SBHSE | School of **Biological** and **Health Systems Engineering**

Biomedical Engineering Symposium

Spring 2019

ASU Ira A. Fulton Schools of Engineering
Arizona State University

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Welcome

On behalf of the presenting students, staff, faculty and affiliated colleagues of the School of Biological and Health Systems Engineering, one of the six schools in the Ira A. Fulton Schools of Engineering at Arizona State University and the Harrington Bioengineering Program, along with our clinical and industrial partners, it is our pleasure to once again welcome you to our annual spring biomedical engineering symposium. Proudly displayed before you at this 27th annual symposium, are the diverse health care technology innovations under development by our interdisciplinary and multidisciplinary biomedical engineering senior capstone design teams and masters applied project candidates that exemplify this SBHSE signature event. It is a testament to the unyielding leadership support of our medical device product design and development program and our masters applied project program along with the continued support of our dedicated instructors, community mentors, graduate teaching assistants and facilitators, and professional staff who provide a diverse range of interdisciplinary and multidisciplinary expertise and who, year in and year out, support the development of the next generation of biomedical engineering researchers, design thinkers, product developers and innovators. Instilled with state-of-the-art health care technology skillsets together with an entrepreneurial mindset and a rich and deepening culture of global health innovation at ASU, our graduates exemplify ASU's lead as the #1 leading culture of innovation in US universities for the 4th uear in a row. As ASU continues to fuel the rapidly emerging entrepreneurial ecosystem in Arizona, SBHSE is strategically positioned to impact this next generation of health care technology leaders to tackle even the most pressing grand challenges in health care delivery in the 21st Century. A testament to SBHSE's entrepreneurial capacity building of the 21st Century workforce in health care technology is the fury of recent successes of our biomedical engineering design teams taking top honors in local, regional, national and international design competitions, as well as, the significant increase in patent filings. Finally, SBHSE is proud to have yet another stellar group of ten biomedical engineering students selected by our global partner, Kwame Nkrumah University of Science and Technology (KNUST), in Kumasi, Ghana to spend their senior year and also their graduate masters studies at ASU. Our KNUST students together with our sizeable resident international BME students continue to bring a unique and enriching global perspective as witnessed at this symposium and evidenced throughout our SBHSE program. Please join us in celebrating SBHSE's Class of 2019 medtech innovators at our 27th annual spring BME Symposium.

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BME Capstone Projects

1: Laparoscopic Immobilizer: Ergonomic Solution for Minimally Invasive Surgery

Angela Hemesath & Christina Smith - SBHSE

Mentor(s): Dr. Anoop Grewal - FSE

In a study by Norheim, 24.4% of surgeons practicing and performing various laparoscopic surgeries were claimed to have neck pain. An additional 20.8% of surgeons recorded spine disease, and another 3.9% reported radiculopathy/myelopathy, concluding that laparoscopic and endoscopic procedures place surgeons at higher risk of cervical diseases. Additionally, these ergonomic issues have been shown to decrease surgeon performance and efficiency, particularly during multiport surgery (Xiao et al.). This discomfort may be directly attributed to sustained positions during surgery requiring fine upper-limb movement to continuously hold up and operate laparoscopic devices. Current methods of alleviating this discomfort include altering surgeon position through step-stools, requiring multiple personnel, or through robotic laparoscopy. However, these solutions continue to have ergonomic and financial issues of their own, and may drastically increase the price of surgery, as with robotic surgery, so that this method is inaccessible to all surgeons. Therefore, we have designed an inexpensive medical device to immobilize laparoscopic instruments, in order to alleviate pain by reducing time of sustained posture during minimally invasive surgeries. Through customer needs assessments, concept generation and concept selection, we developed a biomedical design that includes a ball-in-socket form with a locking mechanism to allow surgeons the manipulation of laparoscopic instrument placement. From this methodology, our team created an alpha prototype that was tested with force testing, as well as a flexible base to adhere our device. Technical specifications have been further verified using Instron Modulus Testing and Elastics Testing. Through its design, this device increases comfort and efficiency in minimally invasive surgeries.

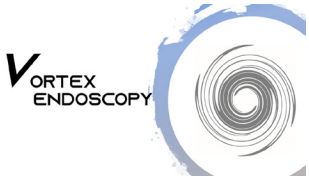
2: PErescue: Effective CPR Modalities and Device for Patients with Pectus Steel-Bar Implants

Dzifa Kwaku, Eman Abu Alrahi, Jaffalie Twaibu & Maitha Alkatheeri - SBHSE

Mentor(s): Dr. Dawn Jaroszewski - Mayo Clinic | Dr. James Abbas - SBHSE

Pectus Excavatum (PE) is the most common congenital chest wall deformity and is denoted by a sunken breastbone. The Nuss surgery is performed to correct the deformity and entails the intrathoracic implantation of stainless-steel bars (Pectus-bars) behind the sternum to elevate the chest wall to its anatomically correct position. These steel implants are left in position for 2-3 years while the chest wall remodels. The metal implants inadvertently impose unintended limitations and consequences related to the effectiveness of conventional CPR modalities on the patients. Given the potential of active abdominal compressions and decompressions to induce adequate resuscitative perfusion, PErescue has developed an automatic abdominal pump. This device belongs to the Global CPR devices market worth USD 124.08 Million by 2024. The PErescue device administers active abdominal compressions and decompression at average pressures of 186 and 112 mmHg respectively, at 100 cycles per minute. To increase the success rate of CPR, the device is set to run for 30-60 minutes. The device's performance specifications can deliver 22-77% restoration of spontaneous circulation (ROSC); and a mean arterial pressure of 50-60 mmHg which can be sustained for more than 20 minutes. The device is adjustable for patients of different age and body sizes. The device is portable enough to be used at home, clinics, hospitals, ambulances and any highly densely populated institution that requires first aid equipment. Furthermore, PErescue has proposed the anterior-posterior placement of defibrillation paddles to allow for adequate current to reach the cardiac tissue and avoid current sinking into the steel implants. The implementation of the PErescue CPR modalities and device in the home, clinics, hospitals, ambulances and any highly densely populated institution that requires first aid equipment can potentially increase the success rates of CPR in all patients especially patients with Pectus bars.

3: Vortex Endoscopy: Gastrointestinal Clot Extractor



Aderonke Adewuyi, Blake Browning, Maame Abena Afrifa & Queen Nyemekye - SBHSE

Mentor(s): Dr. Barbara Smith - SBHSE

Acute upper gastrointestinal (GI) bleeding results in 20,000 deaths annually in the United States. The current issue with acute upper GI bleeding is locating and removing an excessive amount of blood clots obstructing the location and visualization of the wound, commonly seen in most trauma settings. This issue results in unnecessary invasive procedures and multiple blood transfusions. Currently available devices are limited due to not being designed for use with gastroendoscopy procedures. Acknowledging this we are proposing a device that utilizes a high-intensity focused ultrasound (HIFU) method called histotripsy. This device is composed of a focused transducer that emits HIFU at a frequency of 5MHz to induce cavitation to break blood clots in a controlled and localized manner. The device would allow for direct access to the wound without removal of the surrounding clots thus saving time and expense. We have developed a prototype using the data obtained for finding the optimal cavitation energy required to break a blood clot, the depth penetration variation of the ultrasound pulse and the temperature change that occurs in the stomach and effects of surrounding tissues. We collated this data and analyzed them using MATLAB and ANSYS. Through this we have developed a device for use in gastrointestinal procedures in removing blood clots.

4: DEVA Graft: Drug Elution Vascular Access Graft

Melanie Parke, Ermyntrude Adjei, Tanner Ivey & Laura Roa - SBHSE

Mentor(s): Dr. Brent Vernon - SBHSE

In order to facilitate the transfer of blood from a hemodialysis patient to a dialyzer for blood filtration, an arteriovenous graft is used to create an indirect link between the vessels so that cannulations may be performed. Due to blood-biomaterial reactions, thrombosis can occur resulting in reduced patency of the graft. As a result of these interactions, currently available solutions often do not work for long, and/or require frequent de-clogging resulting in decreased mechanical strength and durability of the graft over time.

There have been attempts to reduce the rate of thrombosis and increase longevity by coating the surface of the graft with an anti-thrombogenic drug, such as heparin (GORE ® Propaten ®). This method has slightly increased patency rates, but the need for multiple de-cloggings over the lifetime of the graft still persists, compromising its mechanical strength.

The primary goal of the DEVA (drug eluting vascular access) graft design is to significantly reduce the rate of thrombosis, thereby reducing the need for de-clogging. We are doing this by introducing a drug eluting technology via a degrading bio-inert polymer layer. The DEVA graft is composed of four layers: an PTFE layer, structural coil, silicone self-sealing layer, and an inner PLGA degrading layer which contains the anti-proliferation drug, Paclitaxel, so that it may elute as a sustained release. As a result of this technology, the DEVA graft will reduce the long term costs associated with de-clogging the graft and address the shortcomings of other devices on the market that fail to meet customer needs and demands.

5: Suturistic: A Novel Suture Technology to Prevent Incisional Hernia

Shahzadi Aimen, Mayar Allam, Maryam Alsuwailem & Fangchi Shao - SBHSE

Mentor(s): Dr. Olivia Burnsed - SBHSE | Dr. Jordan Weinberg - St. Joseph's Hospital and Medical Center

Current sutures used in abdominal surgeries have been proven to be ineffective over time. Suture failure can result in muscle weakness at the area of incision which can further cause the underlying tissues or organs to protrude from the wound in a condition called a hernia. This condition affects approximately 15% to 23% of patients undergoing abdominal surgery. Taking this into consideration, our main mission is to create a novel suture that aims to decrease the likelihood of developing incisional hernia after abdominal surgery. This is accomplished by our elastic, biocompatible, and absorbable suture, Suturistic. Suturistic is made of polydioxanone (PDO), which is an absorbable polymer identified to have the best mechanical and biological properties among existing materials for fascia closure. Suturistic is coated with extracellular matrix (ECM), which can enhance proper cell growth, reduce the formation of scar tissue and foreign body giant cells, thus retain the tissue's native mechanical properties. Further, antimicrobial drug is added to the ECM layer to further enhance the local drug delivery and to reduce the rate of infections at the wound site. The strength and elasticity of the suture have been verified via tensile strength testing. The efficiency of an

antibacterial drug to prevent gram-positive bacterial infection in wound site has been verified in vitro by measuring the distance in between the cultured bacteria and the suture. Suturistic's elastic, anti-microbial design prevents the occurrence of incisional hernia post abdominal surgery. In vivo experiments will be conducted to further verify the safety and efficacy of the Suturistic suture.

6: Droplet: Microparticle Fabrication Device for Consistently Sized Microspheres Viable for Drug Delivery

Byron Alarcon, Sheldon Cummings, Rex Moore & Levi Louis Riley - SBHSE

Mentor(s): Dr. Michael VanAuker - SBHSE | Dr. Brent Vernon - SBHSE

Our product is a microfluidic derived fabrication platform which allows for the creation of consistently sized microparticles for drug delivery. The technology uses fluidic principles to fabricate drug-infused biodegradable polymer microparticles made from poly(lactic-co-glycolic acid) [PLGA] which can then be injected into the body via a hypodermic needle. These particles will then sit in the target tissue while being slowly degraded by the body's natural hydrolytic mechanisms[1,2,3]. As the particles degrade, they release the encapsulated drug to the target tissue in a sustained manner.

Current microsphere fabrication methods have limited reproducibility and low yields due to inconsistent particle sizes and high waste. Our fabrication method is built upon microfluidic principles which create more consistent results and maximize yield while minimizing waste. Polymer microspheres show high potential for clinical drug delivery by acting as an alternative to medications with systemic consequences by providing a targeted delivery to the affected area. Microspheres have faced difficulty in the regulatory process due to unreliable mechanical fabrication methods. This product can be sold to biotechnology development and precision laboratory equipment companies who can use our device to load various drugs for research, testing, and further development purposes with eventual clinical outcomes.

Over the course of the Capstone course, the Droplet team has completed multiple digital design iterations, conducted CAD and CFD simulations and verifications, and constructed up to the third generation of beta prototype. In constructing multiple prototypes, the group moved through various fabrication channel geometries until recently settling upon an L-Junction geometry. The third generation beta prototype, which uses this geometry, is currently undergoing testing. After testing, the group will evaluate the results in order to optimize specific parameters which will be used in the next generation prototype.

7: SEDA Solutions - SEDA Scope: Digital Heart/Lung Sound Separating Stethoscope

Angelica Gutierrez, Diane Iradukunda & Sheania Morgan - SBHSE

Mentor(s): Dr. James Abbas - SBHSE | Dr. Wazhma Aslamy - Arizona Cardiology Group

French doctor René Laennec revolutionized the medical world by inventing the first stethoscope in 1816. Since then, the stethoscope has diagnosed countless conditions within the human body, most prominently related to cardiovascular and pulmonary issues. In 2008, more than 616,000 people died of heart disease which accounted for 25% of deaths in that same year. It was reported in 2018 that heart disease related deaths increased to 43.8% in the United States. By 2035, more than 130 million adults in the US population are projected to have some form of cardiovascular disease, and the total costs of treatment of cardiovascular diseases are expected to reach $1.1 trillion (American Heart Association, 2018). Between 1980 and 2014, over 4.6 million Americans died of chronic respiratory illnesses (University of Washington, 2017). In 2010, COPD related patient care was valued more than $32 billion and those costs are projected to increase to $49 billion by 2020.

The SEDA Scope is revolutionizing the current stethoscope design. This innovative device digitally separates heart and lung sounds and displays them on a screen. The device can record and save sound files onto a computer that can be reviewed by users at a later time. To create the SEDA Scope, the SEDA Solutions team placed a microphone inside the diaphragm of an old stethoscope to collect sounds. These sounds were sent through tubing into a microcomputer called a myDAQ. Then, the team plugged the myDAQ into a computer using a USB cord. The team used a computer program called LabVIEW to amplify and filter the sounds as well as record and save them to the computer. The team also used LabVIEW to displays the sound waves on the computer screen. Finally, the team plugged in headphones to hear the sounds more clearly. The device can assist medical students in learning how to diagnose heart and lung abnormalities. The SEDA Scope is a portable, affordable medical device that can be useful in medical school, clinic, and home care environments.

8: BioDetection: A Minimally Invasive Metal Detector

Jacob Aperi, Jarrett Eshima & Tristan Loveday - SBHSE

Mentor(s): Dr. Vikram Kodibagkar – SBHSE | Dr. Jitendran Muthuswamy – SBHSE | Charlotte Spear – Dignity Health

Minimally invasive surgery is becoming an increasingly popular approach. With robotic and laparoscopic probes surgeons can perform entire procedures through small incisions in the thoracic and abdominal cavities. With minimally invasive procedures, however, surgeons face the problem of retained foreign objects (RFOs) left inside the patient after a procedure. Of the nearly 200,000 operations performed at Mayo Clinic Rochester between 2003 and 2006, 68 resulted in additional surgical complications or delays from an RFO. Current image-guided approaches for RFO recovery fail to meet acceptable accuracy rates (67%), indicating an existing gap in healthcare technology that can be improved.

The Minimally Invasive Metal Detector (MIMD) is a probe designed to detect and locate RFOs, and consists of a metal detection circuit, hardware filters, and signal processing software. Having a convenient, reliable method for detecting RFOs will improve patient outcomes and reduce hospital liability in relation to minimally invasive procedures. The MIMD is a Class II device and falls under the FDA's 510(k) guidelines.

