 3: Child with HLHS, status post superior cavopulmonary shunt, ventricular impairment and low saturations. The superior vena cava was detached from pulmonary artery and joined to the IVC with a Gortex conduit. BHE BIVAD was then inserted using the conduit as right atrial reservoir and new BHE outflow cannulae implanted directly into the pulmonary artery and aorta.

### **Results:**

Patient 1 required prolonged mechanical ventilation, high frequency oscillatory ventilation and bronchoscopy to achieve pulmonary rehabilitation. Circulatory support was provided for 66 days. Unfortunately neurological complications precluded transplantation. Mechanical support was provided for 27 days in patient 2. Adequate flow and oxygenation were achieved with LVAD. Severe pre-operative hepatic injury however progressed despite excellent hemodynamic support necessitating eventual discontinuation of support. Patient 3: BiVAD configuration provided predictable systemic and pulmonary blood flow, with excellent hemodynamic support. Anticoagulation management proved challenging in this case resulting in conversion to extracorporeal centrifugal pump support after 11 days.

### **Conclusions:**

These unusual scenarios demonstrate some of the difficulties faced in providing mechanical support in children. Surgical modifications may allow provision of adequate circulatory support, but complex co-morbidity often proves insurmountable.

## Reduction of Driveline Infections through Doubled Driveline Tunneling of Left Ventricular Assist Devices (LVAD)

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### Background:

Durability of left ventricular assist device (LVAD) therapy improved steadily over the past years. However, driveline infections remain a challenging problem.

### Methods:

To test whether an improved surgical implantation technique may lower incidence of driveline infections, we analyzed all patients receiving LVAD implantation in the years 2008 and 2009 (group 1) and compared them to all patients who received a LVAD in 2011 (group 2) after we changed our driveline implantation technique. The novel operation method involves doubled tunnelling of the driveline into the fascia of the M. rectus abdominis, resulting in a longer, intrafascial run to achieve a better resistance against ascending infections.

### Results:

We retrospectively analyzed 40 patients in group 1 and 41 patients in group 2. The patients' characteristics were comparable, in exception of only few distinct differences. One year after implantation, the driveline infection rate was markedly reduced (4.9% (n=2) in group 2 vs. 22.5 % (n=9) in group 1,  $p<0.001$ ) in the second group. There was however no significant improvement in overall mortality. The Cox regression model identified the implantation method as an independent risk factor for a one year after implantation driveline infection ( $p<0.05$ ).

Table 1. Driveline infections. (Data are presented as n; % unless otherwise indicated.)

<i>Driveline infections</i>	GROUP 1		GROUP 2		P
Total driveline infections	42,5	17	7,3	3	<0,001
Driveline infection within 1 year postoperative	22,5	9	4,9	2	<0,001
Driveline infection requiring stationary admission	35	14	7,3	3	<0,001
Conservative approaches		11		1	
Vacuum therapy		5		2	
Ascending infections of assist device		2		0	

### Conclusions:

In conclusion, the new tunnelling technique marks a great leap forward in long term VAD treatment. However, overall mortality remains high and needs further improvement.

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## Clinical Outcomes and Experience of 13 Pediatric Patients after Arterial Switch Operation Managed with Extracorporeal Membrane Oxygenation

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### Background:

To retrospectively summarize and analyze the feasibility of extracorporeal membrane oxygenation (ECMO) using for myocardial and pulmonary recovery after arterial switch operation (ASO).

### Methods:

Reviewed the clinical protocols of TGA patients who underwent ECMO support after ASO from Dec. 2004 to Dec. 2008.

### Results:

Thirteen TGA patients who underwent cardiopulmonary dysfunction were rescued with ECMO after ASO, Heparin coated tubing and oxygenators were employed (Minimax Ox + Biomedicus centrifugal pump 4 cases, Jostra Ox + Rotaflow centrifugal pump 8 cases and Lilliput Ox + Rotaflow centrifugal pump 1 cases). All patients applied veno-artery (V-A) ECMO with drainage from right atrium and perfusion via ascending aorta by sternotomy. Blood flow rate was 20-150ml/kg and ACT maintained 140-200sec. The duration of ECMO was 64-276 hrs. (average 183h). 9 patients weaned from ECMO successfully (69%, 9/13), and 8 patients were survival to hospital discharge (62%, 8/13). 4 patients died of renal failure, bleeding, multisystem organ failure during ECMO running and 1 died of sepsis after 6 days separated from ECMO.

### Conclusions:

ECMO is an effective mechanical assistant therapy for cardiac and pulmonary failure patients after ASO. Perfect correction of abnormality, earlier usage of ECMO and avoiding the main organs from irreversible injury are still the key of success of ECMO.

## The NeonatOx: An Update on Design, In-Vitro, and In-Vivo Testing

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### Background:

Immaturity of the lung regularly impairs the gas exchange in preterm infants. The resulting treatment in order to maintain vital oxygenation and CO<sub>2</sub>-elimination is mechanical ventilation which causes mechanical and inflammatory destruction of lung tissue. Due to the size of currently available oxygenators and cannulas extracorporeal oxygenation is no treatment option.

We hypothesized that by maintenance of the fetal cardiopulmonary bypass and interposition of a tailored passively driven membrane oxygenator a substantial improvement in gas exchange can be achieved either in addition to a more protective or even without mechanical ventilation.

### Methods:

We used modified 14 Ga. Catheters (Arrow Inc.) for cannulation. The ideal length was investigated in a first animal test series on premature Texel lambs ( $n_1 = 6$ ; 2452 g  $\pm$  1,054; 134 days  $\pm$  3 gestational age (term: 150 days)) for max. flow, resistance, and viability. A requirement specification for the complete ECC was based on the collected data. A pumpless oxygenator was designed, produced and tested in-vitro according to ISO 7199. A second animal test series ( $n_2 = 4$ ; 2788 g  $\pm$  800; 135 days  $\pm$  1 gestational age) on premature Texel lambs showed the proof of principle of the novel pumpless extracorporeal lung assist (ECLA) circuit.

Based on the results of the second in-vitro and in-vivo test series the oxygenator was redesigned to achieve better flow distribution, better handling, and higher gas exchange rates. This was conventionally produced in our workshop. It was again tested in-vitro and subsequently, in a third in-vivo test series ( $n_3 = 7$ ; 2293 g  $\pm$  812; 132 days  $\pm$  0 gestational age) with a prolonged test duration of 6 h on the extracorporeal bypass (see figure below).

### Results:

After the redesign the oxygenator had a gas exchange surface area of 0.116 m<sup>2</sup> and 14 ml priming volume (21 ml incl. tubing). In-vitro we measured a typical gas exchange of 82 ml<sub>O<sub>2</sub></sub>/l<sub>blood</sub> and 73 ml<sub>CO<sub>2</sub></sub>/l<sub>blood</sub> at 120 ml/min blood flow.

In-vivo we observed a mean blood flow of 108 ml/min  $\pm$  11 (max. 190 ml/min) through the extracorporeal circuit. Pulmonary ventilation could be interrupted by endotracheal tube clamping for up to 5 hours. All animals were hemodynamically stable.

### Conclusions:

In close cooperation of engineers and neonatologists we developed and tested a pumpless ECLA circuit suitable for premature lambs. It was possible to provide the animals with suitable gas exchange without mechanical ventilation for up to 5 h. The current progress is an encouraging step towards the use of an extracorporeal oxygenator as an artificial placenta.



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## Miniaturisation: The Clue to Clinical Application of the Artificial Placenta

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### Background:

The artificial placenta as a fascinating treatment alternative for neonatal lung failure has been subject of clinical research for more than 50 years. Pumpless systems have been in use since 1986. However, inappropriate dimensioning of commercially available oxygenators has wasted some of the theoretical advantages of this concept. Disproportional shunt fractions cause congestive heart failure. Blood priming of large oxygenators and circuits dilutes fetal hemoglobin (as the superior oxygen carrier), is potentially infectious and causes inflammatory reactions. Flow demands of large extracorporeal circuits require cannula sizes which are not appropriate for use in preterm organisms.

NeonatOx, a tailored low-volume oxygenator for this purpose, has proven the feasibility of this principle before. We now report the advances in biological performance of a redesigned version of this specialized oxygenator.

### Methods:

An animal test series on texel lambs ( $n = 7$ ;  $2293 \text{ g} \pm 812$ ;  $132 \text{ days} \pm 0$  gestational age) with a test duration of 6 h on the extracorporeal circulation (ECC). Animals were born by cesarian section. Catheterization with 14 GA polyurethane catheters was performed directly after birth with the animals still being on placental circulation. All animals were anaesthetized with Remifentanyl and Midazolam. In order to avoid asphyxia between cannulation and connection to the extracorporeal circuit, animals were intubated and mechanically ventilated. A weaning protocol was used for controlled transition from pulmonary to extracorporeal gas exchange. Clamping of endotracheal tube was only performed when central venous  $\text{pCO}_2$  was below 50 mmHg on CPAP (without spontaneous ventilation), Lactate was below 4 mmol/l and  $\text{pH} > 7.2$ .

### Results:

Six animals survived the planned 6 hour period, one animal died after 5 hours. Weaning protocol allowed tube clamping in all but one animal for an average time of  $225 \pm 82 \text{ min}$  (135-300). Only autologous retransfusions of placental and cord blood were performed, no allogenic transfusions were carried out. Average Hb values before connection to ECC were 117 g/l and 91 g/l at the end of the experiment. Mean blood flow through the extracorporeal circuit was  $108 \text{ ml/min} \pm 11$  (max. 190 ml/min).

### Conclusions:

Although the oxygenator was originally designed as an assist device, its excellent performance after re-design now allowed to even use it as a full pulmonary substitution. This is all the more surprising since the average blood flow of 108 ml/min equals no more than approximately 15 % of the estimated cardiac output. Shunt fraction through the natural placenta is about two times higher.

The low priming volume allowed using the system with saline-priming. The decline in Hb through the experiment was acceptable and at least in part attributable to blood loss from procedures and laboratory analyses.



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## The Use of ECMO Utilizing the Rotaflow Centrifugal Pump in Pediatric Patients

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### Background:

Extracorporeal life support (ECLS) has become a standard therapy used to support critically ill pediatric patients in intensive care units today. Technology development has improved the ability to employ ECLS as a rapid rescue for sudden cardiac arrest (E-CPR) as well as mobility within the hospital setting and for use as a transport system. The ongoing education and experience of the inter-disciplinary team is vital in providing optimal care for children. Developing a systematic performance improvement process to review patient and system variables is an important element in learning and promoting improvements to care.

### Methods:

The use of centrifugal pumps for ECLS has increased over the past several years as this technique is utilized more frequently in the patient with congenital heart disease or as a bridge to recovery or heart transplantation. The centrifugal pump eliminates the need for gravity drainage and responds to preload and afterload changes. A smaller prime volume is possible without the need for a reservoir that may reduce the area of blood stagnation and clot formation. In addition, the reduced surface area may minimize blood activation and inflammation. This circuit design provides a mobile system with a low priming volume that supports a simple and effective method to deploy during acute patient de-compensation.

The program at The Hospital for Sick Children initiated their ECLS program in 1989 with the use of a centrifugal pump system. For the past 8 years our program has utilized the Maquet Rotaflow centrifugal pump with a Poy-4-methyl-1-pentene diffusion membrane oxygenator. The Rotaflow pump design provides continuous laminar flow with minimal turbulence and reduced risk of hemolysis as compared to other devices.

### Summary:

The ECLS program at The Hospital for Sick Children has now supported over 500 patients during the past 23 years. The evolution of the program has relied on technology and inter-professional team knowledge and skill development. Patient outcomes for specific diagnosis categories have improved over time however, significant morbidity and mortality remains a challenge.

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## Unfractionated Heparin Monitoring Strategies for ECLS

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### Background:

Unfractionated heparin (UFH) has been used clinically for 5 decades. Despite being a cornerstone of anticoagulation, UFH is limited by its unpredictable pharmacokinetic profile, which makes close laboratory monitoring necessary. The most common methods for monitoring UFH during ECLS are the activated clotting time (ACT), the activated partial thromboplastin time (aPTT) and antifactor Xa heparin assay (anti-Xa HA), but all three present challenges, and the optimal method to monitor UFH effect remains unclear. Antithrombin III also plays a role in UFH effect and its measurement has an impact on monitoring anticoagulation.

### Methods:

Heparin effect is measured using ACT, aPTT, anti-Xa HA during ECLS. Antithrombin III is also measured to look at its influence on monitoring modalities.

### Conclusions:

Inconsistency of ACT measurement at ranges considered therapeutic prompts a multifactorial approach to ECMO management because no single laboratory test can be used to determine appropriate anticoagulation management

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## **Pediatric Extracorporeal Life Support Nursing Education: 2012 Update**

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### **Background:**

In January 2009, a new circuit was established as the standard of care for Pediatric patients requiring Extracorporeal Life Support (ECLS) in the Pediatric Intensive Care Unit at the Penn State Hershey Children's Hospital. The changes in the circuitry translated to changes in the delivery of care model previously in place. The initial education focused on equipment changes and revision of staffing patterns. Continued program development includes advanced education of patient physiology, maintenance, monitoring & troubleshooting the equipment. This presentation reports our training focus in preparation for the transition, and current status of the program.

### **Methods:**

Training for ECLS trained staff consists of both didactic & hands on experience. The focus is set on development of the appropriate skill set and critical thinking. The core didactic portion consists of information related to physiology of the diseases treated with ECLS, pre ECLS procedures, criteria and contraindications for ECLS, physiology of coagulation, review of ECLS equipment, physiology of Venoarterial and Venovenous, daily patient and circuit management, emergencies and complications during ECLS, management of complex ECLS cases (ie: transport, surgery), weaning from ECLS, post ECLS support care. As clinicians gain experiences the core topics are explored in-depth via clinical case reviews, and additional classes.

Hands on experiences include wet-lab opportunities focusing on system maintenance, troubleshooting & emergency interventions. Additional training for staff includes working with trained personnel during patient cases, advanced classes and participation in training at local & international ECLS conferences.

### **Results:**

The staffs in the pediatric intensive care unit have worked collaboratively with supporting departments in our institution to re-design the care for critically ill patients requiring ECLS. From January 2009 to a March 2012, 8 patient, ages 4 months to 22 years old, bodyweight 3.9 kg to 78 kg, have required ECLS for respiratory and or cardiovascular collapse. We report a 50% survival rate.

**Conclusions:** The educational design has established a strong foundation for the Pediatric ECLS program. The collaborative efforts between the Perfusion, Pediatric Cardiothoracic Surgery & Nursing Education departments, are key components of this success. Further refinements of training initiatives and procedures/ policy development continue within our center.

## Translational Research on Neonatal/Pediatric ECLS: 2012 Update

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Based on the results of the translational research and input from the entire clinical team including perfusionists, nurses, surgeons, scientists and engineers, we built our Penn State Hershey pediatric ECLS circuit (Figure 1), which is composed of a Rotaflow centrifugal pump, a Quadrox-iD Pediatric PMP HFMO, two Bio-Medicus ECLS cannulae (arterial and venous), and 3 feet of ¼ inch tubing for both the arterial and venous line (1). All of the components in the circuit have been tested in our center before being used in piglet experiments, including the impact of different lengths and diameters of tubing on the hemodynamics of the circuit. The priming volume of the circuit is 190 ml, and the inner surface has "tip to tip" biocompatible coating. It not only enables rapid priming (less than 10 minutes), but provides superior safety and portability, as well. When we compared this new circuit with the conventional ECLS circuit, the results showed much lower pressure drops and a greater retention of total hemodynamic energy through the new circuit, and there was no retrograde flow using the centrifugal pump at flow rates as low as 250 ml/min (2-7). We have finished the training of the clinical ECLS team including over 150 clinicians from 10 US centers in addition to 182 clinicians from 44 centers in Turkey (8). The objective of this presentation is to cover the newest clinical ECLS systems that are available in 2012.

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## **Congenital Heart Disease: From Computational Fluid Dynamics to Surgery**

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### **Introduction:**

Progresses in the field of bioengineering have resulted in significant improvement in the understanding of cardiovascular patho-physiology of congenital heart disease and have ultimately enhanced the ability to plan appropriate surgical intervention. In particular, computational fluid dynamics (CFD) using geometric meshes derived from in vivo advanced imaging techniques (MRI, CT) and finite element mathematical analysis represents perhaps the paradigm of bioengineering applications to surgery of congenital malformations. Starting from studies in rather simplified models of cavo-pulmonary connections, such as the ones used for palliation of single ventricle lesions, CFD has evolved into a refined methodology able to predict shear stress and velocity vectors in aortic valve replacement and major aortic vascular pathology. More recently, the definition of the complex interaction between congenital aortic or systemic semilunar valve disease and ascending aortic lesions, such as aneurysm or dissection, has further expanded the potential applications of CFD to the field of surgery for congenital heart disease. In spite of a number of theoretical and mathematical limitations, CFD has the unique ability to simulate the individual pathophysiology of cardiac malformations by using custom-made models derived from in vivo advanced imaging tools. In addition, the possibility to generate more theoretical anatomic models allows to speculate on evolution of disease condition, be it in natural or post-operative history, which would otherwise require large patient populations and extensive follow-up to assess.

## Nonsurgical Management of Pulmonary Atresia with Intact Ventricular Septum in Neonates

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### Background:

Pulmonary atresia with intact ventricular septum (PAIVS) is revealed with broad spectrum of heterogenous right ventricular morphology. Perforation of the atretic valve, balloon dilatation and stenting of the patent ductus arteriosus are the percutaneous techniques which are used frequently. It has some advantages over surgery including short hospital stay, short ICU stay and etc. The main goal of the primary interventional approach is to avoid surgery. A group of patient with PAIVS still needs surgery because of the poor right ventricular growth. Therefore the final achievement of the initial percutaneous treatment strategies is still debatable. In this paper we present the early and mid-term results of the percutaneous approach in our clinic to evaluate the final effects of interventional therapy according to initial morphology.

### Methods:

Between May 2010 and November 2011 seventeen neonates diagnosed with PAIVS or critical valvular pulmonary stenosis (almost atretical) underwent transcatheter intervention. Detailed echocardiographic examinations were performed to all patients that focused on right ventricular size, tricuspid valve morphology and coronary sinusoids before intervention. Nine of the patients were boys and 8 were girls. The mean age was  $12.7 \pm 12.1$  days and weight was  $3.2 \pm 0.9$  kg. Table 1 summarizes the patients' characteristics and echocardiographic findings. According to right ventricular morphology patients underwent one or combined of interventional procedures including; balloon dilatation, radiofrequency assisted valve perforation and stenting of the patent ductus arteriosus.

### Early and Mid-Term Results:

Procedures were accomplished without any complication in fifteen cases. Two major complications occurred during procedures which lead to mortality. The types and the early results of percutaneous procedures are summarized in table 2.

The follow-up periods were  $6.9 \pm 5.2$  months (2-19 months). Mean duration of intensive care was  $2 \pm 1.8$  days. One patient died 3 months after stent implantation because of the left ventricular systolic dysfunction. Two patients also died immediately after Glenn operation. Five out of 12 patients achieved biventricular physiology without further interventional or surgical requirement. Three patients were one and a half ventricular repair candidates. One patient achieved one and a half ventricular repair after Glenn operation. One patients who had univentricular morphology underwent Glenn operation are waiting the Fontan completion. Two patients who had univentricular morphology are still waiting for Glenn operation.

### Conclusions:

As a primary treatment, transcatheter management of PAIVS is a feasible, safe, and effective palliation in newborns. Right ventricular size determines the type of the intervention. The early outcomes can be comparable with surgical palliation. However overall morbidity and mortality is still high in a group of PAIVS particularly who have severe right ventricular hypoplasia. Completing surgical approach is mandatory in some of the patients even after primary successfully percutaneous intervention.

TABLE-1.

Patient Data	
Age(day)	12.7±12.1
Gender (M/F)	9/8
Weight (kg)	3.2±0.9 (2.2-4.7)
Echocardiographic Findings	
Right Ventricular Morphology	Number of patiens (n)
Monopartiate	3
Bipartiate	11
Tripartiate	3
Additional Malformations	
Coronary sinusoid (absent/present)	7/10
Ebstein malformation (absent/present)	15/2

TABLE-2

Patient Data	Median( range) days
Days of Intensive Care stay	2.54 ± 3.3 (1-11)
Days of hospital stay	7.2±4.2 (3-23)
Procedure	Number of patiens (n)
Balloon dilatation+PDA stenting	5
RF assisted Valvotomy	3
RF+PDA stenting	6
PDA Stenting	3
Procedure time (minute)	142.27±61.75 (23-240)
X-ray exposure (minute)	43.42±24.66 (23-86)
Pulse oxymetry saturation	
Before procedure	70± 6.14 (60-80)
After procedure	89.27±4.61(80-96)

RF:Radiofrequency, PDA:Patent ductus arteriosus

## Application of Hemodynamic Energy to Cardiovascular Research at Korea Artificial Organ Center

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### Background:

Blood flow is driven by the difference in total energy, not by the pressure gradient, between two points. Generation of pulsatile flow depends on an energy gradient as well.<sup>1-2</sup> We have adopted the concept of hemodynamic energy for various cardiovascular researches at Korea Artificial Organ Center. The study objectives are to observe the physiologic effects of pulsatile vs. non-pulsatile blood flow, the pulsatile pump circuit configuration, the hemodynamic effects of different cardiotonics, the vascular pulsatility after ischemic-reperfusion injury, the effect of fluid viscosity on hemodynamic energy, the distal flow pattern in stenotic vessels, and so on.

### Methods:

Of the various tools evaluating blood pulsatility, energy equivalent pressure (EEP; mmHg) and surplus hemodynamic energy (SHE; erg/cm<sup>3</sup>) have been applied to the studies. As for the comparison of pulse vs. non-pulse effects, a Korean pulsatile ECLS and a centrifugal pump are used. Most of the experimental designs are tested in both in-vitro mock system and in-vivo animal experiment of swine.

### Results:

**[Study 1]** Pulsatile blood flow maintained a higher pulse pressure and a higher mean blood pressure than non-pulsatile blood flow during ECC and had a better effect on renal tissue perfusion ( $47.5 \pm 18.3$  vs.  $83.4 \pm 28.5$  ml/min/100g;  $p=0.026$ ). **[Study 2]** In long-term extracorporeal circulation, pulsatile blood flow may have advantages over non-pulsatile blood flow for decreasing myocardial damage and aiding in a faster myocardial recovery. **[Study 3]** For optimization of pulsatile ECLS circuit, both the parallel and serial circuit configurations of the pulsatile ECLS (T-PLS) generate effective pulsatility. As for the pump output, the parallel circuit configuration provides higher flow than the serial circuit configuration by doubling the pulse rate at a given pump-setting rate. (at 40 and 50 BPM pump-setting rates,  $3.1 \pm 0.2$  &  $3.7 \pm 0.2$  L/min vs.  $2.2 \pm 0.1$  &  $2.5 \pm 0.1$  L/min, respectively,  $p=0.01$ ). **[Study 4]** Centrifugal pump alone was found to have had zero percent change from MAP to EEP. However, the addition of IABP to Centrifugal pump converted the flow to pulsatile and increased pulse pressure significantly from  $9.1 \pm 1.3$  mm Hg to  $54.9 \pm 6.1$  mmHg ( $p=0.012$ ). It also significantly increased the percent change from mean arterial pressure to EEP from  $0.2 \pm 0.3\%$  to  $23.3 \pm 6.1\%$  ( $p=0.012$ ) and SHE from  $133.2 \pm 234.5$  to  $20,219.8 \pm 5842.7$  erg/cm<sup>3</sup> ( $p=0.012$ ). **[Study 5]** There was no significant difference in coronary flow and hemodynamic energy in combined CP with IABP and a pulsatile device. **[Study 6]** In the fibrillating heart, the non-pulsatile pump may require 25%–28% higher pump flow than the pulsatile pump to maintain equivalent coronary blood flow. **[Study 7]** the change in hemodynamic energy induced by dopamine, esmolol, and epinephrine may be expressed in terms of the EEP and SHE. In addition, there was a strong correlation between the EEP and flow. **[Study 8]** Most (80%) of the total hemodynamic energy generated by a pulsatile pump is absorbed by components of the extracorporeal circuit and only a relatively small amount of pulsatile energy is delivered to the patient. Therefore, to optimize pulsatile CPB machines and ECLS systems, pulsatile flow pumps are most essential. **[Study 9]** Surplus hemodynamic energy showed more significant changes than PP or EEP during reperfusion period ( $p < 0.05$ ). SHE was found to be a more sensitive hemodynamic energy parameter during ischemia-reperfusion injury than PP or EEP. **[Study 10]** Hemodynamic energy is maintained until 50% stenosis of vessel diameter. Pulsatile blood flow can be more protective in vascular obstructive disease.

### Conclusions:

The precise quantifications of pressure flow waveforms, EEP and SHE are valuable tools for evaluating pulsatility in the circulatory system. They are expected to be used as additional performance indexes of a blood pump.

