THIRD INTERNATIONAL SYMPOSIUM ON VASCULAR TISSUE ENGINEERING

JUNE 5 - JUNE 6, 2017
NATIONWIDE CHILDREN’S HOSPITAL
Nationwide Children's Hospital is excited to host the 3rd Annual International Symposium on Vascular Tissue Engineering (2017 ISVTE) in Columbus, Ohio, USA on June 5-6, 2017 at Nationwide Children's Hospital. Tissue engineering is a new horizon field that engages physicians and scientists from biomedical engineering, biologic and materials sciences, cardiology, cardiovascular surgery, chemical engineering, general surgery, interventional cardiology, macromolecular science, mechanical engineering, nephrology, orthopedic surgery, pathology, vascular biology, and, of course, vascular tissue engineering.

We do hope that you will enjoy your stay in our vibrant, welcoming cosmopolitan city. In addition to being the fifteenth largest city in the United States (US), the political capital city of the state of Ohio and a major commercial crossroad for half of the US population, Columbus is home to The Ohio State University, one of the largest public colleges in the US and to Nationwide Children's Hospital, which is now the largest children's hospital in the US. Furthermore, Columbus hosts a dynamic visual and performing arts scene, many downtown restaurants in an environmentally conscious local-sourced culinary movement and, finally, professional sports (Columbus Blue Jackets hockey, Columbus Crew soccer and Columbus Clippers baseball).

We are especially honored to welcome Dr. John Mayer of The Children's Hospital, Boston as the Fung Wexner Lifetime Achievement Award recipient presented at this year's Symposium. We have 28 additional distinguished faculty from 8 countries presenting over the two days as well as and 30+ scientific oral or poster presentations.

This symposium brings together researchers, clinicians and trainees from academic institutions, industry and hospitals. You will see that the program offers excellent lectures and in-depth discussions. This is the third symposium following the Second International Symposium on Vascular Tissue engineering in Shanghai, China in 2015, and is organized and sponsored by Nationwide Children's Hospital, Columbus, Ohio, USA.

The co-chairs of the 2017 ISVTE are Drs. Toshiharu Shinoka, Professor of Pediatric Cardiothoracic Surgery, Christopher Breuer, Professor of Surgery (Co-Directors of the Tissue Engineering Program at Nationwide Children's and The Ohio State University), and Laura Niklason, Professor of Anesthesiology and Biomedical Engineering at Yale University.

We thank you for attending and hope you have an enjoyable and productive experience at the Third International Symposium on Vascular Tissue Engineering.

Sincerely,

Toshiharu Shinoka, MD, PhD Co-Chair
The Heart Center and Research Institute,
Nationwide Children's Hospital

Christopher Breuer, MD Co-Chair
The Heart Center and Research Institute,
Nationwide Children's Hospital

Laura Niklason, MD, PhD Co-Chair
Yale University
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LIVE CASE PRESENTATION
Participants will have the opportunity to observe a live demo during day one of the Program. Dr. John Cheatham will demonstrate the angiography of a tissue engineered inferior vena cava (IVC) six weeks after implantation in a sheep model through a live broadcast from his lab in the Research Building to the Auditorium. At the same time, he will also perform an IVUS (Intravascular ultrasound) evaluation of TEVG.

ORAL PRESENTATIONS
All Main Symposium Sessions will be held in Stecker Auditorium. In addition to keynote addresses from leading experts in aspects of vascular tissue engineering, there will be oral presentations from submitted abstracts. Time will be given for Q&A after each presentation.

SCIENTIFIC POSTER SESSION
The Scientific Poster Session will be held in ED138, across from the Stecker Auditorium, on Monday, June 5th, 4:40-5:30 p.m. All posters will be displayed during the entire symposium, beginning on Monday morning at 8:00 am. Posters are numbered according to the Abstracts by Title section of this book and should be hung in the pre-function area on the poster board assigned to this number. Presenters will stand by their posters during the time of the poster session.

CATERING
Breakfast, lunch and snacks will be offered throughout the symposium. Breakfast, lunch and snacks will be served in the Stecker Lobby.

SHUTTLE SERVICE
Parking is limited and Nationwide Children’s Hospital, therefore shuttle services will be provided to participants to and from the Hilton Columbus Downtown.

EVENING EVENTS
Evening Reception
Monday, June 5, 5:00-7:00 p.m.
Stecker Lobby
All symposium attendees are invited for cocktails and hors d’oeuvres at a special welcome reception on Monday evening. Optional Hospital Tours will be available for Symposium participants during the Reception.

Experience the music of Senri Oe. Bestselling Sony music recording artist, Oe’s international debut all-jazz album, “boys mature Slow” earned "the album of the year: new star at the jazz japan awards. Before extending his talent in the TV and film industry, Oe was active and influential in the Japanese music scene as a lyricist, composer and arranger since he debuted. Oe is currently living in New York City, performing and writing music.

LOCAL RESTAURANTS – SHORT NORTH DISTRICT
Symposium attendees are free to have dinner on their own on Tuesday night. A large number of restaurants are within walking distance of the Hilton Columbus Downtown.

See restaurant section on page 66 for other local establishments in the downtown area.

CME & EVALUATION
The Nationwide Children’s Hospital is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to provide continuing medical education for physicians.

Nationwide Children’s Hospital designates this live activity for a maximum of 11.5 AMA PRA Category 1 Credit(s) TM. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

A completed evaluation within 30 days of the conference is required for CME credit. Please complete the evaluation Online at: https://www.surveymonkey.com/r/2017ISVTE

CME certificates will be emailed to participants who have completed the evaluation after the close of the evaluation.
**MONDAY, JUNE 5**

07:15 08:00 AM  BREAKFAST | PARTICIPANT & SPEAKER CHECK-IN

08:00 08:25 AM  OPENING REMARKS
Larry Moss

08:30 08:55 AM  RECENT PROGRESS IN SCAFFOLDS FOR TEVG – 1
Chair: Anthony Weiss | Gary Bowlin | Peter Ma

08:55 09:20 AM  Designing Scaffold Microenvironments to Direct Blood Vessel Regeneration
Peter Ma

09:20 09:45 AM  Designing Bioresorbable Vascular Prosthetics to Regulate Outcome Derived from Acute Confrontation with Neutrophils
Gary Bowlin

09:45 10:05 AM  BREAK

10:05 10:25 AM  Hemodynamic Changes and Hepatic Remodeling
Yasuoku Iwakiri

10:25 10:50 AM  Novel Aspects in Cardiovascular Research
Elena Aikawa

10:50 11:10 AM  Pathologic Considerations in Cardiovascular Tissue Engineering
Frederick Schoen

11:10 11:30 AM  Computer Model Driven Design of Tissue Engineered Vascular Grafts
J.D. Humphrey

09:45 10:05 AM  LUNCH & VISIT WITH POSTER PRESENTERS

11:30 01:00 PM  FUNG WEXNER LIFETIME ACHIEVEMENT AWARD PRESENTATION
Abigail Wexner & Toshiharu Shinoka

**MONDAY, JUNE 5 CONTINUED**

01:00 1:20 PM  CLINICAL NEEDS OF VASCULAR TISSUE ENGINEERING
Chair: Toshiharu Shinoka

01:20 1:50 PM  Implantation of Tissue Engineered Inferior Vena Cava in a lamb model
Christopher Breuer

01:50 2:15 PM  Transcatheter Assessment of TEVG from Catheterization Laboratory in Animal Facility at Nationwide Children's Hospital
John Cheatham

02:15 02:40 PM  Core Matrix Valve Conduit
Patrick McConnell

02:40 03:05 PM  Patient Specific Hemodynamics and Growth and Remodeling in Congenital Heart Disease Surgery
Alison Marsden

03:05 03:25 PM  BREAK

03:25 03:50 PM  Modification of Vascular Grafts with Vasoactive Substances to Improve Blood Vessel Regeneration and Function
Deling Kong

03:50 04:15 PM  Nanofibrous Tube Scaffold for Blood Vessel Tissue Engineering
Xiumei Mo

04:15 04:40 PM  Polymer Design and Processing for Cardiovascular Applications
William Wagner

04:40 07:00 PM  POSTER SESSION & RECEPTION WITH HEAVY HORS D'OEUVRES & OPTIONAL NCH TOUR
Live Music | Stecker Lobby
### 3rd International Symposium on Vascular Tissue Engineering

#### Program Agenda

**Tuesday, June 6**

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<td>07:15</td>
<td>**Breakfast</td>
<td>Check-In**</td>
<td>Speaker Check-In</td>
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<tr>
<td>08:10</td>
<td><strong>Opening Remarks</strong></td>
<td>Stecker Auditorium</td>
<td>John Barnard</td>
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<tr>
<td>08:15</td>
<td><strong>Current Strategies for Tissue Engineering Artery</strong></td>
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<td>Joris Rotmans</td>
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<td>08:40</td>
<td>Contribution of Stem Cells to Vascular Regeneration and Fibrosis</td>
<td>Song Li</td>
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<td>09:05</td>
<td>In Situ Tissue Engineering of Blood Vessels</td>
<td>Yadong Wang</td>
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<tr>
<td>09:30</td>
<td>Vascular Tissue Engineering: “Quo Vadis”?</td>
<td>Beat Walpoth</td>
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<tr>
<td>09:55</td>
<td>Human Adipose-Derived Mesenchymal Stem Cell-Based Engineered Vascular Grafts: Practical Considerations for Translation</td>
<td>David Vorp</td>
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<tr>
<td>10:20</td>
<td>Autologous In Vitro Engineered Vascular Grafts for Hemodialysis Access</td>
<td>Joris Rotmans</td>
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<tr>
<td>10:45</td>
<td><strong>Break</strong></td>
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<tr>
<td>10:45</td>
<td><strong>Oral Sessions</strong></td>
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<td>Chair: Toshiharu Shinoka</td>
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<td>11:00</td>
<td>An Optimized Induced Pluripotent Stem Cell-Derived Tissue Engineered Blood Vessel Model Of Hutchinson-Gilford Progeria Syndrome For Drug Toxicity Testing</td>
<td>Leigh Archison, Elizabeth Snyder-Mouton, Ken Cao &amp; George Truskey</td>
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<td>11:15</td>
<td>Adipose-Derived Stem Cells And Vascularized Lymph Node Transfers Successfully Treat Mouse Hindlimb Secondary Lymphedema Through Early Re-Connection Of The Lymphatic System And Lymphangiogenesis</td>
<td>Sadasiri Akita</td>
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<td>11:30</td>
<td>First clinical application of the human Biotube to the congenital heart disease</td>
<td>Shuhei Fujita , Masaaki Yamagishi, Kenichi Kanda, Takako Miyazaki, Yoshinobu Maeda, Masashi Yamanami, Taiji Watanabe, Hitoshi Yaku</td>
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<td>11:45</td>
<td>In Vivo Tissue-Engineering of Poly (ε-caprolactone) Reinforced Vascular Grafts</td>
<td>Kai Wang, Qiuying Zhang, Dengke Zhi, Delang Kong</td>
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<td>12:00</td>
<td>Excellent Long-Term In-Vivo Data with Bioabsorbable Carotid Grafts</td>
<td>Marielle Brugmans, Nicolas L’Heureux, Luke Burke, Martijn Cox, Maria Romero &amp; Renu Virmani</td>
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**Tuesday, June 6 Continued**

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<tr>
<td>01:30</td>
<td><strong>Working Lunch &amp; Progress Toward A Tissue Engineered Heart Valve</strong></td>
<td>John Mayer, Jr. - Fung Wexner Lifetime Achievement Award Recipient</td>
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<tr>
<td>01:30</td>
<td><strong>Future Clinical Application of Tissue Engineering Vascular Grafts</strong></td>
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<td>Chair: Christopher Breuer</td>
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<tr>
<td>01:30</td>
<td>Completely Biological “Off-the-Shelf” Vascular Grafts</td>
<td>Robert Tranquillo</td>
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<tr>
<td>01:30</td>
<td>Design and Preclinical Validation of Small-Diameter Vascular Grafts</td>
<td>Didier Letourneur</td>
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<td>01:30</td>
<td>Vascular Tissue Engineering for Skeletal Muscle Regeneration/Repair</td>
<td>George Christ</td>
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<td>01:30</td>
<td>Bioengineered Solutions for Dialysis Vascular Access Dysfunction: Challenging the Status Quo…</td>
<td>Prabir Roy-Chaudhury</td>
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<td>03:10</td>
<td><strong>Break</strong></td>
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<td>03:30</td>
<td><strong>Current Status of Clinical Application of Tissue Engineering Vascular Grafts</strong></td>
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<td>Chair: Christopher Breuer</td>
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<td>03:30</td>
<td>Tissue Engineered Vascular Grafts for Use in Congenital Heart Surgery</td>
<td>Christopher Breuer</td>
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<td>03:30</td>
<td>Building Completely Biological, Woven, Human Tissue Engineered Blood Vessels</td>
<td>Nicolas L’Heureux</td>
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<td>03:30</td>
<td>Long term clinical outcomes of Tissue Engineered Vascular Conduits in Pediatric Cardiovascular Surgery</td>
<td>Toshiharu Shinoka</td>
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<td>03:30</td>
<td>Clinical Follow-Up of Patients Receiving Tissue Engineered Arteriovenous Grafts</td>
<td>Laura Niklason</td>
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<td>03:45</td>
<td><strong>Closing Remarks</strong></td>
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<td>Laura Niklason</td>
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CHRISTOPHER K. BREUER, MD is Co-Director of the new Tissue Engineering Program at Nationwide Children’s Hospital and Director of Tissue Engineering at The Ohio State University Wexner Medical Center’s new Center for Regenerative Medicine and Cell Based Therapies. His clinical and research interests center on bioengineered tissue for use in surgery. Working with Dr. Toshiharu Shimo, he was the first in the world to tissue engineer blood vessels and implant them in human infants. Dr. Breuer has many honors recognizing his contributions, including the Jacobsen Promising Investigator Award from the American College of Surgeons which is given to the most innovative young surgical investigator in the country.

JOHN P. CHEATHAM, MD is Co-Director of The Heart Center at Nationwide Children’s Hospital, Columbus, Ohio. He holds the George H. Dunlap Endowed Chair in Interventional Cardiology. He is also a Professor of Pediatrics and Internal Medicine at The Ohio State University College of Medicine. After graduating from the University of Oklahoma College of Medicine, he completed his residency at Boston Children’s Hospital, followed by a fellowship in Pediatric Cardiology at Texas Children’s Hospital in Houston. Dr. Cheatham’s area of expertise is transcatheter intervention and Hybrid therapy of newborns, children, and adults with complex congenital heart disease. He has pioneered several new techniques and devices in nonsurgical intervention, as well as being a world leader in developing new Hybrid therapies. He has been a principal investigator in numerous FDA sponsored clinical trials evaluating nonsurgical closure devices and stent therapy over the past two decades. Additionally, Dr. Cheatham designed the world’s first Hybrid Cardiac Catheterization Suites and advanced imaging equipment at Nationwide Children’s Hospital, which allows the interventionalist & cardiacsurgeon to perform combined therapy in order to improve clinical outcomes in patients referred to The Heart Center. He serves as a consultant to various medical companies and proctors, or teaches, new transcather techniques and devices to other physicians around the world. Dr. Cheatham is Co-Director of the Nationwide Children’s Hospital International Program and has implemented a formal physician exchange program with two of the leading medical institutions in China. Dr. Cheatham has authored more than 185 manuscripts, 25 book chapters, over 475 national and international presentations, and is co-editor of the book, “Complications in Percutaneous Interventions for Congenital and Structural Heart Disease.” Dr. Cheatham was selected as one of the top 25 Innovators in Healthcare by Health Imaging & IT. He was also honored as the recipient of the Career Achievement Award at the prestigious 2007 PICC & AICCS conference, attended by interventional cardiologists from across the world. In 2015, Dr. Cheatham was named to the new class of Master Fellows of the Society for Cardiovascular Angiography and Interventions (MSCAI), the professional medical society for adult and pediatric invasive/interventional cardiologists.

