
FIU
Engineering
& Computing
Department of Biomedical Engineering
9th Annual
Undergraduate Research Day
Friday, September 28th, 2018

Program

8:15 AM	Breakfast with Student Presenters (EC 2300)
9:00 AM	Seminar: Dr. Sheldon Weinbaum (EC 2300)
10:30 AM	Undergraduate Student Poster Presentation (Panther Pit)
12:30 PM	Lunch with Student Presenters and Faculty Mentors (Panther Pit)
2:00 PM	Panel Discussion with BME Alumni (EC 2300)
3:30 PM	Awards and Reception (EC 2300)

FIU Engineering & Computing
Department of Biomedical Engineering

Wallace H. Coulter Foundation

WH Coulter Biomedical Engineering
Distinguished Lecture Series

"From Red Cells to Skiing, to a Jet Train that Travels at 700 km/hr on a Giant Ski"

Keynote Speaker

Sheldon Weinbaum, Ph.D.

Distinguished Professor Emeritus of Biomedical and Mechanical Engineering at The City College of New York

Sheldon Weinbaum is an American biomedical engineer and biofluid mechanician. He is a CUNY Distinguished Professor Emeritus of Biomedical and Mechanical Engineering at The City College of New York. He is is a member of all three U.S. national academies (NAS, NAE and NAM) and also the American Academy of Arts and Sciences. He was the founding director (1994-1999) of the New York Center for Biomedical Engineering, a regional research consortium involving the BME program at The City College and eight of the premier health care institutions in New York City. He has been a lifelong advocate for women and minorities in science and engineering. He was the lead plaintiff and organizer of a class-action lawsuit (Weinbaum vs. Cuomo) charging New York State officials with racially discriminatory funding of its two university systems, CUNY and SUNY, the first CUNY faculty recipient of the Public Service Award of the Fund for the City of New York, and the Inaugural Recipient of the "Diversity Award" of the Biomedical Engineering Society (2009). He is also chair of the Selection Committee that chooses the annual Sloan Awardees for the outstanding math and science teachers in New York City public high schools.

WALLACE H. COULTER Foundation

Table of Contents

Aortic valve leaflet curvature alterations after elastin degradation

Authors

Ahmed Ali, Melake Tefsamariam, Daniel Chapparo, Melissa Hendon, Joshua Hutcheson, Sharan Ramaswamy

Faculty Adviser Sharan Ramaswamy

Figure 1: 2/3 normal bend of aortic leaflet

Figure 2: 2/3 bend degraded aortic leaflet

Abstract

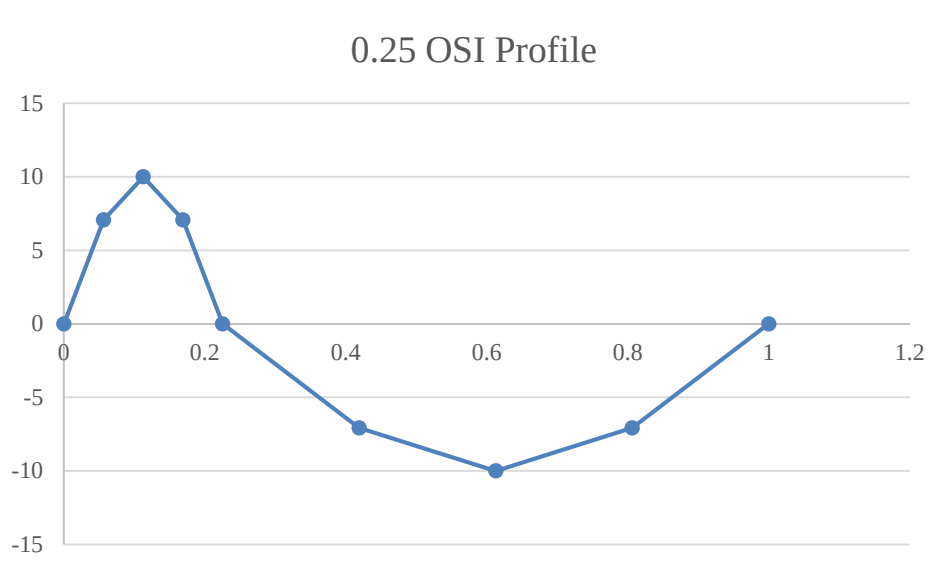
Among acquired valve diseases, stenosis is often a result of aortic valve calcification (AVC). Fibrotic tissue forms and calcified mineral is deposited within the valve. The hardening of the valve leads to decreased functional area, causing an obstruction to the outflow and an increasing pressure across the aortic valve causing workload of the heart to drastically increase. If the stenosis of the valve is left untreated it will lead to a heart failure. Surgical valve replacement using a mechanical or bioprosthetic valve is the only current available treatment for critical stages of AVC. Nonetheless, early detection of AVC may aid the physician in implementing a treatment plan to delay the progression of the disease. Elastin within the valve matrix has a relative slow rate of remodeling relative to other matrix components and contributes towards the valve dynamic structure during the cardiac cycle. Recent evidence has suggested that elastin degradation may have an important role in the development of AVC. Therefore, in this investigation, we conducted experiments using n=4 groups that include control group that has no elastin degradation, two hours, three hours and one week elastin degradation to investigate the association of leaflet structure with elastin in aortic valve leaflets.

The effect of oscillatory shear index on communication between vascular endothelial and smooth muscle cells

Authors

Alexandra Tchir, Denise Hsu

Faculty Adviser Sharan Ramaswamy



Abstract

Cellular response to oscillatory shear index (OSI) may have an effect on cellular communication between vascular endothelial cells (ECs) and vascular smooth muscle cells (SMCs). In other systems OSI has proven to be important for tissue development, such as in the differentiation of bone marrow stem cells. Physiologically speaking, only ECs are exposed to blood flow. We hypothesize OSI characteristics will change the ECs resulting communication factors to SMCs. To test this, ECs will be grown in two different OSI profiles, 0.25 OSI and 0 OSI. The shear stress will be kept constant since previous literature has found shear stress to be a known component of the vascular environment, necessary in combination with OSI. Shear stress will be applied at a value known to be in the physiological range. We will expose SMCs to OSI conditioned media from ECs. A qPCR test and Western Blotting will be run on SMCs in order to see gene expression and protein analysis and the effect OSI had on it. We expect the 0.25 OSI profile will be more physiologically relevant and will produce a higher vascular phenotypic gene expression. We expect protein analysis to yield.

Aortic valve leaflet curvature as a function of elastin degradation

Authors

Amanda Barreto, Asad Mirza, Ahmed Ali , Sharan Ramaswamy

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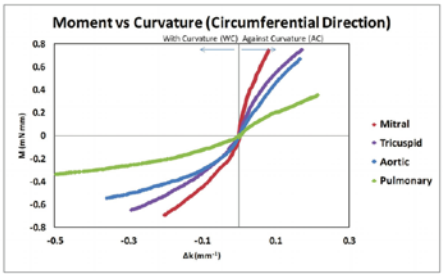


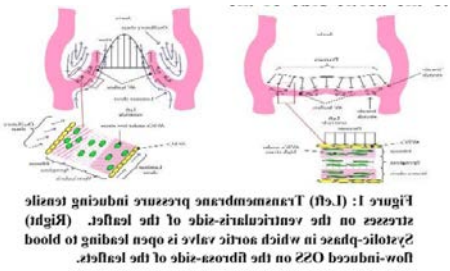


Figure 1: (Left) Transmembrane pressure inducing tensile stresses on the ventricularis-side of the leaflet. (Right) Systolic-phase in which aortic valve is open leading to blood flow-induced OSS on the fibrosa-side of the leaflets.