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## The Use of Blood and Strategies of Blood Conservation in Infant Cardiac Surgery Using Cardiopulmonary Bypass

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### Background:

Cardiac surgery using cardiopulmonary bypass (CPB) is associated with bleeding and thrombosis that is exacerbated in the infant compared to older patients. Transfusion-free surgery in neonates is very difficult due to excessive hemodilution, the immature coagulation system and heightened inflammatory process. Predictors of transfusion may include the pre-operative hemoglobin, age and weight at time of surgery, longer CPB and x-clamp times as well as the use of deep hypothermic circulatory arrest. Both quantity and quality of allogeneic transfusion is associated with higher rates of morbidity and mortality in infants compared to older children and adults.

### Methods:

Pre-operative screening and management of patients' in a blood conservation program is useful to achieve successful patient outcomes. Iron therapy to optimize the hemoglobin in patients that are being referred for elective cardiac surgery is an important step in the preparation for a blood conservation strategy. Intra-operative management may include; autologous blood donation or acute normovolemic hemodilution, fluid restriction pre-CPB, meticulous surgical technique, miniaturized perfusion circuitry, hemoconcentration and cell salvage systems as well as retrograde arterial prime and venous antegrade prime. Post-operative management may include the use of noninvasive monitoring and limiting blood sampling.

The use of fresh whole blood during infant heart surgery has been shown to reduce bleeding and transfusion while improving early clinical outcomes. Recent evidence also supports the use of fresher red cells during the peri-operative period. The reduction of dilution may benefit the patient by reducing the need for transfusion and it may also ameliorate inflammatory responses independent of blood transfusion. The development of transfusion guidelines and adherence to them has also been shown to reduce transfusion throughout the hospital stay.

### Summary:

Reports have demonstrated that achieving bloodless heart surgery in infants is possible with an interdisciplinary team approach that advocates for a program-wide blood conservation program. Consistent goals and the use of multiple blood concentration strategies will result in success. Finally, finding ways to balance a scarce blood donation resource with the need for quality products continues to be a challenge.

## Biomarker Response to Cardiopulmonary Bypass in Pediatric Population

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### Background:

Cardiopulmonary bypass (CPB) is associated with peri-operative myocardial and cerebral damage. Close monitoring can prevent post-operative morbidity and mortality in pediatric cardiac surgery. Alterations in the levels of biomarkers related to inflammation, tissue damage, and other tissue pathologies can be useful in early and accurate evaluation of children after cardiac surgery. Several novel techniques such as Multi-Analyte Profiling (MAP) can measure biomarkers as a potential surrogate marker of clinical outcome in pediatric cardiac surgery.

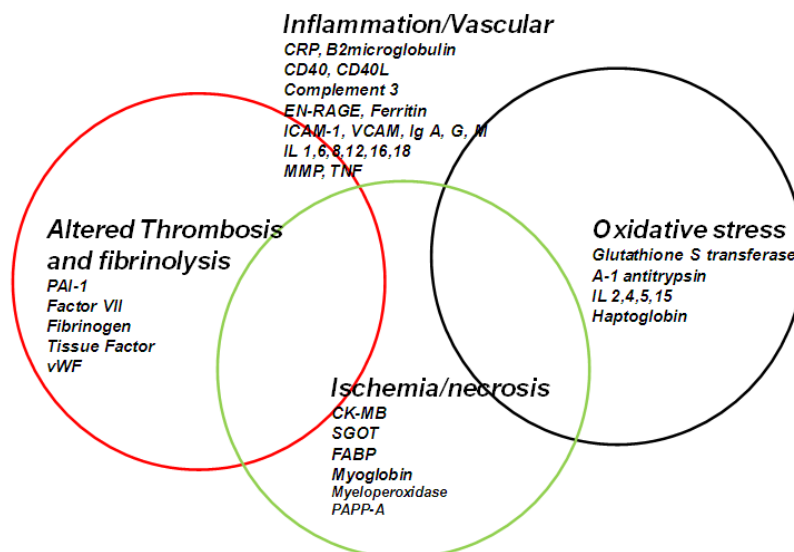
### Methods:

We previously reported 90 different biomarkers using only 200 to 300 µl of plasma by MAP technology (Rules Based Medicine, Austin, TX) after pediatric cardiac surgery. The alterations in biomarkers are analyzed. Plasma samples (200-300 µl) were collected at different time points: 1. before mid-line incision, 2. on CPB for 3 to 5 minutes, 3. at the end of CPB, 4. 1 hour (h) after CPB, 5. 24 h after CPB.

### Results:

The pilot protocol included 10 patients (ages from 3 month to 4 year old).with similar Jenkins risks stratifications who underwent non-pulsatile CPB. Myeloperoxidase (MPO) and pregnancy associated plasma protein (PAPP-A) were the earliest markers to rise with 49 and 18 fold increase 3-5 minutes after the onset of CPB respectively. The most striking increase was noted at the heart-type fatty acid-binding protein (FABP) levels. FABP increased 25,193, 151 and 4 fold at time points 2,3,4 and 5 respectively. Surge in the novel markers of injury was followed by the markers of inflammation (i.e. C-reactive protein, interleukins) peaking at 24 h after CPB.

### Included biomarkers



### Conclusions:

This pilot study shows that it is possible to measure 90 different biomarkers using only a very small sample of plasma to evaluate the effects of CPB. Novel markers of tissue injury (FABP, PAPP-A or MPO) are the earliest markers to rise. Serial monitoring of multiple biomarkers may help to predict and improve outcome after pediatric cardiac surgery. **The central hypothesis is that** continuous monitoring of the biomarkers by a **novel technique** can add valuable information to the clinical armamentarium in pediatric surgery. **Elevated biomarker levels after congenital heart surgery can be surrogate marker for adverse remodelling of the ventricle, heart failure, poor tissue response, enhanced fibrosis, impaired response to anticoagulation, activated neurohormonal response cascade as well as inadequate ventilation or ICU care. Subjects with elevated biomarker levels can benefit from evidence based interventions to reverse ventricular remodeling, effective doses of anticoagulation, enhanced monitoring to identify subjects with poor response to treatment and close monitoring for recurrent thrombosis, mechanic and arrhythmic complications.**



## Importance of Complete Modified Ultrafiltration in Pediatric Cardiac Surgery Patients

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### Background:

Modified ultrafiltration (MUF) is employed at the termination of cardiopulmonary bypass (CPB) in pediatric and neonatal patients undergoing congenital heart surgery to reduce the accumulation of total body water thus increasing the concentration of red blood cells and the other formed elements in the circulation. MUF has also been shown to remove circulating pro-inflammatory mediators that result in systemic inflammatory response syndrome (SIRS) postoperatively. It is important to completely ultrafiltrate the entire bypass circuit volume and the patient to a hematocrit of at least 40% to gain the beneficial effects of MUF.

### Methods:

One hundred consecutive patients undergoing cardiac surgery requiring cardiopulmonary bypass and weighing less than or equal to 20 kilograms were evaluated for the effectiveness of MUF. After the termination of CPB, blood was withdrawn through the aortic cannula and passed through a hemoconcentrator attached to the blood cardioplegia set and returned to the patient through the venous cannula. The entire CPB circuit volume in addition to the patient's circulating blood volume were concentrated until the hematocrit value displayed on the CDI cuvette within the MUF circuit reached 45% or there was no more volume to safely remove.

### Results:

MUF was performed in all 100 patients with no MUF-related complications. The table below displays the average amount of volume removed and the pre and post-MUF hematocrits for the patients in the study.

Patients	Kg	Pre-CPB HCT (%)	First On-CPB HCT (%)	Last On-CPB HCT (%)	MUF Effluent Volume (ml)	MUF Volume / Kg	HCT post MUF (%)
≤ 20 Kg	6.8 ± 4.7	38.4 ± 7.8	31.0 ± 4.2	29.4 ± 3.7	592.8 ± 139.2	115.9 ± 53.2	40.5 ± 4.6
< 10 Kg	4.7 ± 1.8	38.8 ± 7.6	32.1 ± 3.5	30.2 ± 3.5	554.2 ± 100.6	131.8 ± 46.5	40.9 ± 4.4

### Conclusions:

Complete MUF enables the clinician to safely raise the post-CPB hematocrit to at least 40% while also removing mediators that result in SIRS.

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## Pediatric Perfusion in Japan: 2010 Practice Survey

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\*Department of Anesthesiology and Pediatric Cardiac Surgery, Hospital Necker-Enfants Malades, Paris, France

### Background:

To date, little is known about actual perfusion management and the organization framework in Japan. We report here Japan's first pediatric perfusion survey. The aim of the survey was to determine current practice across Japanese centers.

### Methods:

We sent a 45-question perfusion survey in June 2010 by government mail and electric mail to chief perfusionists in 70 congenital heart centers in Japan. The survey, which enquired about perfusion practices from January 2007 through December 2009, covered pediatric caseloads, cardiopulmonary bypass (CPB) circuits (priming volume, solution, coating), CPB components (arterial pump, oxygenator, heart-lung machine), CPB monitoring (regional oxygen saturation monitor, in-line monitor, electronic recording), CPB management (perfusion flow, temperature, filtration, vacuum-assisted venous drainage, blood transfusion), blood gas management, hypothermia technique, myocardial protection (cardioplegia solution, temperature), pediatric extracorporeal membrane oxygenation (ECMO) and employment of perfusionists.

### Results:

Of the 70 congenital heart centers contacted, 53 (76%) completed the survey. They reported performing 3,379 pediatric CPB in 2009, 3408 in 2008, and 3,358 in 2007. Twenty-eight percent of all centers used CPB circuits with a priming volume between 151-200mL. All centers employed pre-bypass ultrafiltration for blood priming and only 6% of the centers employed retrograde autologous priming. A biomaterial-coated circuit was used by 78% of the centers (49% used poly-2-methoxyethylacrylate coating and 29% used a heparin coating), a roller pump as the arterial pump by 91%, vacuum-assisted venous drainage by 39%, dilutional ultrafiltration by 48%, and modified ultrafiltration at the end of the procedure by 30%. A regional oxygen saturation monitor was used by 69% of the centers and high flow (150-200 ml/kg/min) management with alpha-stat blood gas control was standard during moderate to normothermic CPBs. Crystalloid cardioplegia solution was used as myocardial protection by 56% of the centers, electronic recording of monitoring data by 51%. The centers performed 98 pediatric ECMO procedures in 2007, 109 in 2008, and 119 in 2009; 58% of the centers used a centrifugal pump.

### Conclusions:

This survey provides a description of the current pediatric perfusion practice in Japan. Future surveys will identify trends and rate of change in practice.

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*Perfusion* 27(1), 72-77, 2011.

## Evaluation of Neonatal Oxygenators with or without Integrated Arterial Filters

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### Background:

Oxygenators that oxygenate the blood during CPB can significantly influence the quality of blood reaching the patient by their manufacturing designs. Compared with the original hollow-fiber oxygenators, the new hollow-fiber membrane oxygenators are developed with integrated arterial filters to reduce priming volume and eliminate a separate arterial filter in the circuit. In this study, we evaluated different neonatal oxygenators with or without integrated arterial filters in terms of microemboli capturing and hemodynamic parameters.

### Methods:

The oxygenators evaluated in this study included Capiiox Baby RX05 and FX05 oxygenator, Quadrox-i neonatal and Quadrox-i neonatal with integrated arterial filter. A HL-20 roller pump and 1/4inch tubing were used. A Hoffman clamp was located upstream the pseudo patient to maintain a constant patient pressure of 100 mmHg. Three pressure transducers as well as three EDAC transducers were placed at pre-oxygenator, post-oxygenator and post-arterial filter sites (for oxygenators with IAF, the third transducer was placed at distal arterial line). In each circuit, we measured the pressure drops of the oxygenator, the shunt flow from the purge line, as well as the gaseous microemboli capturing by injecting air (5ml) from the venous line. The system was primed with Lactate Ringer's solution; human blood was added to maintain the hematocrit at 30%. The volume of the pseudo-patient was 200ml. For each setup, six trials were conducted at both 35°C and 25°C.

### Results:

In terms of oxygenators without IAF, Capiiox RX05 is more effective at reducing the number of microemboli that can potentially be delivered to the neonatal patient while Quadrox-i has lower mean pressure drop and better energy retention across the oxygenator. In terms of oxygenators with IAF, Quadrox-i and Capiiox FX05 produced similar results for microemboli capturing. However, Capiiox FX shows a decrease in microemboli when the purge line is opened, whereas Quadrox-i shows an opposite trend except for 700mL/min at 35°C. Compared with FX05, Quadrox-i still has lower pressure drop at all experimental conditions. The comparisons between the oxygenators with IAF and their earlier version (without IAF) showed that Integrated arterial filter designs are either equally effective or better than separate arterial filters in reducing total emboli delivered to the patient. The shunt flow using FX05 was much lower than the separate AF02 arterial filter as well as the integrated filter on the Quadrox-i.

### Conclusions:

These results suggest that the integrated arterial filters are safe and effective in microemboli capturing and reducing the priming volume of the CPB circuit. However, special attention should be paid on the difference in the shunt flow in the purge line to perform adequate hemofiltration and at the same time, avoiding hypoperfusion during the CPB procedure.

### References:

1. NM Dogal, RK Mathis, J Lin, F Qiu, A Kunselman, and A Ündar. Evaluation of three hollow-fiber membrane oxygenators without integrated arterial filters for neonatal cardiopulmonary bypass. *Perfusion* published online November 24, 2011.
2. J Lin, MN Dogal, F Qiu, A Kunselman and A Ündar. Evaluation of Quadrox-i and Capiiox FX neonatal oxygenators with integrated arterial filters in eliminating gaseous microemboli and retaining hemodynamic properties during simulated cardiopulmonary bypass. *Perfusion* published online 15 February 2012.

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## **Pediatric / Neonatal MCS & CPB in Guys & St Thomas' Hospital NHS Foundation Trust**

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Huriyet Ersayin-Kantas, FCCP, London, UK

### **Background:**

Guys & St Thomas' Hospital NHS Foundation Trust (GSTFT) is one of the leading cardiac surgery centers in the UK. Approximately 1500 cardiac operations were done last year and about 400 of these were children with congenital heart defects. Congenital heart surgery is a very complex procedure and demands specialist skills and cohesive team work. Being a member of the cardiac surgery team, the GSTFT Perfusion Department's objective is to deliver best care for patients by maximizing clinical effectiveness, minimizing patient trauma and optimizing risk management.

### **Methods:**

This paper presents reparation, operating and troubleshooting for infant and pediatric CPB that aim to ensure safe and effective conduct of CPB in accordance with the Code of Practice of the Society of Clinical Perfusion Scientist of the Great Britain & Ireland and locally agreed protocols. These include; equipment, monitoring, safety, blood flow calculations, selection of CPB tubing and oxygenators, prime and prime constituents, conduct of bypass, myocardial preservation, blood gas management, hemofiltration, cell saving, cerebral perfusion, all of which are the sole responsibility of the accredited perfusionist.

There will be two pumps with neonatal and pediatric perfusion systems for the wet lab. Setting up, priming, safety features, online blood gas monitoring, hemofiltration, cardioplegia delivery systems and identifying and solving the problems- will be demonstrated according to GSTFT Pediatric perfusion protocol.

## Multi Year Clinical Experience with Affinity Pixie™ Oxygenation System in Pediatric and Infant Patients

Nigel Cross, Chief Perfusionist  
Great Ormond St NHS Trust, London UK

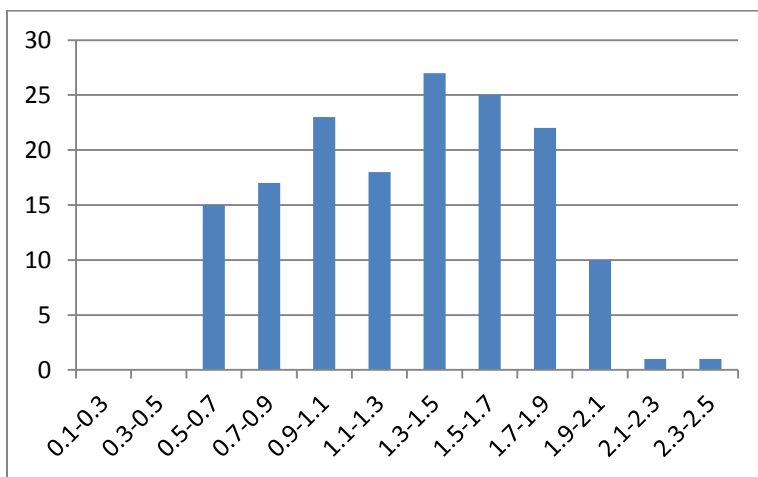
### Abstract:

Great Ormond Street Hospital for Children NHS Trust ranks amongst the most prestigious paediatric medical institutions in the world, and was the first hospital in the world to clinically use the Medtronic pediatric oxygenation system.

This presentation is an overview of two year's clinical experience in routine use of the Affinity Pixie™ Oxygenation System in 250 infant and pediatric cases from 2011 and 2011 as a part of the standard treatment protocol at Great Ormond Street. Topics will include a discussion concerning the ranges of perfusion and patient management from neonate to large children. Patients covered from flow rates of 500cc/min up to 2.3 lpm and various pathologies are to be presented including clinical results of measured including pressure drop, gas transfer, FiO<sub>2</sub>, temperatures, flow rate and patient demographics and pathologies.

Priming volume solution and treatment will be presented, as will a discussion of the circuit organization and the use of an arterial filter in routine extracorporeal circulation at the clinic. The discussion of different protocols for fluid management as well as the use of the Gampt Bubble Detection system in routine cases will also be presented. Case examples of gaseous microembolic load based on specific patient pathologies are presented and discussed.

Distribution of Patient Size, 2010 Case Load.



Case Load, # cases vs. actual flow rate



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## Myocardial Protection in Pediatric Cardiac Surgery

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Rıza Türköz, MD

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### Introduction:

The combination of hypothermia and potassium cardioplegic arrest has become the most common method of myocardial protection in the evolution of myocardial protection. In the 80's, blood was added to cardioplegia solution in order to supply the myocardium with oxygen, nutrients, and for buffering purposes. Similar myocardial protection methods have been used in adult and pediatric group for many years. However, the immature heart in pediatric group differs in many ways from the mature hearts in adults. In neonates, only 30% of the myocardial mass comprises contractile tissue whereas it is 60% in the adult heart. Pediatric myocardium has fewer mitochondria and oxidative capacity. Experimentally, it has been demonstrated that immature myocardium has a greater tolerance to ischemia than mature myocardium. On the other hand; in clinical practice, the hypoxic neonatal heart is more sensitive to ischemia than the adult heart. Cardiac output is more dependent on heart rate and sinus rhythm in pediatric patients. Increase in afterload produces significant hemodynamic impairment in pediatric heart. The sensitivity to catecholamines in pediatric heart is diminished. Immature myocardium is dependent on extracellular calcium for contractility due to underdeveloped sarcoplasmic reticulum and lower sarcoplasmic calcium ATPase activity. Ischemic preconditioning is without effect in immature myocardium. In adult myocardium, up to 90% of ATP production is derived from the oxidation of fatty acids, whereas the main substrate for the neonatal heart is glucose. Poor myocardial protection is still considered as a significant cause for hospital mortality in children.

Immature and cyanotic myocardium is more susceptible to stretch injury, reperfusion injury, edema and more vulnerable to ventriculotomy, pressure and volume load. Low cardiac output is more often observed in pediatric patients. TEE is a valuable tool in identifying the etiology of low cardiac output state when metabolic events are excluded.

Most of cardiac operations are performed under cardioplegic arrest in pediatric cardiac surgery. Today there are a lot of different types of cardioplegia solutions and methods used in pediatric cardiac surgery. Cardioplegia solutions with high potassium, magnesium and low calcium rates, containing glucose and buffering solutions have been commonly used in most of the cardiac centers. Soon after normothermic perfusion was used in the adult cardiac surgery in the beginning of the 90's, normothermic perfusion and cardioplegia was started to be used in pediatric myocardial protection. The most important advantage of normothermic blood cardioplegia is preserving the functions of sodium-potassium, ATP'ase and calcium ATP'ase enzyme systems of the sarcoplasmic reticulum under normothermia. Retrograde cardioplegia is advantageous in certain cases such as aortic valve and root surgery.

Myocardial protection is more challenging in particular cases such as; a) long and complex cases in which repetitive cardioplegia administration through aortic root is difficult, b) newborn patients and c) cases with preoperative damaged myocardium. If the mortality and morbidity rates of the centers in complex and long procedures are higher than the reported rates in literature, myocardial protection method must be suspected and reorganized.

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## Is There any Rationale for The Choice of A Time Interval between Cardioplegia Injections?

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Department of Perfusion and Intensive Care, Institut Hospitalier J. Cartier – Massy, France

### Introduction:

Evidence-based medicine is a fashionable way of thinking in modern medicine. However, all significant achievements in perfusion were done through experience-based medicine. Cardioplegia, a major component of myocardial protection, is, both in terms of composition and way of administration, the archetype of an experience-based technique.

The literature is not helpful to find any consensus about interval between cardioplegia re-injections:

- During cold crystalloid cardioplegia the classic interval is 30 min but varies from 15 to 60 min except for Custodiol® with which a single dose is proposed irrespective of the length of aortic cross clamping.
- A single dose of cold blood cardioplegia was proposed for arterial switch procedures (mean aortic cross clamping time of  $64 \pm 6$  min) and was associated with better results than multidose cardioplegia. [1]

Calafiore described intermittent warm blood cardioplegia every 15 min. Some authors were less tolerant and proposed very short periods of time, others 5 to 10, and others 13 min intervals. On the other hand, some authors used intervals of 20, 25 and even 30 min. It is noteworthy that everyone found very good reasons to state that the limit they proposed was the only safe way to perform myocardial protection.

The most provocative recent study in adults is entitled: Is repeated administration of blood cardioplegia really necessary? [2]

In our pediatric experience with intermittent warm blood cardioplegia, we have progressively increased the routine interval between re-injections from 15 min to 35-40 min. We did not notice any modification in inotropic use, but time to extubation and intensive care length of stay decreased, which is unlikely to be associated with poor myocardial protection.

There is currently no rationale for the time interval between cardioplegia injections but this doesn't mean that we don't need it.

1. Ann Thorac Surg 1988;45:548-553
2. Interact Cardiovas Thorac Surg 2009;8:517-521

## Relation between Warm Ischemic Time and Peak Level of Troponin Following Cardiopulmonary Bypass

M. Rubatti MD, R. Couturier MD, C. Credico MD, Y. Durandy MD.  
Institut Hospitalier J. Cartier – Massy, France

### Background:

Troponin is considered the best clinical biological marker for myocardial protection. There is a major concern about myocardial protection during intermittent warm blood cardioplegia. Recently we have increased the interval between two cardioplegia injections to 35-40 minutes. The goal of this work is to measure the peak level of troponin following surgery and its relation with clinical immediate outcome.

### Methods:

Troponin T (TnT) peak level is considered to occur 12 hours following myocardial injury. Dosages were performed 12 hours after aortic unclamping, after weaning from CPB for beating heart surgery, and after surgery in closed heart surgery. We have divided the patients with aortic cross-clamping in three groups: the group 1 received one cardioplegia, the group 2 two cardioplegia and the group 3 three cardioplegia. Patients with beating heart or closed heart surgery were control groups. 167 consecutive congenital heart diseases were included: 120 with aortic cross-clamping, 18 with beating heart and 29 with closed heart surgery. The results were expressed as median (min-max) for TnT peak level (mcg/l), for time to extubation (hours) and for ICU length of stay (hours).

### Results:

It is noteworthy that there is a significant overlapping of troponin values between the groups, large variations of troponin level within the same group and no correlation between troponin level and immediate clinical outcome.

	TnT mcg/l	Ti to Ex hours	ICU LOS hours
Group 1	0,50 (0,04-46,47)	2 (1-61)	24 (10-310)
Group 2	1,73 (0.29-13)	5 (1-93)	36 (11-408)
Group 3	3.77 (0.75-9.78)	12 (1-120)	48 (18-140)
Beating Heart	0.35 (0.07-2.26)	2.5 (1-100)	22.5 (18-132)
Closed Heart	0.03 (0.01-2.97)	4 (1-12)	22 (14-56)

### Conclusions:

Peak level of troponin is not only related with length of aortic cross clamping (warm ischemia), but also with the quality of perfusion, surgery, and anesthesia.

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## Protective Effects of Limb Ischemic Preconditioning Pretreatment to the Brain after Cerebral Ischemic Injury

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Department of Pediatric Cardiothoracic Surgery, Shanghai Children's Medical Center, Shanghai Jiaotong University School of Medicine, Shanghai, China, 200127.

### Objectives:

Brain injury is not uncommon after open-heart surgery with cardiopulmonary bypass. To investigate whether limb ischemic preconditioning (LIP) pretreatment has protective effects to the brain after cerebral ischemic injury by investigating the effects of LIP pretreatment on anti-inflammation and apoptosis of pyramidal neurons in the CA1 hippocampus.

