Modern Human Anatomy Program

UNIVERSITY OF COLORADO
ANSCHUTZ MEDICAL CAMPUS

2020

Capstone Project Presentations

Monday, April 27th

2020 Modern Human Anatomy Program
Capstone Poster Presentations
Agenda

April 27, 2020

9:00 AM	Welcome and overview, Dr. Ernesto Salcedo
9:03 AM – 10:00 AM	Capstone Presentations for Session I (Password: 756088) Moderator: Dr. Ernesto Salcedo
10:15 AM – 11:15 AM	Capstone Presentations for Session II (Password: 984002) Moderator: Dr. John Caldwell
11:30 AM – 12:30 PM	Capstone Presentations for Session III (Password: 770424) Moderator: Dr. John Thompson

Session I Presenters
9:03 AM – 10:00 AM

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Charlotte Wilson	**2**	7	Development of augmented reality and mixed-media trainer for dental anesthetics
Wyatt Colloty	**3**	8	Distribution of Herpes Simplex Virus Type 1 Infection in Wild Type Mice Following Intranasal Inoculation
Lindsey Milgrom	**4**	9	Parvalbumin axons may be more susceptible to demyelination
Tara Brooks	**5**	10	Elucidating the Mechanisms of Developmental Cell Death in the Retina Using Stem Cell-derived Organoids
Lisa Hirt	**6**	11	Quantifying Circuit Activation in Deep Brain Stimulation Surgery For Essential Tremor
Jake Shearer	**7**	12	Keyframed Anatomy: Developing Anatomical Digital Education Resources for Distance Learning

Session II Poster Presenters
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Capstone Poster Presenter	Presenter #	Abstract Page #	Poster Title
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Megan Ryan	**2**	14	Postsurgical complications in patients undergoing baclofen pump implantation
Yuna Park	**3**	15	"My Vagina Did What?": Evaluating a Mobile App of 3D Enterocele Anatomy in Post-Hysterectomy Women
Cody Buongiorno	**4**	16	Interactive 3D Resources to Improve Parent Understanding of Obstructive Sleep Apnea (OSA) in Children with Down Syndrome (DS)
Leanne DeMay	**5**	17	Evaluating Bilateral Asymmetry in the Proximal Femora of Homo sapiens and Pan troglodytes
Christopher O'Neill	**6**	18	
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Capstone Poster Presenter	Poster #	Abstract Page #	Poster Title
Alexander Berthusen	**1**	20	Check That Flow Out: A Hemodynamic Comparison Study of Fick and Phase-Contrast MRI in Children with Tetralogy of Fallot
Tanner Bloks	**2**	21	A 3-D Printable Ultrasound Phantom For Subclavian Central Lines
Yu Jung Choi	**3**	22	"Build an Embryo": Educational Efficacy of 3D Printed Embryo Models in Pieces or En Bloc in Enhancing Spatial & Temporal Anatomy Learning
MariaFrancisca Zabalaga-Haberman	**4**	23	Twisted Development: Assessing the educational value of a 4D interactive embryonic gut tube model
Nazeen Morelli	**5**	24	Cardiovascular Disease Risk Begins Early In Males With Klinefelter Syndrome
Rocio Griggs	**6**	25	Evaluating the Adrenal Glands During Simian Varicella Virus Infection in Rhesus Macaques

Thank you to faculty serving on capstone committees, as these projects would not be possible without your commitment to the success of our students.

MSMHA Student	Capstone Committee Chair	Capstone Mentor	Committee Member	Committee Member
Berthusen, Alexander	Ernesto Salcedo, PhD	Alexander Barker, PhD	Michal Schäfer, PhD	
Bloks, Tanner	Ernesto Salcedo, PhD	Timothy Tran, MD	Cory Buenting Gritton, MS	
Brooks, Tara	Maureen Stabio, PhD	Natalia Vergara, PhD	Thomas Finger, PhD	
Buongiorno, Cody	Chelsea Lohman Bonfiglio, PhD	Stephen Hawkins, MD	Emily DeBoer, MD	
Choi, Yu Jung	Ernesto Salcedo, PhD	Lisa Lee, PhD	Jennifer Stratford, PhD	
Colloty, Wyatt	Thomas Finger, PhD	Maria Nagel, MD	Christy Niemeyer, PhD	James Hassell, PhD
DeMay, Leanne	Ernesto Salcedo, PhD	Caley Orr, PhD	Anna Warrener, PhD	
Finger, Laura	John Thompson, PhD	Rachel Davis, MD	John Caldwell, PhD	
Griggs, Rocío	John Caldwell, PhD	Maria Nagel, MD	Christy Niemeyer, PhD	
Hirt, Lisa	Maureen Stabio, PhD	John Thompson, PhD	Steven Ojemann, MD	
Johnson, Tyler	Caley Orr, PhD	Chelsea Lohman Bonfiglio, PhD	Monika Wittig	Cory Buenting Gritton, MS
Milgrom, Lindsey	Thomas Finger, PhD	Ethan Hughes, PhD	Brian Moore, MD	
Morelli, Nazeen	John Caldwell, PhD	Jill Kaar, PhD	Shanlee Davis, MD	
O'Neill, Christopher	Ernesto Salcedo, PhD	Peter Pressman, MD	John Thompson, PhD	
Olson, Holly	Ernesto Salcedo, PhD	Paul Rochon, MD	Jonathan Lindquist, MD	
Park, Yuna	Lisa Lee, PhD	Tyler Muffly, MD	Janet Corral, PhD	
Ryan, Megan	John Thompson, PhD	Corbett Wilkinson, MD	Kim Sawyer, CPNP	
Shearer, Jake	Maureen Stabio, PhD	Vic Spitzer, PhD	Bradon Lewis	
Wilson, Charlotte	Caley Orr, PhD	Thomas Greany, DDS	Brian Kelly, MS	
Zabalaga-Haberman, MariaFrancisca	Norma Wagoner, PhD	Lisa Lee, PhD	Jennifer Stratford, PhD	Cory Buenting Gritton, MS