Abstract

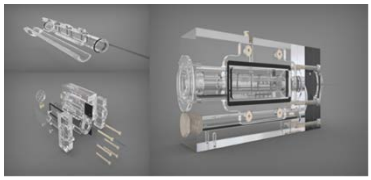
During the cardiac cycle the heart valves assist in the coordinated blood flow. Aortic valve calcification (AVC) is a health condition which usually entails surgical valve replacement. Elastin degradation in the extracellular matrix (ECM) could play a significant function in the progression of AVC. The elastin protein within the aortic valve leaflets coordinates leaflet structure and recoil during the opening and closing of the valve. The leaflet curvature is critical during the blood flow through the valve and to the rest of the heart. The proposed project is to capture images of the leaflet curvature. These will be tested with different degree of elastin degradation. An analysis will be made for the correlation of elastin degradation and curvature that may lead to AVC. To observe the changes in curvature an un-degraded (control group), semi degraded elastin and critically degraded elastin, from porcine aortic valve leaflets will experience flexure. The curvature of the leaflets will be captured using a high-frame rate video system. The aortic valve leaflet flexure experiments will be produced using a mechanical testing instrument (Electroforce, 2300, TA instruments, New Castle, DE). The elastin degradation in each sample will dictate its subsequent curvature.

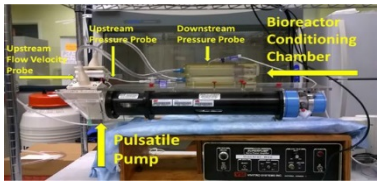
Design features to enable physiological-relevance in flow for optimizing engineered valve tissues

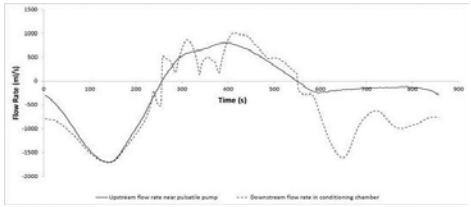
Authors

Anderson Milfort, Manuel Pere-Nevarez, Omkar Mankame, Elnaz Pour Issa, Alex Williams, Alejandro Pinero, Sharan Ramaswamy

Faculty Adviser Sharan Ramaswamy







Abstract

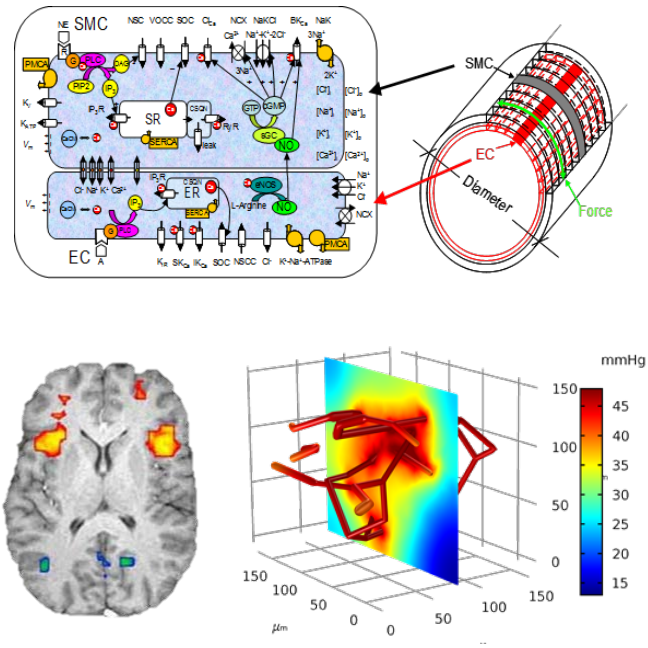
Tissue engineering and regenerative medicine show promise for application in various diseases ranging from structural tissues such as cartilage, and bone, to organs such as liver, and myocardium. Critical heart valve diseases in children are one of the most challenging problems. In any case, such a disease may be possible to treat utilizing a tissue engineered scaffold approach, which is promising since it would provide growth and self-repair. Past studies in our laboratory have demonstrated direct change in gene expression supporting the valve phenotype when stem-cells were conditioned under native, human aortic pulsatile flow conditions. To further this work to 3-dimensional tissue growth, the objective of the current investigation is to assemble an in vitro system, which can deliver physiologically-relevant pulsatile flows to growing engineered valve tissue constructs.

Multiscale modeling of neurovascular coupling: from ion channel activity to bold fMRI responses

Authors

Baarbod Ashenagar, Arash Moshkforoush, Asad Mirza, Manuel Russo, Nikolaos Tsoukias

Faculty Adviser Nikolaos Tsoukias



Abstract

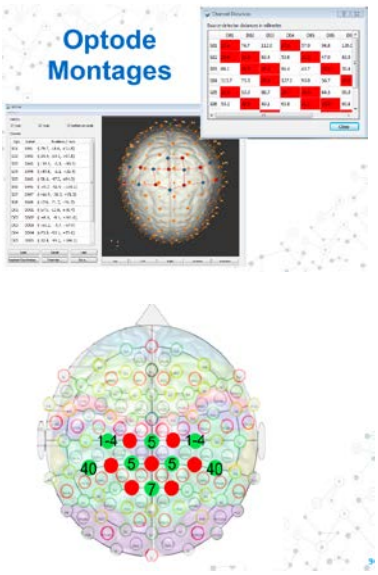
Neuronal activity signals local changes in blood flow that match metabolic demands for oxygen referred to as Neurovascular Coupling (NVC). We propose an integrative modeling approach to model microcirculatory responses to NVC mediators and their effect on the regulation of blood flow, tissue perfusion and oxygenation. Multicellular models of microcirculatory vessels simulate the effect of ions, flow, pressure, and stimuli. Multiple capillary and arteriolar segments are coupled together to form a microvascular network that examines the effect of localized stimuli. Simulations are extended at a macroscale level, incorporating regulation of vessel diameter by electrical signals, shear stress, and pressure. The model predicts changes in tissue perfusion and O2 distribution in response to neuronal activity. Simulations suggest that the inwardly rectifying potassium channel as an important mediator in NVC. A localized K + challenge (10 mM) can hyperpolarize nearby capillary ECs. The hyperpolarizing current can be transmitted upstream to feeding arterioles leading to dilation and increased blood flow. The changes in shear stress and pressure feedback to alter microcirculatory tone and diameter throughout the vascular network. The theoretical framework presented will allow for testing of proposed NVC mechanisms and assist in the interpretation of macroscale functional responses in health and disease.

Evaluating the effects of sensory feedback on motor control using functional near-infrared spectroscopy

Authors

Brigette Manohar, Michelle Huang, Anil Thota, Dr. Brian Hillen, Ranu Jung

Faculty Adviser Ranu Jung



Abstract

To date, approximately two million people are living with an amputation, and nearly 25% of those amputees suffer from upper limb loss. Many of these amputees use prosthetic limbs in order to regain a range of function. However, these prostheses are often difficult to maneuver, as amputees are not receiving the sense of touch they need to perform precise daily activities. The Adaptive Neural Systems Lab is conducting “first-in-human” clinical studies for providing sensation to amputees through electrical stimulation of peripheral nerves. We are collecting multiple outcome measures that quantify the quality, location and strength of the sensations provided to the amputees. There is some evidence that amputee’s brains remap due to the loss of sensation from their limb, however we have yet to evaluate the modulation of brain activity due to reintroduction of lost sensations. The long-term goal of this study is to image superficial cortical brain areas using functional near-infrared spectroscopy (fNIRS) for evaluating the effects of sensorimotor re-integration in amputees. We have mapped the cortical brain areas (Brodmann Areas 3-2-1, 4 and 5) that represent sensory activity and their scalp locations. The mapped region of interest (ROI) brain areas were transformed to fNIRS montage. A standard fNIRS montage and scalp shape may lead to projecting brain activity at inaccurate locations on the head model. To reduce the inaccuracies, we have used 3D head tracking system (Xensor) to create a subject-specific unique head model and calculated accurate optode locations on the scalp of the subject. This current approach will help in creating accurate images of brain activity obtained with fNIRS. This study is supported by the HSAP & URAP Army Education Outreach Program from Army of Research Office and the Science Research Internship Program at FIU.