GEORGE CHRIST, PHD has a broad interest in muscle physiology, intercellular communication and the role of smooth muscle in the function and dysfunction of visceral and vascular tissues. Dr. Christ’s research interests are in the area of Functional Genomics, that is, establishing a verifiable link between changes in gene expression and alterations in cell/organ/tissue function/dysfunction, and then using this information to improve the understanding, diagnosis and treatment of smooth muscle diseases/disorders. To this end, Dr. Christ has developed a multidisciplinary approach that utilizes various visceral and vascular smooth muscle tissues/organs to attempt to establish “cause and effect” relationships between molecular/ genetic alterations and measurable changes in organ function, namely, contraction and relaxation of smooth muscle cells. Animal vascular and visceral tissues are studied both in vitro and in vivo. Molecular, biochemical, electrophysiological, pharmacological, immunohemical, and whole animal techniques (rat and mouse transgenics and knockouts) are all used to study the mechanistic basis for integrative tissue physiology. Parallel in vitro studies are conducted on corresponding human tissues for target validation whenever possible. The overall goal of his work is to translate scientific discoveries into technologies that can improve human health (i.e., translational research). In this regard, Dr. Christ is a co-inventor on more than 20 patents issued or applied for related to gene therapy treatments for smooth muscle disorders/diseases, and the Co-Founder and Directing Member of Ion Channel Innovations, LLC, a development stage biotechnology company pioneering the use of gene therapy for the treatment of human smooth muscle disorders. Recently, Dr. Christ has also focused on the fields of tissue engineering and regenerative medicine. In particular, he is interested in developing in vitro protocols and bioreactor systems for the accelerated maturation of engineered tissues; in order to further enhance their applications in regenerative medicine.
SYMPOSIUM FACULTY LISTING

J.D. HUMPHREY, PHD received a Ph.D. in Engineering Science and Mechanics from The Georgia Institute of Technology and completed a post-doctoral fellowship in Medicine - Cardiovascular at the Johns Hopkins University. He is currently John C. Malone Professor and Chair of Biomedical Engineering at Yale University. His primary technical expertise is in vascular mechanics and mechanobiology, with particular interests in vascular aging, hypertension, aneurysms, and tissue engineering. He authored a graduate textbook (Cardiovascular Solid Mechanics) and co-authored both an undergraduate textbook (An Introduction to Biomechanics) and a short handbook (Style and Ethics of Communication in Science and Engineering). He also co-edited a research text (Cardiovascular Soft Tissue Mechanics), published chapters in 25+ other books or encyclopedias, and published over 250 archival journal papers. He served for a decade as founding co-editor-in-chief for the international journal Biomechanics and Modeling in Mechanobiology, which continues to have the highest impact factor in the field of biomechanics. He currently serves as a US representative to the World Council for Biomechanics and served previously as Chair of the US National Committee on Biomechanics. He is a Fellow of the American Institute of Medical and Biological Engineering and the American Society of Mechanical Engineers and is an elected member of the Connecticut Academy of Science and Engineering.

YASUKO IWAKIRI, PhD is an Associate Professor of Medicine, in Internal Medicine: Digestive Diseases: Iwakiri Lab | Liver Center at Yale University School of medicine. Dr. Iwakiri is also a faculty researcher leading the Vascular Biology and Therapeutics Program and Office of Cooperative Research at yale university. She earned her PhD from Colorado State University (2000), an MS from Oregon State University (1995) and a BS from Miyazaki University, Japan (1988). Yasuko has earned recognition for her research and scholarly activity. Her research interests include Hypertension, Portal; Liver Cirrhosis; Liver Cirrhosis; Hepatitis; Necroinflammation; Hepatic Inflammation; NLRP3; NLRP1; Mitochondria; Liver; Liver regeneration; Hepatitis; Tissue engineering; Nanoparticles; Tissue engineering; NLRP3; NLRP1; Mitochondria; Liver; Liver regeneration; Hepatitis; Tissue engineering; Nanoparticles. She is the Editorial board member for HEPATOLOGY. Her research has led to a string of high-impact publications (FASEB J., Nature Med., NEJM, The Lancet) and have had a marked impact on the field. Her research interests include stem cell engineering, vascular tissue engineering, vascular remodeling, mechanobiology and mechanotransduction. This work is a rare example of combining basic and applied vascular biology principle to generate an actual clinical application.

YASUKO IWAKIRI, PHD is an Associate Professor of Medicine, in Internal Medicine: Digestive Diseases: Iwakiri Lab | Liver Center at Yale University School of medicine. Dr. Iwakiri is also a faculty researcher leading the Vascular Biology and Therapeutics Program and Office of Cooperative Research at yale university. She earned her PhD from Colorado State University (2000), an MS from Oregon State University (1995) and a BS from Miyazaki University, Japan (1988). Yasuko has earned recognition for her research and scholarly activity. Her research interests include Hypertension, Portal; Liver Cirrhosis; Liver Cirrhosis; Hepatitis; Necroinflammation; Hepatic Inflammation; NLRP3; NLRP1; Mitochondria; Liver; Liver regeneration; Hepatitis; Tissue engineering; Nanoparticles; Tissue engineering; NLRP3; NLRP1; Mitochondria; Liver; Liver regeneration; Hepatitis; Tissue engineering; Nanoparticles. She is the Editorial board member for HEPATOLOGY. Her research has led to a string of high-impact publications (FASEB J., Nature Med., NEJM, The Lancet) and have had a marked impact on the field. Her research interests include stem cell engineering, vascular tissue engineering, vascular remodeling, mechanobiology and mechanotransduction. This work is a rare example of combining basic and applied vascular biology principle to generate an actual clinical application.

DR. DELING KONG is a Professor of Biochemistry and Molecular Biology, Director of the Key Laboratory of Bioactive Materials, Ministry of Education at Nankai University since 2003. He also serves as the Vice Director of the Institute of Biomedical Engineering, Chinese Academy of Science & Peking Union Medical College since 2010. He finished his four-year undergraduate studies in the Department of Chemistry in Nankai University, and then received his PhD degree from Nankai in 1997. He did postdoctoral training for 5 years, and moved back to Nankai University In 2003, where he was appointed as a professor in the College of Life Science. Dr. Kong won the Outstanding Young Fund of NSFC in 2007. He won the 2nd class National Scientific Technology Progress Award of China in 2009, and the 2nd class Natural Science Award of Tianjin in 2010. He has published more than 100 peer reviewed papers, including those published as first author and corresponding author in Circulation, Cardiovascular Research, Biomaterials, J Am Chem Soc, Angew Chem Int Ed Engl, ACS Nano, Biomacromolecules, etc.; these papers have been cited over 3000 times. He also holds more than 10 approved patents.

DIDIER LETOURNEUR, PhD, engineer, doctor in chemistry, is Research Director at CNRS. In 2002, he founded a research structure Inserm-University Paris 13, focused on the use of biomedical polymers for 3D structures and contrast agents for vascular imaging. Since 2005, he has lead the team of Cardiovascular Bioengineering at Inserm (CHU X Bichat, University Paris Nord and Paris Diderot). He is now the Director of the Laboratory for Vascular Translational Science (LXVT-Inserm U1148) with about 160 persons. D Letourneur is actively involved in several national grants, the Health regional cluster Medicen, and since 2013 as European coordinator of NMP “NanoAtheno” large scale project (16 partners, 10 countries - http://www.nanoatheno.eu). He was also involved in several FP7 projects (Health 2007-2013 “FAD” Large scale coordinated by its Research Unit, Health 2010-2014 Prestige (WP2 co-leader), and NMP 2009-2012 “Nanointerna”). D Letourneur is the author of 138 international publications (H-index 31), inventor of 16 patents, and has won several prizes such as the “Coup d’Elan for Research” Foundation Bettencourt 2001, Diderot Innovation Award 2009 CNRS-University Paris 7, Cardiovascular Innovation Award 2011 from FRM (Medical Research Foundation), and OSEO/BPI emergence 2012 & Creation-Dv 2013 for start-up creation and G Winter Award 2016 - highest distinction from the European Society for Biomaterials. In 2016, he found the start-up SLITSS for the development of innovative orthopedic implants. He has more than 100 invited lectures and seminars and is the co-organizer of numerous national and international conferences (India, Tunisia, Canada) and two Inserm training workshops for Regenerative Medicine (2009 and 2012). He serves from 2013 at AVIESAN-TMTO for Health technologies in the scientific council. He was vice-chairman for Regenerative Medicine at the European Technology Platform for Nanomedicine and is now General Secreteraire. Since 2009, he is President of BIOMAT, French Society for Biomaterials.

NICHOLAS LHEUREUX is Director of Research at the Inserm (National Institute of Health and Medical Research) Unité 1026 BioTis, Université de Bordeaux. In this role he is involved in training masters and Ph.D. students as well as post-doctoral fellows. Dr. L’Heureux is also a Tissue Engineering and Biofabrication Coordinator at the Bordeaux Consortium for Regenerative Medicine (BxCRM). He serves as an editorial Board member on SCTM ed. Board and Regenerative Medicine. Prior to joining Inserm, he was the Co-Founder and Chief Scientific Offices at Cryograft Tissue Engineering, Inc. In the early 90’s, he invented the Tissue Engineering by Self-Assembly (TESA) approach, a radically new method that allows the production of mechanically strong tissues without the need for synthetic biomaterials. Out of all the possible applications for TESA, he focused on developing a tissue-engineered human blood vessel. From in vitro feasibility to first-in-man study, this research has led to a string of high-impact publications (FASER J., Nature Med., NEJM, The Lancet) and have had a marked impact on the field by promoting more biological approaches for tissue repair. This work is a rare example of combining basic and applied vascular biology principle to generate an actual clinical application.

PROFESSOR SONG LI recently joined UCLA Bioengineering this past Fall. At UCLA, he is the Chancellor Professor and Department Chair, in the Department of Bioengineering, Department of Medicine. Prof. Li received his B.S. in Mechanical & Engineering Science in 1988 and M.S. in Biomechanics in 1991 from Peking University. He then received his Ph.D. in Bioengineering at UC San Diego in 1997 where he investigated the mechanotransduction of vascular endothelium under the mentorship of Dr. Shu Chien. Following a postdoctoral fellowship with Dr. Chien on fluid shear stress-responsive molecular signaling, Dr. Li joined the faculty of the Department of Bioengineering at UC Berkeley in 2001, where he developed a stellar independent research program, emerged as an internationally recognized scientist, award-winning teacher, and effective administrator who has contributed at the highest level to Departmental service. His research interests include stem cell engineering, vascular tissue engineering, vascular remodeling, mechanobiology, and mechanotransduction. He is a fellow of the American Institute for Medical and Biological Engineering, the Biomedical Engineering Society (BMES) and the International Academy of Medical and Biological Engineering. His research is focused on cell and tissue engineering, mechanobiology and cardiovascular bioengineering. He has edited 3 books, and served on the editorial boards of 5 scientific journals. He has co-authored over 200 papers, and is well recognized in the field of bioengineering. He is a Fellow of the International Academy of Medical and Biological Engineering, Bioengineering Society and American Institute for Medical and Biological Engineering.
PETER X. MA, MS, PHD received his BS and MS from Tsinghua University in Beijing, PhD from Rutgers University, and conducted postdoctoral research at MIT and Harvard Medical School. In 1996, Dr. Ma joined the faculty of the University of Michigan. He is currently the Richard H. Kingery Endowed Collegiate Professor with quadpule Professor appointments in the Departments of Biologic and Materials Sciences, Biomedical Engineering, Macromolecular Science and Engineering, and Materials Science and Engineering (Schools of Dentistry, Engineering, and Medicine). Dr. Ma’s research is focused on biomaterials, biodegradable polymers, controlled biomolecule delivery, and tissue engineering. Dr. Ma has been an invited/keynote/plenary speaker more than 230 times at conferences and institutions worldwide. He is an inventor of more than 30 US patents and patent applications. He has published 4 books and 268 peer-reviewed articles. Dr. Ma reviews grants for NIH, DOD, NSF and many other national and international funding agencies. He also reviews articles for numerous journals. Professor Ma won a Whitaker Foundation Young Investigator Award in 1999, a DuPont Young Professor Award in 2000, was named one of the Top 100 materials scientists in the world (2000–2010) by Thomson Reuters in 2011, won a Distinguished Scientist Award from International Association of Dental Research in 2013, and won a Clemson Award from the Society for Biomaterials in 2013. He is an elected Fellow of the American Institute for Medical and Biological Engineering, Fellow of Biomaterials Science and Engineering, Fellow of the Materials Research Society, and Fellow of American Association for Advancement of Science.

ALISON MARSDEN, PHD, MSE, BSE is an Associate Professor and Wall Center scholar in the departments of Pediatrics, Bioengineering, and, by courtesy, Mechanical Engineering at Stanford University. From 2007-2015 she was a faculty member in the Mechanical and Aerospace Engineering Department at the University of California, San Diego. She graduated with a bachelor’s degree in Mechanical Engineering from Princeton University in 1998 and a PhD in Mechanical Engineering from Stanford in 2005 working with Prof. Parviz Moin. She was a postdoctoral fellow at Stanford University in Bioengineering and Pediatric Cardiology from 2005-07 working with Charles Taylor and Jeffrey Feinstein. She was the recipient of a Burroughs Wellcome Career Award at the Scientific Interface in 2007, an NSF CAREER award in 2011, and is a member of an international Ledcuq Foundation Network of Excellence. She received the UCSD graduate student association faculty mentor award in 2014 and MAE department teaching award at UCSD in 2015. She has published over 80 peer reviewed journal papers, and has received funding from the NSF, NIH, and several private foundations. She is currently on the editorial boards of several leading journals in biomechanics. Her work focuses on the development of numerical methods for cardiovascular blood flow simulation, medical device design, application of optimization to large-scale fluid mechanics simulations, and application of engineering tools to impact patient care in cardiovascular surgery and congenital heart disease.

PATRICK I. MCCONNELL, MD is an Attending Surgeon in the Department of Cardiothoracic Surgery at The Heart Center at Nationwide Children’s Hospital. He is Assistant Professor of Surgery at The Ohio State University College of Medicine. Dr. McConnell received his medical degree from University of Nebraska Medical Center and completed Surgery residency at the University of Utah. He completed fellowships at New York Medical College, Oregon Health & Science University, The Ohio State University Medical Center and Nationwide Children’s Hospital. Dr. McConnell’s clinical activities include congenital cardiac surgery for adult congenital heart disease and pediatric mechanical assist devices. His primary research interests involve the use of mechanical assist devices and associated therapies targeting heart recovery. He is board certified in Surgery, Pediatrics, and Critical Care.

LAURA E. NIKLASON, MD, PHD is the Nicholas M. Greene Professor at Yale University in Anesthesia and Biomedical Engineering, where she has been on faculty since 2006. Dr. Niklason’s research focuses primarily on regenerative strategies for cardiovascular and lung tissues. Niklason’s engineered blood vessels are currently in clinical trials, and are the first life-sustaining engineered tissue to be studied in any Phase III trial. Niklason’s lab was also one of the first to describe the engineering of whole lung tissue that could exchange gas in vivo, and this work was cited in 2010 as one of the top 50 most important inventions of the year by Time Magazine. She was inducted into the National Academy of Inventors in 2014, and was elected to the National Academy of Medicine in 2015. Niklason received her PhD in Biophysics from the University of Chicago, and her MD from the University of Michigan.

XIUMEI MO earned a PhD degree from Dohusha University in 1991, and then worked as an associate professor at East China University of Science and Technology from 1991 to 1997. She spent two years as a Postdoc experience in Kyoto University, three years as a research fellow experience at National University of Singapore, and one year as a visiting professor at Aachen University of Applied Science and Technology. She has served as a professor at Dohusha University from 2004 and built a Biomaterials and Tissue Engineering Lab. She was granted 20 projects related with nanofiber fabrication for different tissue regeneration. Her research are related to electrospinning nanofiber for drug delivery and injectable hydrogel for tissue engineering. She has published 200 papers. She received the Science Technical Innovation Awards from Shanghai Municipality in 2008 and Science and Technology Progress Awards from State Department of People’s Republic of China in 2009. She is a committee member of the China Biomedical Engineering Society Biomaterials Branch.