Our current prototype probe can fit inside a standard 7mm surgical port and is capable of detecting carbon steel pieces in tissue-simulating phantom gels. We have seen statistically significant signals at distances of 3cm and have calculated a calibration curve for detecting carbon steel. Future work includes optimizing the device to decrease noise, increase detection range, and testing with smaller objects such as stainless-steel suture needles.

9: Adaptive Omphalocele Protective Device

Romann Arizmendi, Matt Chrest & Shannon Grassi - SBHSE

Mentor(s): Candace Fradette - Phoenix Children's Hospital | Dr. Sydney Schaefer - SBHSE

The Adaptive Omphalocele Protective Device is a novel medical device to help families safely transport their children born with an omphalocele; a birth defect of the umbilical cord, causing the internal organs to balloon out of the abdomen. According to the CDC, 1 in every 5,386 children born in the US has an omphalocele birth defect. Traditional car seat harnesses cause problematic pressure on the omphalocele, which can lead to rupturing of the defect and/or harm to the infant. The current market standard is a car seat with a market value of approximately $1,500 which provides no protection to the omphalocele and simply implements a strap system that works around the defect. We have developed a device that can be provided as a protective device for the omphalocele. Based off of our research, hospitals would be able to bill for reimbursement of the device via CPT codes, therefore creating a self-supporting business model. After initial validation of structural safety via stress testing and model fitting, the device has demonstrated successful progress towards being feasible within the product market. The product structure and materials have been tested through material testing and have been validated to endure pertinent forces as dictated by ASTM standards. Thus far, the device has had successful prototype development and demonstrated market potential from both an engineering and clinical approach.

10: Wipe-Aid: Endoscopic Lens Shielding Device

Emmanuella Adjei-Sowah, Pedro Lopes, Racheal Atanga & Rohan Joshi - SBHSE

Mentor(s): Dr. Michael Bohl - Barrow Neurological Institute | Dr. Rosalind Sadleir - SBHSE

The endoscope is a device used for performing minimally invasive surgeries. Minimally invasive surgeries are safer and more cost-effective than invasive surgeries and hence have larger markets. During endoscopic endonasal surgeries, the probe of the endoscope which has a lens at its end is inserted to the site of surgery through the nose. More often than not, the surface of the lens comes into contact with blood and other fluids in the body during the surgery. Blood from other parts, mainly the nose, which may be bleeding also drips down the probe and soils the lens. This obstructs the view of the surgeon and significantly slows down the surgical procedure. A number of methods which the surgeon may employ to clean the lens include either using a flush of saline, CO_2, a suction device, or cleaning the lens against a nearby surface. In extreme situations, the surgeon may have to completely withdraw the probe from the patient, clean the lens surface, and then re-insert the probe. This leads to a delay in the surgical procedure and a loss of focus on the part of the surgeon which may consequently lead to further consequences.

Wipe-Aid is a device that functions by preventing the blood from the nasal cavity from reaching the surface of the lens. It employs an inflatable balloon, which will be inflated by the surgeon once the device has been positioned at the site of the surgery, and will function by blocking all the blood coming from the nasal cavity.

Wipe-Aid will be a better option as compared to other cleaning methods because it will be a portable, cheap, single-use device which will significantly reduce the total surgical time while maintaining the clear view of the lens throughout the surgery.

11: FirstBreath: Automated Oxygen Regulator

Riley Barnett, Nicholas Grant & Joseph Schreiber - SBHSE

Mentor(s): Dr. William Tyler - SBHSE

Chronic respiratory diseases such as Chronic Obstructive Pulmonary Disease (COPD) are expected to increase, requiring Oxygenation treatments to alleviate symptoms and increase a patient's quality of life. The medical gas industry as of 2014 maintained a 708 million dollar share of the global market and is expected to increase over the coming years. FirstBreath offers a revolutionary solution in Oxygen therapy that promotes patient health by removing the variability of treatment, while maintaining the human element. The FirstBreath Automated Oxygen Regulator© will directly improve patient lives by regulating the flow rate of supplemental Oxygen based on real time patient data, designed to assist nurses and doctors to continuously monitor and adjust oxygenation of patients. This data is read into our system via a traditional pulse oximeter as SpO2 measurements, which are then processed via a microcontroller device to adjust the Oxygen flow as needed. The Automated Oxygen Regulator© makes it easy for doctors and nurses to preset desired oxygen levels and receive alerts so that they can treat their patients effectively. We aim to increase the time nurses and doctors have to provide meaningful care to patients, rather than responding to countless alarms. The final design of the Automated Oxygen Regulator© will be made of uniform medical grade brass alloy material designed to encase all essential components and include screens and gauges to assist medical professionals. FirstBreath promises improved patient outcomes through consistency and innovative technologies.

12: Trek Tips: Reusable Pipette Tips

Raegan Barry, Morgan Cobban, Gabrielle Mills & Amber Sogge - SBHSE

Mentor(s): Dr. Jerry Coursen - SBHSE

A single lab can burn through hundreds of pipette tips a day. This unsustainable use of resources produces 4 million pounds of plastic waste each year in the US alone that not only will take hundreds of years to degrade but also must be treated as bio-hazardous materials and disposed of meticulously. An alternative would be a pipette tip that could be autoclaved and reused. In rural clinics especially, receiving new shipments of materials and proper disposal can be an extremely difficult task. Our product, Trek Tip, would eliminate these issues of hazardous waste and distribution altogether while providing a more environmentally-conscious alternative for eco-friendly labs. Polysulfone, the proposed material, is used as an autoclavable plastic for multiple laboratory practices. The material prototype successfully proved it can be autoclaved, and a 3D-printed alpha prototype showed it is compatible with a wide range of devices and has the necessary pressure component. It is estimated that the average pipette tip produced by our company, Sana Terrae, will be a cheaper alternative in the long run per NPV analysis. Manufacturing will produce the Trek Tips through injection molding, a sustainable practice. All applicable quantitative product specifications (23/24) have been verified as stipulated in the design phase. The final product is ready to be manufactured on a wider scale for marketing as a 501k premarket FDA exempt device.

13: BTS Impetus Inc.: Ergonomic Chair for Robot-Aided Surgery

Ahmad Basiri, Steven Stamm & Michael Tyson - SBHSE

Mentor(s): Dr. Paul Del Prado - District Medical Group & Maricopa Integrated Health System | Dr. Thurmon Lockhart - SBHSE

With advancements in medical technology, the use of robotically assisted surgeries have become more prevalent in the modern operating room. Surgeons who utilize this equipment often find themselves seated at a robotic control console where they must lean forward in an uncomfortable and potentially compromising position for many hours while performing critically intensive work. To address this issue, BTS Impetus Inc has developed an ergonomic chair for use during these robotically assisted surgeries.

It offers a forward-leaning support system which decreases the overall force and isotonic tension placed on the lower back by supporting the user from under the arms which absorbs some of the user's weight. The BTS Impetus design team also implemented innovative self-locking wheels that safely secure users in a locked position while seated. The US market for examination chairs was estimated at about $124 million in 2014 and is projected to increase by 46.2% in 10 years. BTS Impetus Inc anticipates accounting for approximately 10% of this market which would represent a $12.4 million market share. The original design of the surgical chair was strictly centered around meeting the demands of surgeons. However, the design team is currently investigating ways to deliver and adapt its current device to additional markets such as those related to laboratory research and within the art industry. Thus, the future aims of BTS Impetus Inc include filing a patent application for its locking wheel mechanism and also marketing the product to companies in the medical device and diagnostic industry as well as those outside of this industry.

14: BloodWorks, Continuous Insulin Sensor (ISense)

Connor Beck, Taylor Brown, Jared Johns & Mukund Khanwalker - SBHSE

Mentor(s): Dr. Jeffrey LaBelle - SBHSE

Roughly 100 million Americans have been diagnosed with diabetes or prediabetes, and this number is quickly growing due to the increasing population and changing lifestyle habits. The most common method of treating diabetes involves measuring blood glucose levels and administering a rough estimate of insulin to counteract the increase in blood sugar levels. The prominent method to measure insulin incorporates a sandwich assay, primarily used in a hospital or laboratory settings, and current protocols for measuring insulin in diabetic patients are non-existent for a point of care setting. I-Sense utilizes an electrochemical technique called electrochemical impedance spectroscopy (EIS) to address the current gap in the diabetic patient market. The electrochemical technique was combined with an insulin aptamer to test continuous monitoring of insulin levels in a purified solution. The team has tested four factors by performing experiments with I-Sense, including continuous measurement, sensor lifetime, detection range, and accuracy. The team has identified the optimal binding frequency (OBF), at which insulin best binds with the aptamer, to be 1.76*10^4 Hz. At this frequency, the sensor has displayed a prominent response (slope), along with a good correlation (RSQ). I-Sense will reduce the frequency of expensive lab tests for insulin levels and will provide faster results directly to the patient. The sensor will help diagnose type II diabetes in pre-diabetic patients and help type I diabetics administer a more accurate amount of insulin. Doctors will be able to prescribe the I-Sense device and obtain a baseline value of a patient's insulin levels, allowing for a faster diagnosis of type I and II diabetes and reducing the number of diabetes related complications in the patient population.

15: DURALance: The Dural Elevating and Cutting Mechanism

Ambike Bhraguvanshi, Alexander DaSilva, Richard Li & Jake Xu - SBHSE

Mentor(s): Dr. Michael Bohl - Barrow Neurological Institute | Tomasz Taubert - Tomar Electronics

The DURALine is a multifunctional surgical tool designed to expedite and increase the safety of Durotomy procedures in neurosurgery. A small mistake, like cutting a blood vessel or into the brain itself, can result in a detrimental loss of function or life. Current tools to perform surgeries require surgeons use up critical time alternating between different tools, leading to mistakes in surgeries. Presently, there is a need for Neurosurgeons and surgical staff to utilize a tool which can perform the actions of multiple tools at once. The DURALine addresses this need by including the membrane elevating function of a Dura elevator (DURAShield), the cutting function of a standard surgical blade (DURALance) and combining the functions to be used simultaneously in a singular surgical tool for multiple neurosurgical procedures, such as for brain tumor removal. The testing experiments were designed to analyze the flexibility of the blade, mechanics of the attachment, handle ergonomics, and the ability to operate and replace the current SOTA methods. The DURALine has undergone various design iterations to maximize use and efficiency, to emphasize its significance in a clinical setting. The DURALance device has proven to be an important addition to the Surgical Instruments market as a multifunction tool with the capability to dominate over the rather limited capabilities of single-function tools.

16: CerebroField: Implantable Tumor Treating Field Device

Kolby Black, Xavier Richmond, Tevon Sinica-Williams & Jesse Yepiz - SBHSE

Mentor(s): Dr. William Tyler - SBHSE | Dr. Ben Hendricks - Barrow Neurological Institute

Glioblastoma multiforme (GBM) is a fast-growing type IV glioma cancer. According to the National Cancer Institute, as of 2015, 22,850 Americans have been diagnosed with GBM. The localization of tumors in the supratentorial region of the brain presents challenging issues that inhibit effective drug delivery during radiation and chemotherapy. In most cases, a diagnosis of GBM is terminal, with most patients not surpassing a prognosis of 16 months. Currently on the market there is a device that has extended patients lives by two months. This has been accomplished by creating electric fields throughout the brain which alternate at low frequencies, the acronym used to describe this treatment is TTF, formally known as Tumor Treating Fields. The current treatment requires substantial changes to one's lifestyle, one such changes being the requirement for the patient to shave their head. Cerebrofield presents a minimally intrusive implantable TTF device, acting upon rapidly-dividing cancer cells without affecting normal neural cells. Operating at a low-frequency Cerebrofield disrupts cancerous cells during their mitotic phase through alternating voltage sources at electrodes. This impacts the natural dipoles within the cancer cells, preventing cancerous cells from dividing normally thus leading to apoptosis. Cerebrofield is a tri-component system, consisting of an implanted electrode array and battery pack, controlled by a programmable computer. The class III medical device, has future consideration for interventional therapy in recurrent and newly diagnosed glioblastoma patients. Cebrofield aims to provide a superior solution to those suffering from GBM and positively impact the lives of thousands without lowering their standard of living. Through numerous tests, our prototype has met the treatment specification for electric field strength, temperature, and frequency as identified in tests involving a tank with gelatin to mimic the brain tissue. Through verification in a cadaveric study with respect to treatment specifications, next steps will include live porcine studies.

17: PTA Lesion Model Demo

Alex Rico, Destinee Martin-Karim & Ethan Blank - SBHSE

Mentor(s): Kyle Thomas - Becton Dickinson | Dr. Brent Vernon - SBHSE

Peripheral artery disease affects an estimated 3 million people per year in the United States. PAD is a circulatory condition in which the peripheral arteries in the legs are narrowed, limiting blood flow to the lower extremities. The common cause of this is atherosclerosis, the accumulation of calcium, plaque or fatty acid deposits on the walls of arteries. Currently, the leading prevalent treatment method is through the use of percutaneous transluminal angioplasty (PTA) catheters. Below the knee, lesions tend to be much more highly calcified. As a result of this, PTA balloon catheters can deform around the plaque. Currently, there is a need to model these lesions to simulate vessel dilations and plaque fracturing/scoring so PTA balloon catheters can be tested more accurately. Our group has partnered with the medical device company, Becton Dickinson (BD), to help solve this problem. To do so, our group has worked at BD facilities to test competitor products, bio-materials of interest and begin the prototyping process. The PAD lesion model invokes cost-effective, fast and easy to replicate materials to mimic the mechanical properties for simulated use of lesion testing. We have created two prototype design concepts we believe can achieve this. One method is through 3D printing an artery with flexible filament and by either adhering the plaque directly onto the vessel walls or by placing it in between special printed artery wall layers. Our second concept takes advantage of casting and molding. Adjusting the ratio of molding compound mix allows us to create a flexible artery model with more anatomical-like mechanical properties. The plaque material can be adhered onto this design as well. The success of this device will increase accuracy for testing angioplasty catheter devices to optimize patient outcome and reduce potential irreversible damage to vital arteries.

18: Solacium: The Microelectrode Delivery Catheter for Peripheral Nerve Stimulation

Earl Brown, Kianna Browning, Bailey Gasvoda & Alexandria Morales - SBHSE

Mentor(s): Dr. Jitendran Muthuswamy - SBHSE | Dr. Stephen Foldes - Barrow Neurological Institute

There are over 50 million people in the United States that suffer from some sort of chronic nerve pain. The most commonly prescribed treatment for this nerve pain is prescription medication, which contributes to the opioid epidemic currently plaguing the United States. Nerve stimulation is a growing treatment in the field of pain management, but patient access is limited due to delivery complications. Current microelectrodes for nerve stimulation are challenging to implant and are restricted to delivery of a single electrode at a time. Because numerous injections are needed and the process of injecting the electrodes disturbs the nerves and causes them to shift, a long healing process is needed before the stimulation can be done. Solacium delivers a string of Transverse Intrafascicular Multichannel Electrodes (TIME) down the length of the nerve in a single injection. In conjunction

with an ultrasonic vibrator to improve accuracy of delivery, our needle and vibrator apparatus delivers a chain containing multiple microelectrodes. TIME provides more specificity with relatively negligible physiological impact on the nerve. These electrodes are wirelessly triggered to stimulate the nerve and relieve the patient's pain. We have tested our device for needle penetration force, successful diode delivery into nerve models, and successful diode deployment into frog and rat sciatic nerves. Solacium utilizes TIME to increase patient use of electrical stimulation as an alternative to opioids for pain management.

