BME PULSE

VANDERBILT UNIVERSITY

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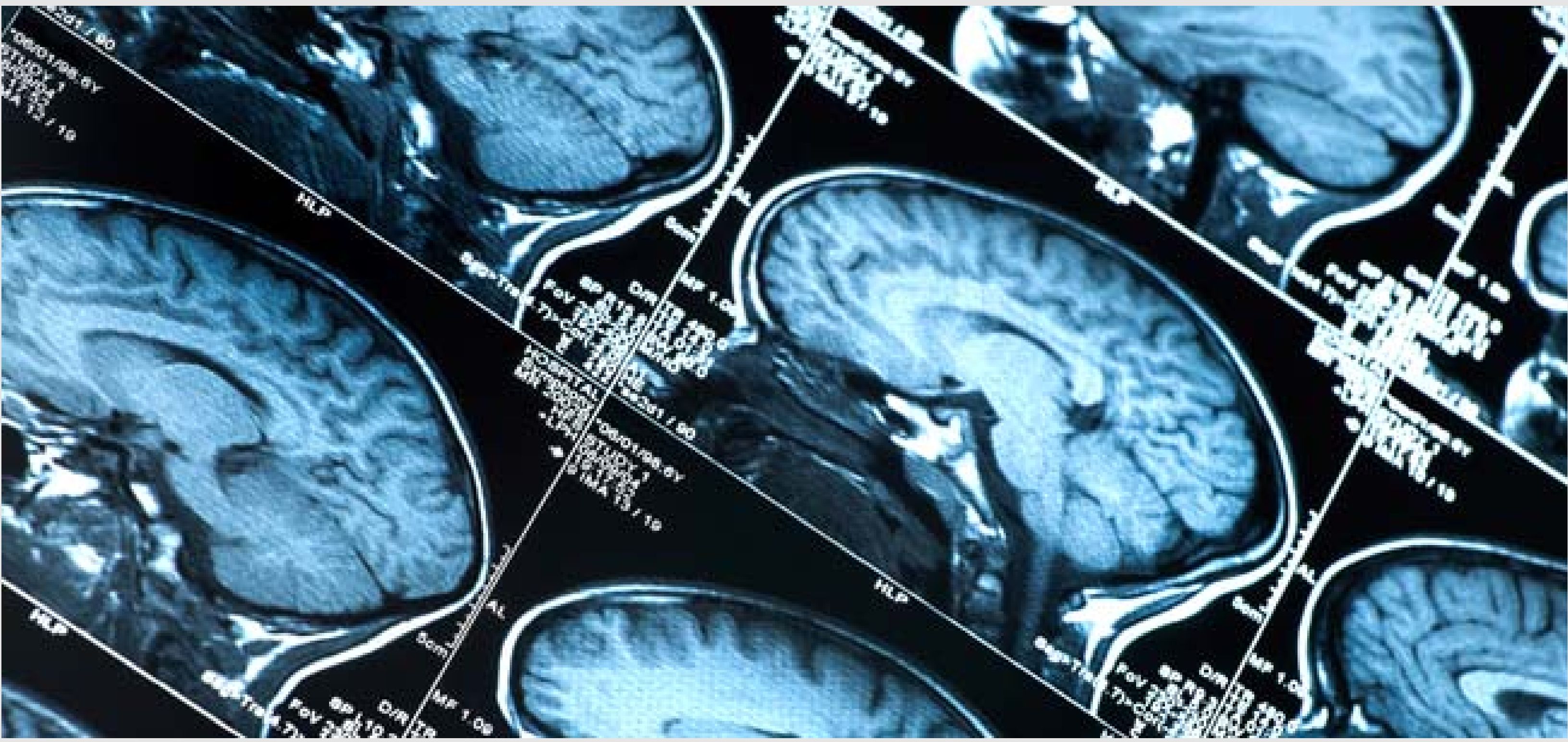

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FACULTY ADVISOR MICHAEL MIGA, Ph.D.

INSIDE THIS ISSUE

Cover image courtesy of Vanderbilt University Biomedical Engineering Department

SMART HEALTHCARE: THE FUTURE OF MEDICINE

RYAN SPEARS

> "Vanderbilt is the emerging center of the smart healthcare revolution and is primed to become the launching platform for many commercial devices..."