Session I: 9:05 AM – 10:00 AM

Presenter #1 Tyler Johnson

Developing and Printing 3D Printed Hearts for Graduate Level Ultrasound Training

Capstone Committee: Caley Orr (chair), Chelsea Lohman Bonfiglio (mentor), Monika Wittig, Cory Buenting Gritton

ABSTRACT:
Many graduate and medical programs have begun to incorporate ultrasound into their curriculum but lack physical models for students to understand the non-standard angles used in ultrasound. Cardiac ultrasound can be especially challenging for students and currently some schools have begun to use plastinated hearts cut in the Parasternal Long Axis (PLAX) and Parasternal Short Axis (PSAX), in addition to two-dimensional pictures, to help students understand what they are scanning on the ultrasound screen. Fused Deposition Modeling 3D Printers combined with industrial 3D scanners provide a unique opportunity to reproduce platinated specimens without the ethical concerns associated with plastinates. Scanning PLAX and PSAX plastinated hearts and printing them on widely available FDM printers present a unique opportunity to allow students a cheap physical model of those views of the heart. After printing these, a proposed pilot study has been constructed to compare the educational outcomes and student perceptions of 3D printed vs. Plastinated Hearts for graduate level ultrasound training. If 3D printed models are determined to be equal or greater for educational outcomes, the use of 3D printed models of all varieties may be implemented into undergraduate and graduate level education. Additionally, future studies may look at using fresh cadaveric specimens to recreate for those organizations without access to plastinated specimens.

Presenter #2 Charlotte Wilson

Development of augmented reality and mixed-media trainer for dental anesthetics

Capstone Committee: Cale Orr (chair), Thomas Greany (mentor), Brian Kelly

ABSTRACT:
Local anesthesia is a critical skill to master while in undergraduate dental education as it typically predicates most dental procedures and treatments. The importance of administering such injections safely require excellent anatomical knowledge. Most dental anesthetics courses in dental school require students to practice such injections on one another, which does not allow for review of the relevant anatomy before practicing on another person. Therefore, the aim of this study was to develop a mixed-material physical model with an accompanying augmented reality app that allows students to better visualize the needle as it passes through the soft tissue as well as better understand the surrounding anatomy as it pertains to the inferior alveolar nerve.

Presenter #3 Wyatt Colloty

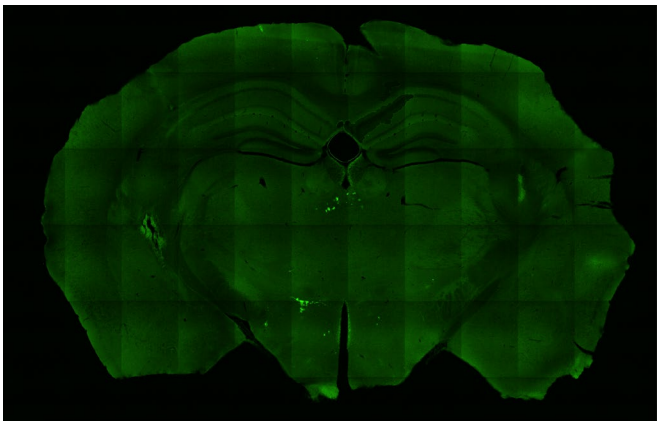
Distribution of Herpes Simplex Virus Type 1 Infection in Wild Type Mice Following Intranasal Inoculation

Capstone Committee: Thomas Finger (chair), Maria Nagel (mentor), Christy Niemeyer, James Hassell

ABSTRACT:
Alzheimer's disease (AD) is a progressive neurodegenerative disease characterized by inflammation, cellular dysfunction, and protein deposition. Sporadic AD accounts for over 90% of all AD cases, which implies that environmental factors might be linked to the disease. Recently, an epidemiological study showed that those infected with Herpes Simplex Virus Type 1 (HSV-1), an extremely common virus that typically causes cold sores around the mouth, were 2.56 times more likely to develop dementia than those who have not been infected with the virus. In this study we set out to characterize the distribution of HSV-1 infection in the brain. Because the hippocampus is the first area effected in AD, we hypothesized that HSV-1 viral antigen (VA) will be present in the hippocampus. Additionally, we hypothesized that hallmark characteristics of AD, such as inflammation and cellular dysfunction, will also be present in HSV-1 infected brains.