19A: Maroon Bionics: Advanced Bionic Finger Technology to Mimic Natural Finger Movements

Mossab Asiri & Mason Buseman - SBHSE

Mentor(s): Dr. Jeffrey LaBelle - SBHSE

Within the prosthetics industry there has been a common customer complaint relating to biomimicry. The majority of prosthetics on the market tend to be incredibly heavy, bulky, and lacking natural biological function. Our design team is creating an advanced EMG powered finger prosthetic using Fishbone technology to completely minimize the weight. Fishbone technology consists of interlocking components that provide solid structural support while minimizing material being used. This technology was developed within our mentor Dr. Jeff Labelle's lab. By incorporating the Fishbone technology, we are able to provide a sturdy finger prosthetic that uses minimal material while still maintaining an impressive compressive and tensile strength. By minimizing the weight of the prosthetic, we aim to provide the user with a natural balance of weight in order to offer comfortable control over the hand while using the finger for natural daily functions. With the EMG technology we are able to produce a fully functioning finger prosthetic that reacts to the biological stimulus in the same way a natural finger would in order to give the user the feeling that their prosthesis is mimicking their other fingers. The end result of our device is a fully functioning finger that almost completely mimics the dimensions, strength, weight, and functionality of a natural human finger.

19B: ProsTech: Three-Axis Gait Monitoring System

Allison Schmidli & Jonathan Talos - SBHSE

Mentor(s): Dr. Sydney Schaefer - SBHSE

Currently, for an individual to receive insurance coverage for a prosthesis, their ability and potential to ambulate must first be rated using the Medicare Functional Classification Levels, otherwise known as K-Levels. Physicians determine these levels by using a set of questionnaires, namely the Amputee Mobility Predictor (AMP), along with qualitative physical examinations. Due to the lack of easily accessible and quantifiable ambulation analysis methods, a large number of amputee's are assigned the incorrect K-Level. Individuals with transtibial amputations currently have the highest chance for misdiagnosis of K-Level. With this device team ProsTech aims to minimize the chances for misdiagnosis of K-Level for trans-tibial amputees by providing meaningful quantitative data analysis for patient ambulation. This data will be collected and analyzed in real time through the use of a IMU/3D accelerometer placed at the top of the foot and force sensors attached at the ball and heel of the foot, one device will be worn on each foot for determination and comparison of individual gait characteristics. The motion sensors will record 3-dimensional data points which will be translated through Lyapunov's Function to determine gait trajectory and stability. Data from the force sensors will be used to analyze kinematic work through by analyzing the symmetry of external work to determine the percentage of asymmetry in total work performed by each limb. Although the foot is not considered the best point of reference for determining gait, it is a great point of reference to determine asymmetry and irregularities of gait kinematics in regard to trans-tibial amputees. This device will assist the observing physician analyze the patient's gait qualitatively while also providing them with meaningful qualitative data to provide a higher level of confidence in the determination on patient K-Level.

20: SNPSors, Inc.: Navajo Neurohepatopathy Molecular Biosensor

Sydney Connor, Ishitha Jagadish & Jordan Todd - SBHSE

Mentor(s): Dr. Michael Caplan - SBHSE | Dr. David Carpentieri - Phoenix Children's Hospital | Dr. Sivakumaran Theru Arumugam - Phoenix Children's Hospital | Dr. Mitchell Shub - Phoenix Children's Hospital

Navajo neurohepatopathy (NNH) is a fatal, metabolic disease that impacts 1 in 1600 children in the Navajo Nation each year. This disease is caused by a missense mutation in the MPV17 gene, for which targeted sequencing of all protein coding exons

and the flanking non-coding regions of MPV17 is the standard of care at Phoenix Children's Hospital (PCH) for diagnosis. The current diagnostic process is neither time- nor cost- efficient when a patient requires immediate care. Through compliance with Clinical Laboratory Improvement Amendments (CLIA) validation requirements and College of American Pathologists (CAP) standards, molecular diagnostic technologies can be implemented in a clinical setting such as PCH. This study aimed to develop a molecular diagnostic biosensor that achieves sensitivity and specificity required for CLIA validation. A customizable quantitative PCR (qPCR) assay was designed and validated to improve diagnostic turnaround. This diagnostic tool is minimally invasive, as it only requires minimal input of genomic DNA derived from the saliva of a patient, and time-efficient, generating results in less than 24 hours. In addition, the diagnostic tool can successfully be utilized as a genotyping assay, as it can detect heterozygous carriers of the NNH mutation. This technology is still in the process of being optimized for this application.

21: Trigeminal Nerve Stimulation (TNS) for Migraine Treatment

Cynthia Crockett, Kasun Daundasekara, Antonio Lopez & Joseline Valenzuela - SBHSE

Mentor(s): Dr. Stephen Helms Tillery - SBHSE | Dr. Jitendran Muthuswamy - SBHSE

The sixth most debilitating medical condition in the world is migraines and approximately 12% of the population has this condition. In 2015, direct medical costs for treating migraines was $5.4 billion worldwide, though in the United States the total amount lost both to treatments and productivity loss was approximately $36 billion. The primary method for treating migraines is pharmaceutical medications, which often have debilitating side effects and can lead to worse and chronic migraines. In response to this problem, JACKmed Innovations has developed an alternative migraine treatment device that utilizes trigeminal nerve stimulation (TNS). This treatment is applied by delivering a biphasic waveform at 60 Hz with a corresponding current output of 20mA to the trigeminal nerve. It is possible to reach these specifications by using a 555 timer chip which converts a direct current signal to an alternating current signal. This, and the other electrical components, are contained in a plastic case to keep the user protected from unwanted electrical contact. The current is then delivered to the trigeminal nerve in the temple region of the head by the use of electrodes. Stimulating the trigeminal nerve for 30 minutes gives the user symptom relief and allows the user to avoid the side effects that occur from taking migraine medications. This will produce a device that is both safe and effective at treating migraines symptoms. We will validate this through clinical trials designed specifically to test the safety and efficacy. Current testing for device verification and validation show that the device can reach the desired specifications (current and frequency), that the electrodes do not irritate the skin, that the response of the device is consistent, and that the potential market is interested in the production of this device. It is expected that this device will be class II and approved through the use of a 510(k) provision based on substantially equivalent devices. JACKmed Innovations plans on manufacturing this device and bringing it to the market as soon as possible.

22: Apex Technologies, Responsi-Pill: Automated Medication Sorting and Dispersion System

Elizabeth Delgado, Jesus Escobedo & Austin Morgan - SBHSE

Mentor(s): Dr. Barbara Smith - SBHSE

Almost 50% of the United States population uses prescription drugs, and in developed countries patients only attain an average of 50% adherence to long-term regimens. Of those 182 million prescription drug users in the US, 44.3 million take five or more different medications. This creates complex regimens which make it harder for already struggling patients to comply with their dosage schedules. Non-adherent patients may experience worsening of their condition, increased risk of hospitalization, or physical harm and episodic symptoms; this results in an avoidable $300 billion burden on the US healthcare system every year. Traditional methods of regimen management include pill boxes which separate medication by dosage time. However, these solutions rely on users and caretakers to accurately complete the lengthy and cumbersome process of medication sorting on top of the user's mental capability to maintain their regimen. Responsi-Pill will curtail this hardship by automating the process of medication adherence. Our two-part system will incorporate a portable medication container with time slots and an alarm system- similar to current solutions- with an at-home base which will receive prescription information from the user through a Graphic User Interface on an LCD screen at the front of the base. The patient or caretaker will then put each medication into individual storage chambers in the base which are fitted with individual dispensing mechanisms. As an improvement upon current solutions, these two components will interface each night through a docking system on the base to allow the chambers to dispense a day's medication into the portable device's time slots per the input prescription information. Responsi-Pill will ultimately reduce the strain on the US healthcare system by saving caretakers invaluable time, reducing unnecessary financial burden, and assisting patients in maintaining optimal adherence and well-being.

23: Priority Life Health and Wellness Devices: Transcatheter Blood Vessel Occluder

Kyle Durrant, Kyle Hull, Devin Lillegaard, Patrick Panattoni & Nick Whitley - SBHSE

Mentor(s): Dr. Todd Abruzzo - Phoenix Children's Hospital | Dr. Brent Vernon - SBHSE

Congenital arteriovenous shunts (CAVS) of the brain are life-threatening lesions that become symptomatic in infancy. Current and past treatments include transcatheter endovascular shunt occlusion with adhesives, detachable balloons, coils and plugs. These methods present challenges with stability and safety. A device that employs a photopolymer gel (PPG) to achieve precise, stable, operator controlled transcatheter target occlusion was developed and design tested. Detachable, dual-layer, balloons mounted on microcatheters are proposed as a means of performing fluoroscopically guided endovascular shunt occlusion. The device would comprise inner, impermeable, 3 mm balloons inflated with radio-opaque PPG at the target site. The outer balloon layer would comprise a mesh enclosing a reservoir of photo-activated adhesive (PAA). As the inner balloon is inflated, PAA extruded through the mesh is trapped between implant and vessel wall. Subsequent irradiation of the implant with a catheter mounted light source converts the PPG filled balloon into a solid incompressible plug, and activates the surrounding PAA, bonding the implant to the vessel wall. Initial tests of balloon burst conditions, photo-initiator:photopolymer ratio and photopolymer:iodine contrast (ICT) ratio have been completed. Optimal PGG formulation with 20 ml PEGDA, 1 g photo-initiator and 4 ml ICT can be solidified with 12 seconds irradiation. In vitro testing showed proper ratios of PPG could harden quickly upon irradiation and could prove effective in detachable balloons using proposed catheter mounted light sources. Future testing will assess dual-layer balloon design efficacy, and move into in vivo testing.

24: Ulsensor, PUMPS: Pressure Ulcer Monitoring and Prevention System

Glenna Bea Embrador, Toan Nguyen, Ekta Patel & Bhavna Ramesh - SBHSE

Mentor(s): Dr. Sandeep Gupta - CIDSE | Dr. Timothy Schaub - Phoenix Children's Hospital & St. Joseph's Hospital | Charlotte Spear - Dignity Health

In 2014, pressure ulcers, most commonly known as bedsores, affected approximately 2.5 million people and caused 60,000 deaths due to infection in the United States. These injuries progress if left untreated and are prevalent primarily among bed-ridden patients in hospitals and assisted living facilities. If pressure ulcers develop, the wounds require constant cleaning to allow the body to heal itself. Despite existing protocols and devices that can monitor these pressure ulcers, they lack the ability to customize patient treatment and to continuously monitor patients. To resolve this problem, Ulsensor aims to develop the Pressure Ulcer Monitoring and Prevention System (PUMPS). PUMPS will utilize a machine learning algorithm that will input patient metrics such as body mass index (BMI) and albumin levels to output the optimal pressure offloading time to prevent pressure ulcer formation. The PUMPS design consists of pressure sensors embedded within a seat pad and will be supplemented with an air pump that will inflate and deflate according to the determined optimal offloading time. This movement will mimic natural micro-movements to alleviate and offload a patient's pressure. Furthermore, the seat pad features a combination of concave and convex areas to secure the patient in place and will be covered in polyester wicking material to absorb any moisture that accumulates on the patient's skin. Testing was performed to verify product specifications relating to continuously monitoring devices, sensor performance, and ergonomic design to reduce pressure. The results from testing procedures demonstrated the sensor's ability to withstand various weights in addition to retaining accuracy after 24 – 72 hours of continued use. Through continuous pressure monitoring, PUMPS will greatly help to improve hospital experiences by providing a safe and effective method to reduce pressure ulcer formation.

25: Fetobeats: Enhanced Fetskope

Tamara Gajanovic, Christy Goudamanis, Eduardo Huapaya & Nima Sadeghi - SBHSE

Mentor(s): Dr. Jitendran Muthuswamy - SBHSE | Hung Tran - Chandler Regional Medical Center

With 2.7 million stillbirths occurring each year, primarily in countries with poor healthcare, the fetoscope is the primary tool used, due to low cost, to detect a heartbeat. The Doppler Ultrasound that exists to 1% of low income countries is not a viable option for multiple uses due to the intensity of radiation on the baby. It is recommended to be used only once between six and nine weeks. The fetoscope then is used instead of the ultrasound, but it is not able to detect a heartbeat until ~22 weeks. The Fetskope serves to enhance the fetoscope, currently existing in market, by amplifying the sound waves of the heartbeat of the baby to be able to detect the heart at the earlier stage of about fifteen weeks. Customers like midwives, OB GYNs, and other neonatal

physicians operating in a developing country with poor access to healthcare can use the Fetskope to increase the chances of detection of problems earlier on. In our Phase II design of prototype we built our device and start testing it. The specifications that were important to us were that the device is able to filter out the excess noise and output 300-600 Hertz. From the filtered sound, we then amplified the output by 60 decibels so it can be heard by the human ear at the level of conversation. Through testing and timeless hours of work our prototype device is able to filter out ambient noise and amplify the output sound to be able to hear with the human ear. Midwives and OBGYN's with this prototype device will be able to detect heartbeat sounds at around 16 weeks after consumptions.

26: GI Endoscopy Solutions: Obstruction Removal Device during Upper Gastrointestinal Bleeding (ORDUGIB)

Bernard Silverman, Daniel Gaytan-Jenkins, Drew Worman & Jose Luis Rivera - SBHSE

Mentor(s): Chris Pina - W.L. Gore | Dr. Barbara Smith - SBHSE

Acute upper gastrointestinal bleeding (UGIB) was the most common medical emergency treated by gastroenterologists in (year). UGIB accounts for more than 250,000 hospitalizations annually in the United States with 85% of patients receiving endoscopic treatment. Between 1989 and 2009, the median length of hospitalization for upper gastrointestinal bleeding has decreased from 4.5 days to 2.8 while the median hospital charges increased from $9,249 to $20,370. This has driven the direct in-hospital economic burden on a national level from $3.3 billion in 1989 to $7.6 billion per year as of 2009 and is expected to continue to increase. Additionally, in 2010 30-day readmission rate for patients with another gastrointestinal bleed was 5.1%, where readmission costs are significantly more costly than the initial hospital stay. The current standards of treatment include a variety of retrieval devices, suction devices, and irrigation. Normally, gastroenterologists must create device impromptu solutions during endoscopy procedures to avoid having to proceed to interventional radiology or surgery where the mortality risk greatly increases. GI Endoscopy Solutions LLC.'s obstruction removal device will provide gastroenterologists with the ability to effectively remove a wide degree of blood clots and obstructions. The obstruction removal device utilizes an external suction channel that attaches to the endoscope providing greater suction capacity than the endoscope's suction channel. The degree of suction is controlled by an external valve to reduce the risk of damage to the mucosa and the lumen of the gastrointestinal system. The device was tested through the use of Ansys Fluent to verify the mass flow rates of the tube in different positions, a deflection test to find how much force is needed to bend the tube and if this force will impede the endoscope's mobility, and a force test to discover the amount of force needed to separate the suction tube from the attaching mechanism. The Upper Gastrointestinal Bleeding Removal Device (UGIBRD) can efficiently remove varying degrees of blood clots while keeping the endoscope's working channel available for other devices, therefore reducing procedure time and minimizes the occurrence of complications.