PHOTO COURTESY OF THE TENNESSEAN

InvisionHeart Cofounders Dr. Susan Eagle and Dr. Franz Baudenbacher pictured with CEO Josh Nickols (right)

If we've learned anything over the past few years, it's that healthcare has become a hassle. It's complicated, expensive, and inefficient, but does it have to stay that way? Dr. Franz Baudenbacher of Vanderbilt University doesn't think so. He envisions a future in which healthcare is integrated into patients' lives, no longer just a service but a partnership; he sees it being more accessible, providing important information anywhere with an Internet connection. He wants it to be more efficient, facilitating further patient independence and engagement on an intuitive level; to put it simply, he thinks healthcare should be smarter.

Dr. Baudenbacher, an associate professor of biomedical engineering and physics, has taken the first steps in transforming smart healthcare from a thought experiment to reality. Originally born from an undergraduate senior design project, this first step centered on constructing an electrocardiogram recording system connected wirelessly to an external data infrastructure compatible with devices like smartphones and tablets. This device will remove the burden of much of the bulky equipment that seems so intrinsic to a hospital room while simultaneously allowing the data to be accessed anywhere with an Internet connection (access requires authorization, of course).

This technology, currently being marketed by a startup company called InvisionHeart, will soon be the first device of its kind on the open market, but it doesn't seem like it will be alone for long. Franz Baudenbacher himself has several other projects in the works, including a cardiac impedance device used to monitor cardiac failure patients through their day-to-day lives. In addition, Vanderbilt's senior design seminars continue to produce novel ideas and prototypes for innovative implementations of smart healthcare. In order to enhance students' projects, Dr. Baudenbacher will be introducing a class on smart healthcare to help students develop the skills they need to make a marketable product.

As it is, Vanderbilt is the emerging center of the smart healthcare revolution and is primed to become the launching platform for many commercial devices, but in order to realize the future Dr. Baudenbacher envisions, other innovators must follow his example in making devices that meet three criteria: One, they must address a clinical need; Two, they must produce clinically relevant data based on physiological variables, and Three, they must be easily integrated into the workflow. If all this can come to pass, then healthcare reform will soon take on an entirely different meaning.

IMAGING BRAIN TRAUMA: TWO APPROACHES

JENNIFER DUAN & SIMENG MIAO

Throughout their sports career, many athletes will suffer at least one concussion, particularly if they play a contact sport. Because concussions are a type of brain injury, it is important for the health and safety of the athlete to have accurate imaging techniques determining when they are able to return to play. Here at Vanderbilt, Dr. Victoria Morgan is exploring a myriad of techniques to characterize sports concussions.

PHOTO COURTESY OF VU BME

Dr. Victoria Morgan, M.S and Ph.D. Biomedical Engineering Vanderbilt

Dr. Morgan's study targets 18-22 year old college athletes who have recently suffered a concussion. The athletes then undergo several Magnetic Resonance Imaging (MRI), functional magnetic resonance imaging (fMRI) scans and diffusion tensor imaging to characterize any brain trauma.

It is known that synchronicity in slow fMRI signal fluctuations, reflecting blood oxygenation, indicate the functional connectivity of networks across the brain. Dr. Morgan's lab compares the functional connectivity of networks across the brain. Results thus far have shown a tendency for long range, general networks to be disrupted in concussion patients. The lab also studies vasoreactivity by having the subjects rest followed by breathing room air with 5% carbon dioxide concentration which causes brain vessel dilation. Vessel dilation is more pronounced in athletes who have recently suffered concussions. This blood vessel overreaction could cause returning symptoms if the athlete returns to play prematurely.

Diffusion tensor imaging is also used to analyze axon damage which could be caused when a force causes the head to whip around and tear the axon fibers to cause swelling. Measurements are made by estimating the rate of water diffusion at different locations. Because water is constrained to move parallel to axons, the diffusion patterns can be analyzed to determine the structural changes as a result of axonal swelling.

Dr. Morgan's work is important in pinpointing early changes in brain structure and functionality after concussion. The results could provide crucial insight into determining when athletes are able to return to the field and return to learning 100% safely.