R. LAWRENCE MOSS, MD, FACS, FAAP joined Nationwide Children’s Hospital in 2011 as Surgeon-in-Chief and the E. Thomas Boles Jr., Professor of Surgery at The Ohio State University College of Medicine. Dr. Moss is internationally known for the application of clinical trials and evidence based techniques in children’s surgery. He led the first multi-center trial comparing operative treatment in neonates, which was reported in the New England Journal of Medicine. He has a strong interest in necrotizing enterocolitis and other life threatening problems in infants. He currently leads a multi-center consortium investigating biologic predictors of outcomes and novel therapies for NEC. Dr. Moss has received over 10 years of continuous research funding from the National Institutes of Health, the FDA, private foundations, and the pharmaceutical industry. He has authored over 150 articles in peer reviewed literature and held numerous leadership positions in surgical societies nationally. Dr. Moss is also interested in the measurement and improvement of surgical outcomes. He is a founding member of the American College of Surgeons Pediatric National Surgical Quality Improvement Program. He has served as the Director of Quality Improvement programs in both pediatric and adult academic medical centers and has held leadership and advisory roles in health quality for the American Academy of Pediatrics, FDA, and the Agency for Healthcare Research and Quality. Dr. Moss received a degree in English Literature from Stanford University. He attended medical school at the University of California, San Diego and completed General Surgery Residency at Virginia Mason Medical Center in Seattle. He then moved to Chicago and completed Extracorporeal Membrane Oxygenation/Critical Care and Pediatric Surgery fellowships at Northwestern University. Dr. Moss spent six years on the faculty at Stanford University before moving to Yale University in 2002. At Yale he served as the Robert Prizker Professor of Surgery and Surgeon-in-Chief at Yale New Haven Children’s Hospital. In this role, he doubled the number of faculty and quadrupled research funding. Dr. Moss’ clinical practice includes the full spectrum of Pediatric Surgery with special interests in neonatal surgery, complex pelvic malformations, and separation of conjoined twins.

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TIM PENNEL, MBChB, PhD obtained his MBChB degree from the University of Stellenbosch, South Africa in 2003. Following two years of general surgery, he joined the University of Cape Town (UCT) as a resident in Cardiac Surgery. During this time Dr Pennel simultaneously completed his master's degree (MMED) and PhD in Cardiothoracic Surgery, and was inducted into the College of Medicine as a specialist Cardiothoracic surgeon in 2014. Under the guidance of Prof Peter Zillia at the Cardiovascular Research Unit in Cape Town, Dr Pennel developed a small animal model to investigate the mechanism of vascular graft healing in high-porosity polymers and decellularized xenografts. Dr Pennel serves as the chair of the surgical research committee at UCT and is an executive committee member of the International Society for Applied Cardiovascular Biology (ISACB). His particular clinical interest in heart and lung transplantation at the Chris Barnard division of Cardiothoracic surgery and is currently overseeing several clinical studies with international collaborators at Groote Schuur hospital.

DR. JORIS ROTMANS is an internist-nephrologist and Associate Professor at the Department of Nephrology of the Leiden University Medical Center (LUMC) in the Netherlands. He obtained his master's degree in Medicine (cum laude) at the Free University at Amsterdam. He received his PhD in 2005 at University of Amsterdam on new therapeutic strategies for vascular access for hemodialysis whereupon he started his residency in Internal Medicine at the University Medical Center in Leiden. Dr. Rotmans' main research interest is in dialysis vascular access and uremic vascular disease and while at the University of Cincinnati (for over 15 years), he directed the Dialysis Access Research Program which was a comprehensive, integrated, multi-disciplinary translational research program, which included basic science, clinical science and patient care components. This translational research program was funded through the National Institutes of Health, the Veterans Administration research program and through industry grants. Dr. Roy-Chaudhury has received national and international awards, has published over 150 peer reviewed manuscripts and is a sought after invited speaker, both nationally and internationally. Dr. Roy-Chaudhury has also been actively involved in the public policy and administrative aspects of dialysis vascular access care and hemodialysis as a board member/council/committee chair for the American Society of Diabetic and Vascular Renal Nephrology, the Renal Network, the Interventional Nephrology Advisory Group of the American Society of Nephrology (ASN), the Cincinnati chapter of the National Kidney Foundation and the Medical Advisory Board of the Life Center (Ohio). He is a member of the ASN Board of Advisors and Capitol Hill advocacy team, the ASN Post Graduation Education Committee and the International Society of Nephrology-India and South Asia Committees, as well as being the President of the American Nephrologists of Indian Origin (ANIO). Dr. Roy-Chaudhury is also the American Society of Nephrology co-chair of the Kidney Health Initiative which is a public-private partnership between the ASN and the Fh which aims to bring together nephrologists, industry partners, patient advocacy groups and regulatory agencies; in an attempt to facilitate the passage of drugs, devices and biologics into the kidney disease space.

PRABIR ROY-CHAUDHURY MD, PhD, FRC (Edin) is a Professor of Medicine at the University of Arizona Health Sciences. He is also the Director of the Division of Nephrology and the Director of the Arizona Kidney and Vascular Center. After graduating from the Armed Forces Medical College, Pune, India, he trained in Internal Medicine and Nephrology at the University of Aberdeen, Scotland and at the Beth Israel Hospital, Harvard Medical School, Boston, USA. In addition to being an active transplant nephrologist, Dr. Roy-Chaudhury's main research interest is in dialysis vascular access and uremic vascular disease and while at the University of Cincinnati (for over 15 years), he directed the Dialysis Vascular Access Research Program which was a comprehensive, integrated, multi-disciplinary translational research program, which included basic science, clinical science and patient care components. This translational research program was funded through the National Institutes of Health, the Veterans Administration research program and through industry grants. Dr. Roy-Chaudhury has received national and international awards, has published over 150 peer reviewed manuscripts and is a sought after invited speaker, both nationally and internationally. Dr. Roy-Chaudhury has also been actively involved in the public policy and administrative aspects of dialysis vascular access care and hemodialysis as a board member/council/committee chair for the American Society of Diabetic and Vascular Renal Nephrology, the Renal Network, the Interventional Nephrology Advisory Group of the American Society of Nephrology (ASN), the Cincinnati chapter of the National Kidney Foundation and the Medical Advisory Board of the Life Center (Ohio). He is a member of the ASN Board of Advisors and Capitol Hill advocacy team, the ASN Post Graduation Education Committee and the International Society of Nephrology-India and South Asia Committees, as well as being the President of the American Nephrologists of Indian Origin (ANIO). Dr. Roy-Chaudhury is also the American Society of Nephrology co-chair of the Kidney Health Initiative which is a public-private partnership between the ASN and the Fh which aims to bring together nephrologists, industry partners, patient advocacy groups and regulatory agencies; in an attempt to facilitate the passage of drugs, devices and biologics into the kidney disease space.

FREDERICK J. SCHOFEN, MD, PhD is Professor of Pathology and Health Sciences and Technology (HST) at Harvard Medical School, and Executive Vice-Chairman of the Department of Pathology at (BWU). His research focuses on the pathobiology of native, conventional substitute and engineered tissue valves and vascular grafts. In institutional roles, he promotes multidisciplinary innovation using technology, provides mentoring and career development leadership for translational research, and teaches Pathology, Biomaterials, Tissue Engineering and Medical Device Development. He serves on the Massachusetts Life Sciences Centers SAB, and many other academic and governmental advisory, grant review and editorial committees, and consults with medical device companies.

TOSHINARI SHINOZA received a MD degree from Hiroshima University in 1983 and worked as a surgical resident at the Heart Institute of Japan, Tokyo Women's Medical University between 1983 and 1989. He had three years Postdoc experience at Boston Children's Hospital, Harvard University. He became associate professor in pediatric cardiac surgery at Tokyo Women's Medical University in 1998, and Professor in division of cardiovascular tissue engineering in 2004. He was recruited to Yale University and went on to become a director of pediatric cardiovascular surgery in 2006. Currently he is a Professor of Surgery at Ohio State University and Director of the Cardiovascular Tissue Engineering Program at Nationwide Children's Hospital.

ROBERT T. TRANQUILLO received his PhD in Chemical Engineering in 1986 from the University of Pennsylvania. He was a NATO Postdoctoral Fellow at the Center for Mathematical Biology at Oxford for one year before beginning his appointment in the Department of Chemical Engineering & Materials Science at the University of Minnesota in 1987. He has served as the head of the Department of Biomedical Engineering since its inception in 2000. Tranquillo has used a combined modeling and experimental approach to understand cell behavior, in particular, directed cell migration, and cell-matrix mechanical interactions. More recently, his research program has focused on the role of these cell behaviors in cardiovascular and neural tissue engineering applications. His research program has resulted in over 110 peer-reviewed original research publications, being recognized with his selection for the TERSIS-AM Senior Scientists Award in 2015. Prof. Tranquillo is a Fellow of the American Institute of Medical and Biological Engineering, International Academy of Medical and Biological Engineering, and the Biomedical Engineering Society, and he is also a Distinguished McKnight University Professor.

DAVID A. VORP, PhD is the William Kepler Whitford Professor of Bioengineering, with secondary appointments in the Department of Cardiothoracic Surgery, the Department of Surgery, and the Clinical and Translational Sciences Institute at the University of Pittsburgh. He received both his BS and PhD degrees in Mechanical Engineering from the University of Pittsburgh in 1986 and 1992, as the founding Director for the Center for Vascular Remodeling and Regeneration, as the Co-Director of the Center for Medical Innovation, and as the Interim Director of the Petersen Institute for Nano-Science and Engineering. Dr. Vorp has worked closely with clinical colleagues to develop a multi-disciplinary, NIH-funded research program focusing on abdominal aortic aneurysm disease, vascular “mechanopathobiology”, and tissue engineering and regenerative medicine applications for vascular and urethral systems. Dr. Vorp has published 110 peer-reviewed articles to date, and currently serves on three editorial boards. His research has been supported by nearly $9 million in funding as principal investigator (PI), and an additional $4 million as collaborating investigator, from foundation and federal agencies, including the American Heart Association (AHA) and the National Institutes of Health (NIH). In 2009, Dr. Vorp co-founded Neograft Technologies, Inc., which focuses on the commercialization of AngioshieldTM, a vein graft modification technology developed in his laboratory which underwent “first-in-man” studies this earlier year. He currently holds four patents in this and other technologies. In 2011 Dr. Vorp was recognized with the Van C. Mow Medal from the American Society of Mechanical Engineers (ASME), was twice awarded a Pitt Innovator Award, and received the Carnegie Life Sciences Award in 2013. He served on the Executive Committee of the ASME Bioengineering Division (BED; 2006-2015), serving as ASME BED Chair from 2013-2014. Dr. Vorp was elected to the Board of Directors of the Biomedical Engineering Society (BMES) for two terms (2006-2009; 2009-2012), and is in his second elected term as BMES Secretary (2012-2014; 2014-2016), an executive post. In 2012, Dr. Vorp became the first non-MD President of the International Society for Applied Cardiovascular Biology, and was re-elected for a second term in 2014. Dr. Vorp is a Fellow of ASME, BMES and the American Institute of Medical and Biological Engineering.
invaluable in the learning experience of group members, not to mention the input such experience has on the creative environment. The front-line experience afforded by the clinical environment has proven to be invaluable to the clinical successes and failures of currently employed cardiovascular devices while concurrently working on projects that are comprised of graduate students in Bioengineering and Chemical Engineering as well as post-doctoral fellows with backgrounds in surgery, polymer chemistry, or engineering. Researchers within Dr. Wagner’s group are afforded the opportunity to observe first-hand the clinical successes and failures of currently employed cardiovascular devices while concurrently working on projects that attempt to describe the current modes of failure, test solutions for the current device shortcomings, or develop technologies that may find application as future cardiovascular therapies. The front-line experience afforded by the clinical environment has proven invaluable in the learning experience of group members, not to mention the input such experience has on the creative environment.

WILLIAM R. WAGNER, PhD is the Director of the McGowan Institute for Regenerative Medicine as well as a Professor of Surgery, Bioengineering and Chemical Engineering at the University of Pittsburgh. He also currently serves as Chairman of the Tissue Engineering and Regenerative Medicine International Society (TERMIS) – Americas, the Deputy Director of the NSF Engineering Research Center on “Revolutionizing Metallic Biomaterials” and Chief Scientific Officer of the Armed Forces Institute of Regenerative Medicine. He holds a BS (Johns Hopkins Univ.) and PhD (Univ. of Texas) in Chemical Engineering. Professor Wagner is the Founding Editor and Editor-in-Chief of one of the leading biomaterials and biomedical engineering journals, Acta Biomaterialia, and currently serves on the editorial boards of the Journal of Biomedical Materials Research Part A, Biotechnology and Bioengineering, Organogenesis, Experimental Biology & Medicine, and the Journal of Tissue Engineering and Regenerative Medicine. Dr. Wagner is a past president of the American Society for Artificial Internal Organs (AASAO; 2010-2011) and has served on the Executive Board of the International Federation of Artificial Organs (IFAO). He is a fellow and former vice president of the American Institute for Medical and Biological Engineering (AIMBE; 2000) and has been elected a fellow of the Biomedical Engineering Society (2007), the International Union of Societies for Bion materials Science and Engineering (2008), the American Heart Association (2001) and TERMIS (2015). He has served as Chairman for the Gordon Research Conference on Biomaterials: Biocompatibility & Tissue Engineering as well as for the Biomedical Engineering Society Annual Meeting, AASAO, and the First World Congress of TERMIS. He was previously recognized by selection to the “Scientific American 50”, the magazine’s annual list recognizing leaders in science and technology from the research, business and policy fields. In 2011 he was awarded the Society for Biomaterials Clemson Award for Applied Research, in 2012 he received the Chancellor’s Distinguished Research Award from the University of Pittsburgh and in 2013 he received the TERMIS Senior Scientist Award. He has served on numerous NIH and NSF study sections, is a member of the NIH College of Reviewers, and has been a member of external review committees for national and international organizations focused on bioengineering and regenerative medicine. His research has generated numerous patents and patent filings that have resulted in licensing activity, the formation of a company that has reached clinical trials, and University of Pittsburgh Innovator Awards in 2007, 2008, 2009, 2010 and 2014. Dr. Wagner’s research interests are generally in the area of cardiovascular engineering with projects that address medical device biocompatibility and design, hypothesis-driven biomaterials development, tissue engineering, and targeted imaging. His research group has comprised of graduate students in Bioengineering and Chemical Engineering as well as post-doctoral fellows with backgrounds in surgery, polymer chemistry, or engineering. Researchers within Dr. Wagner’s group are afforded the opportunity to observe first-hand the clinical successes and failures of currently employed cardiovascular devices while concurrently working on projects that attempt to describe the current modes of failure, test solutions for the current device shortcomings, or develop technologies that may find application as future cardiovascular therapies. The front-line experience afforded by the clinical environment has proven invaluable in the learning experience of group members, not to mention the input such experience has on the creative environment.