27: BlinkCom: Alternative Communication System for Patients with Locked-In Syndrome (LIS) using Electrooculography

Bailey Myers, Spencer Gossel, Theodore Valenzuela & Tyler Mitchell - SBHSE

Mentor(s): Dr. Bradley Greger - SBHSE

Locked-In Syndrome (LIS) is a rare medical condition in which a patient experiences a loss of voluntary movement within the musculoskeletal system, usually as a result of a lesion of an area of the brainstem known as the pons; however, it has been known to originate from other conditions and injuries. LIS does not inhibit cognitive function and most sufferers retain partial eye movement allowing for some, albeit limited, communication. Using an electrooculogram (EOG) in combination with an eye-tracking algorithm, BlinkCom can assist patients in everyday tasks and improve quality of life. The alert system allows for timely communication between a patient and their caregiver using signature eye movements, such as a pattern, e.g. up-down-right, allowing a patient to effectively and efficiently convey a need to their caregiver. With electrodes to record eye movements, a pattern will be defined to allow the patient to easily contact their caregivers and depending on the situation, various patterns will be defined to achieve specificity in communication and provide the caregiver an improved understanding of the patient's needs. BlinkCom also includes an eye tracking-to-cursor control system, giving the user full control over a computer. This provides the user the ability to communicate through writing and use other computer applications. To achieve this, an Arduino DUE is used to facilitate signal processing for the mouse-cursor interface allowing the interpretation of the patient's eye movements into cursor movements. BlinkCom aims to improve the fluidity and effectiveness of communication, not only for patients with LIS but other forms of paralysis, facilitating caregiver assistance and leading to a higher quality of life for the user.

28A: Royal Biotech. Royal Headset: A Pediatric Transcranial Doppler Headset

Jessica Kerlee - SBHSE

Mentor(s): Dr. Todd Abruzzo - Phoenix Children's Hospital | Dr. Brian Appavu - Phoenix Children's Hospital | Dr. William Tyler - SBHSE

At Phoenix Children's Hospital (PCH) doctors use Transcranial Doppler (TCD) to monitor patients who have shown signs of a stroke or seizure. One of the main problems with current TCDs is that none of the products on the market are suitable for pediatrics and are not Operating Room (OR) compatible. Royal Biotech created the Royal Headset to be more comfortable, OR compatible, more adjustable, and easier to use than the current TCD products. The headset was originally designed to fit children from the age of 2 to 18, but the design is capable of fitting comfortably on newborns to adults. This device incorporates parts that slide to allow for maximum adjustability, and each part was designed in order to fit the patient while reducing the chance of a pressure sore. The headset itself uses 3D print material that is strong and flexible, allowing for more adjustability and to be easily cleaned. This material in the device allow the headset to be used in the OR due to the compatibility with PCH sterilizing procedures. The TCD probe screws onto the headset and does not move once the screw is tightened. Since the device has been successful so far, PCH and Royal Biotech will be continuing working with and on the Royal Headset. The team is trying to receive IRB approval, so they can test the parts on patients.

28B: Cranial Crown: A Pediatric Headset for Transcranial Doppler

Kelsey Graft & Jade Nelson - SBHSE

Mentor(s): Dr. William Tyler - SBHSE

Transcranial Doppler (TCD) can be used to monitor for stroke and seizure during cardiac surgery and post-surgery. The TCD probes measure blood velocity through the Middle Cerebral Artery (MCA). A change in the blood velocity can be a sign of stroke or seizure. None of the headsets currently on the market are designed for use on pediatric patients or allow for use in the operating room. The Cranial Crown surpasses the current headset models by allowing for high degrees of adjustability, quick setup and removal, and use during surgery.

The prototype consists of two towers connected across the top with a sliding bar adjustable from 1 inch to 13 inches. The towers would sit on each side of the patients head when they are laying down and the top bar would be above their forehead. Each tower houses a probe holder that is compatible with multiple brands and sizes of probes. The angle of the probe can be adjusted up to 12 degrees using a screw at the bottom of the probe holder, and the height of the probe holder can be adjusted using a screw that tightens the device within the tower and ranges from 0.75 inches to 7 inches high. The probes would be adjusted in the tower so that they will fit to the patients temporal windows on both sides of their head and the width would be adjusted with the top bar to keep the probe coupled to the patients head. The average time to secure the device is less than 6 minutes, and the average time to remove the device is less than 10 seconds. These factors reduce the risk of pressure sores, allow for quick removal in the event of an emergency, and create a customized fit for all patients.

29: SeaLUNG: Light-Activated Pulmonary Sealant and Compatible Delivery System for Prolonged Air Leaks

Aria Huang, Mary Oh, Phuong Tran & Victoria Tai - SBHSE

Mentor(s): Chris Pina - W.L. Gore | Dr. Brent Vernon - SBHSE

Prolonged air leak (PAL) is a common complication that occurs up to five days after lung surgery or trauma. Current solutions to PAL require either open-chest surgeries or post-treatment removals. PAL, if left untreated, can cause collapsed lung and morbidity. There is a need to reduce the duration of hospitalization, cost of treatment, re-operation, and to improve patients' lives. Our capstone project, SeaLUNG, is a minimally invasive hydrogel sealant with a bronchoscopic delivery system that specially targets problems associated with PAL. SeaLUNG will be an efficient, safe, and effective solution for prolonged air leaks in the lungs via bronchoscopy delivery. Compared to conventional sealants in the market, the light-crosslinked property makes the polymerization characteristics of SeaLUNG controllable and compatible with bronchoscopy. The efficiency and safety of SeaLUNG are examined using chemical and physical testing methods in conjunction with computational simulations. Major performance parameters including gelation point, swelling ratio, Young's Modulus and degradation are carefully measured and analyzed to ensure that the final product delivers its promise.

30: Sit Squad: Ergonomic Chair to Provide Proper Lumbar Support During Robotic Surgery

Amar Joshi, Brody Kilgore, Bryce Richards & Zach Humphreys - SBHSE

Mentor(s): Dr. Paul Del Prado - Maricopa Integrated Health System | Dr. Thurmon Lockhart - SBHSE

Robotic Surgery is performed through a console wherein a surgeon is seated in a conventional rolling chair at an isometric position for long periods of time. These ordinary office chairs function more for sitting rather than maintaining proper lumbar support the surgeons desire. Due to this unnatural position, the robotic surgeon's muscles are in isotonic contraction which make them more susceptible to muscle deformation. This deformation over long periods of time lead to discomfort in the neck, trapezius, and the lower back and in some cases causes injuries. If surgeons feel pain during a long surgery, they will not be able to maintain their undivided attention on the surgery itself and the strain can affect the success of the surgery. The aim of this project involves the design of an effective, stable, and mobile chair to provide ergonomic support for Robotic Surgeons.

The Sit Squad solution first includes a memory foam connected to an elastic band on the lumbar region to provide the proper lumbar support the surgeon is seeking. The optimal body position the chair establishes includes the trunk at an erect position and the lower back pushed forward. The elastic band is taut to ensure the surgeon will be able to receive response on his or her lower back. The base of the chair is at an upward incline to guarantee that the surgeons will be leaning their lower back into the memory foam cushion so they can be forced into an upward position. The chair is able to support a person 300 lbs and under. The customer requirements are that the prototype chair provides lumbar proper support with flexion, allows for mobility, stable in order to ensure there is no unnecessary movement, and provides adequate ventilation.

31: CosmoMark Void-Filling Breast Biopsy Marker

Kyra Temple, Nick Keiper - SBHSE | Zach Willis - SEMTE

Mentor(s): Tyson Anderson - Becton Dickinson | Dr. Brent Vernon - SBHSE

Every year, approximately 1.7 million patients undergo a breast biopsy procedure to reach a prognosis for suspicious masses identified via mammography or self-examination. Many patients with suspicious lesions undergo a vacuum assisted biopsy procedure (VABB) using a gauge size between 14G and 7G. Repeated sampling using these devices can remove a significant amount of tissue from a patient, sometimes resulting in a cavity that leaves dimpling on the skin above the biopsy site. The team has identified a clinical and market need to provide a means to mark a breast biopsy site post-VABB that will allow for locating biopsy sites during follow-ups while also providing cosmetic benefits.

In order to solve this identified problem, the team has developed a device with imbedded radiopaque markers that will aid in tissue regeneration, while also providing visibility under all demanded imaging modalities. The device provides hemostatic benefits upon insertion to assist in fluid control, aid in healing, and prevent marker migration. The device is intended to be resorbed over time with degradation starting at the initial phases of tissue regeneration. Following device degradation, the radiopaque markers will become suspended in the tissue to allow for permanent stereotactic visibility and an additional component will remain for permanent ultrasound visibility. The device provides short-term increased ultrasound visibility to allow for imaging during follow-up procedures. The device is compatible with top VABB devices in gauge sizes between 14G and 7G.

32: StimuLate: A Non-Invasive Electrical Neurostimulation Device for Obstructive Sleep Apnea

Stephen Lane, Cami Rowan, Alarmel Sira & Kendra Starkel - SBHSE

Mentor(s): Dr. James Abbas - SBHSE | Dr. William Tyler - SBHSE

Obstructive sleep apnea (OSA) is a common sleep disorder characterized by upper airway obstruction that affects over 12 million people in the US and costs an estimated $150 billion in damages each year (e.g. motor vehicle and workplace accidents, lost productivity, and healthcare expenditures). State-of-the-art devices such as the CPAP are very effective, but offer a bulky design and uncomfortable apparatus, resulting in adherence rates as low as 30% after 1 year. Inspire Medical Systems upper airway stimulation (UAS) device offers a promising solution, but patients are deterred by the invasive surgery and expensive maintenance required to use the device.

The StimuLate device provides non-invasive stimulation therapy to address the pressing problem that OSA poses to patients while improving adherence and effectiveness and positively affecting user outcomes. The device delivers non-invasive electrical neurostimulation to the motor neurons of the lingual muscles inducing an increase of muscle tone in the tongue, adequately eliminating the blockage and returning normal airflow to the patient. The device is paired with a respiratory sensor which detects breath rate and the event of apnea episodes, reducing the total amount of stimulation time to an estimated 1-4 minutes per night for mild to severe obstructive sleep apnea cases.

The final design prototype consists of two sublingual, intraoral electrodes which deliver stimulation generated by an external circuit. The Arduino Uno controls this device to deliver stimulation when the respiratory sensor detects a cessation of breathing. Prototype testing across various individuals has revealed stimulation is most effective when electrodes are placed under the tongue, as posteriorly as possible, and stimulating pulses are delivered at pulse width of 100 µs, frequency of 80-100 Hz and amplitude of 2-2.25 mA. The device is able to induce muscle contraction to move the tongue and clear the upper airway. Subsequent customer testing and verification is needed promote user-friendly development and will solidify the StimuLate device's standing among competitive products.

33: aneurySIM: Parallel Stent Graft Simulator

Casey Silva, Luis Novelo & Tyler Lent - SBHSE

Mentor(s): Dr. Victor Davila - Mayo Clinic

An aortic abdominal aneurysm (AAA) is a life-threatening condition that requires invasive intervention to repair. The American College of Surgeons National Surgical Quality Improvement Program reports that 10,026 patients underwent elective aortic abdominal aneurysm repair between the years of 2011 and 2015. Currently, vascular surgeons rely on three-dimensional models reconstructed from computed tomography (CT) scans in order to better visualize the patient's pathology and conduct pre-operative planning procedures. In order to better inform the decisions of vascular surgeons with data driven analytics, our team has begun engineering a simulator program that can effectively model how aortic blood flow will be affected by various stent configurations within unique patient anatomies. It accomplishes this with a guided workflow, model rendering, and customized user interface that prioritizes physician interaction and pertinent feedback. Simulation results could include potential leakage, pressure gradients, and vessel wall shear.

Interviews with industry professionals and clinicians have guided our identification of customer needs and product specifications. Pursuing best manufacturing practices, we have identified FDA guidance and regulation standards for achieving safe and effective results. Through research and experimentation, various modalities of turbulence calculation and mesh quality parameters have been identified in the pursuit of optimizing simulation time and accuracy. In order to verify the accuracy of virtual simulations, physical simulations have been conducted for comparison using a particle image velocimetry system. Combined with a user interface and accessible workflow within the ANSYS analysis software package, aneurySIM results could provide significant value and insight for pre-operative planning and device development. Research and consultation with professionals have also revealed that making the software extension available on the ANSYS marketplace would provide the necessary accessibility to reach our intended market segments. In conclusion, it can be seen that the program itself is feasible as a product and capable of improving patient outcomes. Further studies and development will be necessary to meet the requirements of efficacy for commercial use.

34: Pressio: An Adjustable Vascular Compression Wrap

Alexis Nelson, Sydney Spicer & Erin Sussex - SBHSE

Mentor(s): Dr. Herman Pang - EnteBella Medical | Dr. Vincent Pizziconi - SBHSE | Dr. Katrina Wadowski - Bell Well Medical

Venous insufficiencies are a prevalent problem with approximately 3 million new cases of varicose veins in the United States each year. Despite this, current treatments for venous insufficiencies deny patients a reliable method of swelling, pain, and clot prevention management. The cheapest option currently on the market are compression stockings, but they do not account for swelling of the lower extremities, which leads to decreased patient compliance. Intermittent Pneumatic Compression (IPC) machines are another option that applies compression via air pressure, but they limit patients to their homes, restrict movement during treatment, cost over $1000 per setup, and are generally not covered by insurance. Additionally, surgery and laser therapies are other expensive options with each procedure costing between $500-$3000, which also tends to not have

permanent effects, resulting in patients requiring multiple during their lifetime. To meet this need, the goal of our project is to give patients the compression they need while allowing them to perform their daily activities, including travel. Our device is a fabric compression wrap that incorporates a series of airbags which can be filled to meet the desired amount of pressure on the leg. The device is powered using a standard cell phone portable charger for easy charging while traveling or at work. We tested the device for total weight, pressure the airbags can withstand, air bag tensile strength, air pump efficiency, and system accuracy. The device is lightweight, 1.5 lbs, for easy use and the airbags can withstand an air pressure of up to 20 psi, which far exceeds the pressure required for treatment. Future iterations of the device will include an electrical stimulation component to have patients actively use their own muscles to pump blood against gravity, improving symptoms and minimizing pain better than a passive treatment alone.

35: Digit-Bots Orthotics: An Orthotic Device to Enable Finger Flexion and Extension

Tanner Levi & Derek Vielhauer - SBHSE

Mentor(s): Dr. James Abbas - SBHSE | Dr. Richard Zimmerman - Mayo Clinic

Finger flexion and extension deficits originate from various complications due to stroke, meningioma, and other motor neuron diseases. Patients with such diseases have difficulties using their fingers for daily tasks and in some cases do not have any function in their fingers. Current solutions include wearables for movement assistance, devices for supporting gripping functions, devices for rehabilitation, and myoelectric hand assisting with finger motion; all of which extend the hand to then be flexed. In some cases, the individual cannot flex or extend, hindering the ability to effectively rehabilitate the impaired hand. Customers for the device are patients with motor neuron disease as well as orthotists, prosthetists, physical therapists, neurosurgeons, and other clinicians. The rehabilitation market size is expected to reach $1.1 billion by 2021, and our device is aimed at accounting for 5% of that market since rehabilitation of the hand accounts for 5% of the economic output for this market. Our device bridges the gap for both finger extension and flexion utilizing other muscle input to output finger motion, which is absent from current solutions. After interviewing various individuals with a motor neuron disease and physicians, target specifications for the device include slim fitting, universal, adjustable, durable, flexible, and longevity. The design of the device includes a shoulder strap, glove, and forearm device which consists of wires, 3D printed components, and velcro straps. The technology was designed to meet customer needs and technical specification requirements. Through this innovative technical solution, we aim to provide patients suffering from motor neuron disease with a better quality of life.