The effects of an MRI scanner setting on alpha waves

Authors

Ernest Mares, Carolina Moncion, Pedro Valdes Hernandez, Jorge J. Riera

Faculty Adviser Jorge J. Riera

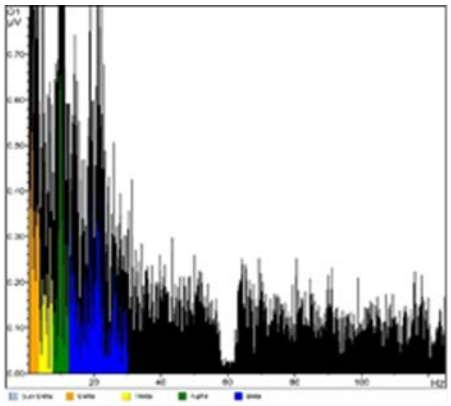


Fig. 1 Power Spectrum of Non-Mock Subject

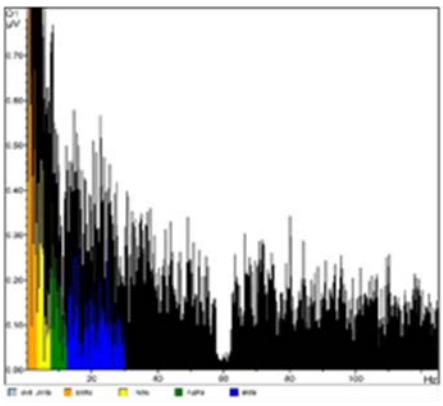


Fig. 2 Power Spectrum of Mock Subject

Abstract

Electroencephalographic (EEG) data can be analyzed in the frequency domain, this depicts the sum of sinusoidal brain waves that contribute the most power to the recorded signal. It is known that subject activity and surrounding stimuli influence the power of each type of brain wave at a given time. Alpha waves are the most commonly observed and an increase in their power can be triggered simply by the subject closing their eyes. They are also known to appear during periods of relaxation when there is a reduction in cortical activity. MRI scanners are known to produce a loud sound during the scanning period and this can affect alpha wave power during simultaneous EEG-fMRI recordings. It is hypothesized that the sound created by the MRI can affect the relaxed state of the subject and therefore affect alpha wave power. This needs to be considered during the analysis of EEG-fMRI recordings as it influences the interpretation of the data. In this study, we evaluate the influence of an MRI setting on the alpha wave power in normal human subjects. The BrainVision EEG cap along with the corresponding software was used to record EEG in a homemade mock MRI including the typical sound. The power spectrum was extracted for analysis, focusing on the O1 and O2 electrodes, as they are located over the visual cortex where alpha waves are typically recorded from.

Using tunable resistive pulse sensing to identify and quantify extracellular vesicles

Authors

Jessica Molina, Mohammad Shaver, Joshua D. Hutcheson

Faculty Adviser Joshua D. Hutcheson

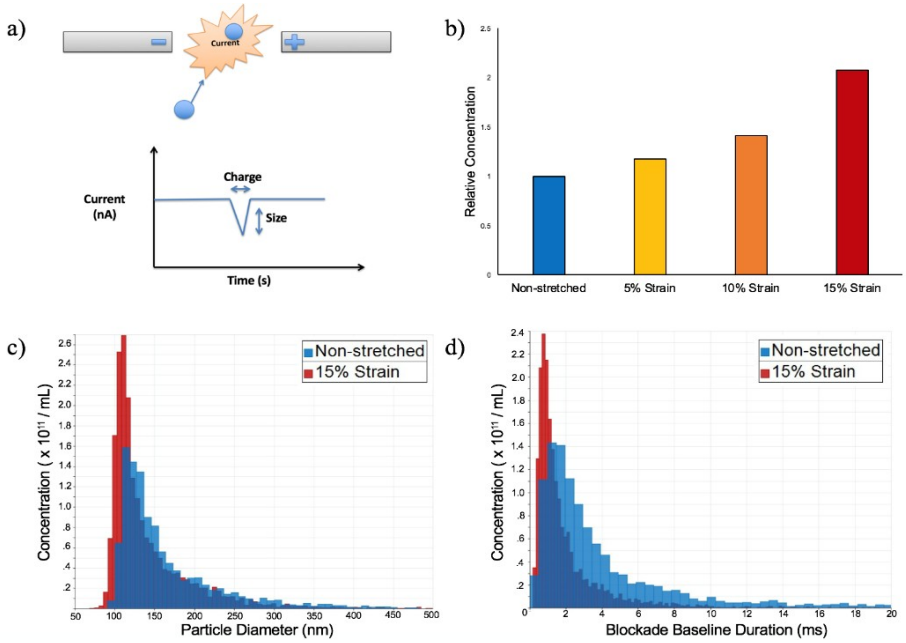
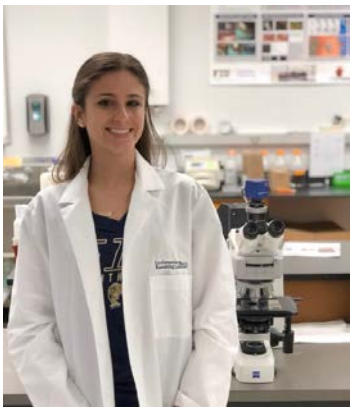


Figure 1. (a) TRPS measures current disruption within a pore to measure EV size and charge (b) Relative concentration of samples based on final particle count (c)EV size distribution for non-stretched control and 15% strain samples (d) EV charge distribution for non-stretched control and 15% strain samples



Abstract

Calcification, a leading contributor to cardiovascular disease, begins with ~100 nm- sized vesicles released by cells in response to pathological conditions. These calcifying extracellular vesicles exist within larger populations of extracellular vesicles (EVs) released during normal cellular processes. One of the biggest challenges in studying EVs comes from their heterogeneity and small size. There are no methods that currently exist to separately assess and quantify calcifying EVs from the total EV population. Tunable resistive pulse sensing (TRPS) allows for EV-by-EV analysis and simultaneously captures both the unique size and charge of each particle, while also calculating EV concentration. Alterations in vascular biomechanics are associated with changes in cell phenotype and tissue remodeling; however, the relationship between biomechanics and EV formation remain unclear. In this study we use TRPS to assess changes in EVs released by vascular smooth muscle cells (VSMCs) exposed to mechanical stretch in vitro. The extracellular components appear to adapt to environmental changes by releasing uniquely sized vesicles into the extracellular matrix. Future studies will compare calcifying EVs from cardiovascular cells (pathologic) to those from bone cells (physiologic) using chemical as opposed to mechanical stimuli to further understand the role EVs play in mediating disease.

Assessment of wound healing in diabetic foot ulcers through the use of subclinical tissue oxygenation measurements obtained with near infrared spectroscopy

Authors

Jorge Barter, Kacie Kaile, Edwin Robledo, Jagadeesh Mahadevan, Sivakumar Narayanan, Varalakshmi Muthukrishnan, Mohan Viswanathan, Anuradha Godavarty

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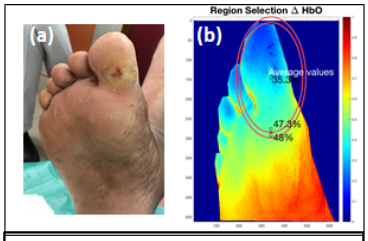


Figure 1. (a) White light image of a diabetic foot ulcer. (b) 2D ΔHbO plot with % values at wound and backgrounds.