BEAT K. WALPOTH, MD, PD, FAHA is a trained cardiovascular surgeon, past Director of Cardiovascular Research in the Department of Surgery at Geneva University Hospital, Switzerland. He obtained his medical degree in 1972 at the University of Zurich, followed by Board of Surgery (including thoracic and cardiovascular) in 1982. Postgraduate training included two years at the Peter Bent Brigham, a Harvard University Hospital, Boston (1973-75) and cardiac transplantation at Stanford University (1982-84). Teaching appointments were held at University Hospital Zurich, University of Bern (Emeritus) and still ongoing in Verona University (Visiting Professor). Dr. Walporth is a recipient of several national and international awards, including the ESAO Wichtig Award in the years 2008 and 2012 for his group’s research on vascular tissue engineering. He has over 150 publications, of which more than 50 are first-author papers, in peer reviewed journals. Past-president of the European Society for Artificial Organs (ESAO); organizer of the Annual Congresses of the ESAO in 2000 in Lausanne, and 2008 in Geneva, as well as co-organiser of ESAO Winter Schools in 2007, 2008 and 2012. He has also been responsible for the bi-annual Swiss Experimental Surgery Symposium (2006, 2008, 2010, 2012 and 2016). He is a member of the International Faculty for Artificial Organs and the Director of the Internationally Co-tutored PhD Course in biotechnology and bioengineering (Universities of Geneva and Verona) since 2005. Currently, he holds the presidency of the International Symposium on Vascular Tissue Engineering (ISVTE) and is creating the TERMIS Thematic Group on Vascular Tissue Engineering. His current main areas of interest include vascular tissue engineering, cell therapy, angiogenesis as well as bio- artificial cardiovascular support. Other areas of interest are cardiovascular physiology, coronary blood flow measurements, rejection and transplantation immunology as well as hypothermia for which he has initiated the International Hypothermia Registry. His future projects are to support the initiated changes from artificial to bio-artificial, i.e. tissue engineered organs, as well as continuing international teaching and networking in the field of cardiovascular bio-engineering.

YADONG WANG, PHD is the William Kepler Whiteford Professor of Bioengineering with adjunct positions in Chemical Engineering and Surgery at the University of Pittsburgh. He obtained his PhD degree in Chemistry at Stanford University in 1999, and performed his postdoctoral studies in biomaterials at MIT. He joined the Bioengineering Department at University of Pittsburgh in 2008 after serving as an assistant professor at the Georgia Institute of Technology for 5 years. His research focuses on creating biomaterials that present controlled chemical, physical, and mechanical signals to cells, tissues and organs. The ultimate goal is to control how the human body interacts with these materials. He is especially interested in applications of biomaterials in the cardiovascular, nervous and musculoskeletal systems. His team enjoys collaborating with other scientists and clinicians who share the same passion in translational research. Current projects include vascular grafts, controlled release of proteins and microfabrication of biomaterials.

ANTHONY WEISS, PHD is the McCaughy Chair in Biochemistry, Professor of Biochemistry & Molecular Biotechnology at the University of Sydney, Professor at the Bosch Institute, Professor at the Charles Perkins Centre, Professor at the Royal Prince Alfred Hospital (Honorary) and biotech company founder. He was Chair SMB Proteomics and Biotechnology at the University of Sydney where he also was also Foundation Chair of Molecular Biotechnology, Awards include FTSE, FRSC, FRACI, FAIMBE, FRSA, FAcSS, Fulbright Scholar, Roslyn Floris Goudston Prize, NIH Fogarty International Fellow, Thomas and Ethel Mary Ewing Scholar, Australian Academy of Science and Royal Society Exchange Scholar, David Syme Research Medal, Amersham Pharmacia Biotechnology Medal, NSW Commercialization Expo Prize, Australian Innovation Challenge Award, Sir Zelman Cowen Exchange Fellow, Fondation des Teillies Scholar, Pauling Prize Medal, Barry Preston Award, Australasian Society for Biomaterials and Tissue Engineering Research Excellence Award, FAOBMB Entrepreneurship Award, Applied Research Medal, and Innovator of Influence Award. National appointments include the Australian Biotechnology Advisory Council, National Enabling Technology Strategy Advisory Council,Institute of Biomedical Sciences and Biotechnology, and Australian Research Council College of Experts where I was national Chair. He is also an inventor with thirty-five awarded international patents. He is on the Editorial Boards of ACS Biomaterials Science & Engineering, Biomacromolecules, Biomaterials, Biomedical Materials, BioNanoScience and Tissue Engineering.
We are pleased to introduce the abstracts accepted for presentation at the 3rd International Symposium on Vascular Tissue Engineering, being held June 5 – 6, 2017 in Columbus, Ohio, USA at Nationwide Children’s Hospital.

Six abstract submissions have been selected for oral presentation. Selected oral presentations are listed in the agenda and also indicated with an asterisk (*) in this section.
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Abstract Author(s): Zhihong Wang, Yifan Wu, Juaning Wang, Deling Kong

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Country of Origin: United States
Abstract Author(s): VK Pepper, CA Best, S Miyamoto, EA Otwuka, H Miyachi, N King, J Reinhardt, A Lee, J Drews, T Shoji, ED Heuer, S Cheatham, JL Chisolm, T Sugiuara, T Shinoka, JP Cheatham, CK Breuer

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Country of Origin: United States
Abstract Author(s): Hannah A. Strobel, Marco Piola, Gianfranco Beniamino Fiore, Monica Soncini, Eben Aldberg, Marsha W. Rolle

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Country of Origin: United States
Abstract Author(s): Takuma Fukunishi, Chin Siang Ong, Huaitao Zhang, Jochen Steppan, Lakshmi Santhanam, Dan Berkowitz, Luca Vicella, Carissa M. Smoot, Seth A. Winner, Jeremy J. Harris, Peter D. Gabriele, Steven Lu, Narutoshi Hibino

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Country of Origin: United States
Abstract Author(s): Cameron Best, Victoria Pepper, Ekene Otwuka, Yong-Ung Lee, Avione Lee, James Reinhardt, Sayali Dharmadhikari, Kevin Blum, Eric Heuer, Nakesha King, Toshiharu Shinoka, Christopher Breuer

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Country of Origin: United States
Abstract Author(s): Yang Lin, Gil Changhyun, Nutan Prasain, Tarnawsky Stefan, Yoshimoto Momoko, Mike Ferkowicz, Sisi Chen, William Shelly, Yan Liu, Yi Zheng, Mervin Yoder

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Country of Origin: United States
Abstract Author(s): Chelsea E.T. Stowell, Piyusha S. Gade, Cody B. Cockreham, Anne M. Robertson, Edith Tzeng, Yadong Wang

27. PREPARATION OF INTEGRATED VALVED CONDUIT VIA TIPS AND 3D PRINTING FOR THE TREATMENT OF CONGENITAL HEART DISEASES
Country of Origin: China
Abstract Author(s): Jiaying Zhang, Jun Du, Dekai Xia, Jinlong Liu, Tong Wu, Jing Shi, Wei Song, Dawei Jin, Haibo Zhang, Xiumei Mo, Meng Yin

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Country of Origin: United States
Abstract Author(s): Anh Lu, Robert T. Tranquillo
A HIGHLY EFFICIENT IN VITRO SMOOTH MUSCLE CELLS (SMCS) DIFFERENTIATION SYSTEM FROM HUMAN ESCS/IPSCS-DERIVED NEURAL CREST STEM CELLS (NCSCS)

Country of Origin: United States
Abstract Author(s): Ping Qiu, Wei Xiong, Jian Gong, Yang Bo

The development of human induced pluripotent stem cells (iPSCs) provides a great promise for disease modeling and tissue engineering. Due to the high frequency of aortopathic complication in ascending aorta of thoracic aortic aneurysm (TAA) patients, there is a big challenge to establish a highly efficient in vitro SMCS differentiation system through patients’ iPSCs-derived NCSCs, by which SMCS could be massively produced in vitro for tissue engineering, as well as the characteristics of embryonic origin of SMCS would be recaptured for disease modeling. Here in this study, we create a highly efficient in vitro SMCS differentiation system that represents ascending aortic SMCS, by which NCSCs could be first induced from both human embryonic stem cells (ESCs) and iPSCs by application of combined three small molecule inhibitors (3i: LDN-193189, SB-431542, and CHIR99021) for Bone morphogenetic protein (BMP), activin/TGF-β, and glycogen synthase kinase 3 (GSK-3) stimulation. Compare to traditional 2i (Noggin plus SB-431542) protocol for in vitro SMCS differentiation from human ESCs/iPSCs, a five-fold expression level of late smooth muscle differentiation marker, myh11, has been detected in 3i-NCSCs-derived SMCS. Other smooth muscle specific markers, such as myocardin, SM-actin, and SM-calponin, in 3i-NCSCs-derived SMCS have also shown significant increased expression levels than ones in 2i-NCSCs-derived SMCS. This optimized protocol also demonstrated preferred SMCS differentiation program than other programs of NCSCs-derived cell-type differentiation (i.e. neuronal differentiation). 3i-NCSCs-derived SMCS functionally contract in response to carbachol treatment. By using the created in vitro SMCS differentiation system, we have successfully recaptured the defected SMCS differentiation process in 3i-NCSCs-derived SMCS from iPSCs of TAA patients with Smad3 mutation.

A “SAME-DAY” SEEDED ELASTOMERIC SCAFFOLD FOR AN AUTOLOGOUS TISSUE-ENGINEERED VASCULAR GRAFT

Country of Origin: United States
Abstract Authors: Darren Haskett, Kamiel Saleh, Katherine Lorentz, Justin Weinbaum, Antonio D’Amore, William Wagner, Lauren Kokai, J. Peter Rubin, David Vorp

Tissue engineered vascular grafts (TEVGs) containing adipose derived mesenchymal stem cells (ADMSCs) offer an alternative to small diameter vascular grafts currently used in cardiac and lower extremity revascularization procedures. ADMSC infused TEVGs have been shown to promote remodeling and vascular homeostasis in vivo and offer a possible treatment solution for those suffering from cardiovascular disease. Unfortunately, the time needed to cultivate ADMSCs remains a large hurdle for TEVGs as a treatment option. The purpose of this study was to determine if the stromal vascular fraction (SVF) (known to contain progenitor cells) seeded TEVGs would remain patent in vivo and remodel after a “same day” implantation.

SVF, obtained from adult adipose tissue, was seeded within 4 hours after acquisition from the patient onto poly(ester urethane) urea (PEUU) bilayered scaffolds using a customized rotational vacuum seeding device. Constructs were then surgically implanted as abdominal aortic interposition grafts in Lewis rats. Implanted scaffolds were allowed to remodel up to 8 weeks. Patency was documented using angiography and gross inspection, while vascular components, along with the presence of any remaining implanted cells, were detected using histology and immunofluorescent chemistry (IFC).

Initial findings demonstrated patency up to 8 weeks in vivo. IFC for human cells using a human nuclear antigen was negative at 8 weeks. Further IFC analysis was positive for von Willebrand Factor indicating the presence of an endothelium, and smooth muscle alpha actin suggesting the presence of smooth muscle cells in the neotissue.

In conclusion, a “same day” SVF-seeded TEVG can remain patent after implantation in vivo, with remodeling and neo-tissue formation occurring by 8 weeks. Future work aims to determine the fate of SVF cells and their ability to initiate in vivo remodeling to advance TEVG technology towards a “same-day” implementation and greatly enhance its appeal for clinical use.
ABSTRACTS

*ADIPOSE-DERIVED STEM CELLS AND VASCULARIZED LYMPH NODE TRANSFERS SUCCESSFULLY TREAT MOUSE HINDLIMB SECONDARY LYMPHEDEMA THROUGH EARLY RE-CONNECTION OF THE LYMPHATIC SYSTEM AND LYMPHANGIOGENESIS*
Country of Origin: Japan
Abstract Author(s): Sadanori Akita

Secondary lymphedema is often observed in post-malignancy treatment of the breast and the gynecologic organ and often results in acute or chronic wounds with persistent exudate and infection, but effective therapies have not been established in chronic cases even with advanced physiological surgeries as treated with lymphatico-venous anastomosis in acute cases. Currently, reconstructive surgery with novel approaches has been attempted with vascularized tissue including functional lymphatic vessels. In order to create chronic lymphedema model and investigate the therapeutic modalities, the hindlimbs of 10-week-old male C57BL/6J mice, after 30 Gy X-ray radiation, surgical lymph node dissection, and 5-mm gap creation, were divided into 4 groups, with vascularized lymph node transfer (VLNT) abdominal flap, and 1.0 x 104 adipose-derived stem cells (ADSC). Lymphatic flow assessment, a water-displacement plethysmometer paw volumetry test, tissue quantification of lymphatic vessels, and functional analysis of lymphatic vessels and nodes were performed via intra-vascular imaging. Photo Dynamic Eye (PDE) images using, indocyanine green fluorescence, demonstrated immediate staining in subiliac lymph nodes, and linear pattern imaging of the proximal region was observed in the combined treatment of ADSC and VLNT. Both percent improvement and percent deterioration in the combined treatment of ADSC and VLNT were significantly better than in other treatments (p<0.05). The numbers of lymphatic vessels with LYVE-1 immunoreactivity significantly increased when treated with ADSCs (P<0.05) and B16 melanoma cells were metastasized in groups treated with VLNTs by day 28. ADSCs increase the number of lymphatic vessels and VLNTs induce the lymphatic flow drainage to the circulatory system. Combined ADSC and VLNT treatment in a secondary lymphedema may effectively decrease edema volume and lymphatic function by lymphangiogenesis and the lymphatic to venous circulation route.

*AN OPTIMIZED INDUCED PLURIPOTENT STEM CELL-DERIVED TISSUE ENGINEERED BLOOD VESSEL MODEL OF HUTCHINSON- GILFORD PROGERIA SYNDROME FOR DRUG TOXICITY TESTING*
Country of Origin: United States
Abstract Author(s): Leigh Atchison, Elizabeth Snyder-Mounts, Kan Cao, George Truskey

Hutchison-Gilford Progeria Syndrome (HGPS) is a rare, accelerated aging disorder caused by an altered form of the lamin A gene termed progerin. The primary cause of death is cardiovascular disease before age 20. The toxic progerin protein has been shown to be present in both HGPS patients and the normal aging population indicating a potential link between the two diseases. This idea, however, is primarily based on studies in 2D cell cultures and mouse models. Due to the inability for these previous models to provide a strong representation of the Progeria cardiovascular disease state, there is a drive to nd a more accurate model to better understand the link between normal cardiovascular aging and Progeria and discover novel therapeutics. We have developed a tissue engineered blood vessel (TEBV) model of HGPS using induced pluripotent stem cell-derived smooth muscle cells (iSMCs) that replicates known pathology of the Progeria phenotype and functional improvement in response to proposed therapeutics. The iSMC TEBV model, however, does not function at the same levels as TEBVs fabricated from primary cells and involves a lengthy differentiation process. To improve the sensitivity of our platform we used a modi ed protocol from Patsch et al. to di erentiate the two main cell types that comprise an arteriole, vascular smooth muscle cells (vSMCs) and endothelial cells (iECs) to create a patient speci c iTEBV platform of the disease. These cells can be di erentiated directly from iPSCs in one week and directly incorporated into our TEBV constructs for immediate perfusion and drug analysis. Our results show that iTEBVs fabricated from vSMCs and iECs derived using the Patsch et al protocol have improved functional response and increased expression of smooth muscle contractile proteins while still maintaining aspects of the HGPS disease phenotype compared to iSMC TEBVs. This improved model will allow for a more sensitive drug testing platform to model this complex disease and help parse out drug candidates as well as the link between normal cardiovascular aging and HGPS.
ABSTRACTS

BIOCOMPATIBILITY OF UREIDO-PYRIMIDINONE COMPOUNDS AND THEIR DEGRADATION PRODUCTS IN RELATION TO ENDOTHELIAL COLONY FORMING CELLS
Country of Origin: The Netherlands

Introduction: Ureido-pyrimidinone (UPy)-based supramolecular biomaterials can be tailored to form versatile hydrogels or thermoplastic elastomers. A long-term success requirement for many regenerative medicine purposes in which UPy biomaterials can be applied, is biocompatibility of UPy compounds. Especially in vascular applications the role of circulating endothelial progenitor cells (EPC) is crucial.

Hypothesis: Due to their resemblance to naturally occurring purines and pyrimidines, UPy-compounds and their degradation products could possibly act as false substrates for several cellular process including nucleo(t/s)ide synthesis and bioenergetics in an EPC population, i.e. the endothelial colony forming cells (ECFC) is crucial.

Methods: Primary human cord-blood derived ECFCs (n=3 donors) were exposed to a dose-range, restricted to the upper range (mM) expected in vivo, of UPy-compounds (n=2), anticipated degradation products (n=4) or a material proposed as both

Results: ECFC viability was preserved with exposure to uM concentrations of UPy degradation compounds, but slightly decreased by mM concentrations. Proliferation was affected at higher uM concentrations, particularly for compounds 2, 5, 6 and 7. Metabolic activity, angiogenic sprouting and cellular migration were not affected by uM ranges.