### Methods:

One hundred and eight sprague dawley rats were divided into 3 groups: experimental group (n=45), ischemic group (n=45) and control group (n=18). Nine samples from five timepoints (6h, 12h, 24h, 48h and 72h after surgical manipulation) were collected for the experimental and ischemic groups, while other eighteen animals were untreated and used as controls. The models with middle cerebral artery occlusion (MCAO) were obtained by thread blocking and the models with cerebral ischemic tolerance (IT) were obtained by LIP pretreatment. Neurological severity score (NSS), histopathological change, number of inflammatory cells infiltrated and living neuronal cells were determined to evaluate the severity of cerebral ischemic injury. The determination of real-time quantitative PCR (QTR-PCR) and enzyme-linked immunosorbent assay (ELISA) were used to observe the expression of interleukin-17 (IL-17) and interleukin-6 (IL-6).

### Results:

There was no significant difference in NSS between experimental and ischemic groups. In contrast, compared with other groups, cerebral pathological change in ischemic group was the most distinct, and significantly more infiltrated inflammatory cells and apoptotic neuronal cells were also observed in the samples collected 24h, 48h, and 72h after surgical manipulation ( $P<0.05$ ). The results of QTR-PCR demonstrated that the expression of IL-17 and IL-6 were reduced significantly in experimental group. Significant difference in the expression of IL-17 and IL-6 were found between ischemia and experimental groups at 12h, 24h and 48h timepoint ( $P<0.01$ ). The data of ELISA suggested that the expression of IL-17 and IL-6 were reduced obviously in experimental group. Significant difference in the expression of IL-17 were found between ischemia and experimental groups at 12h, 24h and 48h timepoint ( $P<0.05$ ), while significant difference in the expression of IL-6 were at 24h and 48h timepoint ( $P<0.05$ ).

### Conclusions:

LIP pretreatment could induce ischemic tolerance, probably by providing probably anti-inflammatory effects and attenuating apoptosis of hippocampal neuronal cells. Therefore, LIP pretreatment could protect brain from infarction after ischemic injury.

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## Size of Berlin Heart Excor Influences Outcome in Children

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Oliver Miera<sup>1</sup>, MD, Stanislav Ovroutski<sup>1</sup>, MD, Michael Hübler<sup>2</sup>, MD, Björn Peters<sup>1</sup>, MD, Vladimir Alexi-Meskishvili<sup>2</sup>, PhD, Yuguo Weng<sup>2</sup>, PhD, Felix Berger<sup>1</sup>, PhD, Roland Hetzer<sup>2</sup>, PhD

<sup>1</sup>Deutsches Herzzentrum Berlin, Dept. of Congenital Heart Disease / Pediatric Cardiology

<sup>2</sup>Deutsches Herzzentrum Berlin, Dept. of Cardiothoracic and Vascular Surgery, Berlin, Germany

### Background:

Berlin Heart Excor Pediatric provides mechanical circulatory support as a bridge to transplantation in children with terminal heart failure. Pump chambers are available in 10, 25, 30, 50, 60 and 80 ml. Especially larger infants with a body weight of between 7 and 9 kg may receive a relatively small or large pump, depending on whether a 10 or 25 ml pump is implanted. The aim of the study was to analyze whether an unfavorable pump size influences the outcome.

### Methods:

We performed a retrospective case analysis of all children who were treated with the Berlin Heart Excor at our institution. Implanted pump size was expressed as ml per square meter body surface area. Children receiving an ideal pump size of 30 – 50 ml/m<sup>2</sup> were compared to children with “small” (less than 30 ml/m<sup>2</sup>) or “large” pumps (more than 50 ml/m<sup>2</sup>). Risk of thromboembolic events, number of pump exchanges and outcome at explantation were analyzed in relation to pump size.

### Results:

Since 1990 114 children (median age 4 years, median BSA 0.69 m<sup>2</sup>) had an Excor device implanted; the majority received a pump of ideal size (n=88). Eleven children were supported with a small pump (8 months, 7.8 kg, 0.41m<sup>2</sup>), 14 with a large pump (16 months, 8.8 kg, 0.43m<sup>2</sup>). Overall survival was 62% and improved with implementation of optimized cannulas, surgical and intensive care management. Since 2000 survival was 69%. Mortality was significantly higher in the group with suboptimal pump sizes (p=0.049). Thromboembolic events occurred more frequently in children with large pumps implanted after 2000 (p=0.033). Need for pump exchanges was higher in infants with large pumps implanted (p=0.036).

### Conclusions:

With a total survival rate of 69% in the modern era outcome on ventricular assist device is acceptable. Suboptimal pump size is a risk factor for adverse outcome.



## Left Atrial Decompression during Extracorporeal Membrane Oxygenation in Patients with Biventricular Physiology: Current Strategy and Clinical Outcomes

Yasuhiro Kotani, MD<sup>1</sup>, Devin Chetan, HBA<sup>1</sup>, Warren Rodrigues, MD<sup>2</sup>, Ben Sivarajan, MD<sup>2</sup>, Colleen Gruenwald, PhD<sup>3</sup>, Anne-Marie Guerguerian, MD<sup>2</sup>, Glen Van Arsdell, MD<sup>1</sup>, Osami Honjo, MD<sup>1</sup>  
Cardiovascular Surgery<sup>1</sup>, Critical Care Medicine<sup>2</sup>, Cardiovascular Perfusion<sup>3</sup>, Labatt Family Heart Centre, The Hospital for Sick Children, Toronto, Ontario, CANADA

### Background:

To review our current clinical practice on left atrial (LA) decompression and its impact on clinical outcome in patients who had left ventricular (LV) dysfunction during extracorporeal membrane oxygenation (ECMO).

### Methods:

From 2005 to 2011, 272 patients required ECMO support at the Hospital for Sick Children. Twenty-three patients had LA decompression for LV dysfunction and dilatation during ECMO. Indications for ECMO included low cardiac output in 16 patients, failure to wean from cardiopulmonary bypass in 6 patients, and combined cardiac and respiratory failure in 1 patient. Eleven patients were placed on ECMO for cardiopulmonary resuscitation. LA decompression was achieved by LA cannula in 16 patients, surgically-created adjustable atrial septal defect in 3 patients, and balloon atrial septostomy in 4 patients.

### Results:

ECMO duration, timing of LA decompression, and outcomes are shown in **Figure 1**. Sixteen (70%) patients obtained LA decompression at the time of ECMO initiation. Duration of ECMO was  $5.9 \pm 4.5$  days. Successful decannulation was achieved in 16 (70%) patients. Subsequent ICU and hospital survival was achieved in 13 (57%) and 12 (52%) patients, respectively. Logistic regression revealed ECMO duration as a risk factor for failure to wean from ECMO ( $p=0.007$ ). Timing of LA decompression was not associated with worse outcomes.

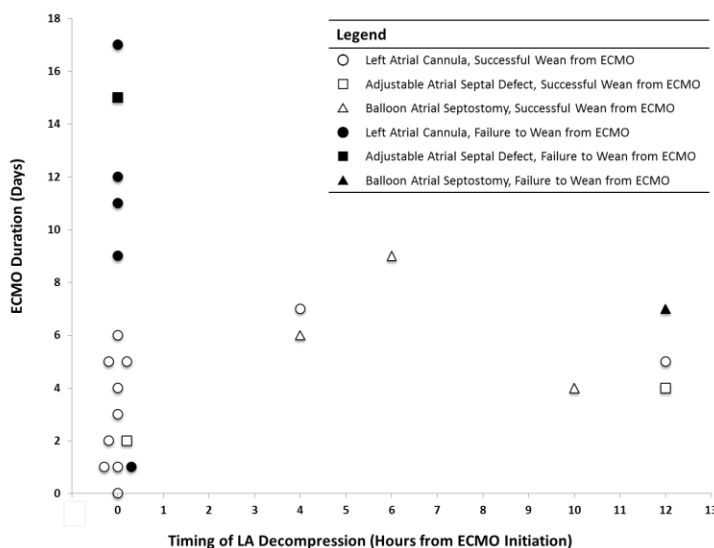


Figure 1. ECMO Duration, Timing of LA Decompression, and Clinical Outcomes.

### Conclusions:

LA decompression is an effective strategy for patients requiring ECMO for LV dysfunction if it is obtained within 12 hours of ECMO initiation and the patient can be successfully weaned from ECMO within a short time frame. Our early LA decompression strategy may be associated with better hospital survival following ECMO for left ventricular failure.

## Dosage of Vasoactive-inotropic Agents: a Powerful Predictor of Acute Kidney Injury in Pediatric Patients with Extracorporeal Life Support

Cui Yongli, MD, Liu Jinping, MD, Feng Zhengyi, MD, Zhao Ju, MD, Long Cun, MD, Wang Wei, MD Department of Extracorporeal Circulation, Fuwai Hospital, CAMS & PUMC, Beijing, China

### Background:

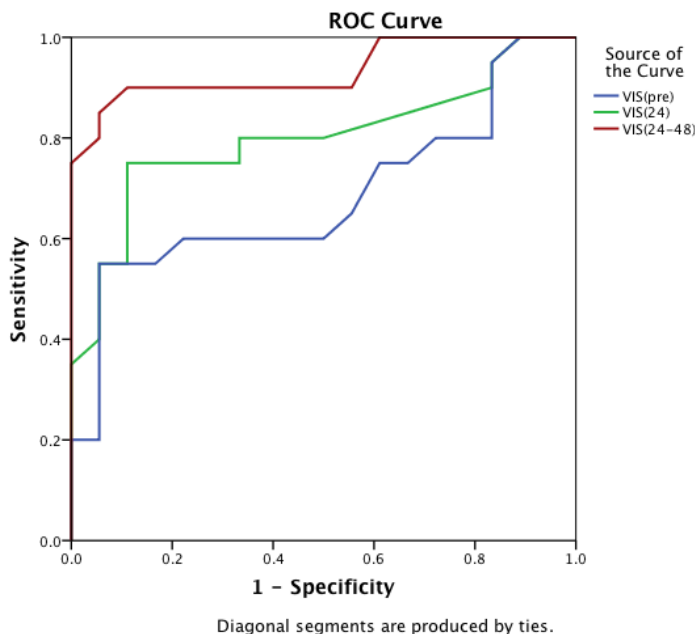
Acute kidney injury (AKI) is a common complication in pediatric cardiac patients with extracorporeal life support (ECLS) and is often associated with poor outcome. The goal of this study is to assess the predictive value of vasoactive-inotropic agents' dosage on AKI events and mortality.

### Methods:

Between December 2004 and December 2009, 38 consecutive pediatric cardiac patients with ECLS, aged 0 to 6 years, were enrolled in this study. The dosage of vasoactive-inotropic agents was recorded hourly. The maximum dosages in every 24-hour, which were maintained at least three hours, were marked for scores calculations. The scores before ECLS, in the first 24-hours during ECLS and in the second 24-hours during ECLS were calculated as VIS (pre), VIS (24), and VIS (24-48) respectively. Receiver operating characteristic analysis was used for assess the predictive value of VIS to AKI and mortality.

### Results:

The area under curve (AUR) of VIS (pre)=0.683,  $p>0.05$ ; AUR of VIS (24) = 0.800,  $p=0.02$ ; AUR of VIS (24-48)=0.933,  $p=0.00$ . The VIS (24-48) showed significant predictive value to AKI and the optimal cutoff was 18.5. After dichotomizing patients by VIS (24-48) cutoff, the high score group received higher AKI risk with odd ratio of 93.333 (95% confidence interval, 9.088-1021.187;  $p=0.000$ ), and they also received higher mortality risk with odd ratio of 14.875 (95% confidence interval, 2.625-84.100;  $p=0.01$ ).



### Conclusions:

The dosage of vasoactive-inotropic agents was a significant predictor to AKI and mortality for pediatric cardiac patients with ECLS. This might have some help to the clinical work of pediatric intensive care unit for condition assessment.

## Methylprednisolone in Neonatal Open Heart Surgery

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### Background:

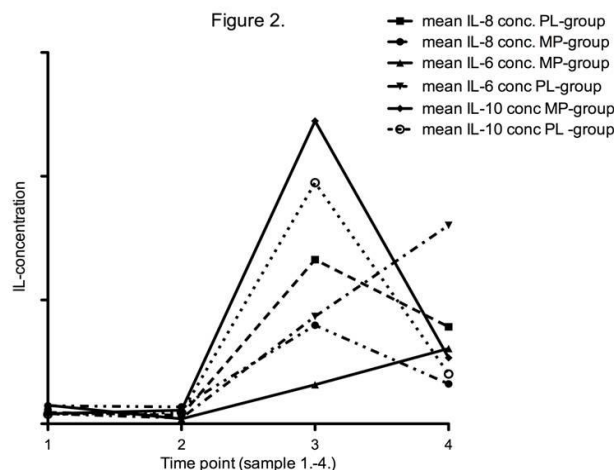
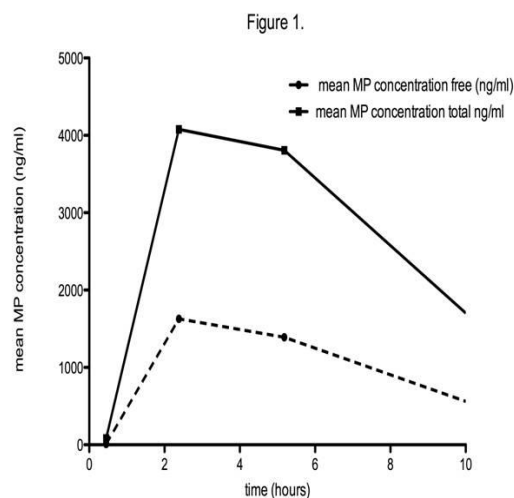
Perioperative corticosteroid administration in children undergoing cardiac surgery involving cardiopulmonary bypass (CPB) has been shown to decrease inflammatory response and reduce myocardial injury. High dose of methylprednisolone (MP) is commonly used, although the optimal dosing, as well pharmacokinetics and pharmacodynamics in this patients population has not been determined.

### Methods:

Forty neonates undergoing open heart surgery were randomised either to receive either MP 30 mg/kg i.v. (MP group, n= 20) or placebo (control group, n= 20) after the induction of anaesthesia. Plasma IL-6, IL-8, IL-10 values, MP concentrations were obtained at four time points: 1) at anaesthesia induction before the study drug, 2) 30 minutes on CPB, 3) five minutes after protamine administration after CPB and 4) six hours after weaning from CPB. In addition troponin T level, used as a marker of myocardial injury, was measured at time points 1, 3, 4 and on the first postoperative day at 6 am. Clinical outcome of patients were recorded.

### Results:

Patients receiving 30 mg/kg MP had remarkably high total and free plasma concentrations of MP (Fig 1.). Mean plasma levels of IL-6 and IL-8 were significantly lower in the MP-group than in placebo group at time points 3 and 4 ( $P<0.05$ ) (Fig 2.). Significantly increased mean IL-10 levels were detected in the MP-group at time points 2, 3 and 4 ( $P<0.05$ ) (Fig 2). There were no significant differences in troponin T levels between the study groups at any time points. No significant differences were observed for clinical outcome measures such as inotrope score, time of intubation or length of stay in PICU between the study groups.



### Conclusions:

Methylprednisolone administration before CPB in neonates resulted in significant decrease in inflammatory markers. However, no cardioprotective effect produced by MP was seen. MP concentrations after the i.v. dose of 30mg/kg was most likely much higher than needed to reduce CPB induced inflammation.

## Tranexamic Acid in Pediatric Cardiac Heart Surgery

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### Background:

Few studies have evaluated the benefit/risk of antifibrinolytics and tranexamic acid (TA) in children. Furthermore, patients were often mixed (a few days to several years old) and there were large differences in doses used (from 10mg to 100 mg /kg). We studied a homogeneous group of 39 children at increased risk of bleeding.

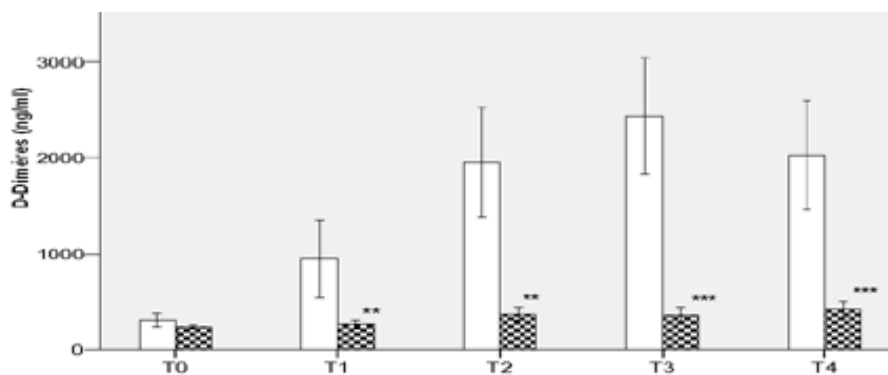
### Methods:

A prospective, randomized, single-center study was designed. 39 children weighing between 10 and 30 kilograms were enrolled. Inclusion: candidates for cardiopulmonary bypass (CPB) surgery with cyanotic heart disease or repeat interventions. Exclusion: pre-existing hemostatic anomaly. The patients were randomized into two groups: a control group (n=21) which did not receive TA and a TA group (n=18) which received TA: 10 mg/kg at induction and in the priming followed by either an infusion of 1mg/kg /h during all the procedure or a bolus of 10 mg/kg after protamine.

Fibrinolysis markers were measured in both groups: tissue plasminogen activator (tPA), plasminogen activator inhibitor (PAI1), D-Dimers and fibrinogen. Blood loss in the first 24 hours was recorded. In the TA group we measured TA levels pre-, intra- and post CPB using chromatography coupled with spectrometry in 8 points.

### Results:

The TA concentrations, using the lowest doses reported in the literature, were comprised between 20 and 60µg/ml equivalent to efficient levels in adults. In comparison to the control group the t-PA and PAI1 levels were similar while a very significant decrease in D-Dimers was noted ( $p<0001$ ) at all times. Blood loss (ml/kg/24h) was lower in the TA group: 28 versus 20 (+/- 4), but the difference didn't reach significance.



Significant decrease in D-Dimers was noted ( $p<0001$ ) in the TA group.

### Conclusions:

This is the first study of TA kinetics in children. We believe it is pointless to use higher dosages (risk of convulsions). The decrease in D-Dimers attests to the decrease in fibrinolytic activity. The influence on blood loss should be confirmed in a larger patient population.

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## Should Peritoneal Dialysis Catheter Be Routinely Implanted In TGA Cases?

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### Background:

Some centers routinely implant peritoneal dialysis catheter in patients who undergo operation for TGA correction whereas others apply only in selected patients. Peritoneal dialysis is frequently used in cases with hemodynamic instability (patients with open or closed sternum) and renal insufficiency. We investigated the clinical outcome of peritoneal dialysis use in our patients who were operated for TGA and had routine intraoperative peritoneal dialysis catheter implantation.

### Methods:

82 patients who were diagnosed TGA, TGA-VSD and TGA-VSD-coarctation with aortic arch hypoplasia and who had undergone TGA correction operation in Baskent University Istanbul Teaching and Medical Research Center between 2007 and 2012 were retrospectively investigated. All of the patients were under 30 days old. Peritoneal dialysis catheters were routinely implanted intraoperatively at the end of the operation. We use early institution of peritoneal dialysis to remove moderate hyperkalemia and in transient renal insufficiency to optimize metabolic status. The patients were divided into two groups according to the need for postoperative peritoneal dialysis (PD and nonPD groups). Peritoneal dialysis was initiated in 32 patients (39%) after the operation, whereas 50 patients (61%) did not need dialysis. The clinical outcomes and perioperative data of two groups were compared.

### Results:

The demographics in two groups were similar. Cardiopulmonary bypass time was longer in PD group [nonPD Group 175,24±32,39 min; PD Group 196,22±44,04 min ( $p<0,05$ )]. Coronary anomaly was found to be higher in PD group [nonPD Group n.=2 patients (4,0%); PD Group n=7 patients (21,9%)  $p<0,05$ ]. There was more need for peritoneal dialysis in TGA+VSD patients [Simple TGA n=14 patients; TGA+VSD patients n=18 patients ( $p<0,05$ )]. Peritoneal dialysis rate was higher in patients whose sterna were left open at the end of operation ( $p<0,05$ ). The ventilator time [non PD Group 4,04±1,51; PD Group 8,12±5,21 days ( $p<0,01$ )], intensive care unit stay time [non PD Group 7,98±5,80; PD Group 15,93±18,31 days ( $p<0,01$ )] and hospital stay time were significantly longer in PD Group [non PD Group 14,98±10,14; PD Group 22,84±20,87 days ( $p<0,01$ )].

### Conclusions:

We advocate routine implantation of peritoneal dialysis catheters to patients with TGA-VSD, coronary artery anomaly and open sternum in which we have determined high rate of postoperative peritoneal dialysis need.



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## Randomized Comparison between Mild and Moderate Hypothermic Cardiopulmonary Bypass for Neonatal Arterial Switch Operation

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<sup>1</sup>Department of Pediatric Cardiac Surgery, <sup>2</sup>Department of Pediatric Cardiology, ISTANBUL, TURKEY, Dr.Siyami Ersek Thoracic and Cardiovascular Training and Research Hospital

### Background:

Comparison of neonates receiving arterial switch operation (ASO) either with mild or moderate hypothermic cardiopulmonary bypass.

### Methods:

Forty neonates undergoing ASO were randomized to receive either mild (Mi > 32°C, n=20) or moderate (Mo > 26°C, n=20) hypothermic cardiopulmonary bypass (CPB) between April 2007 and June 2010. All patients were diagnosed with simple transposition of the great arteries. Mean age (Mi: 8.32 ± 4.5 days, Mo: 7.54 ± 5.0 days, p=0.21) and body weight was similar in both groups (Mi: 3.64 ± 0.91 kg, Mo: 3.73 ± 0.84 kg, p=0.14). Follow-up was 3.1 ± 2.5 years for all patients.

### Results:

Lowest perioperative rectal temperature was 33.5 ± 1.4 °C (Mi) versus 28.2 ± 2.1 °C (Mo) (p<0.001). All patients safely weaned from CPB requiring lower doses of dopamine (p=0.04), dobutamine (p=0.04) and adrenalin (p=0.03) in mild hypothermia group. Intraoperative blood transfusion (p=0.03) and postoperative lactate levels (p= 0.02) were lower under mild hypothermia. Secondary chest closure was performed in 30 % (Mi) versus 35 % (Mo) (p=0.65). Duration of inotropic support (p=0.03), time to extubation (p=0.04), lengths of intensive care unit stay (ICU) (p=0.04) and hospital stay (p=0.04) were significantly shorter under mild hypothermia. Two-year freedom from reoperation was 100 % for both groups.

### Conclusions:

The ASO under mild hypothermia seemed to be beneficial for pulmonary recovery, need for inotropic support, and length of ICU and hospital stay. No worse early or intermediate-term effects of mild hypothermia were found.

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## Angiotensin II Type 1 (AT1) Receptor Antagonist Not Cardioplegia Temperature Regulates Activation of Pro-Inflammatory Signal Transducers and Activators of Transcription (STAT) Proteins in Neonatal Rat Myocytes.

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Division of Cardiac Surgery, University of Verona, Verona, Italy. Department of Medical and Surgical Critical Care, University of Florence, Italy.

### Background:

Cardioplegic arrest even if controlled is a model of ischaemia/reperfusion (I/R) injury and results in the death of irreplaceable cardiac myocytes by a programme cell death or apoptosis. STAT signaling pathways play an important role in the modulation of apoptosis after ischemia and reperfusion. AT1 receptor antagonist added to cardioplegia could represent an additional modality for enhancing myocardial protection during cardioplegic arrest. To test that hypothesis, we studied the effect of AT1 receptor antagonism and cardioplegia temperature perfusion on STATs modulation during cardioplegic arrest in neonatal rat hearts.

### Methods:

Isolated, nonworking hearts (n = 4 per group) from neonatal rats were perfused aerobically in the Langendorff mode accordingly following scheme: DMEM solution (Group 1); cold (4°C) modified St. Thomas' Hospital no. 2 (MSTH2) cardioplegic solution (Group 2); cold (4°C) MSTH2 cardioplegic solution plus AT1 antagonist (Valsartan) (Group 3); warm (34°C) MSTH2 cardioplegic solution (Group 4). Thus, myocytes were isolated by enzymatic digestion, and STAT1, STAT2, STAT3, and STAT5 were investigated in Western blot studies.

### Results:

Times to arrest after cardioplegia were 6-10 seconds for all groups with exception of Group 1 (spontaneously arrest after 16 seconds). Total cardioplegia delivery volume was about 300 mL in 15 minutes. Perfusion with cold MSTH2 supplemented with AT1 receptor antagonist (Group 3) induced a significant reduction in STAT1, STAT2 and STAT5 tyrosine phosphorylation versus other groups ( $P < 0.05$ ). The decreased activation of STAT1, STAT2 and STAT5 observed in Group 3 was accompanied by reduction of interleukin-1 $\beta$  ( $P < 0.05$ ). Differently, STAT3 activation was significantly reduced in Groups 1 and 4 ( $P < 0.05$ ).