Abstract

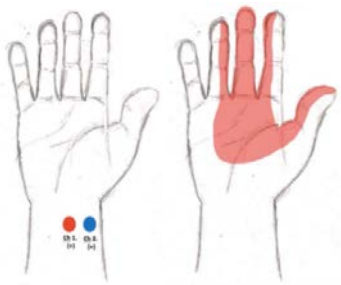
Diabetes affects 29.1 million Americans, with 15% of diabetics developing a diabetic foot ulcer (DFU). About 12-24% of patients with a DFU require an amputation. Conventional diagnosis of DFUs relies on examination of the wound area by a physician. The use of near infrared optical spectroscopy (NIROS) to evaluate hemodynamic changes could improve physicians' ability to diagnose this condition and determine wound healing. This study aims to assess the healing status of a DFU by using tissue oxygenation measurements obtained with NIROS by comparing the wound-background contrast of several hemodynamic parameters with respect to distance of back-ground regions from the wound, over the course of several days. NIROS was used to image DFUs using two wavelengths, 735nm and 805nm. Modified Beer-Lambert's law was used to determine changes in oxygenated hemoglobin (ΔHbO), deoxygenated hemoglobin (ΔHbR), total hemoglobin (ΔHbT), and blood saturated oxygen (ΔStO2) from the near-infrared images and generate hemodynamic maps. Five patients were imaged across sever-al days of healing. The wound-background contrast of this hemodynamic data was analyzed to determine wound healing. For each image, background regions were selected at varying distance from the wound at regular intervals, which was repeated for all image sets acquired. Figure 1 shows a white light image and ΔHbO image of a DFU case, with values at wound and background locations shown. Based on the results, tissue oxygenation maps of DFUs were obtained, providing subclinical information on wound healing, apart from clinical visual assessment.

Evoked referred sensations through quadripolar transcutaneous electrical neurostimulation

Authors

Luis Herran, Andres Pena, Ranu Jung

Faculty Adviser Ranu Jung



Abstract

Introduction: People rely on sensory feedback for everyday function, including planning and control of even simple movements, such as reaching for an object. Loss of sensory function due to disease or limb amputation can be a devastating, life-changing event. Despite the recent advances in myoelectric prostheses, they remain limited in their ability to provide sensory feedback to the users, which increases reliance on visual cues and attentional demands, resulting in substantial functional deficits and negative impact on their quality of life. Recent efforts to incorporate sensory feedback into prosthetic systems include invasive approaches through the use of implanted electrodes for direct sensory nerve activation; while non-invasive approaches have relied on the activation of sensory receptors through mechanical or electrical tactile input. Non-invasive electrical stimulation through single-channel, bipolar surface electrodes has been shown to evoke referred sensation in able bodied subjects. However, this approach is hampered by limited selectivity and stability, distracting local sensations, and requires the use of large currents to overcome the skin resistivity. This study focuses on investigating the potential benefits of using multichannel interleaved stimulation of the median and ulnar nerves thorough a quadripolar surface electrode configuration to evoke distally referred sensations more comfortably, efficiently and consistently than traditional bipolar stimulation.Results and Discussions: An early pilot study with single-channel stimulation was performed to activate the median nerve afferents in a single subject to test the functionality of the stimulation system and the S-D determination protocols. The perceived sensation characteristics as well as the S-D relationship were evaluated under three different PF values (1Hz, 10Hz and 100Hz). The subject reported a comfortable “tapping”, “tingling” and “vibration” sensation that spread around the thumb, index and middle fingers. Ongoing work is focused on using the stimulation platform to evaluate the performance of quadripolar stimulation against bipolar stimulation. Multichannel stimulation with interleaved current pulses could potentially create the conditions for both temporal, and spatial summation of the electric fields at the crossover region deep within the tissue, facilitating sensory fiber activation at lower thresholds. While sensation quality and location are not expected to be differ between the two approaches, the quadripolar configuration is expected to evoke more comfortable sensations, with higher intensity gradation and lower activation current amplitudes.

Application of structural tensegrity models to the initiation of vascular calcification

Authors

Manuel Garcia Russo, Mohammad Shaver, Amirala Bakhshiannik, Joshua Hutcheson

Faculty Adviser Joshua Hutcheson

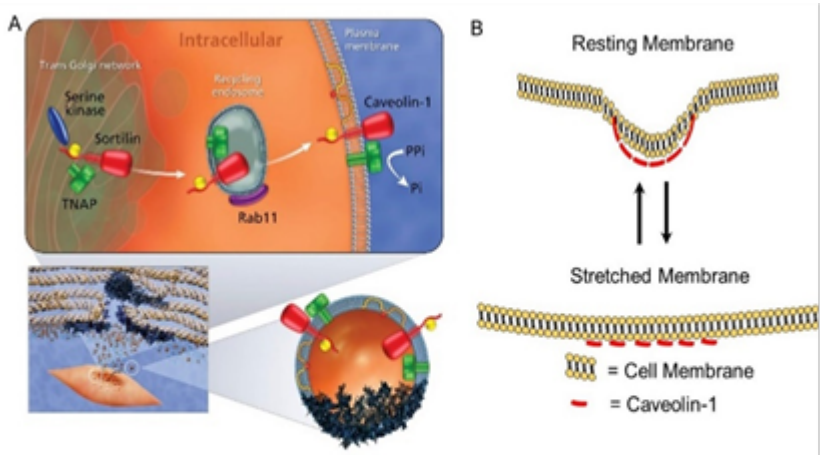


Figure 1. A) Caveolin-1 helps assemble proteins required for the formation of calcifying EVs [3]. B) Caveolin-1 forms caveolae, small invaginations in the cell membrane that buffer the cell to mechanical deformations.

Abstract

Cardiovascular calcification, deposition of bone-like mineral in heart and vascular tissues, is the most significant predictor of morbidity and mortality. However, no therapeutic options exist to prevent or treat this pathological remodeling. Mineral deposition begins in small (~100 nm) extracellular vesicles (EVs) released by cells within cardiovascular tissues, and the formation of these calcifying EVs requires the presence of a specific plasma membrane protein, caveolin-1 (cav-1). One function of cav-1 is to allow cells to respond to changes in the mechanical environment, but the role of mechanical stimulation in the production of calcifying EV formation has not been reported. Given that cardiovascular cells exist in a dynamic mechanical environment and that changes in mechanical stresses (e.g., elevated blood pressure) are known risk factors for cardiovascular disease, studies on the role of mechanics in the initiation of cardiovascular calcification may provide new insight into mechanisms of cardiovascular disease and potential points of therapeutic intervention. We hypothesize that elevated cellular mechanical stress promotes changes in the localization of cav-1, favoring the formation of calcifying EVs. We will test this hypothesis using the concept of tensegrity, which analogizes cell mechanics to self-supporting structures often employed in architecture.