Conclusions: Soluble products of UPy-based biomaterials do not affect viability or interfere with endothelial function in biologically relevant concentrations, indicating that UPy biomaterials are biocompatible in human systems.

DEVELOPMENT OF A TISSUE ENGINEERED VASCULAR GRAFT FOR VASCULARIZATION OF LARGE TISSUE CONSTRUCTS
Country of Origin: United States
Abstract Author(s): Alexander Stahl, Yunzhi Peter Yang

Introduction: Many tissue engineered constructs are unsuitable for clinical implementation due to their limited ability to vascularize, which can lead to graft necrosis - especially in large-scale implants. We aim to engineer a large vascularized graft as an alternative for free ap transfer that can be surgically attached to host vessels to provide immediate blood ow upon implantation of large tissue constructs.

Hypothesis: Our overarching hypothesis is that the integration of a synthetic polymer vessel surrogate within a hydrogel-based microvascular network will yield a hierarchical vascular bed that can be included within large-scale tissue constructs to rapidly restore blood perfusion.

Methods: To produce the synthetic polymer vessel grafts, biodegradable polyester was covalently linked to an antithrombotic drug, followed by heat curing in a tubular mold. We characterized the properties of the grafts in terms of mechanical properties, degradation, and drug release. Human umbilical vein endothelial cells (HUVEC) and human smooth muscle cells (hSMC) were cultured on and adjacent to the polymers to characterize vascular cell responses to the synthetic sca old materials.

Results: We developed elastomeric materials with variable levels of antiplatelet drug and crosslink density. e sustained release of the active drug from the polymer into surrounding aqueous media was confirmed by mass spectrometry and UV-vis spectrophotometry. HUVEC and SMC proliferated both in direct and indirect contact with our polymers. HUVEC seeded on the materials presented both confluent monolayers and angiogenic sprouting behavior when embedded in a collagen gel.

Conclusions: We have developed biodegradable elastomers for use as synthetic blood vessel surrogates. Covalent drug incorporation enables the release of an antithrombotic agent throughout the polymer lifetime. e material sti ness can be tuned within a range relevant to vascular tissue engineering. Robust vascular cell proliferation suggests the materials and their degradation products are non-toxic and cytocompatible. HUVEC cultured on the polymer surface displayed both endothelium-like and sprouting microvascular phenotypes, supporting the candidacy of our materials as substrates for engineering vascularized grafts.
ABSTRACTS

DEVELOPMENT OF IN VIVO TISSUE ENGINEERED XENOGENIC VASCULAR GRAFTS

Country of Origin: Japan
Abstract Author(s): Yamanami M, Kawasaki T, Kami D, Watanabe T, Kanda K, Gojo S, Yaku H

Objectives: Small-caliber synthetic vascular grafts (< 6 mm) are unsatisfactory. We have developed in vivo tissue-engineered autologous small-caliber vascular grafts, named “Biotubes”, which is constructed by a novel concept of regenerative medicine. We have reported Biotubes withstood systemic blood pressure and exhibited excellent performances as small caliber vascular prostheses in animal models. However, as it takes 4 weeks to fabricate Biotubes, they cannot respond to emergency surgery. Also, to flexibly respond to various types of surgery, it is ideal that grafts of various diameters and lengths are readily available for use in advance. The objectives of this study are to fabricate off-the-shelf small-caliber vascular grafts using xenogeneic animals.

Methods and Results: Silicone rod molds (diameter: 2mm, length: 10 cm) were placed into subcutaneous pouches of beagle dogs, and after 4 weeks the implants with their surrounded connective tissues were harvested. Biotubes with internal diameter of 2 mm were obtained as tubular connective tissues from the implants after pulling out the impregnated molds. Biotubes were perfused with 1% sodium dodecyl sulfate (SDS) and 1% Triton-X. After decellularization, total DNA content was less than 50 ng/mg dry tissue weight, which was considered as complete removal of genetic material. Tensile strength of the Biotubes did not significant change before and after decellularization, and sufficient strength were maintained. Decellularized biotube grafts (length: 10mm) were stored in phosphate-buffered saline (PBS) at 4 degree for 1 week. Decellularized biotube grafts (length: 10mm) were transplanted to the abdominal aorta of the rats (n = 3). After implantation, neither antiplatelet, anticoagulant nor immunosuppressive agents were administered. All rats survived without any signs of abnormal inflammation or immunological problems due to the xenogeneic material. After 1 month, echocardiography revealed all grafts were patent. Histological evaluation revealed that grafts formed neointima on the luminal surface and graft walls had cell infiltration.

Conclusions: The xenogeneic decellularized bionube functioned as a small caliber vascular graft as well as an autologous biotube. With this technology, grafts could be fabricated using xenogeneic animals in advance and stored for a significant period, which satisfy the condition for off-the-shelf grafts.

DIRECTING VASCULAR REGENERATION OF A-CELLULAR GRANTS IN-SITU

Country of Origin: United States
Abstract Author(s): Randall J. Smith Jr, Sindhu Row; Daniel Swartz, Stelios Andreadis

Introduction: Recently our group demonstrated that immobilized vascular endothelial growth factor (VEGF) can capture circulating endothelial cells from the blood in-vitro. Furthermore, we have demonstrated proof of concept by implanting a-cellular tissue engineered vessels (A-TEVs) comprised of small intestinal submucosa (SIS) immobilized with heparin and VEGF into the arterial system of sheep which remained patent (92%, n=12) for 3mo. Upon analysis, the lumen of these grafts was comprised of a fully functional endothelium as early as 1mo post implantation. This study sought to identify the type of cells that are captured by VEGF on the lumen of A-TEVs in-vivo and understand how these cells turn into an endothelial (EC) monolayer that is capable of maintaining patency in-vivo.

Materials and Methods: A-TEV implantations were performed as previously published. Fixed explants of 1wk-6mo are assessed via IHC for MC and EC markers. Capture of VEGFR expressing cells from blood under flow will be assessed in a microfluidic device with a flat surface comprised of chitosan, heparin, and VEGF (CHV) as previously published. Blood borne mononuclear cells that are captured on surface immobilized VEGF are coaxed to differentiate into EC with a combination of soluble and biophysical signals.

Results and Discussion: A-TEVs were implanted as interpositional grafts into the arterial circulation of an ovine animal model. As early as 1mo post-implantation, the graft lumen was fully endothelialized as shown by IHC for EC markers, CD144 and eNOS. At the same time, luminal cells co-expressed leukocyte markers CD14 and CD163. Furthermore, blood mononuclear cells expressing high levels of VEGF receptors were captured on CHV surfaces with high specificity under a range of shear stresses and expressed high levels of CD14 and CD16. Finally, captured cells were differentiated towards an EC phenotype as shown by expression of CD144 and eNOS, additional 3C analysis, WB, qRT-PCR, and flow cytometry.

Conclusions: We demonstrate the ability of VEGF functionalized surfaces to capture cells directly from the blood in-vitro and in vivo. In the presence of the right biochemical and biophysical signals these cells differentiate into EC like cells that maintain graft patency and vascular function. Our results shed light into the process of vascular tissue regeneration in situ using the body’s regenerative capacity.
To promote vascular regeneration, three requirements for grafts should be considered: 1) appropriate biodegradation rate to match the speed of new vascular tissue formation; 2) material's elasticity to match the compliance of the adjacent native artery; 3) highly interconnected pore architecture for host cell infiltration to promote vascular remodeling. Here, a biodegradable elastomeric PLCL vascular graft with double layers was designed and fabricated using fiber-based techniques. The internal layer composed of circumferentially aligned microfibers was prepared by wet-spin, which can facilitate smooth muscle cells infiltration and alignment. The external layer composed of random nanofibers was prepared by electrospinning, which can enhance longitudinal mechanical strength and prevent bleeding. Further, rat abdominal aorta replacement model was used to investigate the performance of the grafts. At various time points (1, 4, 12 months), the grafts were explanted for functional, mechanical, biochemical and histological characterization. All grafts were patent, no formation of thrombosis or intimal hyperplasia was observed up to 12 months post implantation. The grafts became transparent and showed dynamic change of lumen area and wall thickness. The compliance of the new arteries increased gradually as PLCL degraded over time which was detected by Doppler ultrasound. In addition, a complete and confluent endothelium formed at one month. The regeneration of smooth muscle layer was accompanied by ECM deposition including collagen, elastin and glycosaminoglycan at 12 months. The regenerated neartery exhibited robust pulse and tough mechanical properties close to those of the native artery, and displayed obvious contraction and relaxation property in response to the vasoactive agents. The immunofluorescence staining and western blot illustrated that the protein expression level of smooth muscle cell phenotype markers including α-SMA, SM-MYH and calponin increased with the implantation time, which may be correlated with polymer degradation and compliance change of the implanted graft. Analysis of inflammatory factors showed slight inflammation in the whole regeneration process, which may be caused by polymer degradation. In summary, these results suggest that this PLCL vascular graft shows a great potential for the development of small diameter vascular grafts and deserves further investigation.
ABSTRACTS

ENZYME-PRODRUG TECHNOLOGY BASED ON MODIFIED-GALACTOSIDE/MUTANT-GALACTOSIDASE PAIR TO ENHANCE THE THERAPEUTIC EFFICACY IN HINDLIMB ISCHEMIA

Country of Origin: China
Abstract Author(s): Yiwa Pan, Jie Shen, Qiang Zhao, Deling Kong

Nitric oxide (NO) is an important signaling molecule mediating the angiogenesis. Previously, enzyme-prodrug technology (EPT) was employed based on β-galactosyl-caged-NO-donor (Gal-NO) and the relevant β-galacosidase for the vascular repair and regeneration as well as glaucoma therapy[1-4]. In spite of the therapeutic efficacy provided by the sustained release of NO, we also observed the unspecific release of NO catalyzed by the low level of endogenous enzymes in serum, which may lead to the side effects such as increased heart rate from 330 per minute to over 450 per minute when Gal-NO was i.v. administrated at 10 mg/kg dose. In this work, the Gal-NO was modified with a methyl group at the 6-O of the Gal unit. This new NO donor (O6M-Gal-NO) could hardly be hydrolyzed by endogenous galactosidase. Pharmacokinetic studies showed the elimination half-life of O6M-Gal-NO was 1.2 hour, which was almost three times longer than that of Gal-NO. Additionally, even i.v. administrated at 100 mg/kg dose, no dramatic side effect was observed. Then, based on crystal structures, a panel of mutant galactosidases were designed and expressed, from which H362A mutant derived from Thermusthermophilus A4 could efficiently hydrolyze O6M-Gal-NO. This O6M-Gal-NO/H362A pair was then evaluated by a critical limb ischemia model. Blood reperfusion was utilized to evaluate ischemia restoration, which showed a significantly increased reperfusion on day 7 and day 21 after surgery in the H362A group. The angiography results demonstrated that O6M-Gal-NO/H362A pair markedly augmented the generation of collateral vessels at the ischemia site. In addition, immunofluorescence staining also revealed that the number of capillaries in H362A group was 10% higher than that in control group. Histological analysis showed that the modified group exhibited obviously less fibrosis and better muscle regeneration. In summary, the O6M-Gal-NO donor could be effectively and specifically recognized by H362A galactosidase to release NO locally in vivo. Therefore, this modified-galactoside/engineered-galactosidase pair is promising to alleviate ischemic diseases via targeted NO replenishment. Moreover, our current work also highlights the broad potentials of this novel approach in clinical applications for tissue regeneration.

*EXCELLENT LONG-TERM IN-VIVO DATA WITH BIOABSORBABLE CAROTID GRAFTS

Country of Origin: The Netherlands
Abstract Author(s): Nicolas L’Heureux, Marieke Brugmans, Luke Burke, Martijn Cox, Maria Romero, Renu Virmani

Introduction The shortage of autologous vascular grafts and the suboptimal durability of the commercially available permanent synthetic grafts is an important clinical problem. Bioabsorbable vascular grafts can offer a new solution as they enable the patient’s body to restore a functional living tissue that replaces the implant material with time. This process is called endogenous tissue restoration (ETR). The objective of this study is to obtain long-term data on patency and ETR of bioabsorbable vascular grafts, implanted as an interposition of the carotid artery in the ovine model.

Methods: A total of 6 adult sheep underwent carotid artery replacement with an electrospun bioabsorbable vascular graft with an internal diameter of 6 or 7 mm (n=4 and 2, length 3-5 cm). Perioperative anticoagulation was achieved with heparin. Postoperatively, daily aspirin (125 mg) and enoxaparin (40 mg) were administered. Hemodynamic performance was assessed by monthly Doppler ultrasound measurements as well as by angiography (flow patterns, and patency) after implantation and before sacrifice at 6 months (n=3) or 12 months (n=3). Explanted grafts were analyzed by histology, x-ray imaging, and gel permeation chromatography (GPC) to study ETR.

Results: The absorbable grafts showed excellent handling and hemodynamic performance, with patent grafts in all animals. No signs of stenosis or dilation were observed. At 6 months, the lumen of the grafts is well covered by a mature neointima of variable thickness and shows thin elastin fragments and an endothelialized surface, preventing thrombus formation. Graft absorption and tissue replacement was shown by both GPC and histology. Minute focal calcifications were mainly observed in the direct vicinity of sutures. Twelve-month follow-up was still pending at time of abstract submission but will be available at time of conference.

Conclusion: In conclusion, we have shown that bioabsorbable vascular grafts showed excellent handling and hemodynamic performance. As the graft material is absorbed, it is replaced by neo-tissue without any signs of stenosis or dilation. Endothelial coverage was demonstrated and no thrombus formation was observed. Together, this data shows the potential of this novel absorbable graft for small diameter vascular applications.
**ABSTRACTS**

**FABRICATION OF NATURAL ACCELLULAR AND CELLULARIZED SMALL-DIAMETER TISSUE ENGINEERED VASCULAR GRAFTS FOR IMPLANTATION**

**Country of Origin:** United States

**Abstract Author(s):** Morgan Elliott, Brian Ginn, Takuma Fukunishi, Marcel Rauer, Lakshmi Santhanam, Nanotoshi Hibino, Hai-Quan Mao, Sharon Gerecht

The use of synthetic vascular grafts for treating pediatric congenital cardiovascular defects is common, but remains the leading source of morbidity and mortality. We fabricated natural, acellular and cellularized small-diameter tissue engineered vascular grafts (TEVG) for off-the-shelf and biologically active options for implantation. Our hydrogel fibrin microfiber scaffold exhibits a microscale, longitudinally aligned surface topography and is a hollow conduit, which can be immediately perfused. The 1mm diameter allows for small animal models and presents a challenge due to decreased diameter leading to increased thrombus formation. The acellular grafts (n=3) have a burst pressure and compliance of ≥140mmHg and 32.9±20.8%, respectively.

For cellularized TEVG, endothelial colony forming cells (ECFCs) were seeded onto the microfiber tube and cultured in vitro for 3 days (static, n=3), after which time perfusion at a shear stress of 7dyn/cm^2 was applied for 24 hours (perfusion, n=2) in a LumeGen bioreactor.

A monolayer of ECFCs, indicated by membrane expression of VECad and CD31, was achieved. The cellularized fibers also stained positive for laminin, fibronectin, and collagen IV. The unique surface topography led to ECFC alignment at 31.6±24.9 degrees relative to the horizontal fiber axis. Perfusion at 7dyn/cm^2 for 24 hours did not affect cell density on the fiber or lead to loss of alignment. The sample cell wall thickness after perfusion (17.17±1.43 µm) was significantly thicker than the static samples (13.40±2.96 µm, p<0.001). The lack of stacked nuclei and decreased deviation suggest an increased ECM production and wall regularity due to perfusion.

Perfusion of a blue dye through acellular and cellularized TEVGs indicated no leaks from the fiber or chamber during experiments, as shown by the dye concentration in the chamber after 24 hours (perfusion, n=2) in a LumeGen bioreactor.