We found that 89.76% of infected cells were in the brainstem, 5.10% of infected cells were in the hypothalamus, 2.02% were in the thalamus, 1.16% were in the periaqueductal grey (PAG), 0.48% were in the amygdala, 0.03% were in the olfactory bulb, and 1.44% of infected cells were scattered throughout the rest of the brain. Additionally, we found signs of inflammation based on the presence of activated microglia, and we found cellular dysfunction based on the down-regulation of GFAP in infected areas.

Although VA was not present in the hippocampus, VA was abundant in areas of the brain, such as the hypothalamus, that have direct pathways to the hippocampus. More surprisingly, however, was the systemic activation of microglia, which were even present in areas of the brain with no VA. These activated microglia contribute to neuroinflammation and are known to cause neuronal death. Once infected with HSV-1 a person has the virus for life. Moreover, the virus is known to cause "outbreaks" or recurrent infections over time. We believe that during each outbreak microglial activation occurs which is leading to chronic inflammation and cellular dysfunction associated with AD.



Herpes Simplex Type 1 (HSV-1) viral antigen (VA) immunofluorescent stain taken at 20x. VA is present in the Dorsomedial Hypothalamic Nucleus (DMH), as well as Thalamus.

Presenter #4 Lindsey Milgrom

Parvalbumin axons may be more susceptible to demyelination

Capstone Committee: Thomas Finger (chair), Ethan Hughes (mentor), Brian Moore

ABSTRACT:
Loss of myelin in neurologic disease disrupts critical functions of cortical neurons that, in a healthy brain, are regulated by inhibitory interneurons. Fast-spiking, GABAergic parvalbumin-positive (PV+) interneurons are preferentially myelinated during neurodevelopment, but demyelination of these interneurons at an axon-specific level has not yet been explored. Using a cuprizone model of demyelination, we show that approximately 47% of cortical myelin is lost in early demyelination and that demyelination may be more severe on PV+ axons. Additionally, we show that 41% of cortical sodium channels (Nav) are lost and that sheaths absent of Nav may be more susceptible to demyelination than other sheaths. Using immunohistochemistry of nodal and myelinic proteins along parvalbumin neurons, we examine whether PV+ interneurons exhibit unique rates of demyelination when compared to other cortical neurons. Analyses of axon-specific demyelination such as these will be instrumental in the creation of more accurately targeted therapies for demyelinating injuries.

PV+ interneurons are extensively myelinated in the cortex. Representative example of a reconstructed PV+ interneuron. Soma and axons are shown in purple, and myelin sheaths are shown in grey. Note the interspersed unmyelinated branch points between sheaths. Modeled after Stedehouder, et al. 2017.

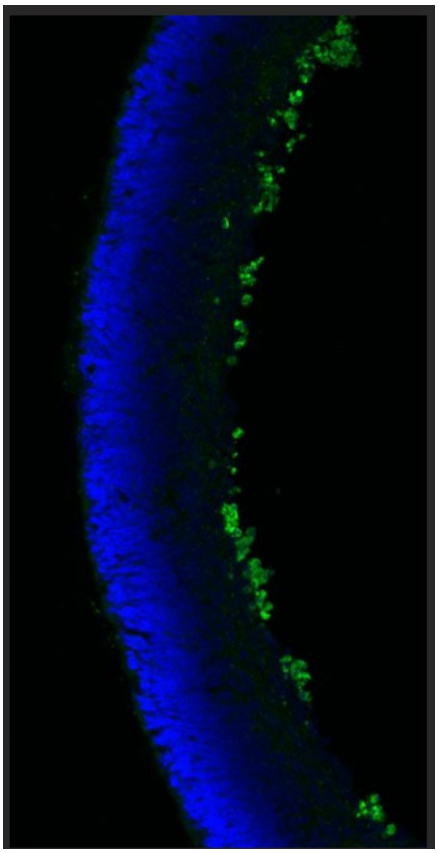
Presenter #5 Tara Brooks

Elucidating the Mechanisms of Developmental Cell Death in the Retina Using Stem Cell-derived Organoids

Capstone Committee: Maureen Stabio (chair), Natalia Vergara (mentor), Thomas Finger

ABSTRACT:
The development of stem cell technologies has opened up new opportunities for research and therapeutic development that, until recently, were unavailable. In particular, the development of human stem cell derived 3D tissues or "organoids" that recapitulate the native histoarchitecture, and to some degree the native functionality, have provided incredible advancements in our understanding of human physiology and disease. In this study we take advantage of retinal organoids as a new model to study the mechanisms of cell death affecting retinal ganglion cells during human development.