Inflammation and calcification: from correlation to causation in cardiovascular tissue remodeling

Authors

Maria C. Giraldo , Joshua Hutcheson

Faculty Adviser Joshua D. Hutcheson

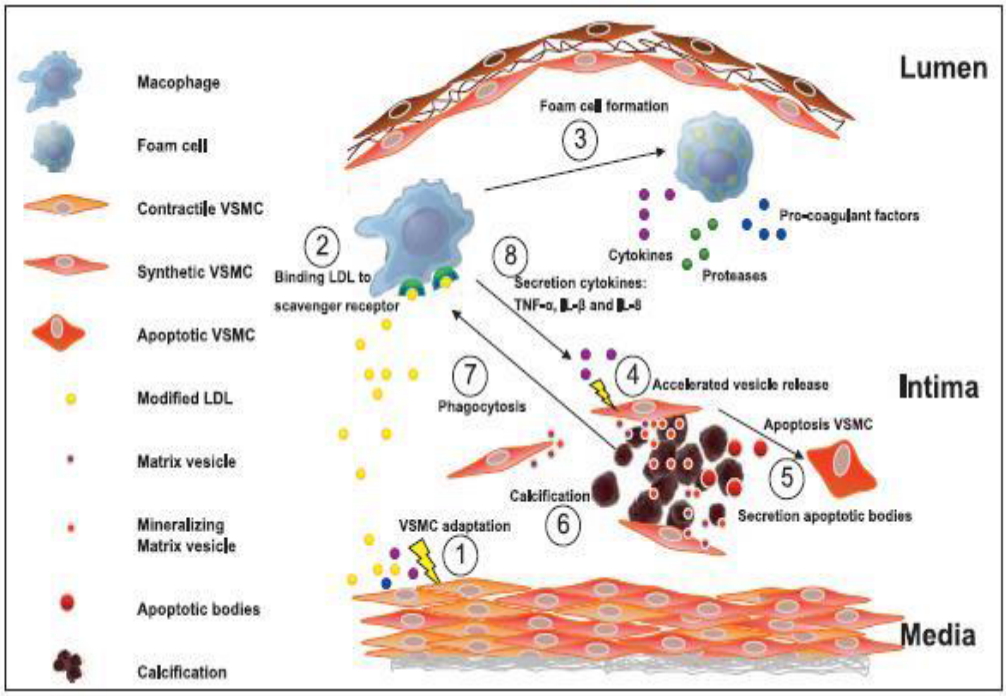


Figure 1. Calcification Pathway in Cardiovascular Tissues

Abstract

Cardiovascular disease is the number one killer in the United States, and calcification significantly predicts and contributes to cardiovascular morbidity. Inflammation of cardiovascular tissues has been shown to precede calcification. The mechanisms that govern inflammation and calcification are not completely understood. The presence of inflammatory cells (macrophages) within and surrounding calcified tissues is common, hence, these cells may play a role in triggering calcification. However, anti-inflammatory therapeutics have been observed to exacerbate calcification. Vascular smooth muscle cells (SMCs) are primarily responsible for depositing calcium mineral during calcification, so studies are needed to assess the interaction between inflammatory macrophages and SMCs. Understanding the role of inflammation in the initiation and progression of calcification within cardiovascular tissues is the focus of this study. We hypothesize that inflammatory cells release factors that initiate calcification processes but mineral deposition accelerates following the termination of inflammation. We will test this hypothesis by culturing pro-inflammatory macrophages in vitro. The conditioned media, containing factors released by these macrophages during culture, will be added to vascular SMCs cultured under pro-calcific conditions for varying amounts of time. We will then assess the degree of calcification using assays that detect calcium mineral deposition. According to results obtained during this stage of the research, further experimentation will be planned to eventually reach the main goal of the study. This study aims to establish methods that controllably reduce inflammation and promote the regeneration of the cardiovascular tissues without calcification.

Tissue oxygenation changes in a large diabetic foot ulcer: longitudinal case study

Authors

Maria Saavedra, Kevin Leiva, Kacie Kaile, Francisco Perez-Clavijo, Anuradha Godavarty

Faculty Adviser Anuradha Godavarty

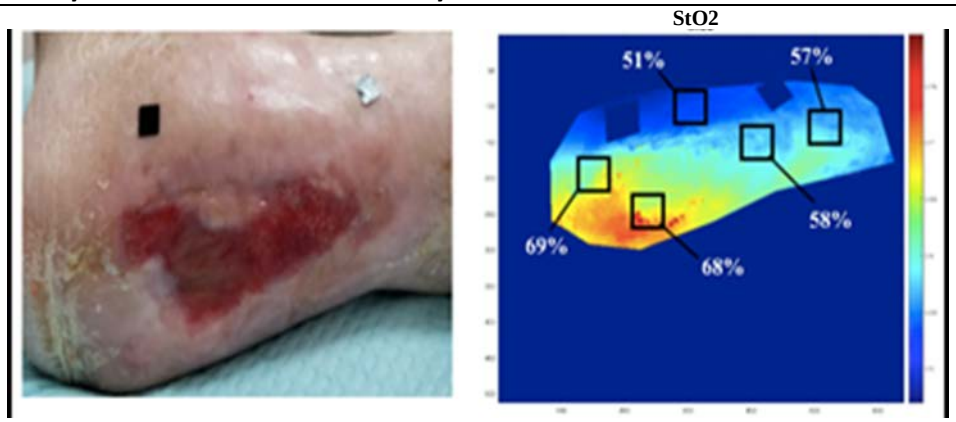
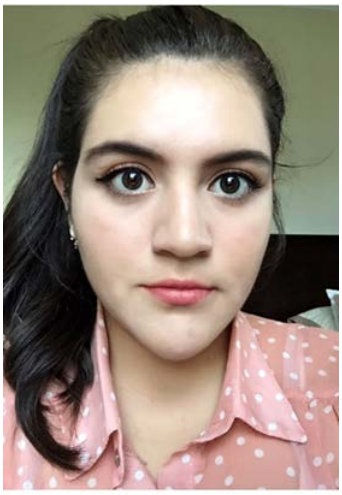


Figure 1. White light image and changes in saturated oxygen (ΔStO_2) map of the right posterior distal leg for a mixed DFU/arterial case.



Abstract

Diabetic Foot Ulcers (DFUs) are responsible for 20% of diabetic-related hospitalization and for 85% of diabetes related amputations. A near-infrared optical scanner (NIROS) was developed to image for tissue oxygenation of DFUs and assessing the healing status of the wounds. The device was capable to imaging smaller DFUs but was limited to image large wounds. A non-contact hand-held NIROS was developed to image large tissue surfaces. NIROS was used to collect diffused reflected images at 10Hz frequency and the light source composed of several multi-wavelengths LEDs covering a range of 600-900nm. This allowed collection of diffused reflectance images, which were in turn used to obtain hemodynamic maps in terms of oxy- (ΔHbO), deoxy- (ΔHbR), total hemoglobin (ΔHbT), and saturated oxygen (ΔStO2). A week by week basis study (~ 20 weeks) was performed on a mixed DFU/arterial wound subject. The images were later processed using modified Beer-Lambert's Law (mBLL) to obtain tissue oxygenation parameters of the entire imaged tissue. Picking different discrete points on the large wound lead to a similar trend where for each week was observed that at the bottom region of the wound more oxygen concentration and for the upper region of the wound it was more deoxygenation concentration. Evaluating mixed DFU/arterial wound subject using NIROS is potentially useful as a means for noncontact monitoring of large wound healing process and to measure subsurface changes in StO2 of different regions.

Intraspinal microstimulation for motor rehabilitation modulates neural transmission in spinal pain pathways

Authors

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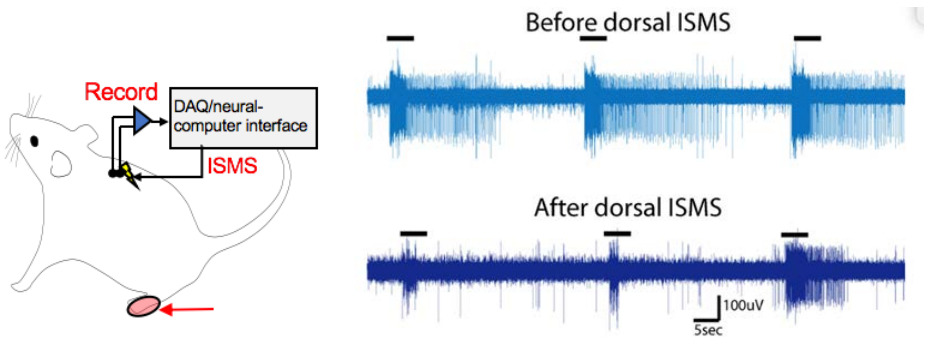

Abstract

Spinal cord injury (SCI) results in dramatic changes in neural excitability below the lesion, leading to debilitating motor impairments, dysregulation of reflexes, and neuropathic pain. Broadly, voluntary motor output is reduced below the lesion, whereas the spinal effects of sensory feedback become pathologically increased, contributing to hyperreflexia and neuropathic pain. Therapies seeking to restore sensorimotor function after SCI therefore face a dual challenge: increasing spinal motor output in response to descending motor commands while decreasing the spinal responses to sensory feedback that contribute to hyperreflexia and pain.