**FIRST CLINICAL APPLICATION OF THE HUMAN BIOTUBE TO THE CONGENITAL HEART DISEASE**

**Country of Origin:** Japan

**Abstract Author(s):** Shuhei Fujita, Masaaki Yamagishi, Keiichi Kanda, Takako Miyazaki, Yoshinobu Maeda, Masashi Yamanami, Taiji Watanabe, Hitoshi Yaku

Introduction: There are various materials which can be used to augment pulmonary artery (PA) stenosis. But such as homografts, xenografts or several kinds of prosthesis frequently induce unfavorable calcification, immunological reactions or stenosis because of the child's growth. Autologous pericardium is an ideal material and widely used for pediatric PA augmentation. However, its utility for multi-staged operations is limited because of adhesion or complete use during previous surgeries. Recently, in vivo tissue-engineered autologous prosthetic tissues have been developed based on the tissue-encapsulation phenomenon of foreign materials in living bodies. They have been applied to cardiovascular tissues as vascular grafts (called “Biotubes”) in animal experiments.

Hypothesis: Since many congenital heart diseases require staged surgeries, autologous pericardium may not be available at the time of definitive surgery for aforementioned reason. By contrast, staged surgeries are favorable to embedment mold of Biotubes. We hypothesized that an in vivo tissue-engineered autologous “Biotube” graft is constructed uneventfully during waiting period for definitive surgery, can be harvested safely, and is available for PA augmentation in congenital heart surgery.

Methods: For molds of the Biotubes, two silicone 19-Fr drain tubes were embedded in the subcutaneous spaces of a 2-year old female patient diagnosed pulmonary atresia and ventricular septal defect with major aortopulmonary collateral arteries during palliative surgery. When definitive repair was performed after 8 months, the implants were harvested to prepare “Biotubes”, one of which was cut open and autologously implanted into the PA for patch-augmentation. Nine months after implantation, we performed computed tomography (CT) to evaluate the shape of PA.

Results: Two years passed since the surgery, the shape of the augmented PA was well preserved on CT and cardiac catheter examination. Neither aneurysm formation nor stenotic change of the Biotube patch was observed.

Conclusions: Safety and feasibility of Biotubes for pediatric PA patch-augmentation were described. At midterm follow-up, the Biotube implanted in the PA showed excellent macroscopic morphology and mechanical tolerance without aneurysm formation or stenotic degeneration. Since Biotubes are completely autologous, they might be ideal material for pediatric PA augmentation.
GELATIN – PLCL CO ELECTROSPINNING FOR SMALL-DIAMETER BLOOD VESSEL

Country of Origin: China.
Abstract Author(s): Zhiyi Ye, Xiaolin Ran, Haide Wu, Guixue Wang

Objectives: Gelatin and PLCL were used as the electrospinning material, we took advantage of the high biological activity of gelatin and good mechanical properties of PLCL. The artificial blood vessel we prepared has low porosity, compact structure in the early stage, which was conducive to the rapid endothelialization, subsequently the porosity increased with the dissolution of gelatin, which was favorable for cell growth and proliferation.

Method: Then Gelatin -PLCL (2:8) hybrid solution and 10% PLCL solution were choose to prepare Gelatin -PLCL Co polymer fiber membranes and small diameter artificial blood vessel. The Hybrid electrospun was made by the combination of uniaxial and coaxial electrospinning with two nozzles simultaneously spinning. The control was treated with uniaxial electrospinning 10% PLCL and Gelatin -PLCL (2:8) hybrid solution. The spinning structure was shown in figure 1. And finally, the blood vessels were implanted as abdominal aorta interposition grafts in SD rats.

Results: Gelatin hybrid significantly enhanced the biological activity of PLCL materials for cell adhesion, proliferation, migration. (Fig.2.) And mechanical properties of PLCL electrospun blood vessels could be improved by adding gelatin. (Fig.3.) The in vivo experiments has confirmed that hybrid electrospun small diameter artificial blood vessel was favorable for the rapid endothelialization and the migration and growth of vascular cells in the early stage of transplantation(Fig.4.).

Conclusions: In summary, this paper explored the construction of degradable small diameter artificial blood vessels from material choice and structural design, which can achieve rapid endothelialization in early stage and cell migration for vascular reconstruction later, and that has laid a foundation of ideal artificial blood vessels for the clinical application.

HOST REMODELING OF CELL-FREE, FAST-DEGRADING VASCULAR GRAFTS IN A RAT CAROTID ARTERY INTERPOSITION MODEL

Country of Origin: United States
Abstract Author(s): Kee-Won Lee, Liwei Dong, Zhaoxiang Zhang, Ali Mubin Aral, Piyusha S. Gade, Muhammad Umer Nisar, Xiaozhou Fan, Kang Kim, Anne M. Robertson, Vijay S. Gorantla, Yadong Wang

Introduction: There are unmet clinical needs for vascular grafts with the high incidence of cardiac and peripheral vascular diseases. Autologous vessels remain a gold standard, but have limited availability. We have addressed this issue by developing cell-free, fast-degrading vascular grafts, which demonstrated accelerated cell infiltration and host remodeling in a rat abdominal aorta. However, grafts needed urgently in the clinic are for small arteries. The objective of this study is to assess the host remodeling of our grafts using a rat carotid artery interposition model. Compared to the abdominal aorta, the common carotid artery has smaller inner diameter, lower flow rate, and is more muscular, matching clinical needs for small arterial grafts.

Methods: We fabricated bi-layered composite grafts with a salt-leached poly(glycerol sebacate) core and an electrospun polycaprolactone outer sheath. Study included two groups. Group 1 (n = 21) was composite grafts and group 2 (n = 21) was autologous Ixternal jugular vein grafts, which were used as positive controls for our synthetic grafts. We interpositioned both grafts to the left common carotid artery of male Sprague-Dawley rats by end-to-end anastomosis. We also used contralateral common carotid arteries as age-matched healthy controls. We checked graft patency with ultrasound scanning at 2, 4, 8, 12-week post-implantation. We explanted all grafts at 2, 4, and 12-week post-implantation, and assessed host remodeling using histology, immunofluorescence staining, and uniaxial tensile testing.

Results: Overall patency of composite and vein grafts were 90.5 and 100%, respectively. Ultrasound scanning confirmed the graft patency, demonstrating no narrowing and dilation. Histology and immunofluorescence staining demonstrated artery-like structures: fully covered endothelial monolayer in lumen and circumferentially organized contractile smooth muscle cells in medial layer. Composite grafts produced comparable collagen (88%), but less elastin (23%) than native artery. Mechanical testing showed that both composite and vein grafts had comparable burst pressure and tensile strength, but lower compliance than native carotid artery.

Conclusions: Cell-free, fast-degrading grafts demonstrated constructive host remodeling to “neoartery” with good patency and stability in rat carotid artery interposition. These results suggest that our vascular grafts can be ideally suited for small-diameter arterial regeneration.
IMMUNOMODULATORY SYNTHETIC BIOMATERIALS FOR IN SITU VASCULAR TISSUE ENGINEERING

Country of Origin: The Netherlands

Abstract Author(s): Anitha Smits, Tamar Wissing, Valentina Borito, Suzanne Koch, Patricia Dankers, Carlijn Bouten

Introduction: In situ vascular tissue engineering using acellular, resorbable synthetic scaffolds is an attractive strategy given its off-the-shelf availability and cost-effectiveness. A pivotal challenge in using synthetic scaffolds is to balance the degradation of the scaffold with the formation of new tissue. Our recent in vivo studies suggest that this balance is cell-driven and depends on the cellular microenvironment imposed by the scaffold. Macrophages play a hinging role in both scaffold resorption and neo-tissue formation, depending on their polarization state.

Hypothesis: We hypothesize that macrophage polarization state and consequent directing and degrading functions can be controlled via the multi-faceted cues provided by the scaffold, including microstructural, biochemical and mechanical cues. Our goal is to understand and tune macrophage polarization using electrospun immunomodulatory vascular scaffolds in order to control the balance between material resorption and tissue formation.

Methods: Scaffolds were produced via electrospinning from supramolecular elastomers. To study the effect of the scaffold microstructure on macrophage polarization state, scaffolds were spun with either a large (5.7±0.5µm) or small fiber diameter (2.2±0.2µm), and either a random or an aligned fiber orientation. The scaffolds were seeded with human monocyte-derived macrophages. After 4 and 8 days, samples were analyzed in terms of macrophage polarization state and early tissue formation (2.2±0.2µm), and either a random or an aligned fiber orientation. The scaffolds were seeded with human monocyte-derived macrophages. After 4 and 8 days, samples were analyzed in terms of macrophage polarization state and early tissue formation.

Results and Conclusions: Our current results confirm that macrophage-produced degradative products are dependent on macrophage polarization state in 2D culture, with increased levels of esterase production and oxidative stress in IFN-γ-stimulated macrophages. In contrast, however, macrophages in 3D demonstrated increased levels of esterases, but not oxidative stress in response to IFN-γ stimulation. These findings indicate that it is essential to consider the 3D scaffold microstructure when assessing the degradation mechanism (oxidative and/or enzymatic) of vascular scaffolds for in situ vascular tissue engineering. Current work is devoted at unraveling the combined effects of biochemical and microstructural stimuli, as well as incorporating hemodynamic cues on macrophage behavior in 3D scaffolds.

IN SITU REMODELING OF PGS-TA VASCULAR GRAFTS IN RAT COMMON CAROTID ARTERY

Country of Origin: United States

Abstract Author(s): Yen-Lin Wu, Xiaochu Ding, Piyusha Gade, Liwei Dong, Kee-Won Lee, Yadong Wang

Arteries are elastic tissues undergoing cyclic mechanical loading. For arterial tissue regeneration, it is logical to apply materials with elastic recoil and compatible with surrounding tissues. We showed vascular grafts made of a fast degrading elastomer, poly(glycerol sebacate) (PGS), can remodel into tissues within a few months. The objective of this study is to examine a derivative of PGS with higher elasticity as a candidate for arterial tissue engineering. We modified PGS with a natural metabolic compound, tyramine (TA), to introduce π-stacked interaction and hydrogen bonding that substantially increase durability of the material. Hysteresis testing on the PGS-TA showed a 16-fold increment of elastic deformation capability compared to PGS controls. No significant difference on elastic modulus and UTS between PGS-TA and PGS was found. These results indicated PGS-TA remained elastomeric properties comparable to PGS while enhanced endurance to repetitive tensile stress.

A superposition implant model in the rat common carotid artery was used in this study to investigate remodeling outcome of 5 PGS-TA vascular grafts at 1 month period. Patency was monitored using Doppler ultrasound with 2-week interval. Biomechanics of the explants was analyzed by applying biaxial inflation testing. Cellular and extracellular matrix composition were verified with histology and immunofluorescence staining.

In vivo studies showed 100% patency rate at 2-week period, followed by 80% at 1-month. Remodeled grafts had structure and cell density resembled native arteries. Endothelialization of lumen was observed by IF imaging. Smooth muscle cells were observed across remodeled tunica intima through media. Collagen type I and III fibrous structure located in the remodeled tunica externa suggesting potential fibrous encapsulation surrounded slow-degrading graft sheath. We also observed aneurysmal dilation in 60% of remodeled grafts. The collagen deposition correlated with our biomechanical data, which showed lower compliance and higher stiffness of 1 month remodeled grafts compared to native arterial tissue.

We conclude PGS-TA demonstrated good tissue remodeling potential by 1 month period with high patency rate and structural similarities to native artery. Future studies would focus on decreasing unfavorable fibrous encapsulation and dilation with long-term results.
ABSTRACTS

**IN VIVO TISSUE-ENGINEERING OF POLY(E-CAPROLACTONE) REINFORCED VASCULAR GRAFTS**

Country of Origin: China

Abstract Author(s): Kai Wang, Qiuying Zhang, Dengke Zhi, Deling Kong

There is a large clinical need for small diameter vascular grafts. In vivo tissue engineering can prepare autologous vascular prosthetics, called “biotubes”, which have great potential for vascular regeneration. However, it is difficult to maintain the tubular shape and resist the forces of arterial circulation due to their insufficient mechanical strength. In this study, we used a silicon rod with melt-spun poly(ε-caprolactone) (PCL) fibers wrapping as a template for in vivo preparation of biotubes. After implantation into rat dorsal subcutaneous pouches for 4 weeks, these templates were well encapsulated by tissue capsules. PCL-free (control group) or PCL-reinforced tissue capsules (experimental group) were obtained by removing the silicon rods. The histologic analysis of the PCL-reinforced biotubes showed an inner layer of circumferentially aligned α-smooth muscle actin (α-SMA)-positive myofibroblasts and an outer layer of PCL fibers and extracellular matrix. PCL-free biotubes showed similar cellular and extracellular matrix component to the PCL reinforced biotubes. However, the mechanical properties of the PCL-free biotubes were significantly low and were not enough for vascular implantation. Satisfyingly, the PCL reinforced biotubes possessed good tubular shape, elasticity and enough tensile strength for vascular implantation. The middle layer of the vessel wall consists of well aligned smooth muscle myosin heavy chain I (MYH)-positive smooth muscle cells (contractile SMCs). These SMCs may be differentiated from those myofibroblasts in tissue capsules. Our results suggest that the PCL-reinforced biotubes may be a promising candidate for the development of small diameter vascular grafts.

**INCORPORATION OF RESVERATROL IN POLY(E-CAPROLACTONE) ELECTROSPUN VASCULAR GRAFTS LED TO RAPID ENDOTHELIALIZATION**

Country of Origin: China

Abstract Author(s): Zhihong Wang, Yifan Wu, Jianing Wang, Deling Kong

Small diameter vascular grafts (SDVGs) are widely studied as an artery substitute in cardiovascular disease treatment. However, it is still challenging because the lack of endothelium on the graft which caused acute thrombosis and intimal hyperplasia. Rapid endothelialization is one key factor that determines the success of small diameter vascular grafts as an artery substitute in the treatment of cardiovascular disease. Aimed to facilitate vascular regeneration, we developed a vascular scaffold that loaded with resveratrol, which is a natural compound extracted from plants and showed multifaceted effects in cardiovascular protection. The tubular poly (ε-caprolactone) (PCL) scaffold was prepared by electrospinning with resveratrol in the PCL solution. In vitro assay demonstrated that resveratrol could be released from the scaffolds in a sustained and controlled manner. Cell culture indicated that the migration of endothelial cell, NO production and the ability of tube formation increased in the resveratrol-containing PCL scaffolds compared to the PCL group. Meanwhile, TNF-α, the main pro-inflammatory factor, secreted from macrophages reduced, and the expression of the M2 macrophage-related genes was also increased in the resveratrol-containing group. Further, in vivo implantation was performed by replacing the rat abdominal aorta, which demonstrated fast endothelialization and enhanced vascular regeneration in the resveratrol-containing scaffolds. The presence of resveratrol also induced a large number of M2 macrophages to infiltrate into the graft wall. Taken together, the incorporation of resveratrol into the PCL grafts enhanced vascular regeneration by modulation of endothelial cells and macrophages. Resveratrol can be used as a potential bioactive molecular for modification of vascular graft or other scaffolds which may have broadapplication in tissue engineering and regenerative medicine.
**LUMINAL EVOLUTION OF THE TISSUE-ENGINEERED VASCULAR GRAFT**

Country of Origin: United States

Abstract Author(s): VK Pepper, CA Best, S Miyamoto, EA Onwuka, H Miyachi, N King, J Reinhardt, A Lee, J Drews, T Shoji, ED Heuer, S Cheatham, JL Chisolm, T Shinoka, JP Cheatham, CK Breuer

Introduction: The use of tissue-engineered vascular grafts (TEVGs) for patients with congenital cardiac anomalies has shown promise; however, in clinical trials, early luminal narrowing has led to endovascular interventions. Our purpose was to evaluate the natural history of graft remodeling without intervention in a large animal model.

Hypothesis: The luminal narrowing seen in tissue-engineered vascular grafts at early time points resolves without intervention.