Human induced pluripotent stem cells (hiPSC) were directed to follow a neuronal lineage and were then further differentiated into 3D retinal tissue. Retinal organoids were collected at various time points during development and analyzed using immunofluorescent staining for retinal ganglion cells and programmed cell death markers. Our results show that the human retina undergoes an endogenously regulated wave of retinal ganglion cell death during development, and pinpoint the role of caspase 3-dependent programmed cell death as a major mechanism to control this process. This has important consequences for understanding not only basic developmental processes, but also the basis of congenital retinal abnormalities that can lead to diseases of vision. Moreover, this knowledge has potential impact for translational research using retinal organoid models.

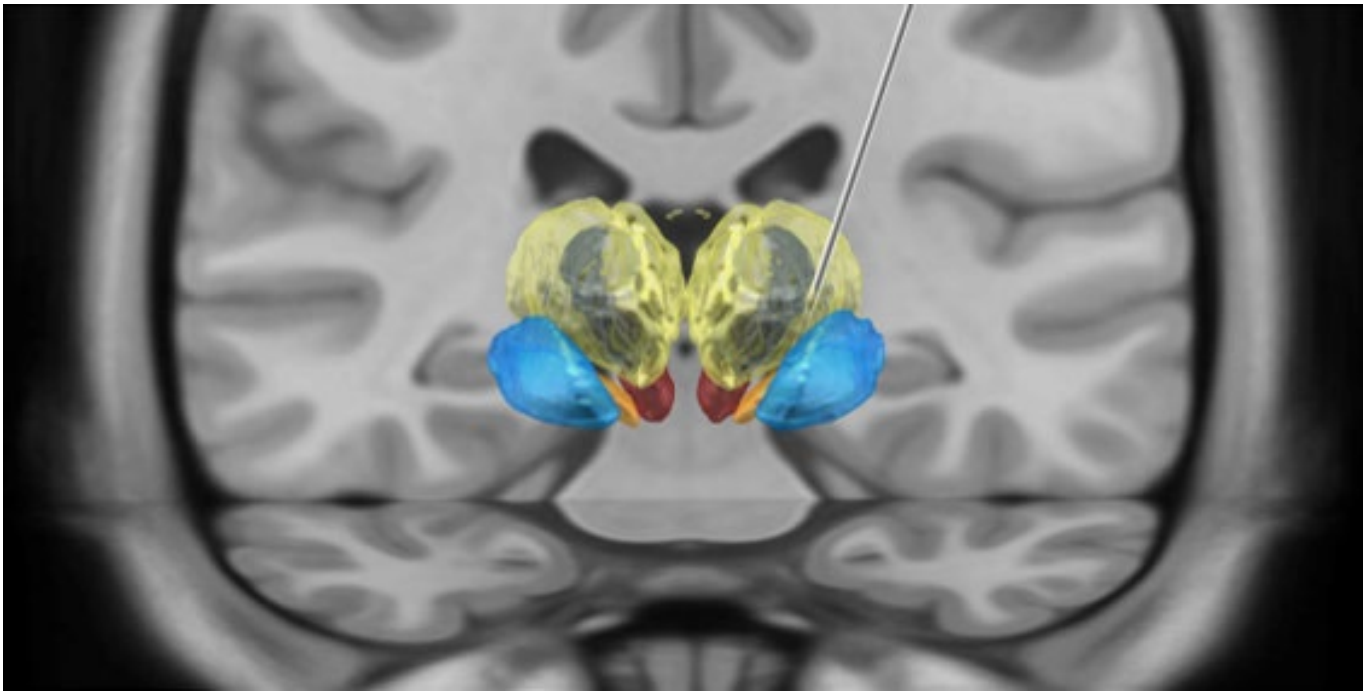


Presenter #6 Lisa Hirt

Quantifying Circuit Activation in Deep Brain Stimulation Surgery For Essential Tremor

Capstone Committee: Maureen Stabio (chair), John Thompson (mentor), Steven Ojemann

ABSTRACT:
Essential tremor (ET) is the most common movement disorder and is more prevalent than Parkinson's Disease and Epilepsy. Even though there is a high proportion of people with ET, recent evidence suggests that refined diagnostic criteria are needed to better classify or treat ET. Deep Brain Stimulation surgery (DBS) is a highly efficacious therapy for several movement disorders, including ET, which modulates pathologic brain activity in deep brain structures. Although DBS has been used to manage motor symptoms in ET, much remains unknown about how DBS activity in ET target affects down and upstream targets. The FDA approved DBS target for ET is within the ventral intermediate nucleus of the thalamus (VIM). Within VIM, DBS stimulation parameters induce an electric field with unique geometric shape modeled as volume of tissue activation (VTA) within each patient. By quantifying VTA, clinicians can estimate the percent of VIM that is activated which could elucidate how the activity is spreading to other brain areas. The aim of the current study is twofold, to explore the localization of the VTA (1) within the area of VIM, and (2) use diffusion tensor imaging (DTI) tractography to trace white matter tracts (WM) traversing through the VTA to examine what cortical areas are being subsequently stimulated. Our findings suggest percent of VIM stimulated differs based on stimulation parameters, and there may be an ideal level of stimulation on WM that achieves symptom relief. Future studies will examine different types of electrodes, and explore different stimulation parameter's effects on WM.