Here, we characterized whether electrical intraspinal microstimulation (ISMS) of the ventral horn, which can increase spinal motor output, concurrently modulates transmission in spinal pain pathways of the dorsal horn. All experiments were approved by the FIU IACUC and conducted in adult Sprague-Dawley rats under urethane anesthesia. After T13-L2 laminectomy, electrode arrays were implanted at the L5 dorsal root entry zone. Electrodes locations for ventral ISMS targeted Laminae 8-9 and electrode locations for quantifying transmission in nociceptive pathways targeted Laminae 1-3 of the dorsal horn.

Prior to and after ISMS, we mechanically stimulated the peripheral receptive field by applying controlled forces of varying magnitude (ranging from non-painful to painful). We classified pain and non-pain-related spinal neurons in the superficial dorsal horn based on their responses to these mechanical stimuli. We found that even short periods of ventral ISMS could modulate transmission in spinal pain pathways, with some effects persisting after ISMS was discontinued. These results could not be explained by direct current spread, and thus reflect transynaptic activation of superficial dorsal horn neurons that led to the induction of neural plasticity.

Our results demonstrate that neuroprosthetic therapies intending to use ventral ISMS only to increase spinal motor output in actuality modulate transmission throughout a wide and functionally diverse set of spinal neurons. Future work is required to systematically characterize these off-target effects, optimizing beneficial changes and mitigating unintended activity that could lead to hyperreflexia or pain.

Ion channel expression regulation by sodium and potassium in vascular endothelial cells

Authors

Monica Karas, Jessica Zatarain, Sana Nasim, Sharan Ramaswamy, Nikolaos Tsoukias

Faculty Adviser Nikolaos Tsoukias

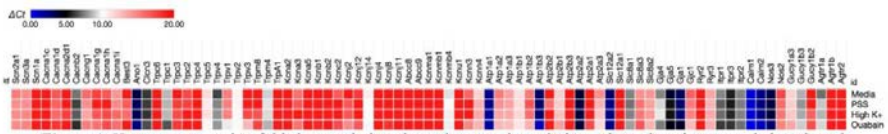

Figure 1. Heatmap presenting fold changes in ion channel expression relative to housekeeping controls in cultured endothelial cells under in standard culture media, in PBS and following exposure to 50mM K^+ or 3mM of Ouabain.

Monica Karas Jessica Zatarain

Abstract

Changes in the expression of ion channels, and of genes involved in membrane potential (Vm) homeostasis and Ca2+signaling have been associated with pathological conditions such as hypertension (1,2,3,4). Little is known, however, for the mechanisms that regulate the expression of the approximately 400 genes encoding for subunits of the 200-250 ion channels. There is evidence that a feedback system exists, capable of sensing changes in cell electrophysiology (5) that leads to altering ion channel transcription levels. The variable(s) that are sensed and controlled have not been established although Na+/K+ sensitive transcriptome has been reported in different cells, including in vascular cells (6) In this study, we will evaluate gene expression changes in cultured endothelial cells exposed to stresses. Different stress conditions will be examined that induce changes in V and in intracellular Na+ and m K+ concentration levels. The Na+/K+ sensitive ion channel transcriptome will be evaluated. The reported changes in ion channel associated transcripts are assessed for their ability to restore proper electrical properties to the cells under stress. RNA-Sequencing data will elaborate more on how these intracellular changes will lead to transcriptomic changes in vascular endothelial cells.

Preliminary data of a large scale ion channel qPCR analysis is shown in Figure 1. The heat map presents the expression of each ion channel gene (ΔCt) relative to Housekeeping genes (GAPDH, PECAM, ACTA2, RN18S). The expression of 8 genes was found to be upregulated during the high K+ stress and 3 were downregulated. Ouabain treatment provoked differential expression in 38 genes. Thus, preliminary evidence suggest that changes in membrane potential and in intracellular concentrations of Na+ and K+ may provoke transcriptional regulation of ion channel expression in vascular endothelial cells. The reported changes in ion channel associated transcripts are assessed for their ability to restore proper electrical properties to the cells under stress.

The reported changes in ion channel associated transcripts are assessed for their ability to restore proper electrical properties to the cells under stress. RNA-Sequencing data will elaborate more on how these intracellular changes will lead to transcriptomic changes in vascular endothelial cells.

Oxygen nanosensor for monitoring heart cell's metabolic activity on different substrates

Authors

Pablo Rodriguez, Maedeh Mozneb, Xiluan Yan, Chen-Zhong Li

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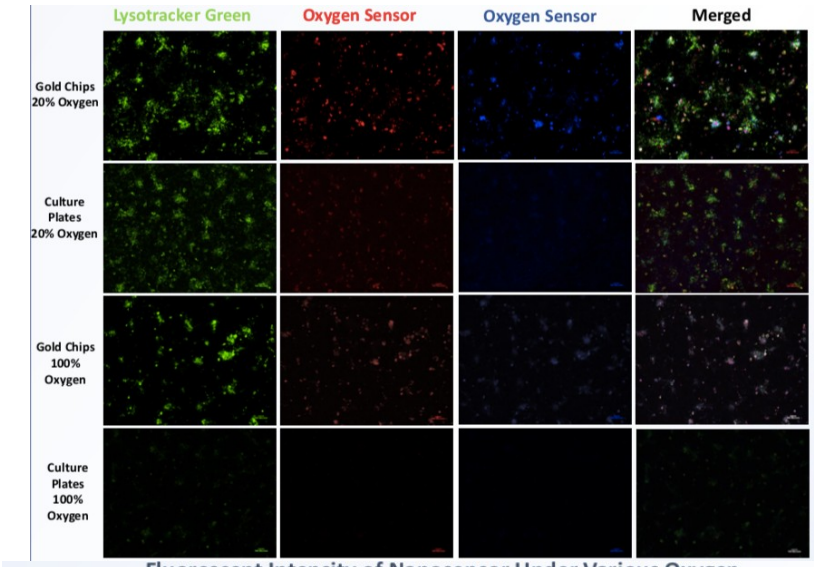
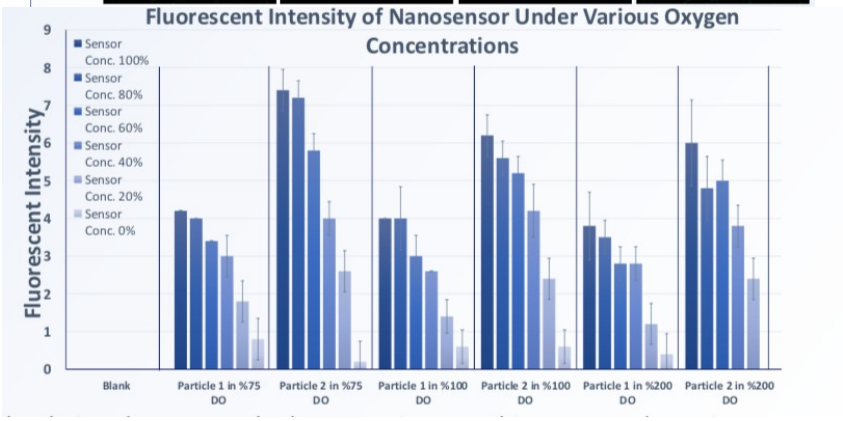




Abstract

Cardiovascular Diseases vary a lot from several types of cardiomyopathy to strokes. Organ-on-chip devices are a fast-emerging technology for drug development and heart tissue fabrication as implants. To develop the closest model of heart-on-chip to human heart, cardiomyocytes' (CMs) programmed maturity is vital. To help mature the cells, their environment (substrate of culture/sensory bed) should be optimized for cell's best performance. Oxygen consumption of cells during respiration is an important factor for CM maturity.