Methods: Juvenile sheep (n=30) were implanted with TEVGs (14-18mm) in the inferior vena caval position. The animals were monitored with serial angiography, intravascular ultrasound (IVUS), and hemodynamic pressure measurements at 1 week (n=30), 6 weeks (n=25), and 26 weeks (n=18).

Results: While there was some degree of surgical luminal narrowing at the baseline of 1 week (Angiography: 29±11%, IVUS: 26±31%), mean pressure gradient was minimal across the grafts (0.6±0.7mmHg). At 6 weeks, stenosis reached 62±10% by angiography and 73±11% by IVUS. Pressure gradient also increased to 10.5±5 mmHg. By 26 weeks, there was resolution of both luminal narrowing (Angiography: 31±15%, IVUS: 38±21%) and pressure gradient (0.8±1.4mmHg). While there were significant differences in luminal narrowing between 1 to 6 weeks (Angiography and IVUS p<0.0001) and 6 to 26 weeks (Angiography and IVUS p<0.0001), no significant difference was noted between 1 and 26 weeks (Angiography: p=0.9992; IVUS: p>0.9999) at the narrowest point with either IVUS or angiography.

Conclusion: In this model, most TEVG stenosis occurring before 6 months may resolve as a result of scaffold degradation and neotissue remodeling. Further, traditional criteria for endovascular interventions may require revision in patients receiving TEVGs.

**MODULAR TISSUE ENGINEERING APPROACH TO MODEL FOCAL VASCULAR PATHOLOGIES**

Country of Origin: United States

Abstract Author(s): Hannah A. Strobel, Marco Piola, Gianfranco Beniamino Fiore, Monica Sancini, Eben Alsberg, Marsha W. Rolle

Tissue engineered blood vessels (TEBV) can potentially model human vascular diseases in vitro. Many approaches exist for fabricating TEBVs, but are not able to create focal heterogeneities characteristic of localized diseases, such as intimal hyperplasia (IH) or aneurysm. To generate TEBVs with focal pathologies, we developed a method to fabricate tubes by fusing individual self-assembled cell-ring units. Human smooth muscle cells (hSMCs) were seeded into agarose molds to aggregate into sca old-free, self-assembled hSMC rings. SMC rings are stacked together, with polymer cu units on each end to provide reinforced extensions for handling. We have demonstrated that degradable gelatin microspheres can be incorporated within rings during self-assembly to deliver growth factors and control hSMC phenotype. In this study, we cultured hSMC tubes with luminal ow, endothelialized hSMC tubes, and used gelatin microsphere incorporation to create focal heterogeneities within hSMC tubes to model IH.

To fabricate TEBVs, human SMC rings were cultured 3 days, then fused into tubes for an additional 4 days with cuon either end. Tubes were mounted onto a custom bioreactor (modi ed from Piola et al., 2013 to t in 15-mL conical tubes), where cu s t snugly over cannulas without suturing. Tubes were cultured for 6 days with 10ml/min luminal ow, demonstrating the feasibility of dynamically culturing modular tissue tubes. Next, hSMC tubes were fabricated and seeded with coronary artery ECs in the tube lumen at 500,000 cells/cm2. e tube was rotated hourly for 6 hours, with additional EC seeding after 3 rotations to ensure even attachment. EC-seeded hSMC tubes were cultured statically overnight, then xed, sectioned, and stained for von Willebrand Factor, which showed an EC layer on the tube lumen. To create focal heterogeneities within tubes, we fabricated hSMC rings with or without incorporated microspheres. Rings with microspheres were fused between rings without microspheres. Microspheres and cells maintained their spatial position within tubes during 7 days in culture. Ongoing work is focused on evaluating EC and hSMC function, and using microspheres to deliver growth factors within functional hSMC-EC tubes to create focal regions of increased hSMC proliferation characteristic of IH.
NOVEL ULTRA-THIN PGA FIBER TEXTILE TECHNOLOGY IN SMALL-DIAMETER TISSUE ENGINEERED ARTERIAL GRAFTS

Abstract Author(s): Takuma Fukunishi, Chin Siang Ong, Huaitao Zhang, Jochen Steppan, Lakshmi Santhanam, Dan Berkowitz, Luca Vricella, Carissa M. Smoot, Seth A. Winner, Jeremy J. Harris, Peter D. Gabriele, Steven Lu, Narutoshi Hibino

Objectives: Existing commercially available vascular grafts, such as Dacron®, have been commercially available in large diameters. However, they display poor patency in small-diameter applications, due to the technical limitations in fabricating small fibers. We have developed novel textile technology using ultra-thin biodegradable fibers to create small-diameter tissue engineered vascular grafts (TEVG). This textile technology enables us to use fast degrading biomaterial which promote ideal neotissue formation, as textile pattern increases mechanical strength of the graft.

Methods: Small-diameter (1.5 mm) arterial TEVGs were fabricated using fast-degrading ultra-thin (12 μm) polyglycolide (PGA) fibers using textile engineering technology. A total of 15 unseeded textile PGA TEVGs were implanted in rats as infrarenal abdominal aorta interposition grafts. Animals were sacrificed at 1 month (n=5) and 3 months (n=10) post implantation and evaluated for neotissue formation, graft patency and mechanical properties.

Results: All 15 rats survived until the time of sacrifice. All small-diameter arterial TEVGs had an endothelial cell monolayer, contractile vascular smooth muscle cells and extracellular matrix (ECM) deposition, without graft stenosis, dilation or rupture. Elastin layers in TEVGs were comparable to native abdominal aorta at 1 month, with no significant difference by Verheoe - von Einseed staining (native: 79.14 ± 3.8μm vs. TEVGs: 86.27 ± 7.7μm, p = 0.26). Masson Trichrome staining positive ECM area increased over 3 months, suggesting remodeling of TEVGs (1 month: native: 57.47 ± 5.77% vs. TEVGs: 62.42 ± 5.24%, p = 0.08). The mechanical properties of TEVGs under maximum stress at 3 months were akin to that of native aorta (native: 2518.65 ± 310.01mN/mm2 vs. TEVGs: 2045.21 ± 481.77mN/mm2, p = 0.16). The remaining scaffold area significantly decreased over 3 months (1 month: 25.15 ± 2.77% vs. 3 months: 6.17 ± 3.51%, p < 0.001).

Conclusion: Novel arterial TEVGs fabricated with ultra-thin PGA braiding technology had rapid and well-organized neotissue formation at 1 month, as well as native-like mechanical properties at 3 months. Our unique textile technology using PGA has the potential to open a new field of small-diameter vascular graft surgery.

OPTIMIZATION OF HIGH-DOSE BONE MARROW MONONUCLEAR CELL SEEDDED TISSUE-ENGINEERED VASCULAR GRAFTS

Abstract Author(s): Cameron Best, Victoria Popper, Ekene Onwuka, Yang-Ung Lee, Avione Lee, James Reinhardt, Sayali Dharmadhikari, Kevin Blum, Eric Heuer, Nakesha King, Toshiharu Shinoka, Christopher Breuer

Introduction: The first FDA-approved clinical trial evaluating the use of tissue-engineered vascular grafts (TEVG) for palliation of congenital cardiac anomalies has demonstrated a significant incidence of stenosis. In mice, bone marrow-mononuclear cell (BM-MNC) seeding of the TEVG prior to implantation reduces the incidence of stenosis in a dose-dependent manner. We recently requested FDA approval to harvest up to 20mL/kg of bone marrow from graft recipients to increase the concentration of autologous BM-MNC within the TEVG. In this study, we sought to optimize this approach prior to clinical translation.

Hypothesis: Through optimization of high-dose cell seeding, we propose that the point of graft saturation can be determined.

Methods: Sheep (Ovis aeries, n=2, ~30kg) were anesthetized and 20mL/kg of whole BM aspirated from the iliac crests. The marrow was characterized in 5ml/kg aliquots to determine cell content. Assuming a 10kg child, the BM was then divided into 5, 10, and 20mL/kg doses and the MNCs were enriched via a closed, disposable system. The BM-MNC concentrate and red blood cell (RBC) filtrate were characterized using CBC and chemistries. 12 and 6cm scaffolds were vacuum-seeded with MNCs from each aliquot (n=2/dose-graft length). DNA assay determined the concentration of cells/mm3/cm for each condition.

Results: There was no significant difference between the aliquots of bone marrow, the doses of BM-MNC, or in the RBC filtrate as measured by CBC and blood chemistry. A marked seeding gradient along the graft length was observed with the 5mL/kg dose. The gradient became less apparent with 10mL/kg, and disappeared altogether at 20mL/kg. Further, there was no difference in the quantity of cells seeded between a 6cm-10mL/kg or a 12cm-20mL/kg TEVG, indicating that a 20mL/kg cell dose may reach the saturation point of the currently used TEVG scaffold.

Conclusion: These preliminary data suggest that an optimal BM-MNC dose exists for seeding of TEVGs prior to implantation, achieved with a maximum bone marrow aspiration of 20mL/kg. Prior to clinical translation, further exploration of the impact of this dose on graft performance in vivo and on perioperative physiologic parameters will be required.
ABSTRACTS

ORIGIN OF CIRCULATING ENDOTHELIAL COLONY FORMING CELLS AND THE ROLE OF ABCG2 IN THEIR FORMATION
Country of Origin: United States
Abstract Author(s): Yang Lin, Gil Changhyun, Nutan Prasain, Tarnawsky Stefan, Yoshimoto Momoko, Mike Ferkowicz, Sisi Chen, William Shelly, Yan Liu, Yi Zheng, Mervin Yoder

Introduction: Human circulating endothelial colony forming cells (cECFC) can give rise to in vitro endothelial cell (EC) colonies that have the ability to form in vivo vessels, which renders them promising agents for the treatment of cardiovascular disease. However, research on cECFC has been hindered by the lack of prior identification of murine cECFC. Thus, cECFC’s origin, function and their mechanism of production are largely unknown.

Objective: We aimed to study the origin/function of murine cECFC and to find the molecular determinants of cECFC production.

Methods: Murine cECFC were identified using OP9 co-culture and their in vivo vessel forming potential was tested by collagen gel transplantation and hind limb-ischemia rescue studies. Lineage-tracing experiments were conducted using different cre lines including endothelial-specific Tie2CreERT;ROSA26 and stem/progenitor-labeling Abcg2CreERT;ROSA26 mice. The role of Abcg2 in cECFC was studied using Abcg2 knockout (ABCG2KO) mice.

Results: Neonatal/juvenile murine peripheral blood (PB) contains cECFC that formed EC colonies on OP9 monolayers in vitro. cECFC derived EC in culture or freshly isolated cECFC formed functional vessels upon implantation in NOD-SCID mice or injected into the ischemic muscle of injured mice. In endothelial-lineage tracing experiments, postnatal injection of tamoxifen into Tie2CreERT;ROSA26 mice induced labeling of endothelial but not hematopoietic cells (HC) with TdT omato. In these animals, 88% of cECFC colonies were TdT omato+, confirming that cECFC are derived from resident EC, not HC. In hematopoietic-specific Flk2cre;mT/mG mice, GFP labeled 89% of PB CD45+ cells, however all cECFC colonies were GFP-.

In Abcg2CreERT;ROSA26 mice, tamoxifen injection at P0 labeled resident endothelial colony forming cells (rECFC), while 31% of cECFC were also labeled. In ABCG2KO mice, the number of rECFC were greatly reduced and the production of cECFC was nearly abolished.

Conclusions: Murine neonatal/juvenile PB contains cECFC that can participate in vessel formation in vivo. cECFC are derived from vascular rECFC but not HC or mature EC. Abcg2, a gene which plays a role in the maintenance of many tissue-specific stem/progenitor cells, plays a critical role in the production of cECFC. Our research provides a foundation for use of murine genetic approaches to unravel cECFC functions and mechanisms of formation that may translate into human subjects.

PRELIMINARY EVALUATION OF A POLY(GLYCEROL SEBACATE)-BASED RESORBABLE GRAFT IN SHEEP
Country of Origin: United States
Abstract Author(s): Chelsea E.T. Stowell, Piyusha S. Gade, Cody B. Cockreham, Anne M. Robertson, Edith Tzeng, Yadong Wang

Introduction: Prosthetic vascular grafts have poor patency in small-diameter applications. Resorbable grafts can induce cell infiltration and matrix production as they degrade, creating a patient-specific living conduit in situ.

Hypothesis: A fast-resorbing, synthetic graft will remodel safely into an artery-like structure in the ovine arterial circulation.

Methods: A 4.5 mm inner diameter poly(glycerol sebacate) (PGS) tube was electrosprun and thermally cured. A layer of polycaprolactone (PCL) was then electrosprun around the PGS tube. Finished grafts were purified and sterilized by gamma irradiation. Grafts were implanted as 4-7 cm long carotid interpositions in 6 mo old Dorset or Suffolk ewes (n = 4). 2 mg/kg enoxaparin was administered every 12 h for the first 14 d post-implant. Patency was monitored by duplex ultrasound and CT angiograms.

Results: The PGS core had a dry porosity of 73±5% (n = 4). The PCL sheath, which dominated the mechanical response of the graft, had wet elastic moduli of 7.90±2.19 MPa circumferentially (n = 3) and 12.51±4.11 MPa axially (n = 3). The graft displayed good suture retention and facile handling. Suture line and transmural leakage resolved naturally within the first minute. No sheep experienced major complications from graft implantation. Complete blood counts and serum chemistry demonstrated no evidence of blood damage, severe inflammation, or toxicity at day 3 (n = 3) or 7 (n = 3). The graft displayed good suture retention and facile handling. Suture line and transmural leakage resolved naturally within the first minute. No sheep experienced major complications from graft implantation. Complete blood counts and serum chemistry demonstrated no evidence of blood damage, severe inflammation, or toxicity at day 3 (n = 3) or 7 (n = 3). Patency was confirmed by ultrasound on days 7 and 24 (n = 1) and by CT angiograms on days 30 and 60 (n = 1).

Conclusions: The graft is implantable in the ovine arterial circulation and is patent to at least 60 d. Future work will quantify patency and diameter over time and assess the structure, phenotypes, and biomechanics of the neotissue.
PREPARATION OF INTEGRATED VALVED CONDUIT VIA TIPS AND 3D PRINTING FOR THE TREATMENT OF CONGENITAL HEART DISEASES

Country of Origin: China
Abstract Author(s): Jialing Zhang, Jun Du, Dekai Xia, Jinhong Liu, Tong Wu, Jing Shi, Wei Song, Dawei Jin, Haibo Zhang, Xiumei Mo, Meng Yin

Surgical repair employing a valved conduit to reconstruct the right ventricular outflow tract (RVOT) is now considered a standard procedure for many complex congenital heart diseases (CHD), such as the Tetralogy of Fallot (TOF). An ideal valved conduit suitable for children must fulfill four basic requirements: enduring mechanical properties, excellent biocompatibility, normal valve functionality and the potential growth ability. In this study, we implemented the thermally induced phase separation (TIPS) method, combining 3D printing technology, to rapidly fabricate poly(L-lactic acid)/poly(L-lactide-co-ε-caprolactone)(PLLA/PLCL) integrated valved conduit with bionic structure. Compared with the physiological pulmonary artery of porcine, not only our novel integrated valved conduit exhibits favorable mechanical properties, but also it is satisfied that the valves function well under simulative pulmonary hemodynamic pressure through the computational hemodynamic simulation analysis. Meanwhile, the excellent biocompatibility and vascularization for regeneration in vivo have also been acquired. Fibers morphology and the collagen production from host cells also supports that it is preliminarily feasible for clinical application. We believe that our research achievement will finally be helpful for those children patients with complex CHD.

REDUCED PLATELET BINDING BY CONDITIONED ADIPOSE-DERIVED STEM CELLS

Country of Origin: United States
Abstract Author(s): Anh La, Robert T. Tranquillo

Tissue engineered vascular grafts (TEVG) have the potential to overcome the major limitations of coronary artery bypass grafting. Lining biological grafts with human adipose-derived mesenchymal stem cells (hASC) that can differentiate into endothelial cells may prevent thrombosis upon implantation, although their reduced platelet bind has never been demonstrated.