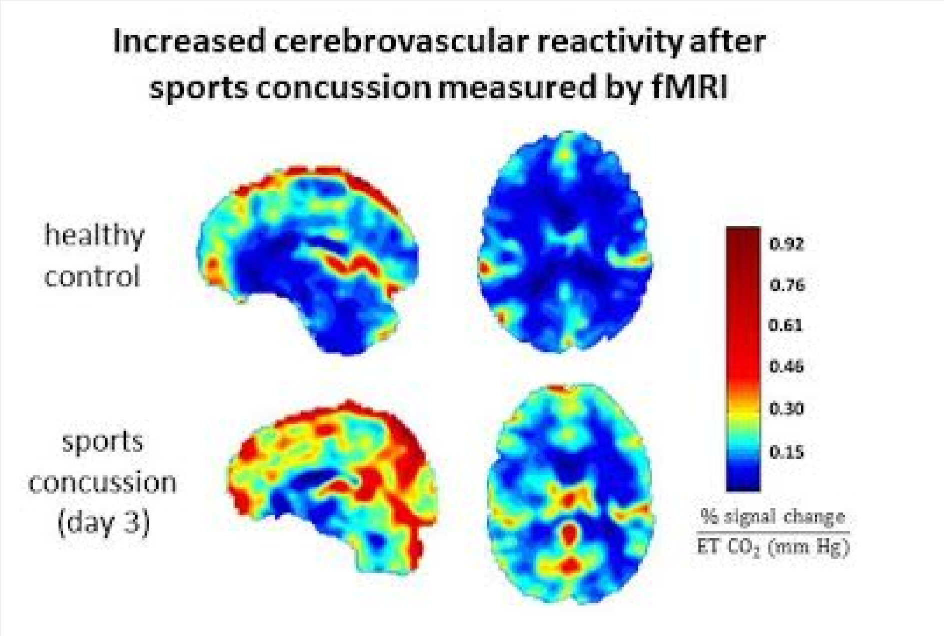

IMAGE COURTESY OF DR. MORGAN

Increased cerebral reactivity during CO_2 breathing test after sports concussion

IMAGING BRAIN TRAUMA: TWO APPROACHES (CONT.)

JENNIFER DUAN & SIMENG MIAO

Although the playing field and the battlefield may not seem to have much in common, athletes and soldiers are susceptible to similar types of brain injuries. Understanding changes in an athlete's brain activity after a concussion may aid in the analysis of brain injuries soldiers suffer due to impacts (such as bullet wounds or explosions) in war. With the information garnered from Dr. Morgan's study of concussions, Dr. Adam Anderson, associate professor of biomedical engineering, hopes to improve characterization of brain injuries in soldiers.

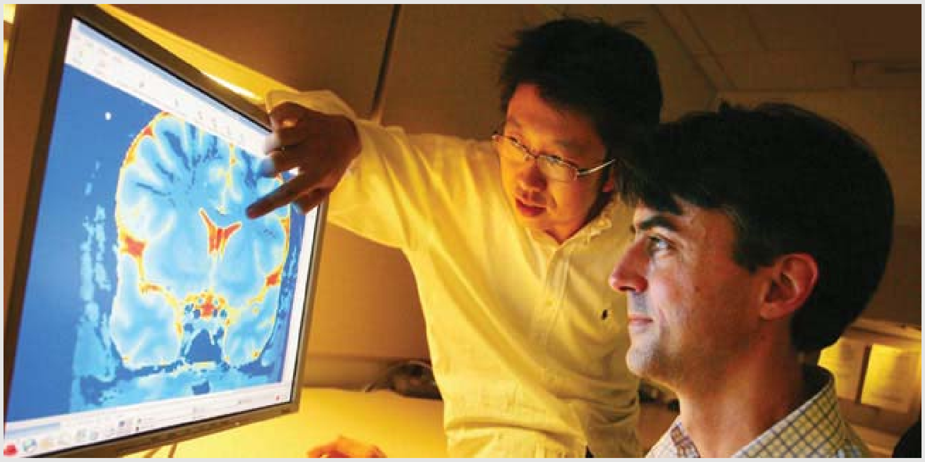

PHOTO COURTESY OF VU BME

Dr. Adam Anderson, M.S. Physics and Philosophy Yale University, Ph.D. Physics Yale University

Dr. Anderson was contacted by the United States Army to study soldiers who had suffered brain injuries of various severities. Severe brain injuries are typically easier to detect through traditional imaging techniques. In cases of severe brain trauma, axonal fiber integrity is compromised. This type of damage can be picked up readily in a scan and the soldier can be treated for brain injury.

Soldiers that have suffered milder brain injuries, however, may not be diagnosed with brain trauma because milder injuries are more difficult to detect in scans. Further complicating matters is the fact that mild brain injuries may be mistaken for post-traumatic stress disorder (PTSD) due to their similar physical manifestations. Both brain injury and PTSD may involve depression, memory problems, and fatigue. As such, soldiers with mild brain injuries often get treated for PTSD rather than their injury.