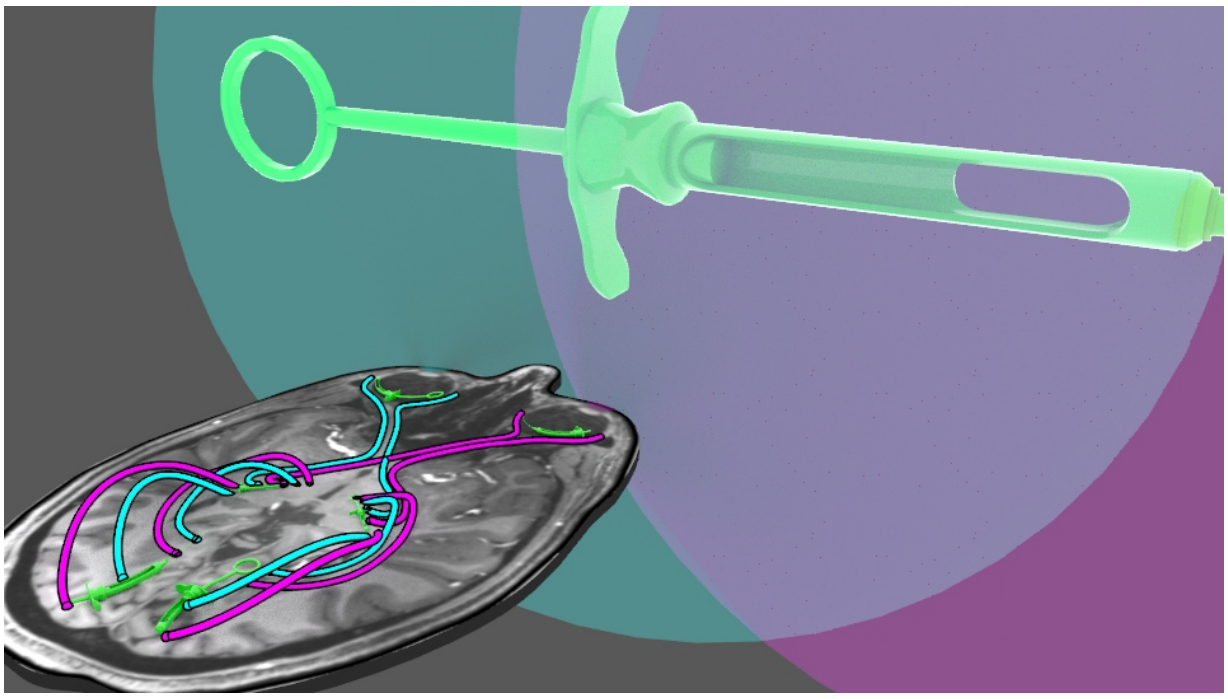
Patient data modeling DBS electrode in relationship to Thalamus for ET.

Presenter #7 Jake Shearer

Keyframed Anatomy: Developing Anatomical Digital Education Resources for Distance Learning

Capstone Committee: Maureen Stabio (chair), Vic Spitzer (mentor), Bradon Lewis

ABSTRACT:
The school closures and rapid transition to remote teaching due to the SARS-CoV-2 novel coronavirus (COVID-19) pandemic have posed many challenges for educators. Educators are learning how to take advantage of and mitigate the disadvantages of a digital education format, and this situation offers rich opportunities to study how to improve distance education protocols. Instruction in the anatomical sciences poses a unique challenge: how to teach a subject that relies on complicated three-dimensional relationships without conventional lab access. This investigational project explores possible solutions drawn from the field of animation. 3D models, animations, and other dynamic resources were developed and implemented in a graduate-level neuroanatomy course. The students were surveyed about their experiences with the digital resources and on distance education broadly. The literature suggests that introverted students are more comfortable in an online classroom setting, so the students were asked to self identify as either introverts or extroverts in a classroom setting. Both groups perceived the resources more positive than neutral (Likert score >3). However, the trends from this project support previous findings. The trends indicate that generally, students who self report as introverts rate these resources 28% higher than extroverts. Additionally, introverts score their comfort level in participating in a digital classroom 68% higher than extroverts do. These indications point to the value of future iterations of this study, to expand the use of digital education resources across larger and diverse student populations both as an enhancement and as a replacement for conventional lecture and laboratory experiences.