### Conclusions:

Only perfusion with AT1 receptor antagonist supplemented cold MSTH2 significantly decreases the inflammatory response of the neonatal rat cardiomyocytes without affecting antiapoptotic influence provided by activation of STAT3. Therefore, AT1 receptor antagonist could play a pivotal role in cytoprotective effect and cardiac recovery in neonates and infants.

## A Microfluidic Device to Continuously Measure Inflammation Biomarkers in Circulating Blood during Mechanical Circulatory Support Procedures

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<sup>1</sup>BioMEMS Laboratory, Department of Biomedical Engineering, Rutgers University, Piscataway, NJ; <sup>2</sup>Pediatric Cardiovascular Research Center, Departments of Surgery, Pediatrics, and Bioengineering, Penn State College of Medicine, Penn State Children's Hospital, Hershey, Pennsylvania, USA

### Background:

Mechanical circulatory support procedures such as cardiopulmonary bypass and extracorporeal life support are known to cause significant inflammatory responses, which lead to complications and diminished patient outcomes. The ability to thoroughly characterize the systemic inflammatory response is limited by the available assaying techniques, especially due to the limited blood volume available for testing. By combining microfluidic technology with a multiplexed microbead-based cytokine immunoassay, we are developing a system which will monitor and thoroughly characterize the inflammatory response at high sampling rates and with real-time output. The assay is based on the popular Luminex xMAP multiplexed bead array technology. Companies such as Bio-Rad currently offer xMAP assay kits for inflammation biomarkers which are compatible with our device.

### Methods:

The device is infused via syringe pumps with antibody coated magnetic microbeads, secondary labeling antibody, and fluorescent tagging solution. The microbead solution is pre-mixed to allow detection of multiple cytokines simultaneously. The blood plasma sample is provided as a continuous stream from a microfiltration device which is connected directly to the mechanical circulatory support loop. Upon reaching the outlet of the device, the microbeads are fluorescently labeled, having a fluorescence intensity which is proportional to concentration of each analyte in the blood. The incubated beads are currently being collected in fractions and interrogated by flow cytometry, but in the final product they will flow directly into a flow cytometer for real-time measurements.

### Results:

The device was capable of continuously processing assay microbeads and tracking the concentration of a time-varying sample concentration with multiple analytes simultaneously (cytokines IL-6 and TNF- $\alpha$ ).

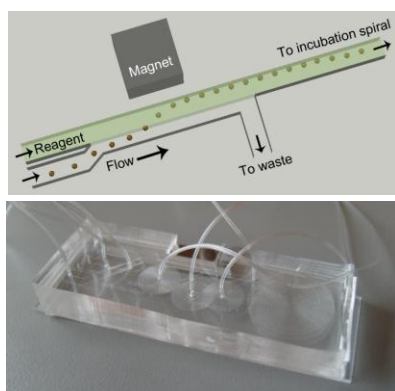


Figure 1: (top) Rendering showing the operating principle of the microfluidic assay device. (bottom) Photograph of microfluidic device.

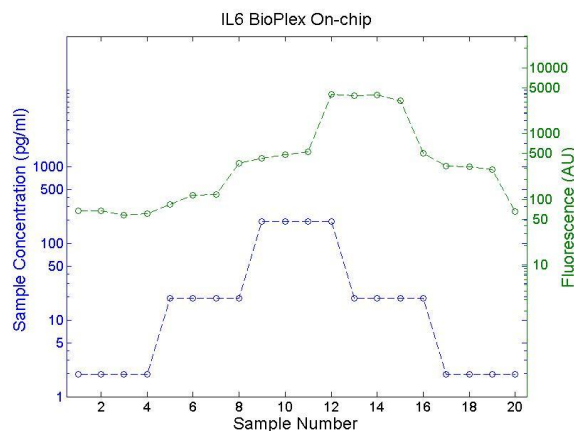


Figure 2: Data showing temporal tracking of one of the two multiplexed analytes.

### Conclusions:

The fully integrated assay should allow continuous measurement of inflammatory markers during mechanical circulatory support procedures such as CPB and ECMO, with very high sampling rates and propagation delays below 20 minutes. This new information will allow surgical teams to reduce the damage caused by systemic inflammation by adjusting surgical procedures and treatments.

## Pre-Surgical Evaluation of Fontan Connection Options for Patients with Apicocaval Juxtaposition, using Computational Fluid Dynamics

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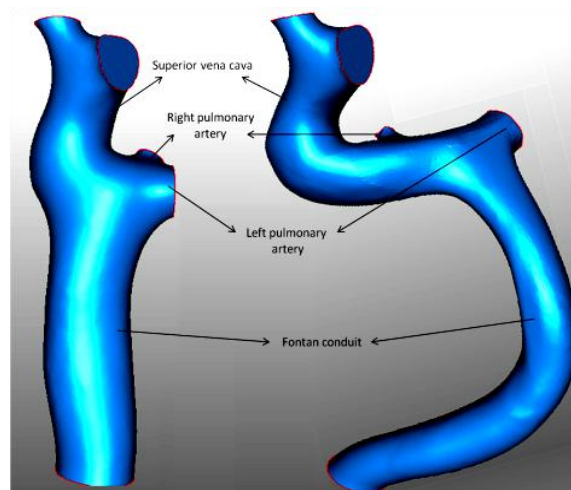
<sup>2</sup> Department of Cardiothoracic Surgery, Children's Hospital of Pittsburgh, Pittsburgh, PA, USA

### Background:

Apicocaval juxtaposition (ACJ) is a rare congenital heart defect associated with single ventricle physiology where optimal positioning of the Fontan conduit for completion of total cavopulmonary connection (TCPC) is still controversial. In ACJ, the cardiac apex is ipsilateral with the inferior venacava (IVC), risking kinking and collapse of the Fontan conduit at the apex of the heart. The purpose of this study is to evaluate two viable routes for Fontan conduit connection in patients with ACJ, using computational fluid dynamics (CFD).

### Methods:

There are two variants to connect the transected IVC and the pulmonary artery in an ACJ scenario i.e. lateral tunnel (LT-TCPC) or extra-cardiac conduit (EC-TCPC). The former involves a shorter, straighter connection through the ventricular apex, whereas the latter involves a longer curved conduit traveling behind the ventricle, connecting the IVC to the ipsilateral pulmonary artery. CFD simulation of internal hemodynamics for each case was conducted using in-silico surgical templates modeled from patient-specific pre-surgical MRI scans (Figure 1). Internal energy loss evaluations were used to determine contribution of conduit curvature to the energy efficiency of each cavopulmonary anastomosis configuration.



**Figure 1.** LT-TCPC (left) and EC-TCPC (right)

### Results:

The contribution of energy loss within the Fontan conduit as a percentage of energy loss across the cavopulmonary anastomosis was found to be greater in the case of the curved conduit (44%, 4.1 mW) than the straighter conduit (6%, 1.4 mW). In contrast, net energy loss across the anastomosis was significantly lower with EC-TCPC (9.3 mW) in comparison with LT-TCPC (23.2 mW). This highlights that a curved Fontan is a favorable trade-off given the superior overall connection efficiency possible with the EC-TCPC.

### Conclusions:

Preoperative evaluation is paramount for deciding upon the most efficient Fontan connection. EC-TCPC is a suitable connection option independent of anatomical situations and can facilitate connections of superior efficiency in ACJ cases.

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## Results of Pediatric Mechanical Assist for Postcardiotomy Ventricular Failure and Cardiac Arrest in Intensive Care Unit: Choice of Device and Modality of Support

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### Background:

Pediatric mechanical assist is a life saving procedure for patients who develop cardiac and respiratory failure after pediatric cardiac surgery. We evaluated the results of pediatric mechanical assist device use for postcardiotomy ventricular failure and cardiac arrest in intensive care unit.

### Methods:

Between February 2000 and February 2012 1800 patients underwent pediatric cardiac operation. Among these patients 10 (0.5 %) needed mechanical assist device support for postcardiotomy cardiac failure and cardiac arrest in intensive care unit. In 5 patients roller pump support was used for temporary left ventricle support and in 5 patients ECMO was used for temporary cardiac and respiratory support.

### Results:

In 5 patients, 3 patients in roller pump support group and 2 patients in ECMO support group, mechanical assist was successfully weaned (50 %). Three patients were discharged from the hospital without permanent major organ dysfunction. Patients' ages were between 2.5 months and 6 years (mean 1.5 years) and 5 were male. Longest mechanical support for left ventricle dysfunction was 160 hours with roller pump and ascending aorta-left atrial appendage cannulation in a 7 months old infant after arterial switch operation. Other 2 patients, after arterial switch operation (4 years old) and anomalous left coronary artery from pulmonary artery anomaly repair operation (2.5 months old), successfully weaned from roller pump support for left ventricular dysfunction after 48 hours. In 2 patients after ventricular septal defect closure, ECMO support was necessary for cardiac arrest in the intensive care unit and ECMO was weaned off after 12 and 48 hours.

### Conclusions:

Pediatric cardiac mechanical assist is a useful procedure for patients who develop cardiac and respiratory failure after cardiac surgery and do not respond to conventional resuscitative efforts. Conventional roller pump support is an alternative method for temporary left ventricle dysfunction in selected cases.



## A Novel Fontan Fenestration with Desirable Flow Characteristics - In Vitro Analysis and Lumped Parameter Modeling

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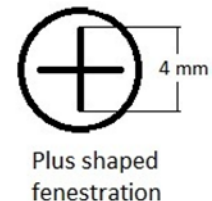
<sup>3</sup>Penn State Children's Hospital and Bioengineering, Pennsylvania State University, USA

### Background:

Introduction of Fontan conduit to divert the venous blood to the pulmonary arteries as a 3rd stage palliation leads to systemic venous hypertension, associated with plural effusions and protein losing enteropathy. In spite of the ongoing debate on its benefits (Hsia et.al, Eur J Cardiothorac Surg, 19, 2001), traditionally a circular fenestration hole (~4mm) establishes the venous shunt to the common atrium, relieving pressure, but with reduced oxygen saturation. The objective of this study was to explore new fenestrations designs and materials that can provide more desirable pressure-flow characteristics.

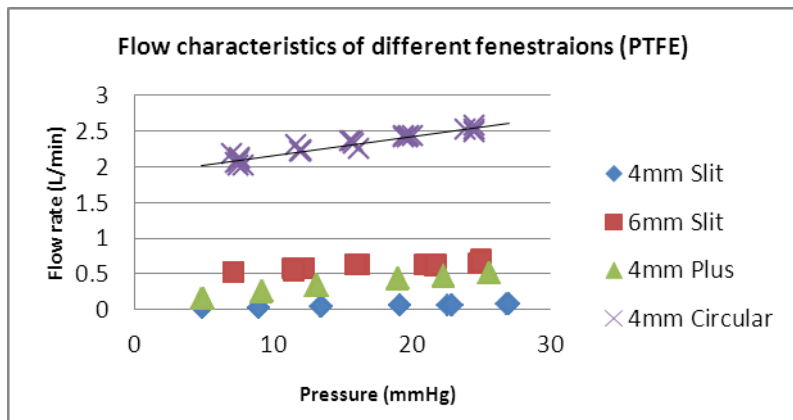
### Methods:

Fenestrations orifices were constructed using 22 mm standard wall PTFE graft (Gore-Tex; W.L. Gore and Assoc, AZ) and impra material in different shapes including the plus (+), slit (|) and the traditional orifice, with sizes ranging from 4mm to 8mm. Steady leakage flow tests were performed at different pressures ranging from 5 to 30mmHg to obtain their flow characteristics. In addition to the pressure-flow measurements, pictures were taken to analyze the opening shapes. The lumped parameter model of the single-ventricle circuit is created in MATLAB to simulate the pulsatile flow conditions through the fenestration. Leakage flow characteristics are employed in the numerical model.



### Results:

For the geometries tested, flow rate increased almost linearly with increase in orifice diameter as expected. Characteristics were compared with the standard 4mm diameter circular fenestration. Nonlinearity in flow characteristics is due to the opening area increase with pressure offering a relatively higher resistance to flow at lower systemic venous pressures. Numerical lumped parameter results and characteristics with different materials and slit shapes will be presented during the conference.



### Conclusions:

A large variability in flow rate can be obtained by changing the shape, material and size of the fenestration to suit the requirements of the patient. Despite the apparent benefits, one of major drawbacks is the risk of systemic embolization (Salazar et.al, JTCVS, 140, 2010), which will be analyzed in future communications using computational fluid dynamics.

## Carotid Doppler Flow after Cardiopulmonary Bypass and Mild Hypothermia in Neonatal Piglets

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### Background:

Although the mechanisms of neurological disorders after cardiac surgery in neonates are still not fully understood, alterations in blood flow after cardiopulmonary bypass may lead to cerebral injury. The aim of the study was the analysis of flow changes in the carotid artery of neonatal piglets after cardiopulmonary bypass.

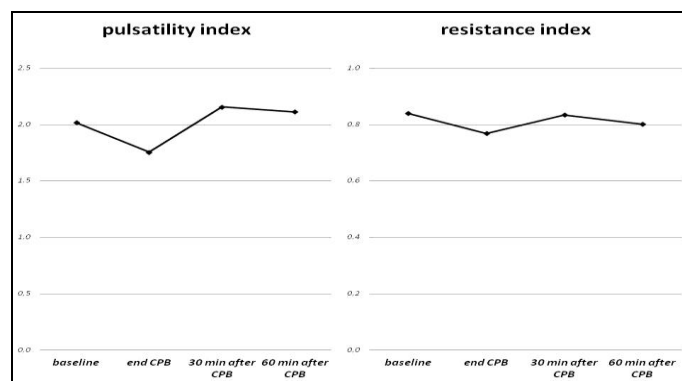
### Methods:

Ten neonatal piglets (younger than 7 days) were connected to the cardiopulmonary bypass (CPB) and further management underwent three steps: (1) cooling to 32°C core temperature within 30 minutes, (2) cardiac arrest under cardioplegic myocardial protection for 90 minutes, and (3) re-warming to 37°C after cross-clamp release (60 minutes of reperfusion). In summary, piglets were separated from CPB after a total duration time of 180 minutes.

The blood flow was measured in the left carotid artery by an ultrasonic flow probe; before CPB (baseline), immediately after CPB, 30 minutes, and 60 minutes after CPB. Additionally, the pulsatility index and the resistance index were calculated and compared. Finally, the relation of the carotid artery flow data with the corresponding pressure data at each time-point was compared.

### Results:

After termination of CPB the carotid artery mean flow was reduced from  $28.34 \pm 13.79$  ml/min at baseline to  $20.91 \pm 10.61$  ml/min and remained reduced 30 and 60 minutes after CPB termination ( $19.71 \pm 11.11$  ml/min and  $17.64 \pm 15.31$  ml/min, respectively). Both the pulsatility and the resistance index were reduced immediately after CPB termination and increased thereafter (figure 1). Nevertheless, values did not reach statistical significance.



### Conclusions:

The carotid Doppler flow after CPB and mild hypothermia in neonatal piglets was reduced but these findings were not statistically significant.

## Evaluation Of Quadrox-I and Capiox FX Neonatal Oxygenators with Integrated Arterial Filters in Eliminating Gaseous Microemboli and Retaining Hemodynamic Properties during Simulated Cardiopulmonary Bypass

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<sup>1</sup>Penn State Hershey Pediatric Cardiovascular Research Center, Department of Pediatrics; <sup>2</sup>Public Health and Sciences; <sup>3</sup>Department of Surgery; <sup>4</sup>Department of Bioengineering, Penn State Milton S. Hershey Medical Center, Penn State Hershey College of Medicine, Penn State Hershey Children's Hospital, Hershey, Pennsylvania, USA

### Background:

Perfusion quality during cardiopulmonary bypass (CPB) procedures can contribute to postoperative neurological complications and influence patient recovery and outcome. Gaseous microemboli generated in the circuit and hemodynamic properties of blood reaching the patient can be monitored during CPB to optimize perfusion. Oxygenators used during CPB can significantly influence the quality of blood reaching the patient by their manufacturing designs. New hollow-fiber membrane oxygenators have been developed with integrated arterial filters to reduce priming volume and eliminate a separate arterial filter in the circuit.

### Methods:

To evaluate the performance of these new oxygenators, we used a simulated model to compare the Quadrox-i Neonatal and the Capiox BabyFX05 neonatal oxygenators and to provide a review of these oxygenators with their respective counterparts which have separate arterial filters.

### Results:

We found that microemboli counts for the new Quadrox-i and Capiox FX05 oxygenators are similar in the arterial line, but different across the oxygenator for all experimental conditions. The arterial purge line diverting blood from the patient reduces microemboli count for the Capiox FX05, but is inconsistent for the Quadrox-i Neonatal (Table 1). While hemodynamic energy delivered to the patient is similar for both oxygenators, shunted blood flow for the Quadrox-i Neonatal oxygenator is three times higher than the Capiox FX05 (103.6 mL/min vs. 33.0 mL/min at 400 mL/min and 35°C) (p<0.001).

**Table 1. Comparison of different oxygenators in microemboli count at 700ml/min, 35°C**

Flow rate	Purge line	Oxygenator	Pre-oxygenator				Post-oxygenator				Distal arterial line			
			Total emboli	0 - 20 µm	20 - 40 µm	>40 µm	Total emboli	0 - 20 µm	20 - 40 µm	>40 µm	Total emboli	0 - 20 µm	20 - 40 µm	>40 µm
w/o IAF	Closed	Quadrox-i	743 ± 132*†	574 ± 77†	152 ± 52	18 ± 8	155 ± 62	108 ± 34	40 ± 22	6 ± 7	40 ± 24	31 ± 17	9 ± 7	0 ± 0
		RX 05	202 ± 18	167 ± 17	34 ± 6	1 ± 2	12 ± 4	11 ± 4	1 ± 1	0 ± 0	1 ± 2	1 ± 2	0 ± 0	0 ± 0
	Open	Quadrox-i	3708 ± 559*	3450 ± 538*	250 ± 36	8 ± 2	66 ± 32	55 ± 26	10 ± 5	2 ± 3	8 ± 4	7 ± 4	1 ± 1	0 ± 0
		RX 05	179 ± 39	137 ± 64	28 ± 11	2 ± 1	10 ± 2	9 ± 2	1 ± 1	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
w/ IAF	Closed	Quadrox-i	450 ± 139*†	355 ± 110*†	84 ± 36*†	11 ± 2*	123 ± 52	90 ± 40	31 ± 15*	2 ± 1	72 ± 28	56 ± 21	15 ± 8	1 ± 1
		FX 05	76 ± 10	64 ± 8	12 ± 2	0 ± 1	6 ± 3	5 ± 4	1 ± 1	0 ± 0	1 ± 0	1 ± 0	0 ± 0	0 ± 0
	Open	Quadrox-i	1267 ± 321*	1123 ± 294*	136 ± 35*	8 ± 4*	27 ± 8	22 ± 6	5 ± 3	0 ± 0	11 ± 3	9 ± 2	2 ± 2	0 ± 0
		FX 05	91 ± 10	68 ± 6	21 ± 6	2 ± 4	9 ± 4	8 ± 4	1 ± 1	0 ± 0	2 ± 2	1 ± 2	1 ± 1	0 ± 0

IAF, Integrated arterial filter.

\*p<0.001, Quadrox-i w/o IAF vs. RX05 and Quadrox-i w/IAF vs. FX05; †, p<0.001, purge line closed vs. open.

### Conclusions:

Both Capiox FX05 and Quadrox-i Neonatal oxygenators with integrated arterial filters are almost 100% effective in eliminating arterial microemboli at low flow rates, independent of temperature. At high flow rates, the Capiox FX05 is preferred at a normothermic temperature for delivering essentially zero arterial microemboli, but, at a hypothermic temperature, both oxygenators perform similarly. (Supported by PSH-PCRFCF)

## Vision-guided Tracking of Multiple Surgical Instruments in Robot-assisted Surgery

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### Background:

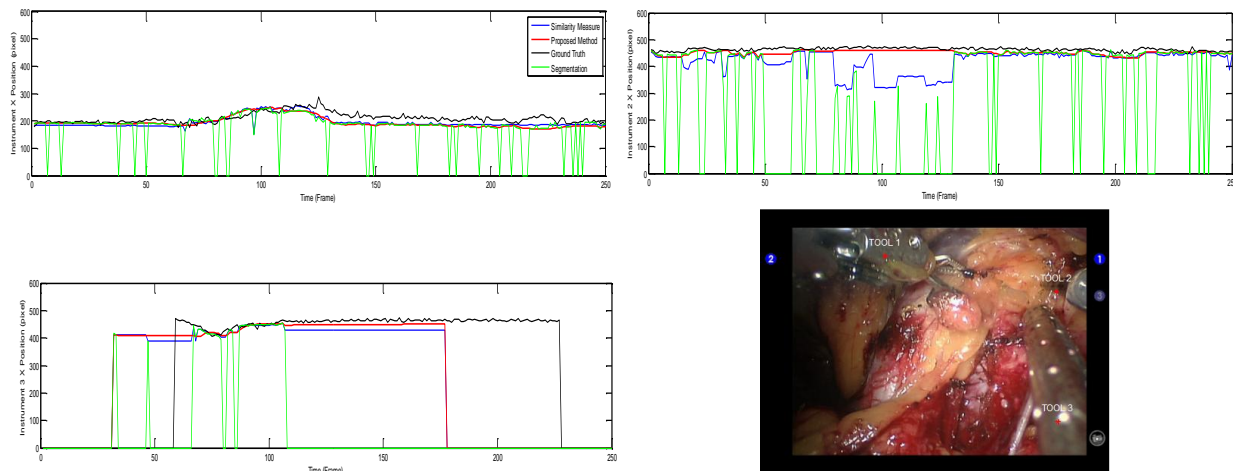
Robot-assisted cardiac surgeries are performed mainly to get precise motion control in a limited space during complex heart surgeries such as: 1) coronary artery bypass grafting and mitral valve repair in adults and 2) ligation of patent ductus and division of vascular rings in pediatrics. Operating multiple instruments against pulsating vital organs requires extremely high dexterousness in surgeon's instrument handling. Automatic safety functions based on multiple instrument positioning will prevent inadvertent harmful events as cardiac tissue perforation and instrument collisions. Vision-guided tracking of multiple instruments plays an important role as a core algorithm to implement such assistive functions.

### Methods:

Real robot-assisted surgery videos with resolution of 640x480, 10f/s in mpeg format cut in approximately 25s were used to test. The proposed algorithm consists of two steps: 1) instrument segmentation and 2) instrument movement tracking. Metallic properties were used to classify surgical instruments using k-means clustering, blob analysis, and edge filtering. Frame-by-frame difference was calculated to eliminate the background noise completely. To compensate the failure of instrument segmentation due to occlusions, Kalman filter and similarity measure techniques were combined. Euclidean distance calculation between instruments and their previous locations were used to finalize instruments position and label them. Ground truth data sets were obtained by manually locating the center of mass of each instrument.

### Results:

The proposed method showed an acceptable performance in tracking multiple surgical tools. Figure 1 confirms the performance of the suggested algorithm (red) by showing reduced peak estimation errors (green and blue) as well as showing highest similarity to the ground truth data (black). Sample image including automatically labeled instruments is also shown in Fig. 2.



### Conclusions:

The developed vision-guided assistance system is a preliminary study that can further be improved to provide surgeons with more valuable information, such as creating safety field around the instruments and thus warning surgeon dangerous manipulation of instruments in cardiac procedures.

## Hemodynamic Energy Could Change Depends on Position of Patients during Extracorporeal Circulation

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### Background:

Most patients in the intensive care unit assisted with the extracorporeal circulation (ECC) are nursed in the semi-recumbent position, resting at an angle of 30–45°. This choice of resting position helps in the prevention of ventilator-associated pneumonia. We evaluated that this semi-recumbent position could effect on hemodynamic energy.

### Methods:

Extracorporeal circulation was constructed for 8 Yorkshire swine using a pulsatile pump (Twin-Pulse Life Support). In the state of heart fibrillation, the pump flow was fixed as 2 L/min. The mean arterial pressure (MAP), mean arterial flow (MAF), energy equivalent pressure (EEP), percent EEP, and surplus plus hemodynamic energy (SHE) at the descending thoracic aorta were measured on supine position and semi-recumbent position (20° of head up position).

### Results:

MAP and MAF of abdominal aorta were increased at semi-recumbent position (Table 1). EEP was increased at semi-recumbent position, though %EEP was decreased. SHE was also decreased at semi-recumbent position.

Table 1. Change of the hemodynamic energy depend on position

	Mean Pressure	Mean Flow	EEP	%EEP	SHE
Supine position	53.47±6.84	1.43±0.31	61.47±7.22	15.16±5.30	10647.85±3439.60
Semi-recumbent position	63.59±17.29	1.51±0.18	70.23±17.89	10.91±2.61	8844.14±1582.59
P value	0.11	<0.05	0.11	0.17	<0.05

### Conclusions:

Position change could effect on hemodynamic energy. For proper delivery of hemodynamic energy, position change should be considered during ECC.