Measuring the oxygen consumption of CMs on two different substrates, which can perform as sensory beds in organ-on-chips, suggests which one is a more suitable environment for growing heart tissue. An oxygen quenching nanosensor was synthesized to monitor oxygen level consumption of CM in a regular petri dish and in one with a gold chip at 100 and 20 percent dissolved oxygen. The Images Suggest that Gold Chip is a suitable environment for the cells to grow, slightly more than just the petri dish. Also, as seen from the intensity analysis, the sensors response to increase of dissolved oxygen is decreased fluorescent intensity.

Validation of near-infrared optical scanner to assess saturated oxygen changes in response to breath hold

Authors

Priscilla Lozano, Kevin Leiva, Anuradha Godavarty

Faculty Adviser Anuradha Godavarty

Figure 1 Pulse Oximeter

Figure 2 Spectrometer

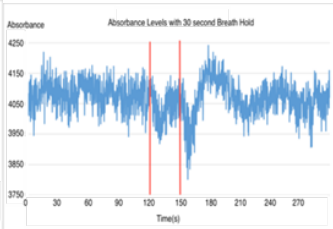
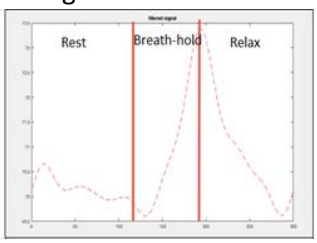


Figure 3 NIROS Data



Abstract

A near-infrared optical scanner (NIROS) was developed in-house, to determine relative oxygenated (ΔHbO) and deoxygenated (ΔHbR) hemoglobin levels in the wound and the surrounding tissue. The goal of this study is to measure perfusion changes in terms of saturated oxygen in subsurface tissues as a response to a breath-holding paradigm using NIROS, and validated against a hospital grade pulse oximeter and photo-spectrometer. Comparison of perfusion changes between the devices can assist in correlating these measurements and thus calibrate and validate our recently developed NIROS device. Furthermore, assessing oxygenated perfusion change can potentially help demarcate regions of poor oxygen flow, thus aiding clinicians assess the potential to heal in chronic or acute wounds. NIROS is a hand-held, non-contact optical device composed of an NIR-sensitive CMOS camera and a multi-wavelength LED source system utilizing wavelengths in the 660nm-805nm, that measures diffuse reflectance signals of 2D tissue regions. NIROS was used to collect diffused reflected images from 729nm and 799nm light, which was later processed with modified Beer-Lambert's Law to produce dynamic ΔHbO and ΔHbR maps. The same study design was used for all imaging modalities. NIROS was able to measure perfusion changes in terms of saturated oxygen in subsurface tissues as a response to a breath-holding paradigm, as observed by pulse oximeter and spectrometer. Extent of correlation across the three measuring approaches will be determined and NIROS calibrated as the next step.

Techniques in theranostic ormosil nanoparticle fabrication for cancer therapy

Authors

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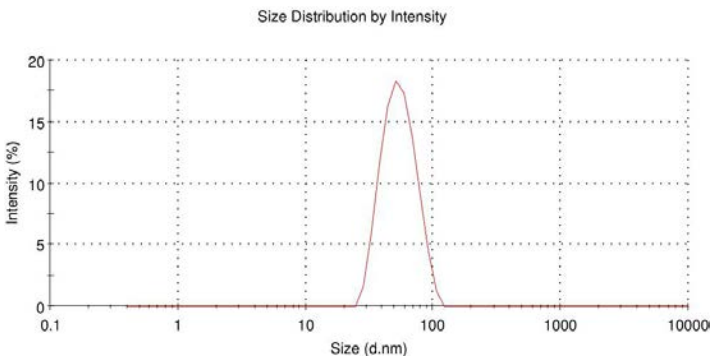
Faculty Adviser **Anthony McGoron**



Abstract

The idea of using nanoparticles for drug delivery is relatively new and will reduce the probability of side effects while increasing the patient's chances of survival. The quality of the nanoparticles is determined by measuring the size, polydispersity (PDI) and the quantity of amine groups on the surface. Once the optimal group has been determined, the second phase of the experiment can start, which is to conjugate imaging agent to the functional amine groups on the particles' surface. Targeted therapies, such as tumors, have become highly important in clinical oncology. However, not every individual requires the same therapy, thus, it is of high significance to develop a system that can be of good clinical benefit in theranostics . Organically Modified Silica (ORMOSIL) nanoparticles have been used for chemotherapeutic, photodynamic, gene delivery and bioimaging applications and have improved pharmacokinetic properties, controlled release of the drug and lowered toxicity. This project emphasizes on making ORMOSIL in multiple ways to generate drug encapsulating medium for theranostics. The size of nanoparticles is critical to take advantage of the Enhanced Permeation and Retention Effect (EPR) of most tumors, which makes size optimization an integral aim for this project. This project involved two different approaches to the synthesis of silica nanoparticles for comparative analysis, in terms of size and yield. One of the methods of synthesis implemented in this project was water-in-oil emulsion and the other being oil-in-water emulsion. Silane, introduced in the formed micelles, was precipitated in ammonia. APTES was introduced to synthesize amine grafted ORMOSIL nanoparticles. These methods of synthesis yielded nanoparticles of various sizes owing to the concentration of the reactants. Size ranges from 30 nm to 100 nm have been synthesized for effective drug delivery and analysis.

Feasibility assessment for shape replication of the aortic heart valve using syringe based 3D printing

Authors

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Faculty Adviser **Sharan Ramaswamy**

Fig.1: Aortic heart valve CAD model and printed samples.

Abstract

Congenital aortic heart valve diseases in children have extremely limited treatment options due to sizing limitations of current artificial heart valves [1]. An ideal solution could be found in tissue engineered heart valves (TEHVs) as a long term replacement [2,3]. It has been shown that a biomimetic shape for TEHVs streamlines and enhances load distribution on the leaflets, therefore reducing mechanical stress, energy loss, and workload for the heart [2].

A 3D printed TEHV is a novel solution with the capability of custom sizing. It can provide a suitable path for the growth of heart valve cells such as Valvular interstitial cells (VIC), which mediate extracellular matrix remodeling and play a vital role in maintaining valve's physical properties [1]. In our study, we have 3D printed an aortic heart valve with biomimetic shape as an appropriate bioscaffold.

These bioscaffolds can be customized by varying conditions of the cells or addition of other compounds in order to replicate diseases that occur in the aortic heart valve. Customization of bioscaffolds with mechanical and biological properties similar to native valves will allow for in depth analysis and deeper understanding of disease states that affect the aortic heart valve.

Effects of subcutaneous fat on wearable heart rate monitoring devices

Authors

Shaylyn Grier, Teshaun Francis, Wei-Chiang Lin

Faculty Adviser Wei-Chiang Lin

Figure 1: Pulse Oximeter utilized for heart rate measurement.

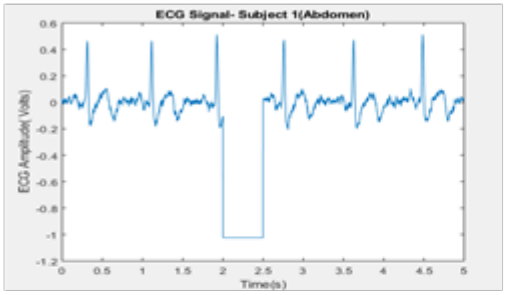


Figure 2: ECG signal acquired from an ECG device built by TF. The raw signals were processed using MATLAB programs developed by SG to derive the heart rate information.