Session II: 10:15 AM – 11:15 AM

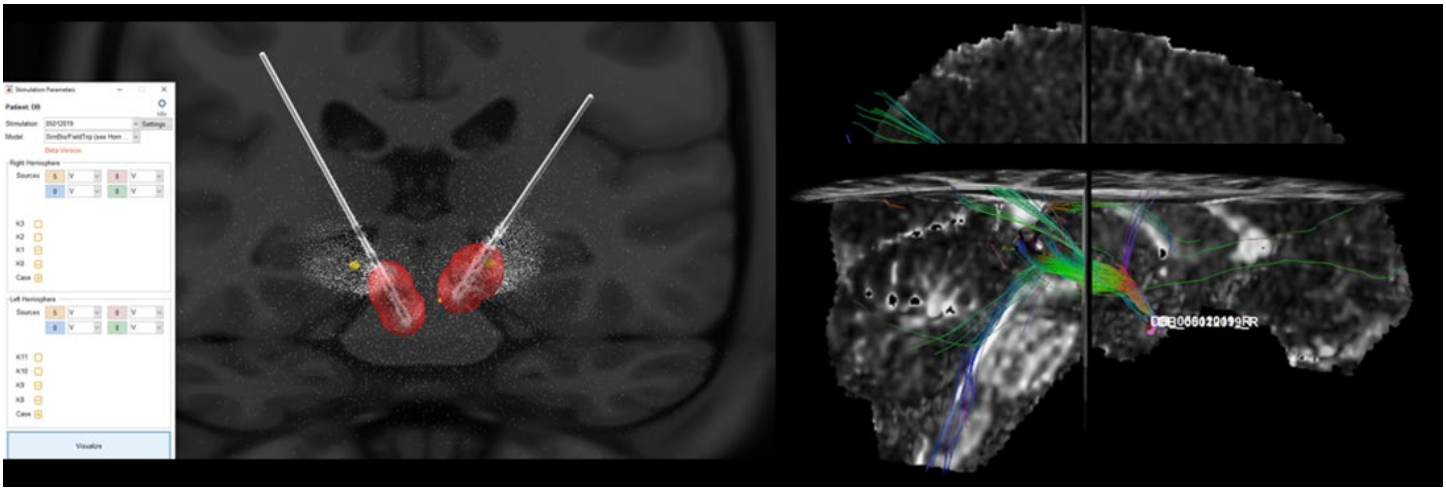
Presenter #1 Laura Finger

Using Diffusion Tensor Imaging to Find Optimal Deep Brain Stimulation Targets for the Treatment of Obsessive-Compulsive Disorder

Capstone Committee: John Thompson (chair), Rachel Davis (mentor), John Caldwell

ABSTRACT:

Obsessive-compulsive disorder (OCD) is a common neuropsychiatric condition that can be severe and treatment-resistant in some patients. Deep brain stimulation (DBS), an invasive neuromodulation therapy has proved efficacious for treatment-resistant OCD (tr-OCD). However, due to the small population of patients with tr-OCD being treated with DBS, there is little consensus on the best target for stimulation. Past research has targeted the anterior limb of the internal capsule (ALIC), ventral capsule/ventral striatum (VC/VS), nucleus accumbens (NAc), the subthalamic nucleus, and the inferior thalamic peduncle. The purpose of this study was to use diffusion tensor imaging (DTI) to refine the optimal target for DBS in patients with tr-OCD, when targeting the ALIC, with the tip of the electrode in the NAc. We performed tractography analysis on fiber tracts traversing the volume of tissue activation (VTA), using each patient's DTI. We then related the change in OCD symptom severity on the Yale-Brown Obsessive-Compulsive scale (Y-BOCS) from pre-surgery, up to last follow-up. Results (n=5) show there was a 44% decrease in OCD symptom severity at one year, and that was correlated with putatively activated tracts within the VTA, or area of stimulation. Comparing the two time points of initial stimulation and stimulation at one year post-DBS surgery, we found that there was change in the diffusion coefficients of 7.03% for FA and 7.31% for MD. Changes in these DTI coefficients between the two-time points suggest that modification in stimulation parameters that led to clinical benefit was associated with activation of putatively distinct fiber populations and thus different neural pathways.