36: Exodontia Recovery Band: A Post-Tooth Extraction Cover Delivering Pain Relief and Antibiotics

Hamida Ismail, Nivenka Mahesh, Shawn Striker & Tudor Sasaran - SBHSE

Mentor(s): Dr. Olivia Burnsed - SBHSE

Every year there are approximately 5 million Americans who undergo painful tooth extraction procedures. After, patients are sent to pharmacies and must wait crucial time for their drugs to be prepared. Chance of infection for this procedure is around 7% which leads to dangerous complications and significant costs. Current treatment drugs are delivered systemically and not locally. This leads to higher dosages and and inefficient usage and exposure to medications. Dentists prescribe 15% of opioids used in the United States, by altering pain management to a local and potent anti inflammatory the magnitude of this crisis can be reduced. Systemic antibiotic use for dental procedures is inefficient and an overuse of antibiotic potency, a topical solution will combat the issue of antibiotic resistance. The Exodontia Recovery Band utilizes Dexamethasone as a local pain reliever and Penicillin-Streptomycin as a topical antibiotic. The different delivery method will allow the dentist to send additional bands home with the patient to avoid unnecessary and painful wait times at a pharmacy. The band will attach firmly to the gum surrounding the extraction site where there will be continuous protection of the wound area. With the development of the Exodontia Recovery Band, there is a quick solution that will deliver pain relief to the extraction site, protect the wound from harmful debris, and deliver antibiotics. These benefits will ensure a positive recovery for the patient and reduce chances of associated dental issues thus providing positive cost-benefits.

37: Thermostasis: Active Thermoregulation Inside Prosthetic Sockets

Andrew Nelson, Corey Soto & Taylor Underwood - SBHSE

Mentor(s): Dr. Jeffrey LaBelle - SBHSE

Transtibial amputees commonly experience temperature discomfort while wearing their prosthetic which is often cited as the number one reason why users are unable to wear their device throughout the day. Residual limb overheating is most prevalent with 53% of users reporting decreased wear time, sweating, skin blistering, infections, and odor. The transtibial amputation population is currently 2 million people in the United States with 185,000 new cases every year and dysvascular related complications due to diabetes will double this population by 2050. Conventional methods of temperature regulation such as passive, air-cooled, and temporary cooling have been tried with little impact on customer satisfaction. The quality of life of an amputee post-surgery relies on the functionality of the prosthetic and the ability for daily use. Thermostasis seeks to address both hot and cold discomfort with active temperature management facilitated by Peltier cooling modules activated by real time temperature feedback. There are two major systems in the design, the residual limb heat transfer layers, and the temperature regulation module. The residual limb heat transfer layers are worn around the residual limb inside the prosthetic socket and are made of thermally conductive materials that are able to transfer heat away from the limb. The temperature regulation module cools water down when activated by a threshold temperature from the prosthetic socket environment. This module will be attached to the prosthetic leg post and can be concealed using an artificial calf housing. This device is designed as add-on components replacing existing prosthetic sock and liner combinations allowing the user to retain their current fitted prosthetic setup. Current design of experiment (DOE) progress includes optimizing Peltier performance, analyzing heat transfer from socket liner to residual limb, and gait analysis of the components added to the prosthetic. Peltier performance was analyzed using two types of heat sinks under three different ambient conditions. Heat transfer from the socket was analyzed by running temperature-controlled water through a 2-dimensional prototype to collect surface temperature data indicative of what the user will be wearing. Finally, gait analysis was analyzed to determine how the added weight of the device affects normal walking. Thermostasis hopes to provide transtibial prosthetic users with increased wear time to keep them comfortable, active, and independent throughout the day.

38: Biomedical Assistive Support Systems (B.A.S.S.): Upper Extremity Orthotic for Dynamic Movement

Ahnaf Rahman, Jagan Pandari, Nick Pederson & Andrew Polson - SBHSE

Mentor(s): Dr. Stephen Helms Tillery - SBHSE | Dr. Shafeeq Ladha - Barrow Neurological Institute

Muscular dystrophy is a group of genetic diseases caused by a mutation that progressively results in weakness or loss of muscle mass. It is estimated to affect 250,000 individuals in the United States alone. Due to the degradation of the muscles, individuals have difficulty completing everyday tasks or hobbies such as putting on clothing or playing an instrument. Currently, there is no cure for muscular dystrophy but medications and therapy can manage symptoms or slow down degradation. This creates a need to explore and manufacture novel solutions to address everyday problems that patients with muscular dystrophy experience. An example of such a solution is orthotic medical devices. Current orthotics fail to provide a balance of functionality and cost-efficiency for patients. Our mission at B.A.S.S. is to create an affordable orthotic to allow those with muscular dystrophy achieve a greater degree of movement. Our interdisciplinary team has created an upper extremity orthotic that is purely mechanical and utilizes adjustable elastic bands to facilitate patients' movements while avoiding issues that arise with complicated electrical orthotics such as lack of insurance coverage. Our orthotic utilizes elastic forces to leverage the arm upward, reducing the required muscle activation to normally lift the arm. Our device allows for a higher quality of life and greater freedom for those patients seeking an affordable but practical orthotic. For future advancements, our team hopes to develop portable devices for those not wheelchair bound, as well as devices to assist in hand movement and other parts of the body. By assisting individuals with muscular debilitating diseases, we can help them live their dreams and fulfill their passions.

39: HexFlex: Improved Force Distribution in Passively Cooled Transtibial Socket

Andrew Smith, Nolan Ross & Patrick Hogan - SBHSE

Mentor(s): Dr. Jeffrey LaBelle - SBHSE | Don LoGuercio - DonJoy/OrthoSport Arizona | Dr. David Vowels - Medsource Prosthetics and Orthotics | Tripp Rice - Augusta Prosthetics

There are currently an estimated 1.46 million lower limb amputees in the US with roughly 185,000 new amputations annually, with only a 70-75% satisfaction rate with current solutions. The majority of these amputees are Class I and II, with low to moderate levels of mobility. The most common lower limb sockets are pin-lock and suction-based design which utilize solid, custom formed outer shell, and exhibit the highest level of force distribution over the residual limb. These sockets allow little airflow, poor heat dissipation, suboptimal moisture wicking, and virtually no volume adjustment which create a stressful environment for the tissue of the residual limb. Current passively cooled sockets utilize large open areas between radially constricting solid struts lined with pads to achieve volume adjustability, fit, and overall cooling. The design of these sockets reduce the area that contacts and constricts around the residual limb, increasing the pressure exerted on small portions of the limb from the downward force of locomotion, which can cause pain and tissue damage. The modular structure of the HexFlex device allows for mass production in generalized sizes, and improved force distribution with end user volume adjustment to provide the maximum level of comfort for Class I and II amputees, without increasing price. The HexFlex socket has already been shown improved force distribution when compared to a state of the art (SOTA) adjustable socket, with far less deviation in force applied around the residual limb and almost 4.5x the active constrictive area. The force distribution tests were conducted using force sensing resistors and were focused on measuring the force exerted on the four most pressure intolerant areas on the residual limb, while the socket was fully constricted. In future work, the heat dissipation and energy loss through torque properties of the socket will be tested and compared to current SOTA sockets. The easily customizable, 'off-the-shelf size' design of HexFlex will improve the overall environment of the residual limb, at a price that undercuts the current market competition. This device will improve the overall user experience and quality of life for amputees who suffer from the shortcomings of current solutions.

40: OBOK Medical: Visual Voice

Andrea Hnatievych, Amy Polanecki, Jose Galaviz Garcia & Maxwell Sakyi - SBHSE

Mentor(s): Dr. Bradley Greger - SBHSE

OBOK Medical has developed the Visual Voice device with hopes of improving the quality of life for patients experiencing Locked-in-Syndrome (LIS), to ultimately create a bridge of communication between patients and caregivers. In terms of specifications, the device is a low-cost, low-power, and portable system that measures real-time eye movements using electrooculogram (EOG) as the driving function. The EOG signal is obtained and filtered through the advanced hardware element and then processed through our cohesive Arduino software coupling. The functionality of the device encompasses two states and both of these acquire the electrical input from the patient via the custom-built EOG circuit. As the patient changes between states, differentiated outputs are represented visually using LEDs such as red, yellow, green, and blue. Blue is indicative of the yes-no state, while yellow indicates the computer interface state. A blink and hold action drives the transition between states, for which auditory output is implemented to inform the user of these changes. For alert functions in the yes-no configuration, a green LED illuminates as the patient looks up, expressive of a "yes" response. On the other hand, red is used to simulate a "no" response and is stimulated by the patient's downward eye movement. For the computer interface functionality, the user has full cursor control capabilities. This software configuration allows for a more interactive environment, offering the patient freedom to navigate their preferred websites, such as Netflix or social media for example. Testing protocols are included for the assurance of comfortable dry electrode configurations, effective bandpass filtering, appropriate amplification, as well as the traceability of accurate software response. The team continues to work with due diligence in the fine-tuning of the specifications for the Visual Voice device. Moving forward, OBOK Medical aims to have the machine fully customizable to the needs of any given patient, allowing for an expansion of the target market to personas suffering from ALS, MS, and other similar conditions.

41: Smart-Apparel: Engineered for Facilitating Rehabilitation in Physical Therapy

Max Fisco, Joshua Hsu & Yassin Youssfi - SBHSE

Mentor(s): Andrew Clary - FROGS Physical Therapy Institute | Dr. William Tyler - SBHSE

Of the 30 million student athletes in the United States, 3.4 million suffer from sports-related injuries that result in musculoskeletal imbalances. Physical therapy is prescribed, but the industry is dominated by qualitative metrics and lacks affordable and accurate tools to provide a holistic analysis on patient progress and overall health. Therefore, the need for a continuous monitoring device to measure patient biometrics is vital to disrupting the industry. The Omniband, developed by Introhm, is a wearable data logging activity monitor that continuously records and quantifies the kinematics of physical exercise activities. The data is transmitted and processed to be utilized directly as form of active feedback for facilitating physical fitness-related activities. The Omniband consists of a pair of adjustable bands containing E-textile electrodes and an inertial measurement unit sensor within the band housing, and a data download, scoring, and report generation tool. It assists in tracking and trending exercise activity as well as promoting muscular endurance, strength, and form during physical exercise. The intention is for the Omniband to be worn only during exercise for the duration of physical exercise. After their exercise, the patient accesses their mobile device and a report is generated for both their care provider and they themselves. The generated reports contain statistical information regarding the movement of the patient during the exercise and includes a graph showing their physiological parameters.

42: ISF-View: Optical Viewing Patch To Allow Real-time Monitoring of Metabolite Levels In Interstitial Fluid

Enock Boakye, Jaycob Proffitt & Sarah Soaf - SBHSE

Mentor(s): Dr. Antonio Garcia - SBHSE

Chronic kidney disease afflicts around 30 million US adults and is the 9th leading cause of death in America. In 2016, $79 billion was used by Medicare beneficiaries on chronic kidney disease. Early detection and treatment is key to avoid developments such as kidney failure. Current biomarker testing methods such as blood and urine tests require lengthy lab analysis delaying treatment. Creation of a real-time system which could easily be incorporated into a yearly physical, such as an optical viewport into the human body is a solution method. Specifically, interstitial fluid has been targeted as it would require no further processing before testing. ISF-View is a novel transdermal microneedle which would allow for collection of interstitial fluid within the needle. This system, paired with a spectroscopy coaxial fiber optic cable would then be used to transmit a signal through the sample, reach a reflective surface and be returned through the cable for analysis. Currently a proof of concept prototype has been developed and different diffraction gradients and geometry within the needle have been fine tuned to maximize signal transmission and collection. Prototype has been verified by standardized testing comparing efficiency to the gold standard over a range of dye concentrations. This system could be used to test not only normal kidney disease biomarkers, such as creatinine and urea, but also novel biomarkers currently being researched within interstitial fluid. This system has the potential for real-time analysis of any biomarker present in interstitial fluid. This would allow for novel biomarker testing over a variety of pathologies improving treatment and patient quality of life.

Masters Applied Projects

1: Real-Time Sonification of Gait for People Living with Parkinson's Disease

Eugene Ablordeppey

Mentor(s): Dr. James Abbas - SBHSE | Dr. Narayanan Krishnamurthi – College of Nursing and Health Innovation (CONHI) | Todd Ingalls – Arts, Media and Engineering (AME)

Parkinson's Disease (PD) is a progressive neurodegenerative disorder that can produce a variety of non-motor and motor symptoms such as short and quick steps, reduced arm swing, and freezing of gait. PD is also associated with problems in posture, balance, cognitive impairment, motor learning, and automatic execution of non-attention demanding tasks.

An estimated of one million people will be living with Parkinson's disease in the United States by 2020 and approximately 60,000 Americans are diagnosed with PD each year. Also, more than 10 million people worldwide are living with PD. The disorders associated with PD are problematic because they not only impede individual mobility and independence but also have an impact on other aspects of life. There is evidence to indicate that the impairments in gait and posture in individuals with PD could be improved through therapy. Current tools used for monitoring movements are designed for use in the lab, may be uncomfortable to wear, and do not provide real-time feedback to the user. Providing real-time feedback may promote the adoption of improved gait patterns and posture control strategies in PD. The main goals of this project are to select suitable sensor placement positions to detect accurate gait events such as heel-strike and toe-off and to provide real-time audio feedback (sonification) of gait for people with PD.

In the system, gait parameters such as step-time, swing-time, and step-length can be utilized for sound generation. These parameters can be used to modulate the pitch or the duration of sound. The audio feedback can be delivered in continuous mode or on-demand mode. The continuous feedback produces sound that is modulated by the gait parameter at each step; the on-demand feedback produces sound only when the measured gait parameter falls outside of the targeted range. The sonification tool is designed to allow the user to select feedback parameter, feedback type, the foot side and the sound encoding strategy.

2: Systems Modeling of the Intercellular Communication of Alzheimer's Disease

Shaheeda Adusei

Mentor(s): Xiaojun Tian – SBHSE | David Brafman – SBHSE | Xiao Wang – SBHSE

Alzheimer's Disease is a progressive neurodegenerative disease characterized by the presence of the extracellular protein plaques and intracellular neurofibrillary tangles (NFT). Amyloid beta (Aβ) protein is the main component of the extracellular plaques, and it stimulates the production of tau proteins which aggregates to form the NFT within the cell. The disease as reported by Alzheimer's Disease International affects more than 5 million people in the United States and 44 million people worldwide. The pathogenesis of the disease remains incompletely understood, and thus no effective cure is available. We built a mathematical model in the systems level based on the cell-cell communication between microglia, astrocytes, and neurons in the presence of amyloid beta and hyperphosphorylated tau proteins. We aim to investigate the underlying mechanism of AD pathogenesis and characterize the dynamics of the disease progression through three different stages, healthy state, asymptotic AD and clinical AD.