## Change of the Hemodynamic Energy Depends on Artificial Grafts.

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### Background:

Artificial grafts such as Dacron and ePTFE have been used for various cardiovascular surgeries. The compliance of these artificial grafts is different from the artery. This difference could effect on the hemodynamic energy delivery. We evaluated the hemodynamic energy changes depending on the kinds of artificial grafts.

### Methods:

Ten Yorkshire swine were used. After clamshell incision, 10 mm diameter and 100 mm length of Dacron graft anastomosed by end to side fashion on the descending thoracic aorta. 10 mm diameter and 100 mm length of ePTFE graft was anastomosed by end to side fashion on the descending thoracic aorta 10 mm proximal site of the anastomosis of Dacron graft. After anastomosis, extracorporeal circulation was constructed (right atrium to ascending aorta) using a pulsatile pump (Twin-Pulse Life Support). The extracorporeal circulation was started with cardiac fibrillation and pump flow was fixed 2L/min. Hemodynamic energy of Dacron was measured when ePTFE and descending thoracic aorta was blocked with clamp. Also hemodynamic energy of ePTFE was measured when Dacron graft and descending thoracic aorta was blocked with clamp.

### Results:

Mean pressure and mean flow of both graft was not significantly different (Table 1). EEP of Dacron was higher than that of ePTFE, but it was not statistically significant. %EEP and SHE of ePTFE were higher than those of ePTFE, but it was not significant.

Table 1. Changes of the hemodynamic energy depend on grafts.

Group	Mean pressure	Mean flow	EEP	%EEP	SHE
Dacron	59.53±10.00	1.25±0.35	64.87±11.31	8.92±3.01	7116.75±3031.73
ePTFE	56.83±13.41	1.32±0.29	62.21±14.53	9.54±3.52	7176.46±3100.76
P value	0.62	0.62	0.65	0.68	0.97

### Conclusions:

The difference of hemodynamic energy was not induced by the kinds of artificial graft.

## Cardiopulmonary bypass in neonatal piglets: can survival be predicted?

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### Background:

Mortality rate of neonatal piglets after heart surgery may be high. Searching for the possible cause of death of neonatal piglets after cardiopulmonary bypass we analyzed hemodynamic parameters regarding survival and non-survival in neonatal piglets.

### Methods:

Initially, ten neonatal piglets (younger than 7 days) were connected to cardiopulmonary bypass (CPB). The mean body weight was  $2.98 \pm 0.44$  kg. Exposure of the heart was performed through a median sternotomy and following connection to the CPB the piglets were cooled to  $32^\circ\text{C}$  core temperature for 30 minutes before the ascending aorta was cross-clamped. After 90 minutes of cardioplegic arrest the aortic cross-clamp was released and piglets were re-warmed to  $37^\circ\text{C}$ . Animals were separated from cardiopulmonary bypass after a total duration of 180 minutes. Inotropic support was not given throughout the protocol. The heart rate, the mean arterial pressure, the  $dP/dt_{\max}$ , the  $dP/dt_{\max}/P$ , and the wall thickening were calculated for two hours after termination of the CPB. Thereafter, the piglets were observed for another four hours. One piglet died during the first hour after CPB and was excluded from further analysis. The data of non-survived piglets ( $n=5$ ) were then compared with the data of survived animals ( $n=4$ ).

### Results:

The non-survived piglets died 2.5 to 4.0 hours (median: 3.5 hours) after CPB. Regarding heart rate,  $dP/dt_{\max}$ ,  $dP/dt_{\max}/P$ , and wall thickening there were no statistically significant differences between the survivors and non-survivors. Non-survivors revealed decrease of mean arterial pressure of more than 20% of baseline values, corresponding with a value below 30 mmHg (figure 1).

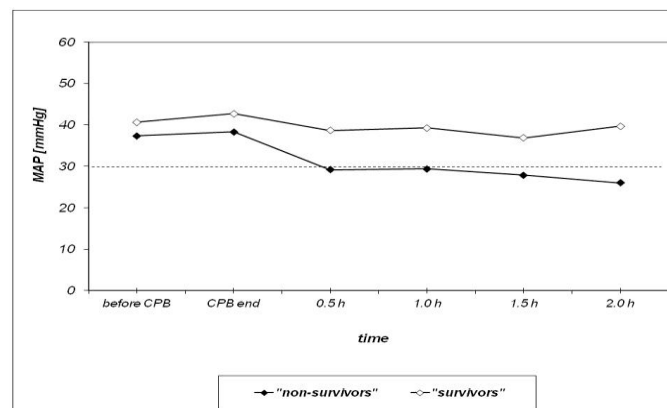


Figure 1: Mean arterial pressure (MAP) after cardiopulmonary bypass in neonatal piglets.

### Conclusions:

Survival of neonatal piglets after cardiopulmonary bypass was determined by the mean arterial pressure rather than the contractility changes.

## Postoperative Prophylactic Peritoneal Dialysis in Neonates and Infants after Complex Congenital Cardiac Surgery

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### Background:

Peritoneal dialysis (PD) after complex congenital cardiac surgery was introduced to a group of neonates and infants (n =1,618, age: 0-1 years) between May 1993 and May 2011. Indications of peritoneal dialysis were determined as well as methods, prolonged dialysis and its outcomes.

### Methods:

Demographic characteristics, preoperative risk factors, intraoperative variables and postoperative complications were compared in 1,618 cases with ages below one year. All cases underwent conventional ultrafiltration during perioperative stage. 402 cases (24.8 % of total) required peritoneal dialysis (in addition to perioperative ultrafiltration). The cardiac pathology was TGA in 281 cases, TOF in 86, IAA-APW in 15, and TAPVR in 11 and other complex pathology in 9 cases. Those patients who required perioperative ventilation, cases that had long bypass and TCA (total circulatory arrest) durations due to their complex pathologic conditions and those experiencing pulmonary hypertensive (PH) crisis were defined as "high risk group". Prolonged peritoneal dialysis was usually required in infants with low-weight, with episodes of PH crisis ( $p < 0.05$ ), and with preoperative renal dysfunction. No major complication (peritonitis or hemodynamic instability) was observed related to the peritoneal dialysis catheter (during the use or following the withdrawal).

### Results:

65 of 402 patients (16.2 %) had acute renal failure (ARF) and 25 of them died (1.6% of all patients underwent operation, 38.5% of those with ARF). It has been demonstrated that the combination of peritoneal dialysis with perioperative ultrafiltration application was effective in providing the required postoperative negative fluid balance in especially complex congenital pathologic cases affected the survival positively.

**Table 1. Features of patients.**

Age (day)	12 (2-72)
Weight (kg)	3.4 (1.8-5.2)
PD timing (postop.hour)	4,2 (4-20)
Total fluid intake (cc/kg/day)	108 (50-180)
Total fluid output (cc/kg/day)	228 (130-560)
- Diuresis	96 (35-180)
- PD UF	121 (40-300)
Negative fluid balance (cc/kg/day)	120 (80-380)

**Table 2. Parameters of pre- and post PD period.**

	Pre-PD	Post-PD	p value
Serum creatinine level (mg/dl)	0.36	0.41	NS
Mean urine output (cc/kg/h)	2.1	3.9	< 0.01
Mean number of inotropics agents	2.12	1.61	< 0.05

### Conclusions:

Protection of the renal functions and its maintenance therapy, which is an important factor in postoperative morbidity and mortality, can be safely and effectively done by prophylactic perioperatively initiated peritoneal dialysis in complex cardiac pathologies in neonatal period.

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## Aorticopulmonary Window w/wo Interrupted Aortic Arch: Surgical Correction Of In Neonatal Period and Results

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### Background:

Aorticopulmonary window (APW), a congenital abnormality, is a rarely seen case. Early diagnosis and surgical intervention is life-saving in such cases. The objective of this study was to discuss our results and management methods of this rare pathology.

### Methods:

Between 2002 to 2011, 18 patients which had APW pathology with the signs of cardiac failure mainly were operated in our clinic. 8 of them had associated with APW and interrupted aortic arch. All of them were low birth weight (under 1500 grams) and mean weight was 1.4 kg. They were taken to the surgery emergently by echocardiographic diagnosis. In all of the cases, complete correction was successfully achieved in a single session via median sternotomy and with cardiopulmonary bypass (CPB) and total circulatory arrest (TCA, 18°C). Pulsatile perfusion mode was used in all cases during CPB. According to our clinical experience, early surgical intervention to aortic arch obstructions by median sternotomy can be performed with an acceptable risk potential. Two patients were died at early postoperative period because of pulmonary hypertensive crises.

### Results:

Early and late postoperative periods of our 16 cases in the 6-48 monthly follow-up have no problem. Because of these rare cases, we think that surgical correction can be possible and safely applied in neonatal period in such combined arch pathologies. We thought that early intervention and especially pulsatile perfusion mode is more suitable choice in these high risk group pathologies (according to improved patient outcome in maintaining better cardiac, renal and pulmonic function) in the early postoperative period. Short intubation period ( $6 \pm 2.32$  hours) and short ICU ( $1.21 \pm 0.03$  days) and hospital stay ( $5.4 \pm 0.42$  days) were observed in all lived patients.

## ABCs of Neonatal Cardiac Anaesthesia

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### Introduction

CHD is relatively common and there are treatment options for virtually every form of CHD. Whilst it remains a significant cause of death in infancy with good care the majority of babies with CHD can reach adulthood. A clear understanding of the underlying pathophysiology and the planned surgical procedure is paramount and attention to detail and meticulous care is important. However there are several standard management strategies that can simplify practice and improve outcome.

### Induction of Anaesthesia

Either intravenous or gas induction of anaesthesia can be safely tolerated by most patients. It is important to ensure adequate oxygenation and normocarbida throughout. Myocardial depression, ↓HR and ↓SVR are the major potential drawbacks, if higher doses/concentrations are used.

**Routine minimum monitoring to start:** ECG, SpO<sub>2</sub>, NIBP, EtCO<sub>2</sub>

### Invasive pressure monitoring:

- **Arterial** - femoral may be better for monitoring invasive arterial pressure and ABG sampling.
- **CVP** - Triple lumen catheter in the internal jugular vein.

Knowing the pathophysiology and the surgical procedure planned may guide SpO<sub>2</sub> probe and arterial line placement.

### Maintenance of Anaesthesia

- Isoflurane with air/O<sub>2</sub> mixture or Propofol infusion (2-6 mg/kg/hr) can be used.
- Nitrous oxide not usually used:
- Fentanyl as a continuous infusion (5-10 µg/kg/hr) or intermittent boluses.
- Rocuronium is my muscle relaxant of choice.

### Other drug therapies

- Steroids: Dexamethasone 1mg/kg (or methylprednisolone) may modify the inflammatory and immunological response to CPB. However there is no final consensus on the benefit (1).
- Antithrombotic agents: Tranexamic Acid - (10-30mg/kg) decreases the postop blood loss and total blood product usage in the post-CPB period. (2). Aminocaproic acid is also effective.
- Magnesium sulphate: (30-60mg/kg)

### Pre-CPB management

The balance between the pulmonary and systemic blood flow should be addressed depending on the pathophysiology.

- Controlled ventilation with adjustments in rate, tidal volume and FiO<sub>2</sub> is a strategic way of manipulating the PVR:SVR and also Qp:Qs.
- Vasoconstrictors (e.g phenylephrine) often necessary to manipulate SVR.
- Heparin (3-4 mg/kg) - Adequate anticoagulation (ACT > 450 seconds) should be ensured before aortic cannulation.

### Discontinuation of CPB

#### Airway

- Ensure that ETT is not kinked.
- Suction any secretions from ETT.
- Ensure that lungs are fully expanded.



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### Breathing

- Use appropriate peak and PEEP pressures to maintain expansion of lungs.
- Low normal PaCO<sub>2</sub> will help to control PVR.
- Further reduction in PVR may be achieved by using inhaled NO at 10 - 40 ppm.

### Circulation

- Heart rate and rhythm:
  - Sinus rhythm 140-160/min are desirable. Higher rates could result in decreased diastolic filling and reduced coronary perfusion.
- Contractility:
  - Suboptimal calcium handling by myocytes → dependence on adequate extra-cellular calcium to maintain contractility.
  - Immature resequestration of calcium → suboptimal ventricular diastolic compliance.
- Preload:
  - LV preload can be assessed by LA pressure (> 12 mm Hg no advantage (preload recruitable stroke volume is limited in neonates).
  - Volume replacement to optimize filling pressures:
  - Cell saver blood/packed cells (to achieve appropriate Hb)
  - Platelets, Cryo, FFP as required for coagulation defects (after protamine given to reverse heparin)
  - Crystalloid or colloid.
- Afterload:
  - Poor LV and RV tolerance to ↑afterload.

### Inotropes:

- Milrinone - 1st line inotrope.
- Dopamine - 2nd line inotrope.
- Adrenaline - occasionally req for complicated CHD.
- Noradrenaline - not often needed.

### Summary

1. A clear understanding of the underlying pathophysiology and the planned surgical procedure is paramount.
2. Attention to detail and meticulous care is important.
3. But there are several standard management strategies that simplify practice but aim to improve outcome.

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## Near-Infrared Spectroscopy

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### Introduction:

Neurological outcome is becoming a major concern in pediatric cardiac surgery and modifiable factors, such as perioperative brain oxygenation, are to be optimized. For this reason, near-infrared spectroscopy (NIRS) has become a standard of care in many pediatric centers.

NIRS is attractive because it's a simple and non-invasive technique allowing a quick answer to cerebral blood flow modifications. It's much easier to use than classical EEG and transcranial Doppler, but the clinical value remains to be validated in pediatric patients.

There are several technical differences in monitors used to assess cerebral oximetry: LED or laser diodes are used as light sources and 2, 3 or 4 wavelengths are used for the measure. Every marketed cerebral oximeter uses proprietary algorithms, with a fix arterial/venous ratio. This explains why the values of NIRS differ from one monitor to another. To overcome this issue, the trend of the NIRS values is considered to be more predictive than the absolute value.

The size of the cerebral tissue analyzed is limited to the frontal cortex and there are wide areas of brain blinded to NIRS assessment.

Furthermore, the relevance of NIRS is difficult to demonstrate as there is no gold standard of brain tissue hemoglobin content.

At this point we can say that while we have promising monitors of brain oxygenation, many questions remain unanswered:

- Are monitors equivalent and if not, which one is the best?
- Can we use NIRS alone as a diagnosis and decision-making tool or do we need a multimodal approach?
- Is there any evidence of clinical benefit of NIRS in pediatric cardiac surgery or do we need more studies to assert this benefit?

Medical engineers have done a great job with NIRS monitors; now the ball is probably in the medical court.

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## Neonatal / Pediatric Neuro-MRI

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### Background:

Magnetic resonance imaging (MRI) is increasingly applied to newborns with congenital heart disease in the attempt to understand mechanisms involved in their neurological outcome. Similarly to premature infants, the neonates with complex congenital heart disease present a very high vulnerability to ischemia, due to delays in myelination, cortical development, maturation of germinal matrix and glial cells migration, with a major risk for brain injury during surgical correction of the cardiac malformation and for consecutive long-term neurodevelopmental impairment.

There are several types of brain injury which could occur in these settings, and the boundaries between these categories, as the mechanisms involved in their pathogenesis are not always very well defined. This presentation will attempt to bring some clarifications, depicting the 3 main types of cerebral lesions arriving in this specific pediatric population (infarction, white matter injury and hemorrhage), their subcategories, the difficulties encountered sometimes in the interpretation of MRI investigations, and also some notions about the injury severity quantification scale and the brain maturity scoring system.

Numerous pre-, per- and postoperative risk factors for brain injury are detected in neonates presenting a congenital heart disease, but only few of them are modifiable. One of these variably intraoperative factors is cardiopulmonary by-pass with recent development of new perfusion strategy for brain protection, such as the warm perfusion. We performed a study that aimed to measure the incidence of abnormalities in cerebral magnetic resonance imaging (MRI) after neonatal arterial switch operation using warm surgery. Neonates admitted for transposition of the great arteries underwent pre- and postoperative brain MRI. On postoperative examination, we detect no worsening of preoperative lesions, except some mild hemorrhagic transformations. These preliminary results show that there is no deleterious effect of warm perfusion and no reason to postpone surgery in neonates with "subclinical" brain injury.

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## **Brain Protection during Pediatric Cardiac Surgery: A Multi-Disciplinary Team Approach at Penn State Hershey Children's Hospital & Pediatric Cardiovascular Research Center**

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Improvements in peri- and postoperative surgical techniques have greatly improved outcomes for pediatric patients undergoing cardiopulmonary bypass (CPB) in the treatment of congenital heart defects (CHD). With decreased mortality rates the incidence of adverse neurological outcomes, comprising cognitive and speech impairments, motor deficits, and behavioral abnormalities, has increased in those patients surviving bypass. A number of mechanisms, including ischemia, reperfusion injury, hypothermia, inflammation, non-pulsatile perfusion and hemodilution, contribute to brain insult, which is further confounded by unique challenges presented in the pediatric population. However, a number of brain monitoring and preventative techniques have been developed or are being currently evaluated in the practice of pediatric CPB. Monitoring techniques include electroencephalography, near infrared as well as Transcranial Doppler (TCD) ultrasound, and emboli detection and classification quantification (EDAQ) at Penn State Hershey Children's Hospital. In our institution, a multi-disciplinary team including surgeons, anesthesiologists, cardiologists, perfusionists, intensivists, neuromonitoring technicians, neurologists and scientists work together for minimizing the multi-factorial causes of neurologic injury in neonatal/pediatric CPB patients (1-4).

Physicians and surgeons continue to face a number of challenges in the management of adverse neurological and neurodevelopmental outcomes relating to pediatric CPB. Non-ideal hypothermic surgical techniques, inflammatory activation, and technological limitations in monitoring and prevention, coupled with pre-existing neurological and developmental morbidities in pediatric patients with CHD, converge and contribute to brain insult as well as multi-organ dysfunction. Current research and clinical practice, however, suggests a set of guidelines which may reduce neurologic abnormalities and optimize outcomes given current limitations. Because many children with CHD exhibit genetic and other neurologic co-morbidities which may adversely impact peri- and postoperative care, careful screening and identification of pre-existing conditions, using patient histories, genetic screens, or MRI, as well as analysis of biomarkers of injury post-CPB, should be considered in any pediatric CPB protocol. Perioperative brain monitoring is a necessity, aiding surgical teams in the identification and response to deleterious events such as loss of adequate perfusion, decreased tissue oxygenation, and presence of emboli. Ideally, multi-modal monitoring techniques should be employed which take into consideration the benefits of newer VLS and EDAQ measures alongside existing processed EEG, NRS, and TCD, where applicable. Finally, all feasible preventative techniques, ranging from conventional DHCA and hemodilution to newer perfusion methods and pharmacologic prophylaxes, should be carefully weighed with a particular regard to the respective risks and benefits. Neurodevelopmental deficits stemming from brain insult incurred during pediatric CPB have the potential to significantly impact quality of life and costs to society. Continued basic, clinical, and translational research is needed, especially in the areas of prevention as well as longitudinal outcome studies, which may yield better peri-operative therapies ultimately leading to improved neurologic outcomes.

In this lecture, monitoring and perfusion techniques used at Penn State Hershey Children's Hospital for minimizing neurologic injury will be discussed.

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## Pediatric/neonatal MCS and Heart Transplantation in Turkey

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### Introduction:

Heart transplantation is indicated as a therapy for stage C and D heart failure associated with systemic ventricular dysfunction in pediatric patients with cardiomyopathies or previous repaired or palliated congenital heart disease and resistant life-threatening arrhythmias. Short- and mid-term results are promising. However, long-term outcome has been a matter of concern because of rejection, allograft vasculopathy and effects of chronic immunosuppression such as malignancy. The survival half-life after pediatric transplantation is 12.5 years, which indicates that re-transplantation becomes more common after post-transplantation 10th year. Nevertheless; as a result of improved surgical and medical management, the cohort of pediatric heart transplant recipients surviving for 10 years or longer is growing.

Although heart transplantation is a highly effective therapy for patients with end-stage heart failure, this therapy can be admitted to only a small percentage of patients owing to the limited number of donors. The number of heart transplants in Turkey is approximately 70-80 per year and very small percentage of this number composed of pediatric patients. While our center has performed 20-25 heart transplantations per year, only 20 pediatric patients had been transplanted in the last 5 years. Especially, donors under 3 years of age are extremely rare.

Because of the long period on the waiting list, several bridge techniques have been used in pediatric patients to prolong survival until a suitable heart becomes available. The use of ventricular assist devices (VAD) in the pediatric population has evolved over the last two years in our center. Nine patients were implanted a paracorporeal VAD's as a bridge to transplantation. Five of them which were relatively older children (mean age 9.2 years) were successfully transplanted. Two patients were died during support and remaining two patients are still on-support. To date, there is no published report of long term VAD support from other centers of our country in pediatric population despite of growing waiting list.

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## Pediatric/Neonatal CPB Procedures: Current Outcomes

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### Background:

The use of cardiopulmonary bypass is necessary for the repair of many congenital cardiac defects; however, its strategy for pediatric and neonatal cardiac surgery is still having challenges. Quality and completeness of cardiopulmonary bypass circuits can decrease postoperative neurological complications and contribute to patient recovery and outcome.

### Methods:

Cardiopulmonary bypass procedures were examined in major pediatric cardiac centres in Turkey. Perfusionists and cardiac surgeons from those centres have been reached and asked to share their data on the usage and selection criteria of cardiopulmonary bypass systems. In light of the information gathered, supported by the latest academic research, current procedures have been determined and discussed.

### Results:

There is no certain standard for cardiopulmonary bypass procedures as well as selection of the circuit components and new techniques for congenital heart patients in Turkey. This variability that exists in the pediatric and neonatal CPB practice affects the success of complex cardiac surgery.

### Conclusions:

The technological advances have contributed to enhanced safety of cardiopulmonary bypass in pediatric cardiac surgery. Selection of new techniques and components without scientific justification may risk the patients' outcomes in both the short and long term. Leaving the old habits, affordable, new and scientific systems should be used.

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## Routine Fenestration during Fontan Procedure

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### Background:

Fenestration during Fontan procedure has been used to decrease surgical morbidity and mortality in only high-risk cases or routinely. We investigated the effects of routine fenestration during Fontan procedures on postoperative hemodynamics.

### Methods:

Between January 2007 and April 2012, 28 patients underwent fenestrated extracardiac Fontan procedure. Following the termination of cardiopulmonary bypass, modified ultrafiltration was applied in all patients. Cardiopulmonary bypass was used in all patients. Cardioplegic arrest was used only in 4 patients in whom intracardiac exploration was needed. The perioperative hemodynamic and echocardiographic parameters of the patients were investigated.

### Results:

The mean age was  $4.7 \pm 2.6$  years. The mean body weight was  $16 \pm 6.1$  kg. Bidirectional cavapulmonary connection (BCPC) had been performed in 22 (78%) patients. The mean time interval between BCPC and Fontan operations was  $35 \pm 22$  months. The mean cardiopulmonary bypass time was  $107 \pm 26.11$  minutes. The preoperative mean pulmonary artery pressure, pulmonary artery index and oxygen saturation were  $14 \pm 4$  mm-Hg,  $252 \pm 37$  mm<sup>2</sup>/m<sup>2</sup> and  $76 \pm 6.7$  %, respectively. The postoperative mean pulmonary artery pressure, transpulmonary gradient and oxygen saturation were  $15 \pm 2$  mm-Hg,  $8.1 \pm 2$  mm-Hg and  $95 \pm 2$ %. The mean chest tube removal and in hospital stay times were  $5.2 \pm 2.7$  and  $9.6 \pm 3.4$  days. The operative mortality was 7% (2 patients). The mean follow up time was  $21.5 \pm 6.7$  months. No patient was lost to follow up and no mortality was detected.

### Conclusions:

Fenestration during Fontan palliation drawbacks include the risks of systemic embolization, systemic desaturation, and need for late catheter interventions for fenestration closure. As shown in our study with low morbidity and mortality rates, we believe fenestration may avoid early low postoperative cardiac output and has low morbidity from pleural effusions.

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## Midterm Results after Arterial Switch Operation for Transposition of the Great Arteries: A Single Centre Experience

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### Background:

The arterial switch operation (ASO) has become the surgical approach of choice for d-transposition of the great arteries (d-TGA); there is however an increased awareness of long term adverse sequelae in some survivors. In order to evaluate operative risk and long-term outcome in this population, we reviewed patients who underwent ASO for TGA in our centre.

### Methods:

In this retrospective study 52 consecutive patients with TGA who had undergone ASO between 04/1991 and 12/1999 were included. To analyze the predictors for mortality and adverse events (coronary stenoses, distortion of the pulmonary arteries, dilatation of the neo-aortic root, and aortic regurgitation) a multivariate analysis was performed followed by 10-years follow up. Follow-up time ranged from 1-10 years (mean 5 years, cumulative 260 patient-years).