To ensure that soldiers are receiving proper medical treatment, it is imperative that even mild cases of brain injuries can be properly detected in scans. Dr. Anderson hopes to apply the findings from Dr. Morgan's study of concussions to improve classification of brain injuries. The collaborated effort of Dr. Anderson and Dr. Morgan may give insight to how an impact to the head affects brain activity and function, leading to promising advances in detection and diagnosis of brain injuries.

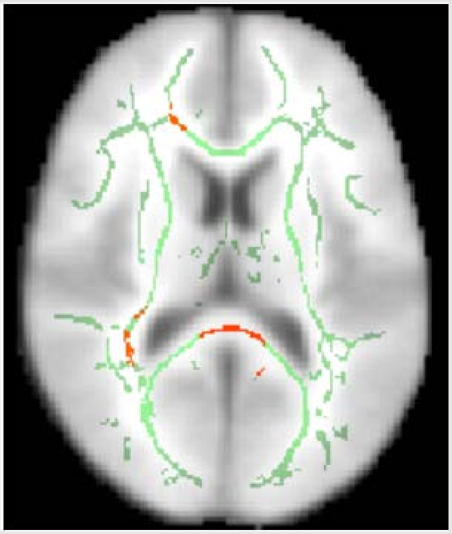

IMAGE COURTESY OF DR. ANDERSON

This image shows major fiber tracts susceptible to injury. Red indicates abnormal fiber integrity for this patient.

FACULTY SHOWCASE

AIMBE FELLOW PROFILES

Michael Miga

Professor of Biomedical Engineering

Professor of Radiology & Radiological Sciences

Professor of Neurological Surgery

Dr. Miga is the director of the Biomedical Modeling Laboratory which develops new paradigms in detection, diagnosis and treatment of disease via integration of computational models into research and clinical practices. He is also co-founder of the Vanderbilt initiative in Surgery and Engineering (ViSE) center. He received his bachelor and master of science in mechanical engineering at the University of Rhode Island. His doctorate in biomedical engineering is from Dartmouth College.

Bruce Damon, Ph.D.

Associate Professor of Radiology & Radiological Sciences

Associate Professor of Molecular Physiology & Biophysics

Associate Professor of Biomedical Engineering

Dr. Damon research focuses on developing more detailed and quantitative magnetic resonance imaging (MRI) methods for characterizing muscle damage related to diseases, specifically muscular dystrophy. He received a bachelor of science in exercise science from the University of Massachusetts, a master of science in kinesiology from the University of Illinois and a doctorate in molecular and integrative physiology from the University of Illinois.

Thomas Yankeelov, Ph.D.

Associate Professor of Radiology & Radiological Sciences

Associate Professor of Physics

Ingram Associate Professor of Cancer Research

Associate Professor of Biomedical Engineering

Associate Professor of Cancer Biology

Dr. Yankeelov is the director of cancer imaging research at VUIIS and develops advanced imaging methods for characterizing human tumors and evaluating their role as surrogate biomarkers of treatment responses and tissue status for use in clinical trials and drug discovery. He received his bachelor of arts in mathematics at the University of Louisville, a master of arts in applied mathematics and a master of science in physics at Indiana University. His doctorate in biomedical engineering was from the State University of New York, Stony Brook.

Mark Does, Ph.D.

Professor of Biomedical Engineering

Professor of Radiology & Radiological Sciences

Professor of Electrical Engineering

Dr. Does uses experimental MRI and nuclear magnetic resonance (NMR) protocols, signal analysis methods and computational modeling to characterize specific tissue characteristics, such as myelin thickness, myofiber size and density, or pore and bound water concentration in bone. He received a bachelor and master of science in electrical engineering and a doctorate in biomedical engineering from the University of Alberta.

BABY HEARTS NEED RHYTHM TO DEVELOP

STEVEN WANG

Mary Kathryn Sewell-Loftin, a graduate student at Vanderbilt University, has been working with a team of Vanderbilt engineers, scientists and clinicians to try and grow replacement heart valves from the cells of the patient receiving the treatment. From the process they have discovered that rhythmic mechanical forces are important for the development of a baby's heart.