3: Regulation of Cancer Metastasis by crosstalk between YAP/TAZ and EMT pathways

Renaad Alawi

Mentor(s): Dr. Xiaojun Tian – SBHSE | Dr. Xiao Wang – SBHSE | Dr. David Brafman - SBHSE

Tissue homeostasis is regulated by the Hippo pathway and epithelial-to-mesenchymal transition (EMT) is important for cancer metastasis, which is the cause for 90% of cancer deaths. This project will focus on the Hippo pathway and its crosstalk with EMT through positive and negative feedback loops. We aim to find the underlying principle for the cancer transition from the "growth" state, also known as proliferation, to the "go" state, or metastasis, with a systems biology modeling approach. The primary miRNAs, mRNAs, and proteins that control these processes were put together to form a regulatory network that best describes their relationship. YAP/TAZ is a component within the Hippo pathway that is responsible for proliferation in cells. Different levels of YAP/TAZ are predicted to determine the transition.

4: Computer-aided Detection and Visualization of Pulmonary Embolism Using a Novel, Compact, and Informative Image Representation

Douglas Amoo-Sargon

Mentor(s): Dr. Jianming Liang - Department of Biomedical Informatics | Dr. Jit Muthuswamy – SBHSE | Dr. Bradley Greger – SBHSE

Pulmonary embolism (PE) is responsible for 100,000 to 200,000 deaths in the United States each year. The precise number of people affected by Pulmonary Embolism is unknown, but estimates range from 300,000 to 600,000 annually in the United States. The morbidity rate for PE is alarming as one of 3 people diagnosed dies. The underlying cause for PE is the travel of blood clots to the lungs due to pulmonary circulation the mortality as well as the morbidity rate can be greatly reduced through accurate early diagnosis however diagnosis of PE is very difficult and generally results in misdiagnosis. Conventional methods of detection include computed tomography and x-ray scans. Other attempts to improve diagnosis has been the use of computer aided diagnosis (CAD). The limitation that exists with these CAD methods are expensive cost in training of convoluted neural network models as the image representation of PE is in 3-dimensional format. Also there exists a higher probability of overfitting due to the small number of dataset available for training which leads to lower accuracy of the CAD methods. This project presents a novel representation of PE images which allows for less expensive, time reduction in computation as well as effective training of convolutional neural networks. The advantages of this approach are 1. Ability to summarize the 3D information of the embolus in 3 image channels 2. Naturally supporting data augmentation that reduces overfitting of the model and improves accuracy. 3. Allows for multi-view visualization which provides opportunity to identify defects from different planes. Lastly it allows the implementation of deeper neural network architectures to be employed in the training. The above advantages result in fast training of the CAD system and provides promising advantages in clinical applications as it helps in improved early detection of PE's to reduce patient morbidity and mortality.

5: Design and Development of a Sub-Millimeter Scale, Wireless, Injectable Neurostimulator for Peripheral Nervous System

Fahhad Ashour

Mentor(s): Dr. Jitendran Muthuswamy – SBHSE | Dr. Bruce Towe – SBHSE | Dr. Arati Sridharan – SBHSE | Jennifer Blain Christen - ECEE

Recent studies have shown promising results in treatments of major neurological disorders using neurostimulation based approaches. However, their chronic performance and stability are often hindered by wires/leads connecting the electrodes to external stimulators, life of batteries, and the foreign body response elicited by the implanted electrodes. The goal of this project is to test the feasibility of a submillimeter, battery-less, wireless device that is implantable in a peripheral nerve fiber. The device converts ultrasonic waves into electrical signals using a 250 μm thick lead zirconate titanate (PZT) that is rectified locally by a Schottky diode in order to produce a monophasic cathodic wave to stimulate the PNS. Two types of neurostimulators where designed and tested using the above approach – first, a device based on volume conduction and second, a device that is hardwired. For the first device, a conductive metal tab is used to short the cathodic terminals of both the PZT and the diode. For the second device, an extra step is added to hardwire the anodic terminals of the PZT and the diode using a wire bonder and a 1 mil gold wire. Platinum electrodes are bonded to both terminals of the diode using conductive epoxy and trimmed to reduce the device's impedance as well as wiring. The ultrasonic coupling capabilities were tested for volume conduction, angle and distance dependence using a specially designed ultrasonic apparatus with 1.25 MHz and a 2.5 MHz transducers. The optimal experimental medium conductance was achieved at 1.2 mS in a 100 ml ultrasound gel mixed with 0.9 mg of NaCl. The obtained data indicates that the 0.3 mm x 0.3 mm device is capable of generating a 1.5 V signal using an unfocused 2.5 MHz transducer. Moreover, the voltage output shows exponential decay with respect to angle of incidence. However, it remains constant with varying distance from transducer. The volume conducted electric field is sufficient to forward bias the diode and allow for signal rectification at the desired order of magnitude for neurostimulation.

6: Silk Fibroin Dressing Accelerates Healing in Full Thickness Diabetic Wounds

Michael Bejarano

Mentor(s): Dr. Kaushal Rege - SEMTE | Dr. Olivia Burnsed – SBHSE | Dr. Jessica Weaver - SBHSE

Chronic non-healing wounds cost the US healthcare system over $16 billion a year and are a common complication of diabetes. Compared to non-diabetic wounds, diabetic wounds take longer to heal, which can lead to the development of chronic wounds that can significantly worsen outcomes in patients. Current methods for chronic wound care include topical antibiotics, dressings, growth factor injections, and skin substitutes. However, these methods are often either costly or fail to achieve proper healing. In previous studies, we have observed accelerated healing of acute and diabetic wounds using silk fibroin dressings compared to traditional Tegaderm dressings. We have also observed the effectiveness of using silk fibroin dressings when supplemented with histamine. In this study, we looked to further accelerate healing by delivering a growth factor, stromal-derived factor 1α (SDF1)-elastin-like polypeptides (ELP), to the wound site in combination with our silk fibroin and histamine treatment. Genetically diabetic BKS.Cg-Dock7m +/+ Leprdb/J (db/db) mice were utilized as a model for chronic wound healing while immunocompetent BALB/c mice served as a model for acute wound healing. 5-millimeter mid-dorsal full thickness wounds were created in the models, and histamine was delivered to the wound beds immediately following the injury. SDF1-ELP was added to the wound beds on either the same day as the wound inducement, Day 0 (simultaneous treatment), or on Day 3 (sequential treatment). Wound beds were covered with either a silk fibroin film or Tegaderm. Wound sites were photographed each day post-wounding and wound areas were measured via ImageJ. After wound healing, rectangular sections of the skin around the wound areas were excised for measuring tensile strength of the repaired tissue. We found that while the silk and histamine treatment accelerated healing compared to Tegaderm and saline treated wounds, adding SDF1-ELP as a simultaneous or sequential treatment resulted in a faster rate of wound closure and higher skin strength recovery. These findings demonstrate a promising treatment option for accelerating the wound healing process for acute and diabetic wounds.

7: Disrupting the Blood-Brain-Barrier via Surgical Resection to Improve Nanoparticle Delivery to Invasive Cells of Glioblastoma

Sara Belko

Mentor(s): Dr. Rachael Sirianni - Vivian L. Smith Department of Neurosurgery, UTHealth | Dr. Sarah Stabenfeldt – SBHSE | Dr. Brent Vernon – SBHSE

Glioblastoma (GBM), the most common malignant brain tumor, has an average survival prognosis of 14 months, due to the tumor's invasive nature. Surgical resection is used to remove the bulk tumor, however, tumors typically recur within the first two centimeters of the resection cavity. It is difficult to administer treatment to these invasive cells due to the intact blood-brain-barrier (BBB) that encompasses them. Currently, we know that injuries, like stroke and traumatic brain injury (TBI), can disrupt an intact BBB, which can enable better delivery of nanoparticles. Based on this knowledge, we hypothesized that the injury caused by surgical resection would enable nanoparticle delivery to improve drug delivery to the brain tissue near the resection site. Using a mock surgical resection to the right frontal hemisphere and 100 nm PEGylated fluospheres as model NPs administered at three injection time points (0, 2, and 24 hour) post-surgery, we characterized NP delivery. We found a significance in NP delivery to the peri-resection tissue of the resection hemisphere compared to healthy, non-surgical brain and the contralateral hemisphere ($P<0.0001$). This supports our over-arching hypothesis that injury via surgical resection can facilitate NP delivery. NP delivery was spatially symmetric; however, the diameter of blood vessels in which nanoparticles clustered was observed to be larger than blood vessels not containing nanoparticles. We found no correlation between distance delivered (DD) and blood vessel diameter (BVD), a negative correlation between DD and NP intensity delivered (NPD) at 0 and 24 hours, and a positive correlation between BVD and NPD at 2 and 24 hours. These results supported our prediction that acute damage will facilitate NP delivery to immediate tissue in larger vessels. These results are significant because improving NP delivery to GBM's invasive cells will increase drug delivery which has the potential to replace harsh chemotherapies transforming the standard of care.

8: Parkinson's Disease Patient's Automated Fall Detection Wrist Wearable Threshold Analysis

Patrick Conely

Mentor(s): Dr. Thurmon Lockhart – SBHSE | Dr. Sydney Schaefer – SBHSE | Dr. Narayanan Krishnamurthi – College of Nursing and Health Innovation

There is projected to be 1 million patients affected by Parkinson's disease living in the US in 2020. Some common symptoms in-

clude tremors, rigid muscles and problems with gait and mobility. These symptoms create a large fall risk for the patients, as they lead to a great amount of postural instability. The current system for reporting falls involves self-reporting from the patient themselves. These are often inconsistent and can lead to more severe injuries. An automated fall detection device would eliminate the inconsistency of fall reporting and decrease injuries by allowing a faster response time to the fall. The proposed solution for the automated fall detector will be worn on the wrist and include an Internal Measurement Unit that will use an accelerometer and gyroscope. This project specifically focuses on the threshold levels that will be set for the detector. Identifying the thresholds is key for the accuracy of the device, as false negatives will miss falls and false positives will deter use of the sensor. To determine these thresholds, perturbation testing was done on subjects with Parkinson's disease to receive sensory values experienced during a fall. These values were compared to sensor values from daily living tasks, such as walking and cutting with a knife, as the signal from theses task could mimic the signal of an actual fall. The results of the daily tasks determined threshold values that the sensor will utilize to avoid false negatives and positives. Using the acceleration, jerk, and angular velocity, thresholds were able to be determined that will maximize the effectiveness of the automatic fall detector.

9: Database Development for Motor Learning in Geriatric Subjects

Molly Golek

Mentor(s): Dr. Sydney Schaefer – SBHSE | Dr. Claire Honeycutt – SBHSE | Dr. Daniel Peterson – College of Health Solutions

Databases are used in many different fields of work to organize information and allow for easy access of that information. The invention of databases resulted in data mining, the act of analyzing data for relationships between variables. Data mining has become increasingly important to research, particularly in larger datasets. Dr. Schaefer is an assistant professor at Arizona State University with a lab focused on rehabilitation and learning in geriatric subjects. She and Dr. Peterson currently have a longitudinal study with over 100 individuals enrolled, yet the data are stored within a single Excel document, making it difficult visualize and query the data.

To improve data analytics and visualization, particularly for larger, longitudinal studies, a new database was created using the program REDCap, a free online database creation website. It is geared towards clinical studies and is designed to comply with HIPAA requirements for storing patient data. The database allows for secure access, as a REDCap account is required and access to the project must be granted in order to see the data. It has also enabled the comparison of data across different subjects at a given time point (i.e., cross-sectional) as well as the same subject over time (i.e., longitudinal). It also provided better storage for data trials compared to a typical spreadsheet, which were previously being stored as averages due to trying to keep the Excel document less cluttered. In addition, it features coding processes that enable the automatic scoring of several motor assessment tests given a subject's raw score, eliminating the need for laboratory personnel to calculate scores themselves.

10: Changes in Neural Activity during Deep Brain Stimulation in Patients with Parkinson's Disease: Correlation with Stimulation Parameters, Tremor, and Outcomes

Dakota Graham

Mentor(s): Dr. Bradley Greger – SBHSE | Dr. Christopher Buneo – SBHSE | Dr. Stephen Helms Tillery – SBHSE

Deep brain stimulation (DBS) has been proven to be a safe and effective treatment for various neurological motor disorders such as Dystonia, Essential Tremor, and Parkinson's disease (PD). Since 1997, over 150,000 patients have undergone DBS implantation. DBS provides substantial clinical benefit to patients with PD, however, very little is known about the mechanisms by which DBS produces such a benefit. The goal of this project is to elucidate how DBS is interacting with neural physiology and provide insight into the mechanisms by which symptoms are ameliorated in PD. Understanding of DBS mechanisms would help drive development of more specialized DBS systems and open avenues for use in other pathologies. We recorded neural signals from patients with PD at the Barrow Neurological Institute (BNI) during the implantation of DBS leads while under general anesthesia. Neural signals were recorded using a microelectrode placed in the subthalamic nucleus (STN) during stimulation with the DBS lead. Stimulation frequency was varied during the recording as this is a key tuning parameter for device programming. We examined changes in action potential firing rates and the action potential (AP) aligned average local field potentials (LFP) at various stimulation frequencies. Preliminary results showed little change in AP firing rate, while changes in AP aligned LFP at 140Hz and 250Hz stimulation were observed when compared to no stimulation. With DBS stimulation at higher frequencies, AP aligned LFP demonstrated a phase relationship like that observed in normal neural tissue. We speculate that DBS stimulation may be restoring a normal relationship between APs and LFPs in the Basal Ganglia. However, these speculations are assuming

the unanesthetized Basal Ganglia circuitry will respond similarly to DBS and that the chosen stimulation parameters would invoke benefit in the awake patient. Future work will include stimulation and recording while the patient is awake and incorporate a tremor measurement system. This will reduce any confounding effects of anesthesia and allow us to directly link DBS stimulation frequency and tremor reduction to the observed changes in neural activity.

11: Modification and Validation of a Novel Upper Extremity Reach Test

Theodore Kyriacou

Mentor(s): Dr. Sydney Schaefer – SBHSE | Dr. James Abbas– SBHSE | Dr. Ayoub Daliri – College of Health Solutions

There is a need within motor control and motor learning research for more functional, ecologically-valid assessments to better understand how the brain controls real-world movements. To this end, a more functional upper extremity motor task has been developed by Dr. Schaefer and has been used experimentally within her lab. Because of its ecological validity, several collaborators have begun to use it as well, thereby creating the need for scalability and standardization. The goal of this project was to model the original task apparatus to allow for better standardization via standard 3D printing. Additional modifications were added to minimize printing cost and allow for easy assembly. This was accomplished with iterative prototyping using the Computer-aided design (CAD) tool, SolidWorks and a 3D printer. The 3D printed version was then validated by testing participants on both the original and new 3D printed versions to determine equivalency.

12: The Effects of Different Frequencies of Low-Level Vagus Nerve Priming Stimulation on Proprioceptive Performance

Andrew Levitsky

Mentor(s): Dr. Christopher Buneo – SBHSE | Dr. Stephen Helms-Tillery – SBHSE | Dr. Marco Santello - SBHSE

Objective: To determine if the administration of low-voltage priming stimulation on the vagus nerve at different frequencies can improve proprioception.