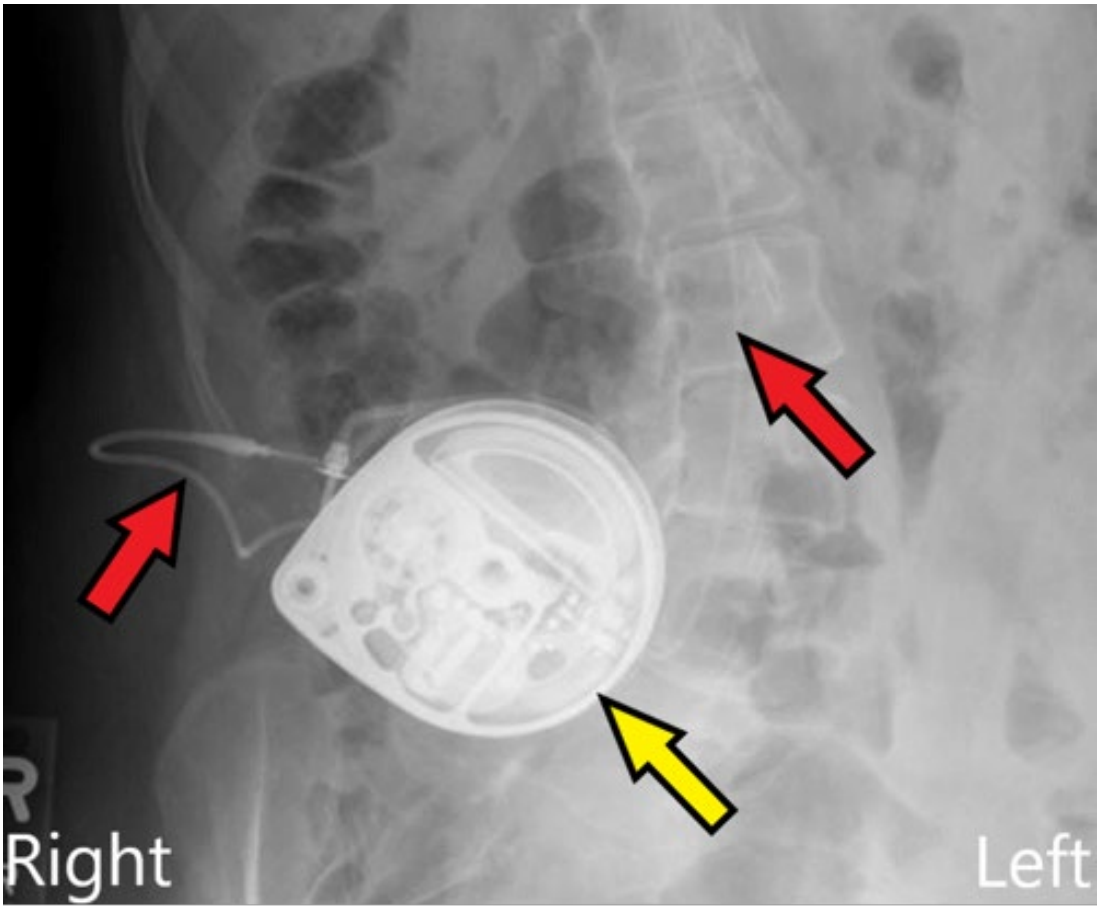


Presenter #2 Megan Ryan

Postsurgical complications in patients undergoing baclofen pump implantation

Capstone Committee: John Thompson (chair), Corbett Wilkinson (mentor), Kim Sawyer

ABSTRACT:
The overall objective of this project was to determine the frequency of complications that occur during intrathecal baclofen (ITB) therapy, both due to the implantation surgery and subsequent revisions, and due to the baclofen drug, itself. Baclofen is a drug that works to relax muscles and is an effective treatment option for muscle spasticity-related disorders, such as cerebral palsy. ITB therapy refers to the method of delivery of baclofen, by using an implanted pump as a reservoir for the drug, that then travels to the intrathecal space of the spinal cord through a catheter. This method of delivery has been shown to be more effective than oral baclofen. By reviewing the medical records of 142 patients receiving ITB therapy, we found that the most frequent complications of ITB therapy and its related surgeries are catheter complications (such as catheter tears and disconnections) and subcutaneous cerebrospinal fluid (CSF) leaks. Catheter complications can further be identified through computed tomography (CT) dye studies, which were reviewed. We also found that the newest catheter model used today to deliver ITB, the Ascenda catheter, was significantly less likely to have catheter complications than older models.



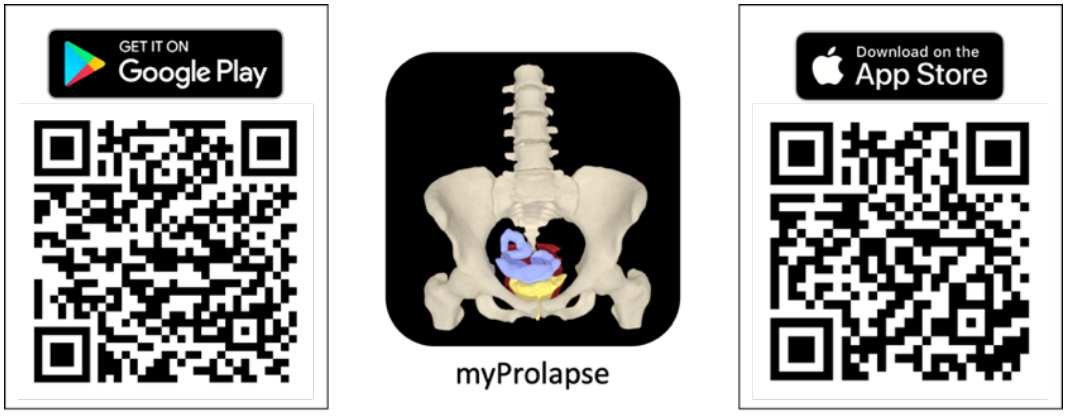
X-ray of a patient's baclofen pump system. The pump is usually placed subfascially within the abdomen (yellow arrow), however, some patients receive subcutaneous implantations. The catheter (red arrows) travels posteriorly towards the spinal column and up through the subarachnoid, or intrathecal, space around the spinal cord.