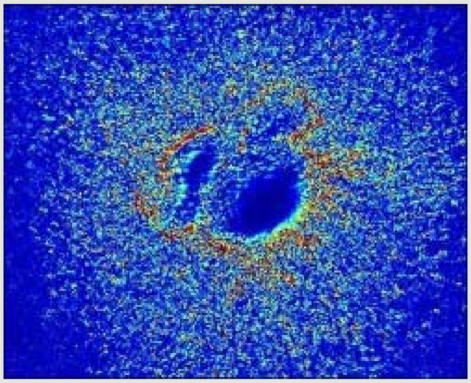

IMAGE COURTESY OF MERRYMAN LAB

Heat map of the valve formation section of a chick embryo.

Assistant Professor of Biomedical Engineering W. David Merryman, who has directed this study for the past three years, states that, "For the last 15 years, people have been trying to create a heart valve out of artificial tissue using brute-force engineering methods without any success." His team, however, focuses to recreate the process of heart valve development from natural growth rather than from artificial creation. The team has published an article in the journal Biomaterials in January 2014 that detailed their findings that the rhythmic movement of the heart from expansion and contraction of cardiac muscle cells contribute mechanical forces that are critical to the beginning of heart valve formation. Their discovery opens up an entirely new perspective with which to view the process of cardiac valve development.

The Vanderbilt program is part of the NIH initiative SysCODE, Systems-based Consortium for Organ Design and Engineering, which hopes to "speed the movement of scientific discoveries from the bench to the bedside."

Professor of Pharmacology Joey Barnett says that this is the second major advance that the team has made. The recent advancement stems from a genetic study the team conducted last spring when they "identified the unique genes and molecular pathways associated with valve formation." Sewell-Loftin modified the conventional technique of using a chick heart from the embryo to culture and included a sugar called hyaluronic acid as part of the process.

Furthermore, she formulated a computer program to measure the amount of deformation that the movement of the heart cells caused to the gel. The final conclusion was that the cells in areas of greater deformation grew more preferentially. A future goal of the team is to work with induced pluripotent stem cells to produce endothelial cells and to use these to produce human VICs.

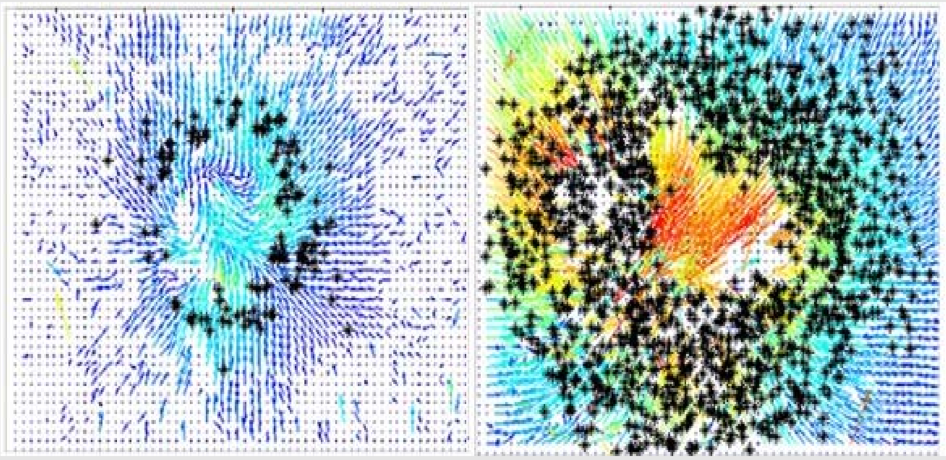

IMAGE COURTESY OF MERRYMAN LAB

The back x's represent where epithelial cells become valvular interstitial cells. The right image is a high stress environment and the left image is a low-stress environment.

SPOTLIGHT

InvisionHeart

American Institute of Medical & Biological Engineering

KEY FACTS

- Developed by a team of interdisciplinary physicians and researchers including BME, ME, cardiology and EE
- Received a $100,000 investment from AOL founder Steve Case at Google Demo Day 2014
- Wireless communication of ECG data via cloud services as opposed to current solution of faxing and mailing
- Won the 2013 Vanderbilt TechVenture Challenge
- Finalist in the November 2013 Global Food and Health Innovation Challenge

COLLEGE OF FELLOWS

- Consists of 1500 outstanding individuals who are leaders in bioengineering academia, government, and industry
- Fellows are nominated by their peers and represent the top 2% of the medical and biological engineering community
- Fellows can be from the United States or abroad, thought most are from the US
- Fellows work toward realizing AIMBE's mission of to use medical and biological engineering advancements to benefit mankind

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Todd D. Giorgio, Ph.D., Chair of Biomedical Engineering

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