Methods: 80 subjects received varying frequencies (30Hz, 300Hz, 3kHz, and control) of transcutaneous vagus nerve stimulation (at 4mV) on the back of the neck for 10 minutes. Following this stimulation block, the subjects participated in a 120-trial experiment during which their arms were moved from an initial position through a distracter loop and they had to determine if they were returned to the original position or a different position. This task was divided into four blocks in which the distance between the same and different points was between 1 and 4cm.

Results: Overall, subjects who received 3kHz performed slightly better at the 1cm and 2cm-distance trials than the 30Hz, 300Hz, and control groups. Both the 30Hz and 300Hz groups had lower mean sensitivities than the control group at those distances. However, none of these differences were statistically significant. During the 3cm and 4cm trials, no group had any clear indication of improved performance over the others. There was a single adverse event reported.

Conclusion: While there were no significant findings, the fact that the performance of those subjects in the 3kHz group trended upwards compared to the control subjects at smaller distances merits further study with larger sample sizes.

13: Reliability Model of Implantable Electrode-Tissue Interface for Neurostimulation using Accelerated Tests

Jinglin Liu

Mentor(s): Dr. Jit Muthuswamy - SBHSE | Dr. Eric Maass - Medtronic and SBHSE | Dr. Arati Sridharan - SBHSE

Reliability and long functional lifetime are critical for clinical applications of implantable neural devices. Accelerated life test (ALT) is commonly applied for the long-term implantable medical products to obtain their reliability data in a timely manner. One common source of failure is metal corrosion due to electrochemical reaction at the metal-tissue interface, which limits the long-term

performance of the implantable neurostimulator applications. We investigate common acceleration factors such as temperature, the concentration of hydroperoxide, and charge/phase of electrical stimulation that lead to the failure of the tungsten electrode-tissue interface used for neurostimulation. We perform 3 accelerating factors with 2-level factorial design of experiments (DOE) to assess relationships among the acceleration factors with respect to the time-to-failure. We employ a combination of different techniques to detect failure such as cyclic voltammetry (CV) for calculating charge storage capacity of the electrode, electrochemical impedance spectroscopy (EIS) for measuring impedance over the range of frequencies, and visual inspection under microscopy to evaluate the metal corrosion at the tip of tungsten wires. The ALT reliability model fits the model to data collected under stress conditions of acceleration factors. We derive acceleration factors (AF) ratio of each accelerating factors using physical/chemical models, including Arrhenius model and inverse power model to account for both thermal and non-thermal factors. Maximum likelihood method (ML) is used to build the ALT model which allows for censored data where the exact failure time of the devices are unknown. ML estimates the model parameters which maximize the probability of experimental data for the model. The modeling results derived under stress levels of the accelerating factors are used to estimate the lifetime of implantable stimulation neural electrodes under normal in vivo use conditions.

14: Photoacoustic Microscopy

Ethan Marschall

Mentor(s): Dr. Barbara Smith – SBHSE | Dr. Vikram Kodibagkar – SBHSE | Dr. Sarah Stabenfeldt - SBHSE

The photoacoustic effect is the phenomenon by which an acoustic wave is generated through thermal expansion caused by light absorption in a material. Applied on the nanoscale, this phenomenon has been utilized to derive contrast from the differences in a cellular structure's optical absorption, in a system known as photoacoustic microscopy. A typical photoacoustic imaging system is comprised of a pulse-energy source and an acoustic detector. Multiple variations of the system exist for different applications, ranging from cancer detection to brain mapping. Photoacoustic imaging systems combine the good contrast of optical imaging with the resolution of ultrasound. However, early attempts have suffered from a lack of simultaneous optical and photoacoustic observation. This project is to overcome this trade-off and allow for simultaneous optical and photoacoustic imaging. A polylactic acid (PLA) model has been designed and constructed which allows for both 40x optical zoom and signal acquisition by 3mm ultrasound transducer, along photoacoustic excitation of a 12mm glass sample slide. Raster scanning is often used in cellular studies, by running raster scanning of black tape and 7.2-micrometer threads, the system has been shown to successfully correlate signal acquisition and excitation while being observed optically. Future steps will explore the validation of the system on in vitro samples.

15: Cellular Detection Using the Photoacoustic Effect

Justin Mieth

Mentor(s): Dr. Barbara Smith – SBHSE | Dr. Vikram Kodibagkar – SBHSE | Dr. Jit Muthuswamy - SBHSE

The photoacoustic effect occurs when a sample is exposed to an intense wavelength of light resulting in the production of pressure waves due to thermal expansion. Information regarding the composition and concentration of the sample can be determined from the onset and amplitude of this phenomenon. The objective of this work is to measure the occurrence of the photoacoustic effect to distinguish cell types from one another. A Lotis TII laser system was used in conjunction with a series of lenses and irises to concentrate the light. A beam-splitter was used to diverge the light into two paths: one measured with a power-meter for real-time evaluation of power output and one directed at a sample with a transducer directly below it. Calibration data were collected to determine the settings of the system for minimum variance and maximum power output. Black electrical tape was exposed to the laser light as a positive control of the photoacoustic effect. Skov3 and HeLa cells were evaluated for their photoacoustic signature between 375nm and 460nm. Future work includes evaluating additional cell types and expanding the range of wavelengths to 350nm to 500nm.

16: Range of Motion Evaluation in Lumbar Spine (L1-L2) by Using Six Axis Robotic Testing Methods

Alireza Momeni

Mentor(s): Dr. Brian Kelly - Barrow Neurological Institute | Dr. James Abbas – SBHSE | Dr. Brent Vernon - SBHSE

Spinal segments are exposed to different types of forces such as bending, shear, compression, or any combinations of them; assessment of their range of motion (ROM) after applying different loads is valuable for both surgeons and researchers. In the traditional way, it is common to measure ROM of each spinal segment, in the forms of flexion/extension, lateral bending, and axial rotation, after applying pure moments in sagittal, frontal, and transverse planes respectively. By using the six-axis robotic machine, it is possible to perform 360-degrees tests of the spinal segment in both direction of clockwise (CW) and counter-clockwise (CCW), which will provide the data about flexion, extension, left lateral bending, right lateral bending, and also the entire path of each spinal segment by doing one single test. In this study, ROM of L1-L2 segment was measured in real-time and force control condition by applying the pure moments in different directions; besides performing 360-degress in CCW and CW. For this purpose, ROM of each healthy specimen in the form of flexion, extension, left lateral bending, right lateral bending, left axial rotation, and right axial rotation was recorded after performing the 3 cycles of loading; the results from performing 360-degress tests (CCW and CW) after first cycle and the third cycles were recorded as well. The comparison of data between pure moment version of loads, and 360-degrees tests demonstrates that there is no statistical difference between them; moreover, there was no statistical difference between CCW and CW version of 360-degrees tests either.

17: Modeling the Effects of Amyloid Beta Aggregates in a Two Cell System Inside the Brain

Jonathan Moroneso

Mentor(s): Dr. Xiaojun Tian – SBHSE | Dr. Rosalind Sadleir – SBHSE | Dr. Xiao Wang – SBHSE

Presently in the United States, there are approximately 5.3 million people with Alzheimer's disease (AD). Over 96% of these individuals are also at or over the age of 65; and as a result of the aging population in the United States, the number of AD affected individuals is expected to grow by 10 million more by 2050. Being a neurodegenerative disease, AD doesn't only lead to dementia but is also the sixth leading cause of death in the United State, fifth in those aged 65 or over. Not only does this put a tremendous emotional burden on the family, but it can be quite the financial burden as well. The cost of treatment from Medicare towards these affected individuals is typically 2.5 times as high as those without the disease, with the total cost of long-term and hospice care estimated at $226 million overall. Research in the disease has typically been centered around the amyloid beta (Aβ) protein. Starting as monomers these can combine to form a soluble oligomer, or longer, insoluble plaques. Initially, the plaques were thought to be the cause of AD; however, a lack of correlation of plaques to cognitive impairment, and the finding of plaques in healthy individuals have shown that the plaques are not the cause. The smaller and soluble oligomers have shown correlations to cognitive deficit, even in scenarios when no plaques were present. In order to get a better understanding on how these oligomers form and aggregate, a model has been constructed involving the formation of Aβmonomers, oligomers, and plaques between two cells and extracellular space inside the brain, and loss to outside of the brain. The Aβ can be formed in either cell or extracellular space and can be transported between cells, extracellular space, or to outside the brain. Once the simulation of the model has been completed to show Aβ aggregation in healthy and diseased individuals, changes to the model can be made to hopefully show a link from diseased to healthy. This can provide the next steps needed to combat this disease before the problem becomes too big.

18: Hemostatic Nanoparticles Effects on Traumatic Brain Injury Associated Coagulopathy

Amanda Oswalt

Mentor(s): Dr. Sarah Stabenfeldt – SBHSE | Dr. Brent Vernon - SBHSE | Dr. Mehdi Nikkhah - SBHSE

More than 200,000 cases of Traumatic Brain Injury (TBI) occur in the United States each year. Around two thirds of TBI patients develop platelet dysfunction contributing to bleeding complications. Coagulopathy is common in TBI and its coexistence with TBI is associated poor patient outcome. Coagulopathy associated with traumatic injury often follows a course of evolution from hyper- to hypocoagulable state demonstrated in disseminated intravascular coagulation. Wafaisade et al., reported, a 50.4% mortality rate for isolated blunt TBI with coagulopathy as compared to 17.3% for TBI patients without coagulopathy. Quick intervention is paramount for positive outcome in trauma cases. Following vascular injury, hemostasis is initiated by the capture of

platelets by the subendothelial matrix exposed at sites of vascular injury forming a platelet-rich plug subsequently activating the coagulation cascade and thrombin generation leads to fibrin crosslinking. While platelet functions following TBI is not well understood, evidence suggests that TBI may result in platelet hyperactivity, in which platelets are partially activated or primed for activation. Clot stability in TBI survivors presented significantly decreased fibrin clot strength as compared to that of non-surviving patients. Hemostatic nanoparticles have demonstrated utility in numerous traumatic injury studies. In a rodent blast models administration of HNP following a blast injury resulted in 95% survival rate as compared to 60% with no treatment. Another study suggests hemostatic nanoparticles achieved 50% reduction in femoral bleeding in rodent models. Hemostatic nanoparticles consist of a PLGA-PLL core and PEG-GRGDS arms. GRGDS ligand mimics that of the α-chain of fibrinogen RGD sequence which bind integrins. The aim of this study was to evaluate the effect of hemostatic nanoparticle in a controlled cortical impact (CCI) model. Three cohorts were investigated: (1) hemostatic nanoparticles, (2) control nanoparticles and (3) control sham at two time points 24 hours and 7 days, each group consisting of (5) male mice. Tissue was evaluated for microglia and astrocyte activation to further quantify the effects of coagulation and better understand the mechanisms effects in TBI.

19: Automatic Detection of High Frequency Oscillations as a Pathological Biomarker in Epilepsy

Aaron Raber

Mentor(s): Dr. Stephen Foldes – Barrow Neurological Institute and SBHSE | Dr. Bradley Greger - SBHSE | Dr. Jit Muthuswamy – SBHSE

Multiple drug-resistant epilepsy accounts for roughly a third of epilepsy cases, whose numbers are close to 3.4 million in the US alone (CDC.gov). In these cases, a common treatment is surgical resection or ablation of the pathological seizure onset zone (SOZ). High-frequency oscillation (HFO) activity in intracranial EEG (iEEG) recordings has been recently used as a biomarker for detection of the SOZ, involving frequencies above the 80Hz maximum used in traditional EEG (Zijlmans et. al.). However, the current gold standard for HFO detection is by visual inspection looking for discrete events in the 80-500Hz band, a process which can be incredibly tedious and time-consuming given long, multi-channel recordings. Current automatic detection algorithms have had issues with maintaining adequate sensitivity and specificity of detection while remaining robust to EEG artifacts and noise. The aim of this project was to develop an automatic detection algorithm for HFO activity in multiple-hour iEEG data in pediatric patients that is robust to recording inconsistencies, artifacts, and noise while retaining acceptable sensitivity and specificity. Working with Barrow Neurological Institute at Phoenix Children's Hospital, I developed a method to extract HFOs from very long (24+ hours) recordings of multi-channel iEEG and display results in a clinically meaningful way. The detection algorithm involved denoising, bandpass filtering, and Hilbert transforming to extract the signal envelope at high frequencies. Events that exceeded 5 standard deviations above the mean of the background for between 20 and 1000ms where considered HFOs. These windows also undergo artifact rejection based on time-frequency spectrum analysis. This algorithm monumentally improved the processing speed for long iEEG data compared to the RIPPLELAB Hilbert algorithm (Navarrete et. al.) on which it is based. Additionally, our method was more robust to artifacts, such as spikes and discontinuities. We are now evaluating the stability of HFO events across long time periods to evaluate HFOs value in clinical decision making. Plans for clinical validation of HFOs include comparing post-surgical seizure freedom to HFO event rates inside and outside of the resected region.

20: Fabrication of Tyrosine Infused Microparticles for Brown Adipose Tissue Stimulation

Diego Reyes

Mentor(s): Dr. Brent Vernon – SBHSE | Dr. Christopher Plaisier – SBHSE | Dr. Antonio Garcia – SBHSE

Obesity continues to be one of the largest ailments effecting the population of the United States, with the center of disease control stating that one third of the U.S. adults are Obese. Along with the fact that obesity is strongly correlated with heart disease, diabetes and stroke makes it one of the leading causes of preventable death. Though within this one third of obese adults lies a population that suffers from the inability to regulate their metabolism or weight through conventional methods of diet and exercise. These people tend to suffer from diseases like hypothyroidism and diabetes which effect the natural metabolism making it exceedingly difficult for them to lose weight or self-regulate their metabolism.

The proposed treatment for this aliment is to produce drug loaded microparticles that would be injected into the patients brown adipose tissue. These microparticles would then release drug over time stimulating the adipose tissue which in turn would stimulate the patient's metabolism. The microparticles in question would be fabricated out of poly(lactic-co-glycolic acid) [PLGA] that are then loaded with drug using a double emulsion technique. With the drugs in question being norepinephrine and tyrosine.

Currently a protocol that can consistently fabricate the drug loaded microparticles has been produced and to test it drug release studies are being performed. From the initial release studies the concentration of drug released will be measured in order to determine how effective the protocol is at producing these drug loaded microparticles. Once the protocol is updated according to the data found from the initial test, more release studies will be performed. From these studies the ratio of drug to polymer or PLGA will be optimized to increase the encapsulation efficiency of the microparticles as well as the release rate. This will be done by adjusting the concentrations of drug, polymer and solvent when creating the microparticles. Lastly once the ratios are optimized they will be translated to the sister project in Dr. Vernon's lab focused on producing microparticles of a consistent size in order to fabricate particles on a large scale of a consist size loaded with drug.

21: Differences in Voluntary Control Dynamics of the Ankle

Abraham Rosengard

Mentor(s): Dr. Hyunglae Lee - SEMTE | Dr. Claire Honeycutt – SHBSE | Dr. Thurmon Lockhart - SHBSE

Ever since Title IX in 1972, females have been known to have an increasingly higher rate of musculoskeletal injuries occurring while playing sports than in males. This study focuses on quantifying the voluntary neuromuscular control of the ankle for each gender during a range of set frequencies. If dynamic ankle stability and motor control is shown to be different between males and females, then neuromuscular training can be specialized and focused around the knee to help reduce the risk of injury among female athletes in high school and college.