### Results:

All over mortality rate was 15.4% and was only observed in the early postoperative period till 1994. The predictors' analysis for poor operative survival was: low APGAR-score, older age at surgery, and necessity of associated surgical procedures. Late reoperations were necessary in 6 patients (13.6%) and included pulmonary artery patch enlargement due to supra-aortic stenosis (n=3), aortic valve replacement due to neo-aortic valve regurgitation with concomitant coronary surgery due to stenosis in type E anatomy (n=2), and patch plasty of a pulmonary vein due to obstruction (n=1). A dilatation of neo-aortic root was not observed in the follow up.

### Conclusions:

ASO remains the procedure of choice for TGA with acceptable early and late outcome in terms of overall survival and freedom of reoperation. Although ASO is often complex and may be associated with morbidity, most patients survived without major complications.

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## Aortic surgery after previous procedure of congenital aortic stenosis

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<sup>#</sup>both authors contributed equally to this manuscript

### Background:

Congenital aortic stenosis may be a life-threatening condition resulting in emergency treatment. Irrespective of previous procedure, aortic surgery later in life may be indicated. The aim of the present study was the analysis of indications, risks, and outcomes of aortic surgery after previous aortic valve procedure.

### Methods:

The data of patients who underwent aortic surgery after previous treatment of congenital aortic stenosis in a 10-year period (from 2000 to 2009) were retrospectively analyzed.

### Results:

Thirty-two patients (23 male and 9 female) underwent redo aortic surgery. The mean age at surgery was  $13.5 \pm 11.3$  years. Seventeen patients had undergone aortic balloon valvuloplasty (BVP) previously and 15 open commissurotomy (COM). Nine cases had undergone the primary procedure in neonatal age (7 BVP and 2 COM; 41.2% vs. 13.3%, respectively). Two patients (one in each group) had undergone cardiac surgery before initial aortic valve procedure. Seven of the patients with previous open commissurotomy (43.8%) had undergone concomitant surgery along with initial commissurotomy. A re-intervention within the first year after the primary procedure was performed in 7 patients (7 after BVP, none after COM;  $p < 0.05$ ). The interval between the last intervention and the first redo aortic surgery was  $7.5 \pm 9.5$  years ( $3.1 \pm 3.5$  years after BVP vs.  $12.5 \pm 11.7$  years after COM;  $p < 0.05$ ). A second redo surgery was performed in 9 patients (4 after initial BVP and 5 after COM).

### Conclusions:

Congenital aortic stenosis is very often presented in combination with additional pathologies. These concomitant diseases along with the underlying disease give the indication for re-operation. Re-interventions are more often indicated after primary balloon valvuloplasty. Long-follow up in specialized centers is mandatory.



## The Comparison of the Effects of Bretschneider HTK and Conventional Crystalloid Cardioplegia on Myocardium at Tissue Level

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### Background:

Cardioplegic arrest is one of the most common myocardial protection strategies. A wide variety of cardioplegic solutions are routinely being used. There is an ongoing discussion about the relative effectiveness of these solutions considering myocardial protection. This study aims to investigate the hypothesis "The use of histidine-tryptophan-ketoglutarate (HTK) cardioplegia leads to decreased ischemic damage on myocardium compared with the use of conventional crystalloid cardioplegia."

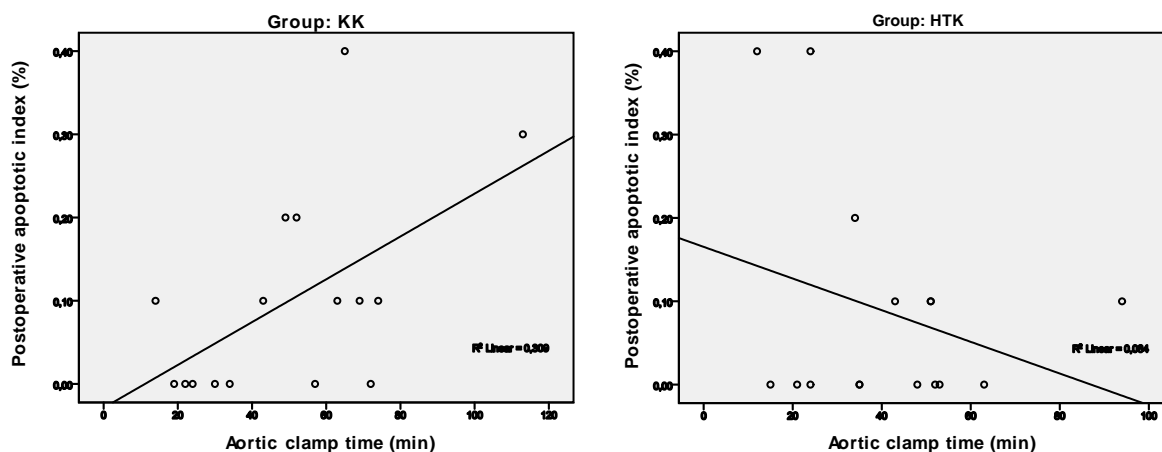
### Methods:

The study population was 32 patients operated in Başkent University Department of Cardiovascular Surgery for congenital heart diseases. The former 16 patients received conventional crystalloid cardioplegia (KK group) which is a modification of St. Thomas solution while the latter 16 patients received HTK solution (HTK group). The echocardiographic measurements and the laboratory values of the patients were taken as the clinical variables. Right ventricular biopsies were taken from every patient before and after cardioplegic arrest. These biopsies were histopathologically examined for apoptosis using caspase - 3 antigen and cell proliferation using Ki-67 antigen.

### Results:

The statistical analysis revealed no significant difference between the 2 groups regarding the clinical variables, apoptotic indices and proliferation indices. The apoptotic indices in the post-cardioplegic arrest biopsies were correlated with aortic clamp time in the KK group but not in the HTK group. Liver function tests on postoperative day 1 were positively correlated with aortic clamp time in both groups. On postoperative day 2 this correlation sustained in the KK group and ceased in HTK group.

Figure 1 shows the correlation of the postoperative apoptotic indices with the aortic clamp times in two groups.



### Conclusions:

The difference in the correlation of apoptotic indices and liver function tests between the groups is accepted as a supportive finding for HTK solution. However it can be postulated that when the aortic clamp times are similar to those in the present study the clinical manifestation of the difference between the two solutions would not be significant.

## Cerebral Perfusion during Pediatric Cardiopulmonary Bypass: Correlations between Near Infrared Spectroscopy and Temperature, Lactate, Pump Flow and Blood Flow

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### Background:

Near Infrared Spectroscopy (NIRS) is a noninvasive modality to monitor regional brain oxygenation (rSO<sub>2</sub>). In this study, we aimed to investigate the correlation between cerebral rSO<sub>2</sub> and lactate, pump flow, hematocrit, pCO<sub>2</sub> and mean blood pressure during cardiopulmonary bypass (CPB).

### Methods:

Between March and September 2011, 50 pediatric patients who underwent congenital heart surgery, were enrolled into the study. Ages ranged from 1 to 168 months (median 14 months). A NIRS sensor (Somanetics 5100B, Troy, MI) was placed on the right forehead of patients. Cardiopulmonary bypass period was divided into 5 stages; 1-at the beginning of CPB, 2-cooling at 32°C, 3-at final hypothermic temperature, 4-re-warming at 32°C, 5-before weaning from CPB. Data collection included measurements of each parameter at 5 stages of CPB. Data were analyzed using Multi-variance analysis within groups and Spearman correlation to test association between parameters.

### Results:

Results are summarized in Table 1. Lactate levels increased significantly from stage 1 to stage 5 during CPB (p<0.05). There was no significant correlation between cerebral rSO<sub>2</sub> and mean blood pressures, pump flows, hematocrit and pCO<sub>2</sub> during CPB. Cerebral rSO<sub>2</sub> levels showed changes between the stages; there was a significant increase during cooling period, compared to the stage 1 (p<0.05). Significant changes during cooling stage did not happened for other parameters. At stage 3, there was a negative correlation between lactate level and mean blood pressure. At stage 4, there was no significant change in cerebral rSO<sub>2</sub> levels despite decreased mean blood pressure. At the warming stage, low mean blood pressures, but normal rSO<sub>2</sub> values, are observed despite increased pump flows.

Table 1: Distribution of parameters according to stages of cardiopulmonary by-pass

Stage	rSO <sub>2</sub>	Lactate	Pump Flow	MBP	pCO <sub>2</sub>	Hematocrit
1	55.7±11.4	2.8±1.4	1073±650	71±12	36.3±1.1	28.2±3.6
2	60.6±11.7	3.0±1.5	1036±630	71±10	33.8±0.8	29.4±4.4
3	59.6±13.1	3.1±1.5	1008±630	70±12	31.2±1.0	29.0±4.0
4	58.1±11.1	3.2±1.9	1155±700	69±11	32.3±1.1	28.9±3.4
5	59.8±11.1	3.5±1.8	1135±690	72±8	40.1±0.8	30.3±2.6

rSO<sub>2</sub>: regional brain oxygenation; MBP: Mean Blood Pressure

\*data are presented as mean values and standard deviation

### Conclusions:

Increased rSO<sub>2</sub> levels despite insignificant changes at other parameters during cooling stage of CPB may show that optimal pump flow with adequate intravascular volume may provide effective cerebral perfusion even without changes at mean blood pressure. Considering normal rSO<sub>2</sub> values during CPB in this study, it may be speculated that, brain protection can be assessed by using NIRS and applying a standard bypass protocol.

## The Effects of Different Ventilator Modes on Cerebral Tissue Oxygen Saturation in Patients with Bidirectional Superior Cavapulmonary Connection

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### Background:

Following the bidirectional superior cavapulmonary connection (BSCC) operations, cerebral blood flow and pulmonary blood flow work in series. High pulmonary resistance and insufficient cerebral blood flow negatively affect this physiology. Positive pressure ventilation has been shown to further decrease cardiac output by limiting forward flow in BSCC. We used near-infrared spectroscopy (NIRS) to document changes in cerebral tissue oxygen saturation (SctO<sub>2</sub>) profile in response to mechanical ventilation mode alterations after BSCC.

### Methods:

20 consecutive patients who have undergone BCCC operation between July 2010 and October 2011 were included in the study. By using NIRS, we measured SctO<sub>2</sub> during weaning in three ventilatory modes (IPPV-SIMV-CPAP) consecutively. We documented the airway pressure, arterial blood gases, lactate levels and blood pressures. Also, we measured and recorded the SctO<sub>2</sub> starting from the onset of preoperative anesthesia induction to the end of intensive care unit (ICU) stay.

### Results:

The age of the patients was  $11.17 \pm 7.80$  months. The body weight was  $8.30 \pm 3.50$  kg. The extubation time was  $18.75 \pm 21.57$  hours. The ICU stay time was  $4.18 \pm 2.45$  days. The transpulmonary gradient was  $7.35 \pm 2.55$ . There was no change in SctO<sub>2</sub> in IPPV and SIMV modes, however there was significant increase in SctO<sub>2</sub> measured during CPAP and after extubation ( $p < 0.05$ ) (Figure 1). The difference in the blood pressure measured during IPPV and SIMV modes was insignificant whereas the increase in systolic blood pressure during IPPV and CPAP was statistically significant ( $p < 0.01$ ). The airway pressure did not change during IPPV and SIMV modes, however there was a significant decrease during CPAP mode ( $p < 0.01$ ).

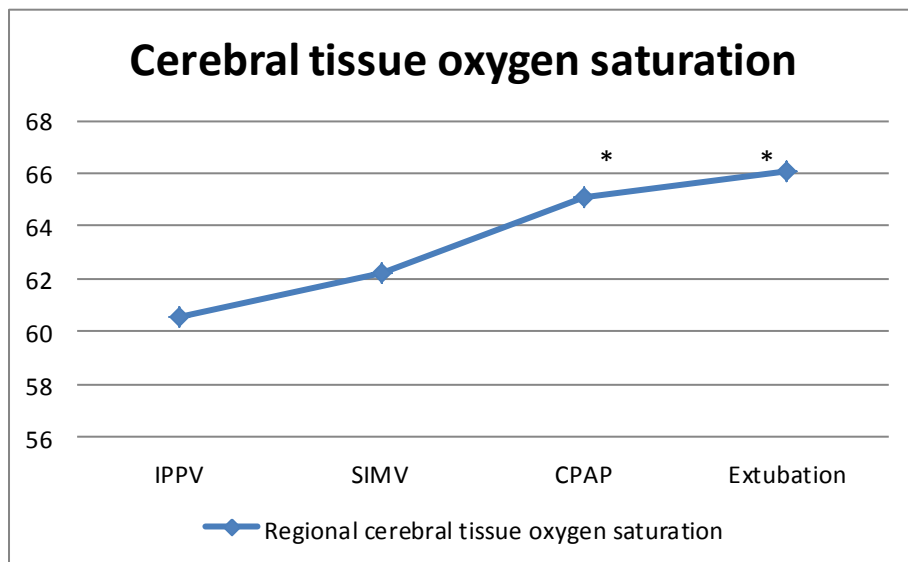


Fig. 1: Changes in regional cerebral tissue oxygen saturation. \*significant  $p < 0.05$

### Conclusions:

We determined the better hemodynamic parameters and SctO<sub>2</sub> levels during CPAP and after extubation compared to other ventilator modes (IPPV and SIMV). CPAP attenuates the negative effects of positive pressure ventilation on cerebral oxygen saturation in patients with BSCC.

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## The Effects of Antegrade Cerebral Perfusion on Prognosis and Outcome in Neonatal and Infant Aortic Arch Repair Concomitant with Intracardiac Surgery

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### Background:

The surgical risk factors in patients undergoing neonatal aortic arch repair combined with intracardiac surgeries remains high. Herein, we report our surgical experiences with selective antegrade cerebral perfusion combined with the intracardiac surgeries.

### Methods:

27 consecutive patients undergoing surgery for aortic arch and intracardiac repair during the period from March 2007 to April 2012 were evaluated in a retrospective study. Perioperative risk factors for 30 day mortality were investigated.

### Results:

Mean age of the infants 44.8 days, mean weight 3.8 kg. Major associated cardiac defects were present in 12 and included truncus arteriosus (Vaan Praagh type 4) (2), transposition of the great arteries (5), and double outlet right ventricle with Taussig Bing Anomaly (2), aortopulmonary window (3). The independent predictors of mortality were found as; cardiopulmonary bypass time, renal failure and the use of peritoneal dialysis. ( $R=0.60$ ,  $R^2=0.57$ ,  $p<0.001$ ).

### Conclusions:

In neonates and infants undergoing aortic arch repair with concomitant intracardiac surgical repair can be done with selective aortic perfusion at a single stage.

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## Comparison between D901 Lilliput 1 and Kids D100 Neonatal Oxygenators: Towards Bypass Circuit Miniaturization.

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### Background:

Progress in biomaterial technology and improvements in surgical and perfusion strategy ameliorated morbidity and mortality in pediatric cardiac surgery. In this study, we describe our clinical experience comparing performance of 2 neonatal oxygenators.

### Methods:

From 01/2002 to 03/2011, 164 <5 kg body-weight babies underwent heart surgery. Ninety-four patients received a D901 Lilliput 1 oxygenator with standard bypass circuit (Group A), while 70 a D100 Kids with miniaturized bypass circuit (Group B). Miniaturization consisted in shortened arterial, venous, cardioplegia and pump-master lines. Priming composition consisted in ringer-acetate solution with addition of albumin and blood, with target Hct of 24 or greater. CPB was vacuum-assisted and started with empty venous line. MUF and Cell-Saver blood infusion was routinely applied.

### Results:

Average  $\pm$  SD age and weight were  $37 \pm 38$  days and  $3.5 \pm 0.7$  kg, respectively, in Group A, while  $49 \pm 46$  days and  $3.7 \pm 1$  kg, respectively, in Group B ( $p = \text{NS}$ ). Male sex was predominant (55% vs 58%,  $p = \text{NS}$ ). Priming volume was  $524 \pm 67$  ml (Group A) and  $307 \pm 18$  ml (Group B) ( $p < 0.05$ ). There were no statistical differences in CPB and XCL time, in Hb at the start, during and at the end of CPB and in blood volume added to priming. In Group B, 2 surgical procedures were completed without blood addition. There were 16 hospital deaths (Group A) and 4 (Group B) ( $p < 0.05$ ). Durations of mechanical ventilation and ICU stay were  $20 \pm 17$  vs  $18 \pm 21$  hours ( $p = \text{NS}$ ) and  $7 \pm 5$  vs  $6 \pm 5$  days ( $p < \text{NS}$ ), respectively. There were significant differences in inotropic score ( $12 \pm 8$  vs  $9 \pm 3$ ,  $p < 0.05$ ) and blood postoperative transfusion ( $156 \pm 226$  vs  $57 \pm 25$  ml,  $p < 0.05$ ). Twenty-seven patients (Group A) and 10 (Group B) presented postoperative complications ( $p < 0.05$ ).

### Conclusions:

Use of neonatal oxygenators with low priming volume, associated with miniaturized bypass circuit, seems to be a favorable strategy to decrease postoperative morbidity after cardiac surgery in neonates and infants.



## Pumpless Extracorporeal Lung Assist as a Rescue Therapy in an Adolescent with Cystic Fibrosis

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### Introduction:

Recently, a pumpless extracorporeal lung assist device (PECLA) was developed that uses a membrane with a very low flow resistance allowing removal of arterial carbondioxide (CO<sub>2</sub>). Two successful adolescent cases are described in literature<sup>1,2</sup>. We report the use of this system in an adolescent with cystic fibrosis(CF).

### Case Report:

A 16 year old girl with CF and worsening acidosis on ventilator support became hemodynamically unstable in our pediatric intensive care unit. With parental consent PECLA was initiated as a rescue therapy (Fig1). The blood gas values and interventions during the initial phase are listed in Table 1. Activated clotting time was kept between 160-180. The sweep gas flow was between 6-10lt/min. The initiation of the PECLA successfully lowered hypercarbia, corrected acidosis and gave the opportunity to decrease the inotropic support and ventilator settings. 4 hours into PECLA epinephrine was weaned from 1 to 0,4mcg/kg/min and dopamine from 15 to 5mcg/kg/min. Ventilator peak pressures decreased by 20%. But the multisystem organ failure did not respond to intense measures, and the patient expired on the fourth day of this support system.

Figure 1



Table 1

Time (min)	Blood pH	pCO <sub>2</sub> (mmHg)	PaO <sub>2</sub> (mmHg)	Intervention
t <sub>0</sub>	6,89	unmeasurable	45	Initiation of ECCO <sub>2</sub> R, SGF at 1 lt/min
t <sub>30</sub>	7,11	unmeasurable	183	SGF at 2 lt/min
t <sub>60</sub>	7,26	>115	98	SGF at 3 lt/min
t <sub>90</sub>	7,37	94	39	SGF at 4 lt/min
t <sub>120</sub>	7,38	85	32	SGF at 5 lt/min
t <sub>150</sub>	7,48	63	31	SGF at 6 lt/min
t <sub>180</sub>	7,52	62	38	SGF at 7 lt/min, ventilator wean

pCO<sub>2</sub>= partial pressure of carbondioxide, paO<sub>2</sub>=partial pressure of arterial oxygen, ECCO<sub>2</sub>R=Extracorporeal carbondioxide removal. SGF=Sweep gas flow

### Conclusions:

The PECLA proved to be a valuable tool for the treatment of hypercarbia. The set up was easy and the initiation of the procedure was smooth in our extremely labile case. Our patient did not survive, but early use could have prevented the multiorgan dysfunction and perhaps the outcome. Optimal anticoagulation strategy needs to be defined as well.

1. Ruettimann U, Ummenhofer W, Rueter F, Pargger H. Management of acute respiratory distress syndrome using pumpless extracorporeal lung assist. *Can J anesthes* 2006;53:101-105
2. Taylor K, Holtby H. Emergency Interventional Lung Assist for pulmonary hypertension. *Anesth Analg* 2009;109:382-5.

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## Experience with Extracorporeal Life Support in Pediatric Patients after Cardiac Surgery

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### Background:

Extracorporeal life support (ECLS) was applied more and more as mechanical circulatory support. We review the results of ECLS as post-operative support in pediatric patients in our institute and try to identify factors associated with the outcome.

### Methods:

Records of pediatric patients (aged less than 18 years) who received ECLS after cardiac surgery between January 2000 and December 2011 were retrieved from our prospectively collected database for this study. The patients were divided into two groups according to cardiac physiology after surgery. Group I consisted of patients with separate biventricular physiology after surgery, group II consisted of patients whose cardiac physiology were not biventricular. Indications for ECLS were: 1) failure to separate from cardiopulmonary bypass; 2) low-output syndrome in ICU; or 3) cardiac arrest in the ICU with ECPR. The ECLS circuit consists of a centrifugal pump and a hollow-fiber microporous membrane oxygenator.

### Results:

There were 148 patients (M:F=86:64) and the median age was 0.2 year-old. One hundred and seventeen (79%) of the patients could wean from ECMO and the overall survival rate of this cohort was 38.5% (57/148). The mean duration of ECLS support was 94.5+/-64.5 hours. Age and gender did not affect survival.

The survival rate was 38% (39/99) for ECLS initiated in operation room, 56% (10/18) for those with low-output in ICU, and 35% (11/31) for those with ECPR.(p=NS) The survival rate of patients with separate biventricular physiology was 49% (37/76) and those with systemic-pulmonary shunt or cavopulmonary anastomosis was 28% (20/72). (OR=1.51, 1.11-2.05). Patients required dialysis during ECLS was significantly associated with increased mortality (OR=4.7, 2.3-9.6).

### Conclusions:

In pediatric patients with post-operative cardiac failure, ECLS could successfully rescue 38.5% of the patients. Patients with non-biventricular physiology and renal failure during ECLS support were associated with higher mortality.

## Development of Nobel Pulsatile Flow ECMO System

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### Background:

ECMO is the most powerful circulatory support modality for the patients with profound shock. However, the current ECMO system provides non-pulsatile flow characteristics, which has sometime inadequate power for organ perfusion, resulting in MOF. Pulsatile flow generates more powerful energy than non-pulsatile system. However, the system is complicated and has potential of blood damage in long-term use. We have developed the simple pneumatic pulsatile flow ECMO system. The purpose of this experimental study was evaluation of the hydraulic property of this system.

### Methods:

The system was consisted of ECMO circuit with centrifugal pump (Senko Medical, Tokyo) and newly developed pneumatic pulsatile flow generator system. The pump speed of centrifugal pump was maintained at from 1000 rpm to 3000 rpm. The pulsatile rate was maintained at 60 beats per minute. The maximum and minimum flow rates, pressure measurement at post (P1) and pre (P2) pulsatile flow generator against the power of pneumatic control drive as ranged 0 (non-pulsatile flow) to 200 mmHg, were recorded. We tested using the system was primed with 33% glycerin solution (compatible with hematocrit 25%) and 50% glycerin solution (compatible with hematocrit 42%).

### Results:

The flow-pressure curve was showed in Fig.1 (non-pulsatile) and Fig.2 (pulsatile) at 33% glycerin. The power of pneumatic control drive range as 0 mmHg could not make any pulsatile flow and pulse pressure (Fig.1). Our pneumatic pulsatile flow ECMO system generated stable pulsatile flow against the centrifugal pump speed with constant pulse pressure at 150mmHg of the power of pneumatic control drives (Fig.2). The pulse pressure was kept at greater than 40 mmHg at between 1000rpm to 2500rpm as pump speed of centrifugal pump at the power of pneumatic control drive range as 150 mmHg at 33% glycerin.

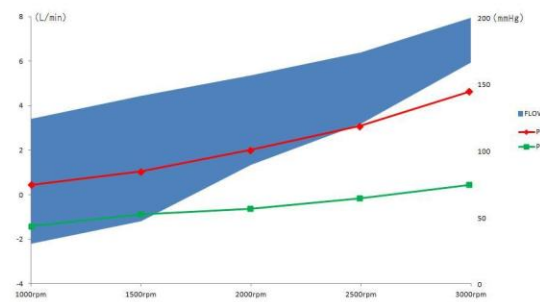
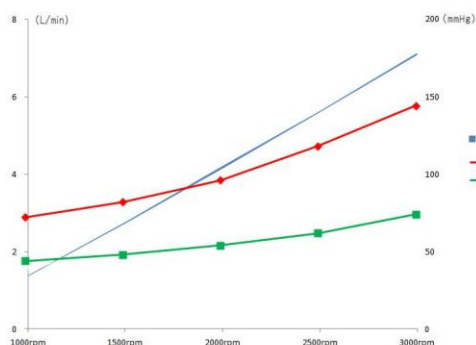


Fig 1. 33% glycerin: 0 mmHg (non-pulsatile flow)

Fig 2. 33% glycerin: 150 mmHg (pulsatile flow)

### Conclusions:

This basic experimental study showed and demonstrates the hydraulic property and the ability of generating enough pulsatile flow for clinical application of new pneumatic pulsatile flow ECMO system using centrifugal pump.