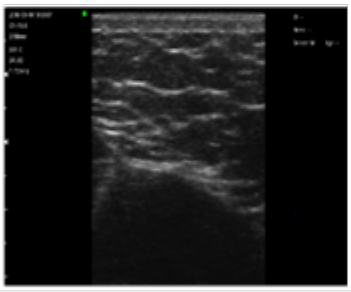
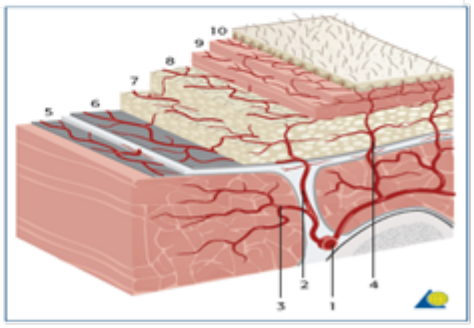


Figure 4: Ultrasound utilized to determine subcutaneous fat thickness

Figure 3: Cutaneous Circulation Diagram



Abstract

The growing prevalence of obesity and its negative effects necessitates sufficient potential treatments, as well as assistive instruments intended for management of the condition and its associated disorders. The growth of the availability of wearable devices which monitor body biometrics introduces a question of the efficacy of such devices on patients affected by obesity. This investigation analyzes the potential effects of subcutaneous fat on wearable technologies, the Apple Watch in particular. Results of this study will demonstrate the accuracy of heart rate data collections obtained for the Apple watch in comparison to an electrocardiography (ECG) and Pulse Oximeter. Resting heart rates will be acquired using an Apple Watch at three body locations (wrist, upper arm, and abdomen) of several volunteers. For reference purposes, the same information will be acquired simultaneously using an ECG system and a pulse oximeter. The thickness of the subcutaneous fat layer at each body location where Apple Watch is placed will be measured using an ultrasound imaging device. The heart rate information acquired by Apple watch will be compared to that by EKG and Pulse Oximeter to access its accuracy. The interrelationship between site-dependent heart rate and density of the subcutaneous fat layer will also be examined.

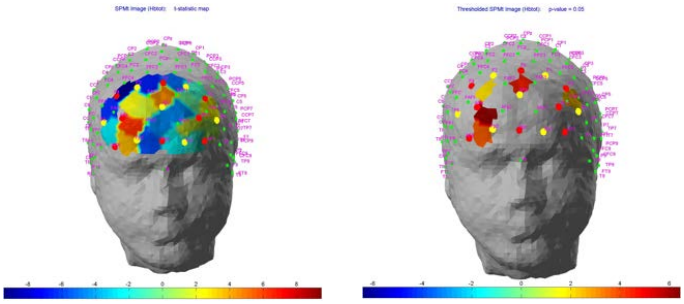
The benefits of bilingualism for children born preterm: An fNIRS study

Authors

Victoria Leon, Valentina Dargam, Caitlyn Myland, Melissa Baralt, Ashley Darcy Mahoney, Ranu Jung, Anil Thota, Liliana Rodriguez

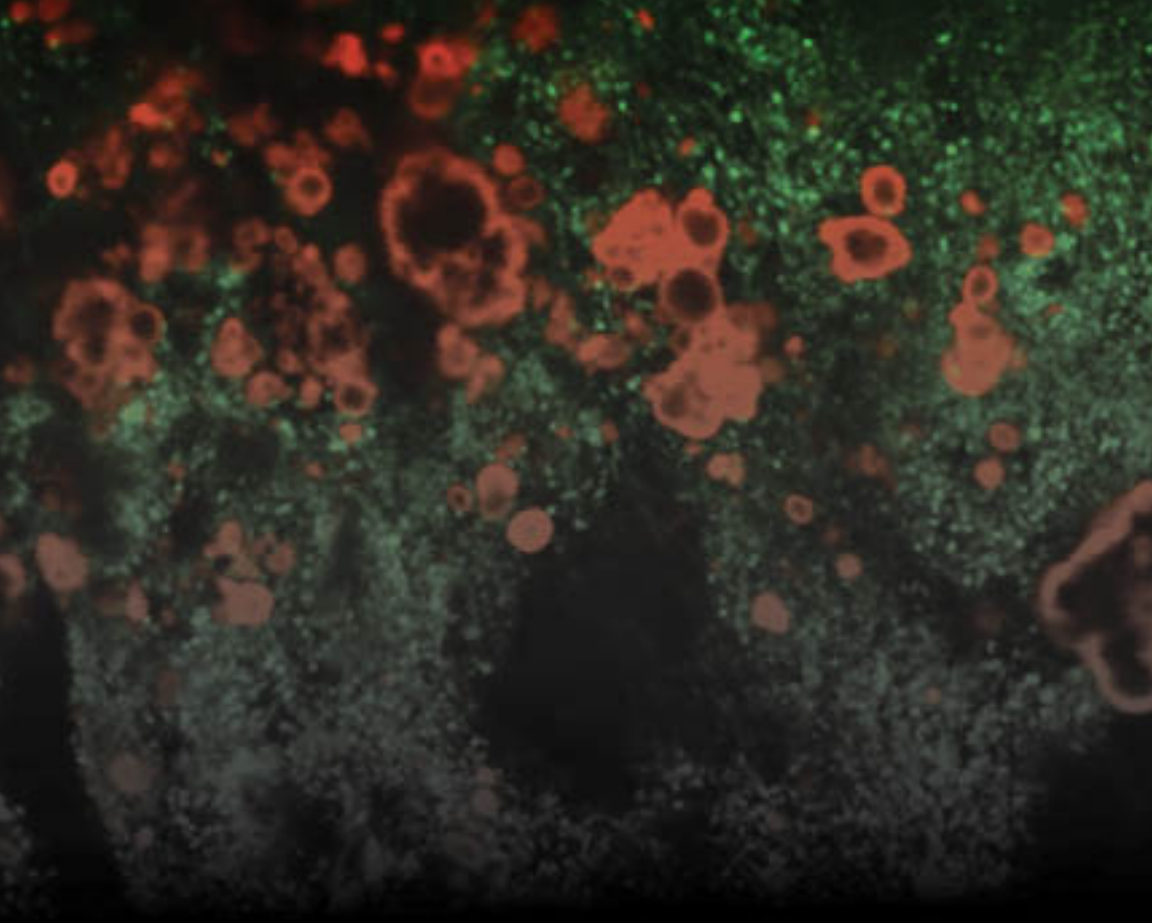
Faculty Adviser Ranu Jung

Example of Statistical Parametric Mapping (SPM) with t-statistic map showing how we are calculating Hb statistical differences across trials (hemodynamic response)



Abstract

Bilingualism can give children a significant edge in executive functioning (EF), which mediates critical aspects of attention that are necessary for academic achievement. To date, however, no study has explored the potential of bilingualism to enhance EF in preterm-born children, who are at risk for EF deficiencies. The present study seeks to address this gap by exploring the potential for bilingualism to mediate preterm-born children's EF. In study 1: 45 preterm-born children, ages 4-8 (half productively bilingual, half monolingual) completed five tasks measuring EF (Simon, NIH Flanker, DCCS task, TEA-Ch Creature Counting Task). There were no statistical differences between gestational age, length of stay, IVH, oxygen at day 28, birth weight, and age. The bilingual children significantly outperformed monolingual children in accuracy, RT, and in the TEA-Ch task, total number of switches. In study 2: 14 preterm-born children, ages 6-7 (half productively bilingual, half monolingual) and right-handed, completed two tasks measuring EF (DCCS task and the Go/No-Go Task) with simultaneous brain imaging via functional Near-Infrared Spectroscopy (fNIRS). We are currently analyzing the imaging data (to be described during the presentation). Study 2 confirms evidence of enhanced EF for bilingual children who have a history of premature birth.



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