22: Gene Expression Analysis to Determine Blueprints for Dopaminergic Neuron Development

Morgan Seburn

Mentor(s): Christopher Plaisier – SBHSE | Dr. David Brafman – SBHSE | Dr. Mo Ebrahimkhani – SBHSE

The central nervous system (CNS) is responsible relaying and interpreting the signals to and from the brain to the rest of the body, which includes sensory and motor signals. Parkinson's disease affects the CNS through the destruction of dopaminergic neurons in the midbrain, resulting in tremors throughout the body. Current treatments fail to significantly improve the symptoms or the patient's quality of life. Regenerative medicine techniques to create new dopaminergic neurons to replace dead nerve cells have been explored, however it is still imperfect and unsuitable for use in humans. Treatments such as SHH, Dual SMAD inhibition and WNT signaling have been used in differentiation protocols for dopaminergic neurons, however a more in depth understanding of the drivers of dopaminergic neuron differentiation's relationship with these treatments is required. Gene expression data from 5 different data sets were used to construct a gene regulatory network. We then discovered drivers by creating a heatmap with a dendrogram that displays the correlation coefficients between the surrogate variables, treatment or no treatment, and the gene expression profiles of transcription factors (TFs) driving differentiation. These results were used to determine key drivers, TFs, for dopaminergic stem cell differentiation and the corresponding treatments. The discovered drivers and interpretations of the data can be used in future research to fine tune the differentiation protocol for dopaminergic neurons.

23: Streamlining the Visualization of Motor Training Data

Marissa Seelhammer

Mentor(s):Dr. Sydney Schaefer – SBHSE | Dr. Claire Honeycutt – SBHSE | Dr. Thurmon Lockhart - SBHSE

The process of neurorehabilitation promotes quality of life following neural injury through the repetition of activities of daily living. As such, principles of motor learning like skill acquisition, skill retention, and skill transfer are fundamental to the clinical practice of neurorehabilitation. Currently, the visualization of longitudinal motor training data can be extremely manual. This project aims to develop user-friendly code to visualize motor training data quickly. Over the semester, code was written to meet the needs of members of the lab. Additional features were implemented as lab members indicated components that would be useful. A survey was developed to evaluate the effectiveness and ease to use of the code. This MATLAB code can provide researchers and clinicians with an efficient, useful, and user-friendly method to analyze longitudinal motor training data both visually and computationally.

24: Optical Smart Stent for Restenosis Monitoring

Timothy Snelling

Mentor(s): Dr. Antonio Garcia – SBHSE | Dr. Jit Muthuswamy - SBHSE | Dr. Jeffrey LaBelle - SBHSE

Heart disease is the leading cause of death for men and women in the U.S. causing over 600,000 deaths per year. Of these, over 370,000 cases are attributed to the most common form, coronary heart disease. Roughly 1/3rd of these patients undergo percutaneous coronary intervention (PCI) which involves angioplasty with the placement of a stent. While the placement of a stent is common practice in both the U.S. and globally, with nearly 650,000 and over 2 million patients respectively receiving them per year, there are still several complications which can arise from such a procedure. One complication commonly seen with the placement of these stents is in-stent restenosis (ISR). Patients with these stents have a 10-20% chance of this occurring within the first-year post-PCI, with the newer generation of drug eluting stents leaning closer to 10%. While there is debate as to the most effective methods for ISR treatment, all methods rely upon imaging techniques for the initial diagnosis. Angiography and Intravascular ultrasonography are the gold standards when it comes to these techniques, however both are invasive and are not without risk when being utilized. Acknowledging this, a novel solution is presented for the monitoring of ISR using a 'smart stent' which can be implanted through a PCI procedure. The stent would utilize inductive charging to power a micronized circuit on the stent's surface to power a LED and photo-transducer, oriented such that the diameter of the vessel could be determined by a function of the incident light upon the transducer. An LC tank can be used along the diameter of the stent to signal to an external reader and indicate the diameter stenosis. The efficacy of this device has been shown through simulations and a proof-of-concept generated to indicate the device's functionality. This device could offer a revolutionary method of monitoring patients with stents which otherwise would require invasive techniques.

25: Investigation of Underlying Mechanisms for the Modulation of Multi-Dimensional Human Ankle Stiffness

Lee Stadem

Mentor(s): Dr. Hyunglae Lee - SEMTE | Dr. Claire Honeycutt – SBHSE | Dr. Thurmon Lockhart – SBHSE

This research investigates the modulation of multi-variable human ankle stiffness in both the sagittal and frontal planes during quiet standing. Ankle stiffness regulation is an essential component of lower-extremity function as the ankle acts as the primary means of absorbing and distributing ground reaction forces. As such, the improved characterization of ankle stiffness is important for better understanding the pathology of injuries and neuromuscular diseases, as well as informing the development of more biomimetic orthotics and prosthetics. Previous works have demonstrated that ankle center of pressure and ankle modulating muscle activation both share a highly linear correlation with ankle stiffness. This research aims to improve upon previous models by further characterizing the relationship of these two independent variables with static ankle stiffness in dorsiflexion, plantar flexion, inversion and eversion directions during quiet standing. By use of a single-foot multidimensional impedance-controlled platform, capable of generating rigid rapid ankle perturbations in both the sagittal and frontal planes, our results further quantify the relationship between ankle stiffness and the independent variables: ankle center of pressure and ankle-modulating muscle activation, during quiet standing.

26: Protecting DNA is a Family Affair: Telomere Length and Cognition in Affected Individuals, Unaffected Siblings, and Parents

Francis Taguinod

Mentor(s): Dr. Blair Braden - College of Health Solutions | Dr. Bradley Greger – SBHSE | Dr. Vincent Pizziconi - SBHSE

Although not a diagnostic criterion, individuals with ASD commonly experience cognitive difficulties. One possible mechanism is shortened telomeres. Telomeres are repetitive non-coding DNA nucleotides that protect genes by capping chromosome ends and progressively shorten with age. Shortened telomeres have been associated with age-related cognitive decline. Recently, two reports associated shortened telomere length (TL) with ASD or familial relation. While previous studies found no relationship between TL and ASD core symptoms, the relationship between TL and cognitive function in individuals with ASD and family members is unknown. We aimed to replicate the finding of shortened TL in children with ASD compared to neurotypical (NT) controls, add new findings concerning TL in unaffected siblings and parents, and investigate relationships between TL and cognition. Participants (n=380) included 71 male NT controls (7.1±2.3 years), 116 individuals with ASD (8.7±8.4 years), 70 un-

affected siblings (10.3±7.3 years), and 67 parents (38.7±8.4 years). TL of DNA derived from blood leukocytes was determined using an established quantitative polymerase chain reaction method. Cognitive function was measured via the Stanford-Binet Intelligence Scales–Fifth Edition (SB5) and core symptoms via Autism Diagnostic Observation Schedule-2. Among male NT, ASD, and unaffected siblings, there was a significant ANCOVA [$F(2, 232)=6.12$, $p=0.003$], with NT males having longer TL than males with ASD ($p=0.001$) and unaffected siblings ($p=0.05$), controlling for age. TL was positively related to cognition in parents only [composite IQ: $r(44)=0.322$; $p=0.029$]. This is the first study to demonstrate unaffected siblings' TL is also reduced, but to a lesser degree than their affected siblings. We replicated findings of no relationship between TL and core ASD symptoms. Further, we demonstrate TL is more tightly coupled with cognition in parents, which is concerning for cognitive aging outcomes in affected individuals with reduced TL at young ages. Further research is warranted to determine if TL is both a biological mechanism of behaviors in individuals with ASD and a potential treatment target.

27: The Biomechanical Impact of Soft, Silicone Coatings on Neural Interfaces

Ferrin George Thomas

Mentor(s): Dr. Jit Muthuswamy – SBHSE | Dr. Arati Sridharan – SBHSE | Dr. Vikram Kodibagkar - SBHSE

Implanted microelectrodes in the brain typically fail several months in rodent models. It is widely hypothesized that the mechanical mismatch between microelectrodes and the brain tissue exacerbates the immune response of the brain to the implant. Recent studies show that soft neural implants cause less inflammation and glial scarring at the neural interface. In one study that used mechanically tunable materials that turn from a stiff to a compliant state immediately after coming in contact with brain tissue, micromotion (breathing and heart rate) induced forces and stresses were significantly smaller. In addition, viscoelastic parameters fitted to a Prony series model show a slower brain tissue relaxation time constant at the interface that may lead to less injury under long-term implantation conditions. While previous studies looked at entire materials that softened when in contact with brain, our primary goal is to assess the mechanical stresses of soft, brain-like silicone coatings at the neural interface. Using microindentation method, a stainless-steel probe with a tapered cone was coated with (1) epoxy, or (2) hard polydimethylsiloxane (PDMS) (Elastic modulus~500 kPa) or (3) soft brain-like silicone (elastic modulus~5-10 kPa) and was implanted at a constant rate of 100 um/sec at a depth of 1 mm in a rat brain. After the motion was stopped, the brain relaxation forces were recorded. Forces were converted to stresses using respective surface area obtained from SolidworksTM CAD drawings. These were then analyzed for (a) stress characteristics (i.e maximum stress during indentation and movement) during the dynamic phase and (b) viscoelastic parameters like curve-fitted time constants for relaxation phase in soft and hard coated electrodes. Stresses induced by breathing related micromotion were also analyzed for soft and hard coatings. In addition, force-displacement curves of different geometries of soft and hard polymers were compared for the above-mentioned parameters. These mechanical assessments will help optimize the geometry of implanted microelectrodes in order to mitigate the mechanical mismatch at the microelectrode-tissue interface.

28: Understanding Electromyographic Responses During Distracted Loss-of-Balance Tasks in People with Parkinson's Disease

Marvin Vergara

Mentor(s): Dr. Daniel Peterson - College of Health Solutions | Dr. Sydney Schaefer – SBHSE | Dr. Thurmon Lockhart - SBHSE

Patients with Parkinson's disease (PD), a progressive nervous system disorder affecting movement and cognition, face an increased risk for falls. These patients lack steadiness and rhythm in terms of their gait. Further, postural response to a loss of balance (i.e. reactive postural control) is negatively impacted by PD and likely contribute to their fall risk. These postural control movements can be observed to obtain better understanding of recovery movements or learning patterns.

Prior research has suggested that improvements in these postural responses can lead to reduction of falling. This process involves motor learning that allow patients to apply their knowledge of fall situations to better prevent injury. However, patients with Parkinson's disease have less pronounced learning capabilities. One possible cause for this involves changes in basal ganglia functionality in these patients.

The measurement of muscle activity via electromyography (EMG) may be able to provide greater insight in to how people with PD respond to slips and (over time) undergo motor learning. This signal is a biomedical measurement of electrical currents generated by muscles during contraction/relaxation and represents neuromuscular activities. It is an important indicator for under-

standing physiological responses to a loss of balance. Understanding the latency of muscle onset for Parkinson's' patients after a loss of balance by analyzing the EMG signal can provide better knowledge about their reactive postural control performance and, when measured over time, learning capabilities.

Even further, falls may occur when attention is divided. Characterizing responses in to a "dual tasking" or "single tasking" condition is important for assessing loss-of-balance responses. Therefore, participants were exposed to a perturbation on a treadmill. The subjects in response took a reactive or "compensatory" step to maintain balance, which was recorded via EMG signal. This project involved comparing the latency of muscle onset in "single tasking" and "dual tasking" conditions and even "dual tasking" conditions over time to understand 1) if adding a secondary task impacted the onset of muscle activity and/or 2) if, over time, if participants improved latency (i.e. learned) over the course of repeated slip exposures.

29: Use of Doppler Ultrasound for Spatial Guidance of an Intravascular Catheter

Joseph Niko Vlastos

Mentor(s): Dr. Marek Belohlavek - Department of Cardiovascular Diseases, Mayo Clinic, Arizona | Dr. Jitendran Muthuswamy – SBHSE | Dr. Bruce Towe – SBHSE

Doppler ultrasound imaging can pick up vibrations from a piezoelectric crystal mounted on the tip of a minimally invasive device, such as an intravascular catheter. The customized catheter then produces a clearly visible, instantaneous color marker in Doppler scans.

As the first step in this project, piezoelectric crystals were utilized to find the speed of sound in tap water, i.e., 1.46 mm/µs. Then, a customized intravascular catheter was prototyped and tested in vitrofor spatial tracking of its tip in tap water and a gelatin phantom simulating a bifurcating blood vessel. Attenuation pads were interposed within the path of the ultrasound imaging signal. The attenuation pads mimicked a loss of the ultrasound signal during its propagation through soft tissues of a human body, thus making the experimental scans more clinically relevant. The modified intravascular catheter was also tested in vivo in two anesthetized adult pigs by tracking its tip by color Doppler ultrasound through the femoral and iliac arteries and abdominal aorta. The study demonstrated the possibility of utilizing piezoelectric crystals for customizing the minimally invasive devices for their spatial guidance inside a body by an instantaneous color marker produced by Doppler ultrasound imaging.

30: Using Bioimpedance to Diagnose Coronary Artery Restenosis

Brittney Wong

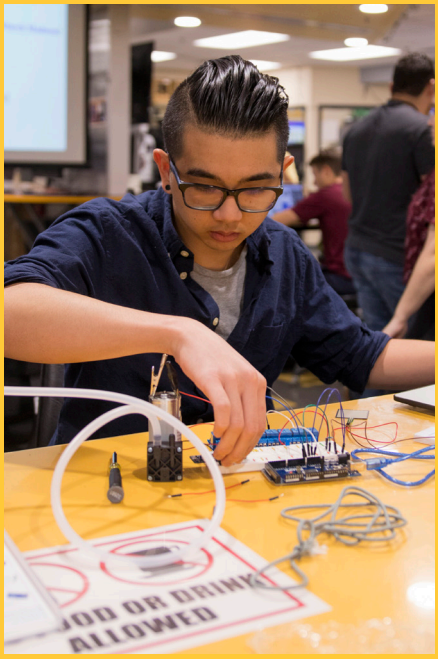
Mentor(s): Dr. Bruce Towe – SBHSE | Dr. Jit Muthuswamy – SBHSE | Dr. Thurmon Lockhart – SBHSE

New approaches towards the utilization of bioimpedance measurements in body tissue have proven the viability of diagnosing physiological functionality. Bioimpedance measurements are typically attained by applying an external current to the tissue, then as physiological changes occur and act as resistance change, the resultant output signal from the electrodes are able to correlate to bioimpedance. In the heart, they have been able to use these findings to diagnose left ventricular failure, arrhythmias, and congestive heart failure. In arteries specifically, this technique can be used to determine the resistance changes due to blood flow. This would allow the opportunity to diagnose restenosis in those with Coronary Artery Disease, as the current methods for detection can be vastly improved upon. This research was conducted to collect bioimpedance measurements in the coronary artery using an implantable piezoelectric microchip to determine the practicality of diagnosing restenosis.


Thank you

On behalf of the SBHSE Design Program, we sincerely thank our BME alumni, industry and clinical partners, and all the mentors for your continued support of our Senior Biomedical Engineering Capstone Design Students and Masters Applied Project Graduates. Please be sure to join us again at our upcoming BME Fall and Spring Symposiums and see what exciting technologies the SBHSE Class of 2020 will be innovating in health care.



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