## Two Jarvik Child Pumps as Bi-Ventricular Assist Device (BVAD) in an Ovine Animal Model

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### Background:

The purpose of this study was to investigate the use of two Jarvik child pumps for full biventricular assist. We therefore examined right and left sided hemodynamic parameters over a range of right and left sided pump speeds in an acute, fibrillating non-beating heart model in sheep.

### Methods:

Six juvenile sheep (mean-weight 39kg) were implanted with two Jarvik child pumps in the RV and the LV through a median sternotomy. The RVAD outflow graft was anastomosed end-to-side to the pulmonary artery, and the LVAD outflow to the ascending aorta. After surgical implantation of both pumps we induced ventricular fibrillation and hemodynamic changes were measured using four different levels of RVAD pump speed (from level 2-5) at while the speed of the LVAD was set constant at level 2, 3, then at 4 and finally at level 5.

### Results:

Average results from the 6 sheep with LVAD speed fixed at level 3 are shown in the figure. At any given LVAD speed, both RVAD and LVAD flow increased identically as RVAD speed was increased. Results were similar with LVAD set at the higher speeds. At the highest LVAD and RVAD speeds, flow averaged 4.38 ( $\pm 1.09$ ) (right 4.38 l/min  $\pm 1.16$  l/min and left 4.37 l/min  $\pm 0.95$  l/min,  $p=n.s.$ ), and pressures in the right atrium, pulmonary artery, left atrium and aorta averaged 10.58 ( $\pm 3.38$ ), 18.75 ( $\pm 4.28$ ), 16.00 ( $\pm 3.61$ ), and 51.50 ( $\pm 7.51$ ) mmHg, respectively.

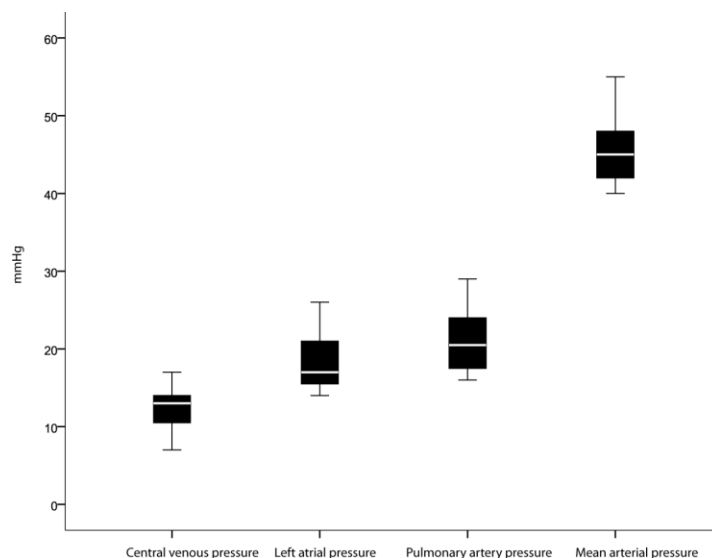


Figure 1: hemodynamic parameters at LVAD speed set to 3.

### Conclusions:

Biventricular assist with the two Jarvik child pumps is feasible and able to provide full hemodynamic support in sheep. This approach holds promise for providing biventricular partial support in humans and, in particular, for full support in small adults and children.

## Implementing a Haptic Augmented Reality Surgeon Console Framework for Enhanced Safety in Robot Assist Minimally Invasive Surgery

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### Background:

Robot surgery has been becoming an established surgical method with evident clinical efficacy in diverse areas including cardiac surgery. However, the technology needs more improvement in terms of safety and dexterous control of the surgical instrument for wider application, especially in the field like pediatric cardiac surgery where far stricter safety control should be implemented. Technologies for advanced human machine interface including haptic feedback control and augmented reality have seen rapid advancement lately. Integration of the advanced human machine interface technologies in minimally invasive robot-assisted surgery for a haptic augmented reality surgeon console to provide enhanced safety has been tried in this study.

### Methods:

The surgeon console is composed of various hardware and software modules for endoscope video signal capture, image/vision signal processing, 3D deformable model handling, haptic and graphic rendering, and interface to displays and haptic devices as shown in Fig.1. Intra-operative endoscopic video signal is captured and converted into digital data and then processed to extract information for the tracking of "Object-Of-Interest(OOI)"s such as organ or anatomic structure that needs cautious handling, vascular/nerve structures and the relative position of the surgical instruments and possible registration to and overlaid display with preoperative medical imaging data. Parts of the extracted or user-defined OOIs can be transformed into a deformable 3D model and interactively manipulated by the surgeon during the operation for intuitive information utilization. The haptic rendering provides virtual force field experience to the surgeon, where various types of augmented haptic feedback such as "virtual force sheath" to the surgical instrument and "virtual wall" around the OOIs, are provided to assist surgeon's better control of the safe handling of the surgical instruments and the dexterous execution of surgical task.

### Results:

The surgeon console framework has been implemented on a PC and a stereo-enabled display. The haptic feedback function was tested in a system with two commercial haptic devices (PHANTOM Omni, Sensable Inc., USA.) for both hand interaction and a custom-developed laparoscopic instrument structure haptic device.

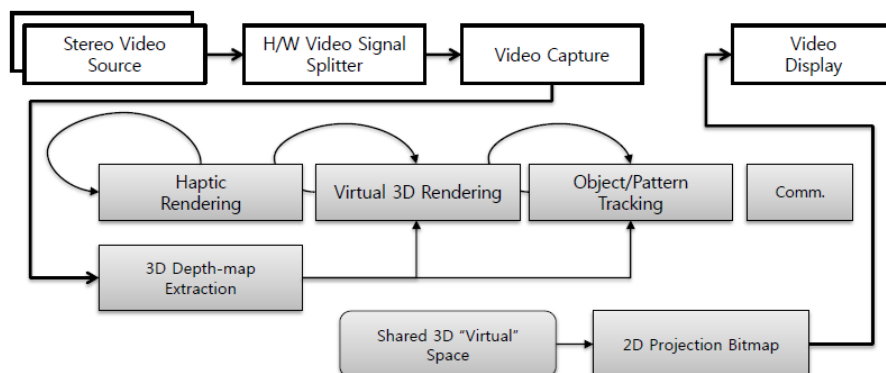


Figure 1. Block diagram of the surgeon console structure

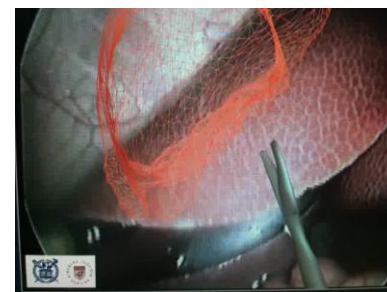


Figure 2. Display example

### Conclusions:

The implemented system showed successfully the feasibility of the proposed concept and further development to incorporate modules for enhance mathematical computation in the framework and to integrate the console into a robot surgery system under development is underway.



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## Initial Clinical Experience with Spectrum Medical M3 Monitor in Pediatric Cardiac Surgery: Gaseous Emboli Monitoring for Capiiox RX05 Oxygenator and Capiiox FX05 Oxygenator

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### Background:

We evaluated the clinical use of Spectrum Medical M3 monitor and compared the results of emboli monitoring for Terumo Capiiox RX05 oxygenator without arterial filter and Terumo Capiiox FX05 oxygenator with built in arterial filter.

### Methods:

The Spectrum Medical M3 is an in-line non-invasive system that allows continuous, real-time arterial and venous oxygen saturation, flow, hematocrit (Hct), hemoglobin (Hb), pH, arterial and venous gaseous emboli monitoring. We have used the system in 50 patients between December 2010 and June 2011. In 30 patients Capiiox RX05 oxygenator (group 1) and in 20 patients Capiiox FX05 oxygenator with built in arterial filter (group 2) was used. Mean age of group 1 was  $15 \pm 12$  months and mean age of group 2 was  $13.5 \pm 11$  months. Heparin dose was 400 units/kg. Activated clotting time was maintained  $> 500$  seconds. Hematocrit was maintained at 25%-30%. CPB flow was maintained at 125-150 cc/kg/min. Moderate hypothermia, alpha stat blood gas management and antegrade isothermic blood cardioplegia were used.

### Results:

No mortality occurred in group 1. Two patients needed prolonged respiratory support for pneumonia in group 1. There was 1 mortality in group 2 due to pulmonary hypertension. Two patients needed prolonged respiratory support for pneumonia in group 2. Number of arterial gaseous emboli in group 1 were mean  $41287 \pm 28534$  particles and volume of arterial gaseous emboli in group 1 was mean  $4.88 \pm 3.4$  cc. Number of arterial gaseous emboli in group 2 were mean  $26460 \pm 21070$  particles ( $p 0.04$ ) and volume of arterial gaseous emboli in group 2 was mean  $2.47 \pm 3.59$  cc ( $p 0.02$ ).

### Conclusions:

Spectrum Medical M3 monitor is a useful device for the monitoring of blood gasses, flow, Hb/Hct and gaseous emboli in pediatric cardiac surgery. Terumo Capiiox FX05 oxygenator with built in arterial filter has better gaseous emboli handling characteristics than Terumo Capiiox RX05 oxygenator without arterial filter.

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## Extracorporeal Life Support (ECLS) Experiences of a New Congenital Heart Center in Turkey

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### Background:

Extracorporeal life support (ECLS) has been an inevitable part of congenital heart centers, it provides mechanical support following cardiac surgery when respiratory and cardiac failure occurs. We retrospectively reviewed medical records of patients, who needed ECLS in a new congenital heart center in Turkey.

### Methods:

Between December 2009 - February 2012, 616 congenital heart operations were performed. A total of 13 patients (7 female) underwent ECLS during this period. The ages of the patients were between 16 days and 33 years. There were 2 neonatal, 7 infant, 3 pediatric and 1 adult congenital cases. Three patients underwent ECLS in intra-operative period (just after operation). Eight patients needed ECLS in early postoperative period. Four of these patients had CPR and 1 had respiratory failure. ECLS was used in 1 patient, who developed pulmonary hypertensive crisis that caused CPR after cardiac catheterization. The last patient, who had BT shunt operation 3 months ago, underwent ECLS due to CPR secondary to shunt occlusion. Medos DPII ECLS system was used in all patients. Mean duration of ECLS was  $6.2 \pm 5.8$  days (ranged from 29 hours to 24 days). While central vascular access with aorta and right atrial cannulation was used in 11 patients, neck vessels including the right carotid artery and right internal jugular vein were used in the other 2 patients.

### Results:

Four patients (30.7%) weaned successfully from ECLS (infant: 2; pediatric: 2), but two patients could be discharged from the hospital (15.4%). One of them had mild neurologic deficit after CPR. No mechanical complication occurred. Bleeding from the surgical and cannulation sites in patients with open chest incision and thrombocytopenia were the most encountered complications.

### Conclusions:

ECLS can be a life saving modality in the perioperative period and therefore. It should be available in all congenital heart centers. Indications and timing of ECLS are the most important parameters to improve the outcome of patients.

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## Comparison of Gluteraldehyde Fixed Autologous Pericardial Patch with Dacron Patch for VSD Closure

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### Background:

Synthetic materials like Dacron and PTFE are commonly used for ventricular septal defect (VSD) closure. Autologous pericardium which has distinguished biocompatibility, pliability and excellent handling characteristics is the other alternative. Myocardial tissue is more fragile in neonatal and in early infancy period. In this study we compared GFP and Dacron material for VSD closure.

### Methods:

105 patients in whom VSDs were closed with patch materials were retrospectively analyzed. In the Dacron group there were 56 patients whose median age was  $14.5 \pm 4.94$  months. The GFP group consisted of 49 patients with a median age of  $10.8 \pm 1.97$  months ( $p > 0.05$ ). In the Dacron group, only 3 patients (5%) were under 4 kg while 12 (24%) patients were under 4 kg in the GFP group. Catheter angiograms and two-dimensional echocardiography were preoperatively employed to all patients. Postoperative follow up echocardiographic evaluations were performed at the postoperative first week, first month and any time between postoperative 6 to 12th months.

### Results:

The two groups were found to be similar in terms of cardiopulmonary bypass, aortic cross clamp, intensive care unit stay and in-hospital stay times and postoperative A-V block rates. Echocardiographic evaluations performed at postoperative 1st month detected residual VSDs smaller than 2.5 mm size in 13 and 16 patients in the Dacron and in the GFP groups, respectively ( $p > 0.05$ ). Echocardiograms at the last follow up examinations showed only 1 residual VSD smaller than 2.5 mm size in each group ( $p > 0.05$ ). Echocardiography revealed moderate tricuspid regurgitation in 3 patients in the Dacron group and in 2 patients in the GFP group ( $p > 0.05$ ). There was no patch aneurysm in any group. There was no early mortality in any group however 2 late mortalities (one from each group) have been determined during the follow up period.

### Conclusions:

In this study, GFP is not found to be superior to Dacron, however it is a valuable alternative material for VSD closure especially in low weight patients.

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## Impact of Pulsatile Perfusion in Neonates and Infants with Complex Pathologies: Results

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### Background:

The aim of this study was to evaluate of the pulsatile perfusion mode in pediatric patients who had complex cardiac pathologies according to Jenkins stratifications (category 4) undergoing CPB in a clinical setting. All of the cases had TGA and VSD in this clinical study.

### Methods:

89 consecutive pediatric patients undergoing open heart surgery for repair of ventricular septal defects were prospectively entered into the study and were randomly assigned to either the pulsatile perfusion group (Group P, n =58) or the nonpulsatile perfusion group (Group NP, n = 31). All patients received identical surgical, perfusional, and postoperative care. Study parameters included intubation time, duration of ICU and hospital stay, the need for inotropic support, pre- and postoperative enzymes (ALT, AST), creatinin , CRP, lactate, albumin (mg/dL) , blood count (leukocytes, hematocrit, platelets), mean urine output (ml/day) and total drainage (ml). Major complications and clinical outcome were documented.

### Results:

There were no statistically significant differences seen in either preoperative or operative parameters between the two groups (age, BSA, weight, X-Clamp and CPB time, base flow, flow rates and hemofiltration). The Group P, compared to Group NP, had significantly less inotropic support (number of agents  $1.2 \pm 0.1$  vs.  $1.73 \pm 0.12$ ,  $p = 0.0041$ ; dopamine  $6.02 \pm 0.47$  vs.  $7.48 \pm 0.49$   $\mu\text{g/kg/min}$ ,  $p = 0.044$ ; adrenalin  $0.015 \pm 0.004$  vs.  $0.038 \pm 0.004$   $\mu\text{g/kg/min}$ ,  $p = 0.025$ ), less intubation period ( $8.45 \pm 1.37$  vs.  $14.51 \pm 1.99$  hours,  $p = 0.0034$ ), less duration of ICU ( $1.05 \pm 0.09$  vs.  $2.34 \pm 0.10$  days,  $p = 0.012$ ) and hospital stay ( $6.71 \pm 0.2$  vs.  $12.12 \pm 0.21$  days,  $p = 0.0028$ ). Although there were no significant differences in either creatinin, enzyme levels and drainage amounts between two groups, lower lactate levels ( $12.45 \pm 2.89$  vs.  $38.76 \pm 3.09$  mg/dL,  $p = 0.00021$ ), higher albumin levels ( $3.51 \pm 0.057$  vs.  $2.78 \pm 0.06$  mg/dL,  $p = 0.048$ ) and higher urine output ( $725.2 \pm 42.8$  vs.  $521.56 \pm 43.2$  ml/day,  $p = 0.018$ ) during ICU period was observed in Group P.

### Conclusions:

We found statistically meaningful results regarding outcomes (shorter ICU and hospital stay period) for CPB in pediatric patients with complex pathologies compared to pulsatile and nonpulsatile perfusion modes. We conclude that the use of pulsatile flow is a good option in the cardiac surgery for complex congenital heart defects.

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## Intraoperative Flow Study in VSD, Pulmonary Atresia and MAPCA

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### Background:

The surgical treatment of VSD, pulmonary atresia and MAPCA is still controversial issue. The decision whether to close the ventricular septal defect at the time of unifocalization may be difficult. Intraoperative flow study performed at the operation can be useful to take a decision about the closure of VSD.

### Methods:

An intraoperative flow study was performed to predict successful closure of the VSD. In these patients, after complete unifocalization while the patient was still on bypass, a pulmonary artery cannula was placed into the new pulmonary artery and incremental volumes of blood were pumped through the unifocalized pulmonary arteries with the use of a standard roller pump. At this stage, pulmonary artery pressure was measured and recorded at each state of flow rate.

### Results:

The mean pulmonary arterial pressure obtained during the flow study closely approximated the postbypass mean pressure. In patients with a mean pressure of less than 25 mmHg at full flow, a decision to close the VSD was taken at the operation.

### Conclusions:

The intraoperative pump flow study performed during the operation provides data about the decision for the closure of the VSD. This allows us to avoid reoperations to reopen the VSD and will also minimize the morbidity related to incorrect decisions. Larger series are needed to achieve more accurate results.



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## Perfusion Practices and Education of Perfusionists for Open Heart Surgery in Turkey

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### Background:

The education of perfusionists is not identical in each country, but the most important fundamental rule is an accredited education for cardiovascular perfusionists. The aim of this study is to make new suggestions for the development of cardiovascular perfusion in Turkey.

### Methods:

We have conducted a preliminary survey on perfusionists during the Symposium 'New ECMO Systems' taked place in Istanbul Mehmet Akif Ersoy Cardiovascular Surgery Center on July 23, 2011, in Istanbul, Turkey.

### Results:

Forty-eight perfusionists from 25 cardiovascular centers completed the survey. Thirteen have a high school diploma, 14 graduated from 2-year colleges of nursing, 15 graduated from 4-year college with a Bachelor's of nursing, 4 graduated from 4-year college with Bachelors of biology and 2 graduated from 2-year colleges of anesthesia. Twenty-three have less than 5 years of experience in perfusion, 12 have an experience between 5 to 10 years, 7 have an experience between 10 to 15 years, 4 have an experience between 15 to 20 years, and 2 have over 20 years' experience in cardiovascular perfusion. The number of CPB cases performed in 25 cardiovascular centers between 2010 and 2011 was 21.946 (17.626 adult and 4.320 pediatric cases). In 7 cardiovascular surgery centers, no pediatric case was performed. In only 1 center, 700-800 pediatric CPB cases were performed during the study period. In 13 centers, 53 patients were subjected to ECMO. Twenty-five of them were pediatric patients, and 28 were adults. Twenty-one of 25 centers use IABP routinely. In 19 centers, perioperative ablation was performed.

### Conclusions:

Based upon the survey data, it appeared that it was mandatory to open academic departments to formally train perfusionists in Turkey. Current perfusionists are to be trained in a short period and the eligible ones are to be certificated after passing the proficiency examination.

## Evaluation of Four Pediatric Cardiopulmonary Bypass Circuits In Terms of Perfusion Quality and Capturing Gaseous Microemboli

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### Background:

This study compared four pediatric cardiopulmonary bypass circuits with four different hollow-fiber membrane oxygenators and their specific reservoirs, Capiiox RX15, Quadrox-i pediatric, Quadrox-i pediatric with integrated arterial filter and KIDS D101, in a simulated CPB circuit, to test their ability to maintain hemodynamic properties and remove gaseous microemboli (GME).

### Methods:

The circuit was primed with human blood (HCT 30%). A 5cc bolus of air was injected just proximal to the venous reservoir and GME were monitored using Emboli Detection and Classification quantifier. Transducers were placed at preoxygenator, postoxygenerator and distal arterial line (post filter) positions. Flow probes were also placed both pre and post filter. The injections were made at three flow rates, hypothermic and normothermic temperatures, and with the purge line in both the opened and closed positions. .

### Results:

Results demonstrated that GME in the arterial line increased with increasing temperature and flow rate. Capiiox Rx 15 had the least GME in the arterial line at all experimental conditions (Table 1). KIDS D101 had the largest pressure drop and the lowest retention of hemodynamic energy, while Capiiox had the lowest pressure drop. All of the oxygenators had a similar amount of stolen blood flow (under 10% of the total flow).

**Table 1. Total GME Count Preoxygenator, Postoxygenerator and Distal Arterial Line at Normothermic Conditions (35°C).**

Oxygenators	Flow Rate	Purge line Status	Preoxygenator		Postoxygenerator		Distal Arterial Line	
			Total Emboli	Over 40 µm	Total Emboli	Over 40 µm	Total Emboli	Over 40 µm
KIDS D101	1 L/min	PC	3444±148	115±12	409±56	3±2	63±13	1±1
		PO	2280±100	92±3	382±16	6±3	66±15	1±1
	1.5 L/min	PC	63990±757	2612±48	20997±438	122±14	3937±198	4±2
		PO	60257±894	2300±71	20403±1314	255±87	3773±457	8±3
	2 L/min	PC	124971±905	5685±133	62945±1389	1270±70	18244±770	87±14
		PO	119732±408	4348±513	58705±460	1107±38	16982±535	74±9
RX 15	1 L/min	PC	2539±75	26±6	33±7	0±0	4±2	0±0
		PO	1334±209	15±7	24±6	0±0	3±1	0±0
	1.5 L/min	PC	49910±435	981±40	6703±127	42±6	824±62	2±1
		PO	42949±619	757±39	5090±324	26±5	647±29	3±1
	2 L/min	PC	105220±1404	2649±85	31309±1504	311±26	6599±433	41±7
		PO	95444±1152	2162±53	29132±747	290±14	6481±144	40±5
Quadrox-i pediatric with IAF	1 L/min	PC	6846±519	35±8	118±44	1±1	10±4	0±0
		PO	4051±256	18±6	53±10	1±1	9±5	0±0
	1.5 L/min	PC	58131±3867	1055±282	14424±402	155±14	3757±215	13±2
		PO	60160±858	1231±42	12782±163	111±7	3269±91	8±2
	2 L/min	PC	100949±1280	3115±86	38076±30	593±30	15324±416	114±16
		PO	91824±713	2535±76	29516±1027	569±24	14890±142	131±9
Quadrox-i	1 L/min	PC	2625±74	70±5	154±106	1±1	3±1	0±0
		PO	919±342	29±15	105±79	0±0	18±20	0±1
	1.5 L/min	PC	40737±2975	1643±185	13739±2381	71±15	2264±761	3±2
		PO	41076±340	1614±51	15503±552	108±17	2602±338	3±1
	2 L/min	PC	95768±1315	4141±114	51795±1257	635±47	15271±683	38±3
		PO	85381±963	3507±65	44117±496	492±25	12746±132	25±4

PC, Purge line closed; PO, Purge line open.

### Conclusions:

This study demonstrated that Capiiox RX 15 circuit was the most efficient pediatric circuit tested in terms of removing GME from the CPB circuit. The pressure drop and THE of the Capiiox and Quadrox-i and Quadrox-i with arterial filter were all similar, while the KIDS D101 had a much higher pressure drop than the other three and less hemodynamic energy retention.

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## Surgical Approach to “Swiss Cheese” VSDs and Our Results

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### Background:

The main handicap of surgical approach to “Swiss Cheese” VSDs is residual VSDs or formation of septal dysfunction. In our series of 6 cases, we repaired the multiple VSDs by using a “single patch” on the right aspect of septum by right atrial approach and double patch on two of the cases. In this paper, we would like to discuss our surgical approach and present our results.

### Methods:

16 consecutive patients (10 male, 6 female) with diagnosis of VSD were operated in our clinic between January 2000 - May 2011. Patients were between 2 months – 2 years old (mean age 6.5 +/- 5.2 months). VSD was accompanied by ASD and pulmonary hypertension (suprasystemic in 9 cases) in all cases. Also, coarctation of aorta in 4 cases, tricuspid insufficiency in 3 cases, left persistent vena cava in 5 cases, and in one case Holt-Oram syndrome were present. In 6 of the cases VSDs were repaired with a single dacron patch. In the remaining two cases muscular VSD was repaired with a single patch, perimembranous VSD was repaired with a second patch. One of the two patients with coarctation of aorta underwent preoperative pulmonary banding for (his (her) pulmonary hypertension and two balloon angioplasties for correction of the coarctation. In the other case coarctation gradient was 20 mmHg therefore no intervention was made and close echocardiographic follow-up was preferred.

### Results:

Early and late mortality was not seen except in last 2 cases. Mean follow-up time was 21 ± 9.4 months. All patients were asymptomatic and followed with echocardiography in the early and late post-operative period. One patient was re-operative in the third post-operative month due to residual VSD. Permanent pacemaker was implanted in the patient with Holt-Oram syndrome in the 3rd post-operative week due to complete AV block. Eight cases experienced mild, six of them moderate and 2 of them significant septal dysfunction. All cases are being closely followed with echocardiogram.

### Conclusions:

In neonates and infants surgical intervention of “Swiss Cheese” VSDs are complicated and present high post-operative morbidity and mortality rates. In the early and late post-operative period follow-up of septal wall motion by echocardiography is crucial.

New modes of therapy such as hybrid approaches with preoperative catheter application or intraoperative closure techniques with “devices” may assist accompanying pathologies and lower risk rates in this complex and risky patient group.