The linear shear stress (SS) parallel-plate chamber of Usami et al1 was modified to study the effects of selected ranges (inlet SS of 15 dynes/cm² linearly decreasing to 7.5 dynes/cm²) of arterial steady SS on hASC (Lonza). Densely-seeded hASC onto our completely-biological TEVG were mounted into our custom flow loop (6 days+24 hr pre-static) and compared to hASC cultured statically (7 days). At day 7, samples were subjected to platelet adhesion assay and immunostaining for GPIIb/IIIA (platelets).

Decellularized-TEVG (positive control) exhibited intrinsic thrombogenicity. hASC cultured statically yielded reduced platelet binding but showed further reduced platelet binding after exposure to the steady SS. hASC exposed to pulsatile SS did not show significant reduction of platelets compared to steady SS and static groups. hASC oriented parallel to the direction of SS whereas hASC cultured statically oriented with the alignment of the matrix (configured perpendicular to flow). Steady shear flow conditioning reduced platelet binding of hASC seeded onto TEVG compared to pulsatile shear flow conditioning and statically-cultured hASC.
ABSTRACTS

RETENTION OF SEEDED MESENCHYMAL STEM CELLS WITHIN AN IMPLANTED ELASTOMERIC VASCULAR SCAFFOLD
Country of Origin: United States
Abstract Author(s): Katherine Lorentz, Antonio D’Amore, Justin Weinbaum, William R. Wagner, David Vorp

Introduction: Cardiovascular disease is the number one cause of death in the US and treatment of this disease often requires the use of a vascular graft. Of the strategies designed by tissue engineers to address this need, many include the seeding of cells in or on a tubular scaffold. Often these seeded scaffolds are then matured into a tissue engineered vascular graft (TEVG) within a bioreactor or in vivo. In our work, we have observed that mesenchymal stem cell (MSC)-seeded scaffolds implanted in vivo remodel after 8 weeks into a parent native-like TEVG containing endothelial cells, smooth muscle cells, collagen, and elastin. However, these TEVGs no longer contain the seeded MSC.

Hypothesis: Seeded MSCs evacuate the scaffold during the first 4 weeks post-implant.

Methods: Human MSCs (RoosterBio) were seeded into porous bilayered polyurethane urea scaffolds using a custom rotational vacuum seeding device. The scaffolds were incubated in dynamic culture for 48 hours to allow for cell binding then implanted as an infrarenal aortic graft in Lewis rats. After 1 or 4 weeks in vivo (n=1 and 3, respectively), patency was tested with angiography and the graft and surrounding aorta was harvested. The grafts were sectioned and stained using immunofluorescent chemistry for human nuclear antigen (HNA) to detect any remaining human cells.

Results: TEVGs were observed to show 100% patency at 1 and 4 weeks post-implant. Immunostaining for HNA was positive at both 1 and 4 weeks post-implant, with no significant decrease in the percentage of vascular cells that were HNA positive from 1 to 4 weeks.

Conclusion: The hypothesis was not supported, since a substantial loss of cells was not observed prior to the 4 week timepoint. These results may indicate a prolonged role for the seeded MSC as active modulators of host cell remodeling or preventing thrombosis. Further analysis at multiple timepoints could provide a more robust picture of cell retention.

THE EFFECT OF DICKKOPF 3 ON ARTERY REGENERATION IN POLY(E-CAPROLACTONE) ELECTROSPUN VASCULAR GRAFTS
Country of Origin: China
Abstract Author(s): Yifan Wu, Zhihong Wang, Qiang Zhao, Deling Kong

In recent years, tissue engineering blood vessels which can induce tissue regeneration in vivo have captured a lot of attentions. To fabricate vascular scaffolds favoring tissue regeneration, both appropriate material and functional modification are required. Vascular smooth muscle cells play an essential role in the physiological functions of blood vessels. As to tissue engineering blood vessels, smooth muscle cells possessing functions such as contraction and relaxation are benefit for the regeneration of endothelial cells. However, the regeneration of functional smooth muscle is still a challenge. Dickkopf 3 (DKK3) is a secreted glycoprotein expressed in a variety of tissue. Xu Qingbo et al [1] discovered that iPSC could differentiate into the contractile phenotype SMCs, and DKK3 was involved in this process. DKK3 regulates the transcriptional activation of SM22 through activation of Wnt signaling.

A recent research indicated that Wnt signaling participates in SMCs’s proliferation, migration, differentiation and apoptosis [2]. According to these knowledge, we speculate that modification of DKK3 on vascular scaffolds would promote the immigration of Sca-1+ stem cells and induce them differentiating into contractile smooth muscle cells. In this study, we prepared hybrid vascular grafts composed of poly(e-caprolactone)(PCL) microfibers and collagen nanofibers by electrospinning. Collagen nanofibers were loaded with DKK3 which would be released by the degradation of collagen, thus to promote the regeneration of vascular smooth muscle. The as-prepared vascular grafts were evaluated by rat abdominal artery displacement model. After 2 weeks or 1 month, the implanted vascular grafts were harvested. More Sca-1+ stem cells were detected in DKK3 group at both time points. We analyzed the regeneration of smooth muscle cells and extracellular matrix by immunofluorescent staining and western blotting. At the protein level, contractile SMC marker Calponin was upregulated in DKK3 group. Furthermore, immunofluorescence showed the consistent result with western blotting. In addition, the arrangement of collagen and elastin in DKK3 group were more similar to the native arteries, although its compactness was lower than that in native arteries. These results demonstrated that DKK3 could promote the adventitial stem cells infiltrating into the grafts, resulting in the regeneration of smooth muscle cells. Altogether, we fabricated hybrid vascular grafts loading with DKK3 and demonstrated the regeneration of functional tunica media.
THE EFFECT OF IN SITU NO GENERATING AND PEG MODIFIED YIGSR COATING OF VASCULAR GRAFTS ON MACROPHAGE POLARIZATION AND ARTERIAL REGENERATION

Country of Origin: China
Abstract Author(s): Di Tang, Siyuan Chen, Jingchen Gao, Li Jiang, Jie Shi, Shufang Wang

Introduction: As a clinic treatment for cardiovascular disease, vascular transplantation gains much attention recently. However, due to the deficiency of structural and functional remodeling, long-term failure of synthetic grafts after implanted in small diameter blood vessel decelerates its commercial use. YIGSR, an adhesion peptide from the B1 chain of laminin, has demonstrated EC-specificity over platelets. Grafting of poly(ethylene glycol) (PEG) to the surface of biomaterials can mitigate nonspecific adsorption via generation of a steric barrier. Nitric Oxide (NO) mediates the anti-coagulation of endothelial cells and inhibition of smooth muscle cells. It can also regulate inflammatory response through adjusting the phenotype of macrophages, thus may improve vascular remodeling process.

Hypothesis: We aim to enhance the endothelial cells adhesion and reduce the acute thrombosis through constructing PEG-modified YIGSR outer layer. Constant NO generation may promote vascular remodel process via modulating inflammation response, especially the phenotype of macrophages.

Methods: We used poly(ε-caprolactone)(PCL) as the matrix material. Organoselenium immobilized polyethyleneimine(SePEI) and hyaluronic acid (HA) were introduced onto the surface of electrospun PCL through lay-by-layer assembly to build a vascular graft with in situ NO generation. On the outmost layer, we introduced PEG modified YIGSR as an antifoul functional group. Grafts were implanted into rat abdominal aorta to replace a segment of native aorta. Evaluation was performed after explantation at the predetermined time points (1 and 2 months).

Results: The result of in vitro catalytic experiment shows that the SePEI/HA layers have a high and stable NO generating capacity. The results of subcutaneous implantation show that PEG-modified outer layer can reduce acute inflammation through inhibiting adhesion of neutrophils and macrophages. The results of abdominal aorta transplantation show that PEG-modified YIGSR outer layer can enhance the endothelial cells adhesion and reduce the acute thrombosis, and release of NO can improve the performance of remodeling through mediating the phenotype switch of macrophages.

Conclusion: In this study, we construct a novel vascular graft with constant NO generating ability, which can promote endothelialization. The released NO also regulates the phenotype switch of macrophages after implantation. The phenotype change of macrophages is helpful for vascular tissue remodeling.

TYRAMINE FUNCTIONALIZATION TUNES THE ELASTICITY OF POLY(GLYCEROL SEBACATE) ELASTOMER

Country of Origin: United States
Abstract Author(s): Xiaochu Ding, Yen-Lin Wu, Jin Gao, Albin Wells, Keewon Lee, Yadong Wang

Introduction: Poly(glycerol sebacate) (PGS) is an elastomer widely used in tissue engineering due to good biocompatibility. We designed PGS particularly for vascular regeneration. The PGS graft is remodeled in vivo by cells to generate a new blood vessel that resembles the native one. The vascular regeneration is benefited from the elastomer that can sustain and recover from reversible deformations without adverse impacts on the surrounding tissues. To further explore the effects of the elasticity on tissue regeneration, we report a tyramine-functionalized PGS (PGS-TA). PGS-TA shows a significantly higher elasticity to restore from large deformations. The material design and characterization are shown here. Use PGS-TA to make a synthetic graft for vascular regeneration is demonstrated in Yen-Lin’s work.

Hypothesis: Tyramine bears phenolic hydroxyl group that can introduce additional hydrogen bonding and aromatic-aromatic interactions to PGS. Pendent tyramine moieties on PGS are more flexible and accessible to form physical bonds and thus enhance the elasticity of PGS.

Methods: Tyramine is immobilized to PGS backbone with succinate as a spacer. Cyclic loading and tensile tests are used to examine the elasticity and mechanical properties. In vitro and in vivo studies are performed to evaluate the biocompatibility and biodegradability.

Results: Compared to PGS alone, PGS-TA shows a 9 to 16-folds increase of elastic deformation depending on the tyramine content. The strain at fracture, ultimate tensile strength and Young’s modulus remain similar to the PGS control. The in vitro studies demonstrate the cell viability and metabolic activity of baboon smooth muscle cells nearly identical to those on TCPS culture. The porous implant of PGS-TA subcutaneously degraded in vivo over two weeks, showing good biocompatibility and biodegradability.

Conclusion: We designed a PGS derivative by tyramine functionalization to tune the material elasticity, whereas the softness and toughness remained similar to PGS control. Both in vitro and in vivo studies demonstrated good biocompatibility, biodegradability and bioresorbability of the PGS-TA. This material is designed for tissue engineering applications where a more stable scaffold is needed to sustain large reversible deformations. We particularly use to study the effects of elasticity on the vascular regeneration.
COLUMBUS WELCOMES

The 3rd International Symposium of Vascular Tissue Engineering


Columbus, the 15th largest city in the country (right behind San Francisco), as well as the largest and fastest-growing city in Ohio, is a smart and open community whose dynamic convention package fits the needs of every attendee. Located within a one-day drive or one-hour flight from more than half of the U.S. Population, Ohio’s state capital is easily accessible for all.

Upon arrival, attendees love exploring the place that is fast becoming known as one of the nation’s most creative, forward-thinking and exciting cities. Celebrated for its incredible arts, entertainment, fashion and culinary offerings; exciting collegiate and professional sports teams and events; and spectacular riverfront with a sprawling ribbon of parkland on the Scioto Mile through downtown, this city on the move has something for everyone.

LIVELY URBAN ENTERTAINMENT DISTRICTS

Convention attendees are right in the middle of “Five on High” – the five-mile span of High Street connecting downtown’s districts – packed with entertainment, restaurants and shops. Many of Columbus’ unique neighborhoods are accessible on foot, including the cool galleries of the Short North Arts District, awesome architecture of Victorian Village, named one of America’s most beautiful neighborhoods by Thrillist; and the energetic crowds of the Arena District. Venture north, and you’ll find yourself in The Ohio State University District. Or, take a short CBUS ride south to check out quaint and historic German Village, with a stop in the Brewery District along the way.

WORLD-CLASS ARTS & CULTURE

The city’s art scene is bursting with creativity, leading it to be named one of the “30 Most Fun Places to Live in the U.S.” by U.S. News & World Report and one of 17 Must-Visit Destinations in 2017® by Expedia. Check out Pushpin Studio, America’s largest resident theater company. A quick browse of the Greater Columbus Arts District won’t miss the world-class visual art at the Columbus Museum of Art, take in what ARTnews calls one of the top art collections in the world at The Franklin Collection or visit the largest collection of local artists just by walking the halls of the Greater Columbus Convention Center.

A FOODIE’S PARADISE

As Food Republic said, “If you can’t find excellent places to eat in Columbus, you’re no food enthusiast.” There are more than 100 restaurants within walking distance of the convention center alone, including the North Market, where you’ll find an array of fresh and prepared foods. Explore the Columbus Ale and Coffee Trail, and don’t miss Columbus-based Jeni’s Splendid Ice Creams, from well-known James Beard Award-winning cookbook author Jeni Britton Bauer, called one of the best ice cream spots in the U.S. by Food & Wine.

FASHION-FORWARD

Columbus has the third-highest concentration of fashion designers in the country, behind New York and Los Angeles. Hit up the Short North’s eclectic boutiques or check out Easton, dubbed the “Rodeo Drive of the Midwest” by USA Today. To this day, Easton serves as a blueprint for the modern shopping center thanks to the brilliant minds behind it, including Les Wexner, founder of L Brands (Victoria’s Secret, Bath & Body Works, etc.), one of five Fortune 500 founder. Due to its openness, Columbus is often named one of the “best places to live.”

TOP-RANKED ATTRACTIONS

Hang out in the Heart of Africa at “Jungle” Jack Hanna’s home zoo, the Columbus Zoo and Aquarium. Get hands-on at COSI, the top ranked science center loved by kids and adults of all ages. Check out Franklin Park Conservatory and Botanical Gardens, the only botanical garden in the world with a permanent collection of glass artwork by Dale Chihuly. Let loose a little at Eldorado Scioto Downs or Hollywood Casino Columbus.

RESPECTED SPORTS SCENE

The Arena District is home to NHL’s Columbus Blue Jackets, as well as The Columbus Clippers, Triple-A baseball affiliate of the Cleveland Indians, whose home stadium, Huntington Park, was named “Ballpark of the Year” four times in its first six years of operation. Nearby MLS’ Columbus Crew SC play at MAPFRE Stadium. The first soccer-specific stadium built in the country, Columbus is also home to The Ohio State Buckeyes, winners of the 2017 College Football Playoff National Championship and the Jack Nishiyama Museum, a tribute to the Columbus native and golf legend.

GETTING HERE AND AROUND

John Glenn Columbus International Airport offers nonstop service to 33 destinations and is just eight miles or 10 minutes from downtown, a short ride on COTA’s AirConnect. Once downtown, hop on the free CBUS circulator or use alternative transportation services such as Uber, Lyft, GRID (bike-sharing) and Car2Go to explore beyond the city limits.

AirConnect | Express bus service runs between John Glenn International, the Greater Columbus Convention Center (GCCC) and downtown hotels. The connector stops at baggage claim every 30 minutes and costs $2.75 each way.

CBUS | The Central Ohio Transit Authority (COTA) operates bus service in Columbus. The CBUS is a free downtown circulator that runs every 10-15 minutes from the Short North Arts District in the north to the Brewery District/German Village in the south, with stops at many popular downtown locations along the way.


It’s our pleasure to assist you with an amazing Columbus experience. To learn more, visit experiencecolumbus.com, follow us on Twitter @expcols or find us on Facebook.

* Columbus, OH received the highest numerical score among 6 cities in the Midwest in the J.D. Power 2016 Destination Experience Satisfaction Study, based on 2,000+ traveler responses. Measuring the experiences and perceptions of travelers who visited a top 50 U.S. destination, surveyed February-July 2016. Your experiences may vary. Visit jdpower.com.

STILL CURIOUS?

• Columbus was the $40 million U.S. Department of Transportation Smart City Challenge.
• The Washington Post calls Columbus “the new destination for food lovers.”
• Time has named Columbus among the top big cities and best places to live for millennials.
• According to Forbes, Columbus is the #1 opportunity city in the country.