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## Congenital Heart Surgery Cases Accompanied with Genetic Syndromes

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### Background:

Genetic syndromes concomitant with the congenital heart defects in the patients who will undergo surgery is diagnosed early through genetic research and evaluation modalities and while the cardiac pathology of the patient is treated, at the same time genetic consultancy is provided to the patient and his/her family to make it possible to take the necessary measures. It is still not clear whether concomitant genetic syndromes have any effect on the development of the cardiac defects.

### Methods:

During our retrospective screening, we found genetic syndromes (in 97 cases) which accompanied with the congenital cardiac surgery cases (total: 2,521 cases) who were operated in our clinic during the period of May 1993-May 2011. The results were confirmed with the genetic research laboratory. Syndromes concomitant with the Fallot's Tetralogy (total : 481 cases) : 22q11.2 microdeletion (Shprintzen syndrome) in 8 cases, Trisomy 21 in 6 cases , Trisomy 18 in 2 case, VACTERL syndrome in 1 case (vertebral, anal, cardiac, tracheoesophageal, renal and extremite anomalies). Syndrome concomitant with atrioventricular channel defects (total: 131cases): Trisomy 21 was present in 47 cases. Holt-Oram syndrome accompanied Swiss-cheese VSDs in 2 cases. Anomalies accompanying Isolated Ventricular septal defect (total: 625 cases): joint congenital glaucoma and Trisomy 21 in 3 cases and Trisomy 18 in one case. Marfan Syndrome was present in 14 cases and surgical approach was applied on aorta and arc in these cases. William's syndrome was present in 4 cases with supravalvular aorta stenosis. In one case, Noonan syndrome accompanied pulmonary stenosis (valvular and infundibular), ASD, and persistent left SVC. 7 of the cases with aorta coarctation suffered from Turner syndrome (45XO). Average follow-up period was:  $52 \pm 7$  months and all patients were given family screening and genetic consultancy along with the clinical controls.

### Conclusions:

Although the 22q11 microdeletion and Trisomy 21 found in Fallot's Tetralogy cases which are described as conotruncal anomalies and are accompanied with genetic syndromes in particular does not affect the clinical course significantly, it is of great importance to diagnose the syndrome, orientate the mental development, and provide psychological and genetic consultancy to bringing these children back into the society. During the screening works, 22q11 microdeletion is diagnosed with the FISH test in TOF cases. Final diagnosis Furthermore, works are under way regarding the effectiveness of this deletion on the cardiac pathology.

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## In Vitro Effect of Clinical Propofol Concentrations on Platelet Aggregation

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### Background:

The inhibitory effect of propofol on platelet aggregation is unclear, and reports on the subject disagree. Furthermore, although propofol infusions are widely used as general anesthetics and sedatives for patients in intensive care unit, little study has been conducted on its concentration or time-related effects on platelet aggregation. Here, the authors investigated the in vitro effect of propofol, at clinical concentrations required for sedation and general anesthesia on platelet aggregation after 1, 2, or 3 hrs.

### Methods:

Blood from healthy volunteers was incubated with propofol plasma concentrations of 0, 2, 4, 10  $\mu\text{g/ml}$  in a water bath at 37°C. Platelet aggregation was measured using a platelet function analyzer (PFA-100) after 1 h, 2 h, or 3 h incubation. Times to occlude collagen/ADP (CADP) or collagen/epinephrine (CEPI) coated membranes (closure times; CTs) were measured.

### Results:

The CEPI and CADP CTs of non-incubated blood were  $125.6 \pm 19.5$  sec and  $93.0 \pm 12.2$  sec. No significant difference in CADP and CEPI CTs among the propofol plasma concentrations 0, 2, 4, and 10  $\mu\text{g/ml}$  were observed at 1, 2, and 3 h (concentration effect). Propofol plasma concentration of 2, 4, or 10  $\mu\text{g/ml}$  had no effect on CADP or CEPI CTs after even 3 h (time effect).

### Conclusions:

These results suggest that propofol at concentrations required for sedation and general anesthesia had no inhibitory effect on platelet aggregation after 3 h of incubation.

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## Role of Negative-Pressure Wound Therapy in Deep Sternal Wound Infection in Open Heart Surgery

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### Background:

Mediastinitis is a devastating complication in open heart surgery. The most common treatments after debridement are rewiring with antibiotic irrigation. Vacuum assisted closure therapy is a recently introduced technique that promotes the healing of difficult wounds, including poststernotomy mediastinitis.

### Methods:

Deep sternal wound infection occurred in 41 patients who were divided into 2 groups according to the treatment method used. Between January 2006 and January 2010, 22 patients with post-cardiotomy deep sternal wound infection were treated primarily by a continue vacuum-assisted closure method (group A) and 19 patients deep sternal wound infection who received closed mediastinal irrigation with antibiotics (group B).

### Results:

The two groups were compared. Three group B patients died during treatment. The median healing time was significantly shorter in group A (mean,  $13.5 \pm 3.2$  days) compared to 18 days (mean,  $21.2 \pm 16.4$  days) in group B. Deep sternal wound infection did not recur after vacuum treatment, while 7 (24%) patients in group B suffered a recurrence. Hospital stay was significantly shorter in group A (median, 30.5 days; mean,  $32.2 \pm 11.3$  days vs. median, 45 days; mean,  $49.2 \pm 19.3$  days).

### Conclusions:

The significantly shorter healing time with vacuum-assisted closure was confirmed. Hospital stay remained significantly shorter in group A (35 vs. 46 days).



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## Is the Devega Reliable Method for Functional Tricuspid Valve Regurgitation Associated with Left-Sided Valvular Disease?

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### Background:

We have reviewed 86 patients who underwent initial tricuspid valve surgery for functional tricuspid valve regurgitation (TR) and analyzed independent predictors for early and late unfavorable results.

### Methods:

Between 2004 and 2010, 86 tricuspid valve operations were performed for functional TR. The mean duration of follow-up was 1-5 years.

### Results:

Hospital mortality was Late deaths occurred. The only predictor of hospital mortality was preoperative highly elevated right atrial pressure. Variables predictive of cardiac-related late death were preoperative New York Heart Association (NYHA) class IV and poor left ventricular ejection fraction (LVEF) Residual TR of more than grade 3+ early after tricuspid annuloplasty was a significant risk factor for late tricuspid valve reoperation. Preoperative TR of grade 4+ was predictive of early residual TR.

### Conclusions:

Tricuspid valve surgery for functional TR can be performed with acceptable levels of early mortality. Cardiac-related late mortality after tricuspid surgery may be improved by earlier surgical treatment before NYHA class IV or deterioration of LVEF occurs. To prevent late tricuspid reoperation, it is important not to leave residual TR of grade 2+ or more after tricuspid annuloplasty.

Keywords: tricuspid, annuloplasty, insufficiency, repair

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## Is the HbA1C Level a Risk Marker in Coronary Artery Bypass Surgery?

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### Background:

The effect of glycosylated hemoglobin (HbA1c) level on short term results following coronary artery bypass grafting surgery were compared.

### Methods:

Two hundred and fifty four patients (151 males, 103 females; mean age  $56.85 \pm 11.03$  years; range 37 to 84 years), who underwent coronary artery bypass grafting surgery in our clinic between 2007 and 2010, were enrolled in this study retrospectively. Every patient including non-diabetics were managed with Portland protocol in the perioperative period.

### Results:

Mediastinitis was observed in five patients (1.9%). Elevated HbA1c levels do not affect the short term infectious complications, however the patients who had elevated perioperative glucose levels had higher incidence (0 vs. 3%,  $p=0.01$ ) of mediastinitis and local sternal infection (2.3% vs. 12.1%,  $p=0.002$ ).

### Conclusions:

Elevated HbA1c levels do not cause any risks in infectious complications following coronary artery bypass grafting surgery.

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## The Use of Ventricular Assist Devices in Pediatric Heart Transplantation

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### Introduction:

End-stage heart failure patients when the drugs are still unable to maintain its blood circulation, or cannot use the traditional surgical correction, are only waiting for a heart transplant. If you give intensive medical therapy, it still unable to provide organs adequate perfusion which is necessary to provide mechanical circulatory assist system [1] [2] [3]. Ventricular Assist Device (Ventricular assist devices, VADs) can be used as a transitional support before heart transplantation. It have been widely used in adult patients, and then extended to the use of heart failure patients for the children [2].

### Results:

In this study, retrospective review of medical records, we collected from January 2002 to February 2010, less than 18 years of age to accept the LVAD implantation surgery children. A total of 10 cases of LVAD as a transition before heart transplantation, 8 (80%) underwent successful heart transplant and was discharged. As for complications, while thrombosis embolism is major, especially in the use of "short-term LVAD patients because blood clots need to replace the pipe. Four patients with stroke, brain CT scan showed multiple infarcts, three patients fortunately without leaving obvious neurological symptoms, a patient death. Up prior to March 2010, the survival rate of successful heart transplant patient was 87.5%. Overall, the Ventricular Assist allows children stage heart failure patients can prolong life and maintain vital functions and successfully received a heart transplant.

### Conclusions:

From our experience, the use of ventricular assist devices in children's stage heart failure patients is feasible. LVAD must always be careful to pay attention to the use of anticoagulants to prevent thromboembolism formation, resulting in neurological complications.

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## Microfluidic-Based System for Continuous Blood Protein Extraction during In-Vivo Piglet Model of Extracorporeal Life Support

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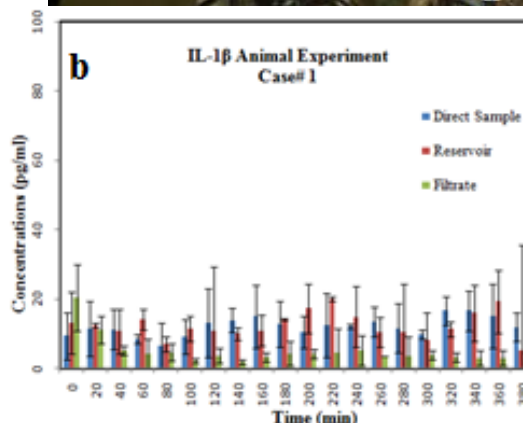
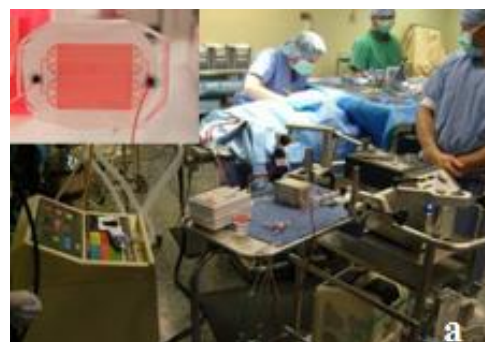
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### Background:

This work, describes the design, fabrication and testing of a microfluidic platform for the continuous extraction of blood plasma from a circulating whole blood sample to assist in continuous monitoring of a patient's inflammatory response during cardiac surgeries involving extracorporeal circulation (ECC) procedures such as cardiopulmonary bypass (CPB) and extracorporeal life support (ECLS). The use of ECC have revolutionized how cardiac surgeries are performed by allowing complicated valve replacement and cardiac repairs, congenital defects in pediatric patients, coronary artery bypass grafts (CABG) and even heart transplants. However, studies have clearly shown that ECC induces systemic inflammatory responses syndrome (SIRS) which can result in major post-operative complications. Continuous patient inflammation monitoring during surgical procedures will allow physicians to anticipate surgical and postoperative complications and to better understand patient morbidity related to ECC induced inflammation.

### Methods:

The microfiltration system consists of two aligned sets of PDMS microchannels, separated by a porous polycarbonate membrane. Blood flows through the channels on one side of the device (reservoir channels) and blood plasma is filtered through the membrane and into the channels on other side of the membrane (filtrate channels). The surface of the microdevice is coated with heparin to prevent blood clot formation inside the device channels. The microfiltration device has been tested during in-vivo piglet model of ECLS circuit primed with freshly drawn donor porcine blood and Plasmalyte A solution. The blood was then circulated at a rate of 500 ml/min at an arterial circuit pressure of 100 mmHg. Nonpulsatile perfusion was performed at normothermia (35 °C) for the duration of the experiment. After all manipulations by the perfusionist were completed, the ECLS circuit was connected to the piglet (9-12 kg). A small portion of blood was redirected from a purge line, which connected the arterial sampling port of the oxygenator and the venous line, to the reservoir channels of the microdevice using a peristaltic pump at a flowrate of 80  $\mu$ l/min. Figure (a) shows a picture of the device being infused with porcine blood during ECLS procedure. The fluid fractions from both microdevice outlets of the reservoir and filtration channels were collected every 20 minute for a total circulation time of over 5 hours. Discrete blood samples of 1 ml volume were also collected from the purge line. The concentration of inflammatory cytokines (IL-1 $\beta$ , IL-4, IL-6, IL-8, IL-10, IFN- $\gamma$ , TGF- $\beta$  and TNF- $\alpha$ ) were measured using multiplex bead array immunoassay.



### Results:

The results tracked cytokine concentrations collected from direct blood draw, reservoir and filtrate for over 5 hours. Among the analyzed proinflammatory cytokines, results of IFN- $\gamma$ , TNF- $\alpha$ , IL-10, IL-4, IL-8 and IL-6 were mostly below detectable range. The results from analyzing TGF- $\beta$  and IL-1 $\beta$  (Figure b) indicated no significant trend in the level of these cytokines. The successful integration and high efficiency of the microfiltration device indicated the effective and reliable device performance for future clinical applications.

## Evaluation of Two Types of Neonatal Oxygenators in Reducing Gaseous Microemboli and Maintaining Optimal Hemodynamic Stability an A Simulated Pediatric CPB Circuit

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### Background:

CPB is associated with significant morbidity in patients, particularly in the pediatric population, due to several reasons including the delivery of gaseous microemboli (GME), high membrane oxygenator pressure drop, and hypoperfusion due to "stolen" blood flow from the arterial filter through an open purge line. In this study, we evaluated the Braile Infant 1500 oxygenator (Braile Biomedica, Brazil) and the Dideco KIDS Neonatal D100 oxygenator (Sorin Group, USA) at normothermic and hypothermic conditions and different flow rates in a simulated CPB circuit, and compared their respective capabilities in eliminating microemboli while maintaining optimal hemodynamic stability of the patient.

### Methods:

The Braile Infant 1500 oxygenator and Venous Reservoir 500 were connected to a Capiiox AF02 arterial filter (Terumo Corporation, Tokyo, Japan), to a HL-20 roller pump, Jostra-30 heat-cooler system (Jostra, Austin, TX), and the Capiiox CR10 hard shell reservoir (Terumo Corporation, Tokyo, Japan) served as a "pseudopatient". The Dideco Kids Neonatal D100 oxygenator was connected to the same system. Two flow probes were placed before the oxygenator and after the arterial filter. Three Emboli Detection and Classification (EDAC) quantifier transducers and pressure transducers were used before the oxygenator, after the oxygenator, and after the arterial filter. The circuit was primed with fresh human blood of 40% hematocrit diluted with Lactated Ringer's solution. The circuit pressure was maintained at 100 mm Hg and the arterial filter purge line was kept open during all trials. Five ml of air were injected into the tubing between the "pseudopatient" and the venous reservoir under both non-pulsatile (NP) and pulsatile (P) perfusion conditions at flow rates of 500 mL/min and 700 mL/min under both normothermic and hypothermic temperatures (35°C and 25°C). A total of 10 air bolus injections were performed at each individual set of conditions for a total of 160 injections.

### Results:

The Braile Infantile 1500 displays lower oxygenator pressure drops and higher blood flow diverted from the patient, but also higher rates of GME capture compared to the Dideco KIDS D100. The KIDS D100 created more total hemodynamic energy (THE) prior to oxygenator but delivered less energy to the patient after the arterial filter (see table).

The pressure drop, stolen blood flow, GME captured, and energy delivery at different flow rates and temperatures

Flow Rate	Oxygenator	Mode	Pressure Drop (mm Hg)		Stolen Blood Flow (ml/min)		% GME Count (Post-Oxy/Pre-Oxy)		THE Delivery (Post Filter/Pre-Oxy)	
			35°C	25°C	35°C	25°C	35°C	25°C	35°C	25°C
700 ml/min	Braile 1500	NP	47.5±0.1	54.3±0.0	154.3±1.5	135.8±1.1	9.7%	13.2%	64.3%	61.7%
		P	49.4±0.3	56.3±0.3	155.4±1.7	136.7±1.7	8.5%	9.1%	64.4%	62.1%
	KIDS D100	NP	125.5±0.2	163.7±2.9	133.1±0.4	115.6±1.4	42.1%	47.3%	47.9%	42.3%
		P	129.8±0.7	168.0±2.9	133.9±1.8	116.1±2.2	41.8%	47.4%	47.2%	41.8%

### Conclusions:

Our results showed that Braile Infant 1500 had a lower pressure drop and a smaller percentage of air emboli as well as a higher total hemodynamic energy delivered to the pseudopatient in our simulated pediatric CPB circuit. However, there was a higher raw number of microemboli seen with the Braile oxygenator at pre-oxygenator and post-oxygenator sites compared to the KIDS D100 due to differences in venous reservoir size.



## A Non-occlusive, Inexpensive Pediatric Pulsatile Roller Pump for CPB, ECLS and LVAS/RVAS

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### Background:

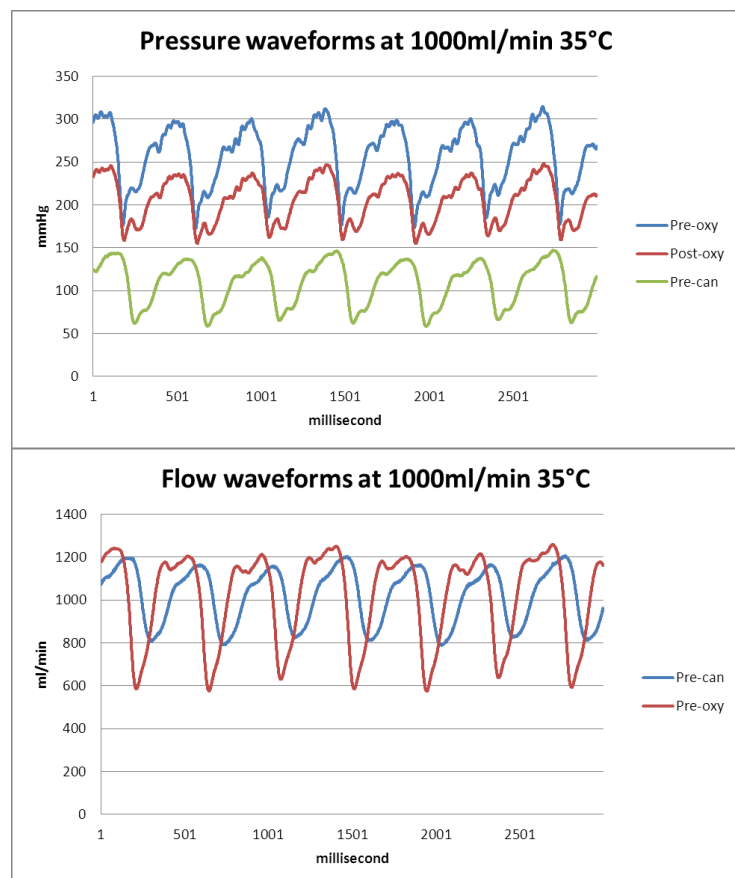
A simple, inexpensive pediatric pulsatile roller blood pump has been utilized for routine cardiopulmonary bypass (CPB) procedures, extracorporeal life support (ECLS) and left/right ventricular assist systems (LVAS/RVAS) for decades in France. This particular non-occlusive pulsatile system has many advantages including several safety features for patients as well as an extremely lower cost. The objective of this study is to evaluate the particular system for CPB, ECLS and LVAS/RVAS in pulsatile mode.

### Methods:

This particular pediatric non-occlusive system was evaluated with pump flow rates of 500ml/min, 750ml/min and 1000ml/min under normothermic and hypothermic conditions in a CPB circuit, ECLS circuit and LVAS/RVAS circuit using clinical disposables.

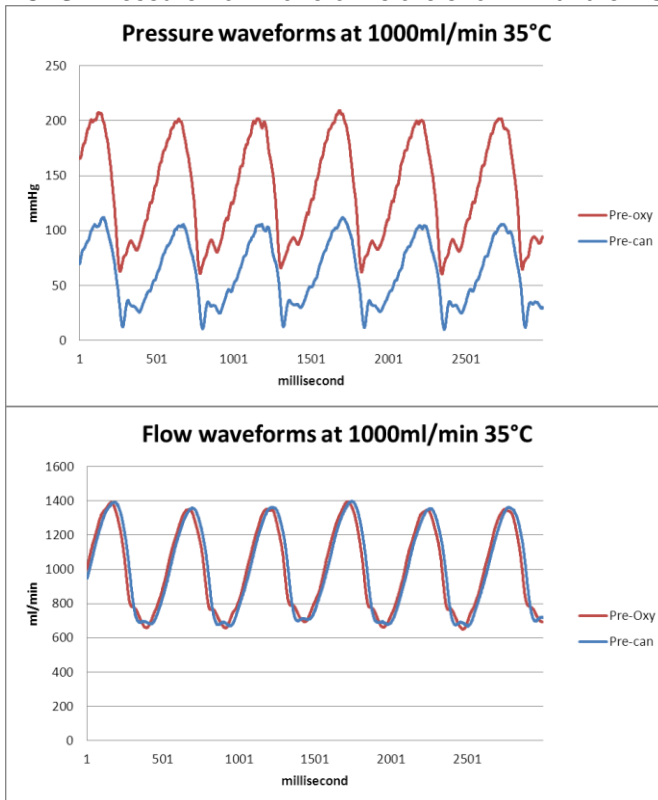
### Results:

**CPB:** Pulsatile pressure flow waveforms of the CPB procedure are shown.

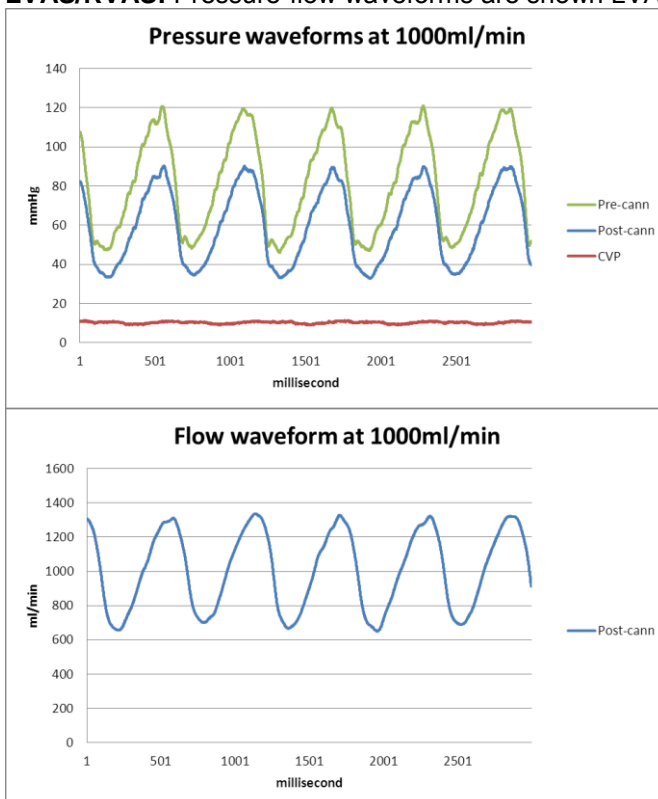




**ECLS:** Pressure-flow waveforms are shown with the ECLS circuit.



**LVAS/RVAS:** Pressure-flow waveforms are shown LVAS/RVAS circuits.



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**Conclusions:**

This particular non-occlusive pediatric pulsatile system performed well during all of the experimental conditions and generates adequate quality pulsatile pressure-flow waveforms using CPB, ECLS, and LVAS/RVAS circuitry.

Although this novel concept was first introduced in 1990 (1, 2), we believe that there is still need for this technology because of significant advantages.



The non-occlusive roller pump for ECMO in France.



The non-occlusive roller pump for LVAS in France.

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## INTERNATIONAL SOCIETY FOR PEDIATRIC MECHANICAL CARDIOPULMONARY SUPPORT

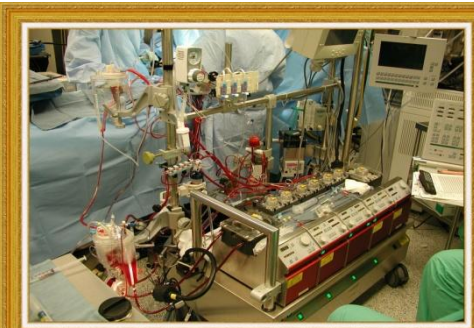
*"If the course of just one child's life is improved as a result of this organization, we have reached our goal"*

Established 2010

Akif Ündar, PhD  
Founder and President

### Mission

The mission of this society is to focus on the current problems associated with pediatric cardiac patients during and after acute or chronic cardiac support. The society will bring together as many distinguished clinicians, bioengineers, and basic scientists as possible to precisely define current problems and suggest novel approaches and solutions.



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