Presenter #3 Yuna Park

"My Vagina Did What?": Evaluating a Mobile App of 3D Enterocele Anatomy in Post-Hysterectomy Women

Capstone Committee: Lisa Lee (chair), Tyler Muffly (mentor), Janet Corral

ABSTRACT:
Enterocele is one type of pelvic organ prolapse in which a peritoneal sac containing the small intestine herniates into the vaginal wall. Despite the complicated anatomy of enterocele, there are few resources to educate women on the anatomy of a prolapse. Knowledge gaps cause patients stress and shame surrounding their condition, limiting their ability to confide in others and seek medical advice. Thus, supplementing counseling with patient education resources may address patient fears and improve communication between patient and provider. The aims of this project were to: (1) develop an interactive three-dimensional (3D) mobile application (app) to assist health care providers in educating post-hysterectomy women on the anatomy of enterocele and (2) assess the educational value of the app as a visual aid during counseling. In a Colorado Multiple Institutional Review Board exempt study (#19-2347), 3D models were segmented from a de-identified CT urogram and pelvic MRI of a female diagnosed with enterocele post-hysterectomy using 3D Slicer. The models were processed in ZBrushCore 2018 and Autodesk Maya 2019 before being imported into a game engine, Unreal Engine 4, to be packaged into a mobile app. The 'myProlapse' app was iteratively designed to allow manipulation of the models and to highlight relevant structures of pelvic anatomy (Figure 1). The app was revised based on surveys from health care providers on the app's need and usability. To test the efficacy of the app, patients will be randomized into two groups: (1) the Standard Counseling group, defined as routine counseling, and (2) the Mobile App group, defined as counseling supplemented by the app. Patients will complete pre- and post-intervention surveys assessing anxiety and anatomical understanding. 53% of the health care providers (n=15) agreed the mobile app is essential for patient education in the clinic, 67% of the providers would always use the app when explaining enterocele to their patients, and 73% of the providers are very likely to recommend the app to their colleagues. Patient data collection is currently halted and will resume upon effective management of COVID-19. Positive provider feedback suggests the 'myProlapse' app has considerable potential to assist health care providers in educating patients. Traditionally, women's perspectives and issues are underrepresented in medicine. By developing a mobile app to increase public awareness, we intend to normalize the conversation and overcome the social stigma of pelvic organ prolapse.



The 'myProlapse' mobile app is free and available to download for Android and iOS.

Presenter #4 Cody Buongiorno

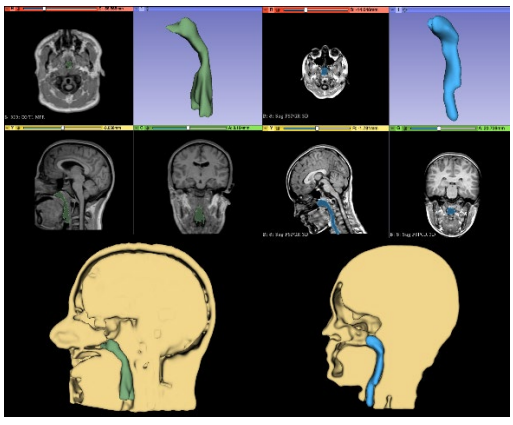
Interactive 3D Resources to Improve Parent Understanding of Obstructive Sleep Apnea (OSA) in Children with Down Syndrome (DS)

Capstone Committee: Chelsea Lohman Bonfiglio (chair), Stephen Hawkins (mentor), Emily DeBoer

ABSTRACT:
Introduction: Sufficient education for parent(s)/caretaker(s) of children with a medical condition is paramount to physicians providing exemplary care. Effectively communicating complex anatomic and clinical terminology is imperative to helping parent(s)/caretaker(s) understand their child's diagnosis along with the cause, outlook, and importance of compliant management to prevent complications.

Objective: The purpose of this study is to improve parent/caretaker comprehension of obstructive sleep apnea (OSA) in their child with Down Syndrome (DS). Our aim is for parent(s)/caretaker(s) to develop stronger knowledge and a better conceptual understanding of the anatomic features that predispose their child to have OSA.

Methods: To elucidate the anatomic characteristics of the head and neck that are causative for OSA in the pediatric DS population (<18 years old), two magnetic resonance imaging (MRI) scans were used to create 3-dimensional (3D) printed models representing: 1) normal pediatric anatomy; and 2) the anatomy of a pediatric DS patient with OSA. An animated video was also designed to highlight the spatial relationship of each airway to the head and neck anatomy and differentiate between both DS and normal cases. While we firmly intend to incorporate these 3D learning resources into the clinic and collect data as outlined below, the trajectory of testing was altered as a result of the COVID-19 pandemic and shelter-in-place orders. Upon implementation into the clinic, these learning resources will be utilized by physicians during educational sessions with parent(s)/caretaker(s) of patients with a new diagnosis of OSA. The effectiveness of these materials in educating parent(s)/caretaker(s) and the perceptions they have towards these resources will be evaluated with a survey of our creation utilizing Likert scale, multiple-choice, and open-ended questions. This survey will be administered to the parent(s)/caretaker(s) on paper before and immediately after the physician-led educational session. We will compare responses of those provided education either with anatomic 3D models and an animated video (intervention) or traditional strategies focused on discussion-based education (control). A dependent t-test will serve as the statistical analysis for Likert scale questions, a qualitative comparison will be conducted for open-ended responses, and thematic analysis will evaluate multiple-choice questions. It's hypothesized that the interactive, tangible, and novel learning resources will contribute to a better understanding of OSA as compared to the control group.

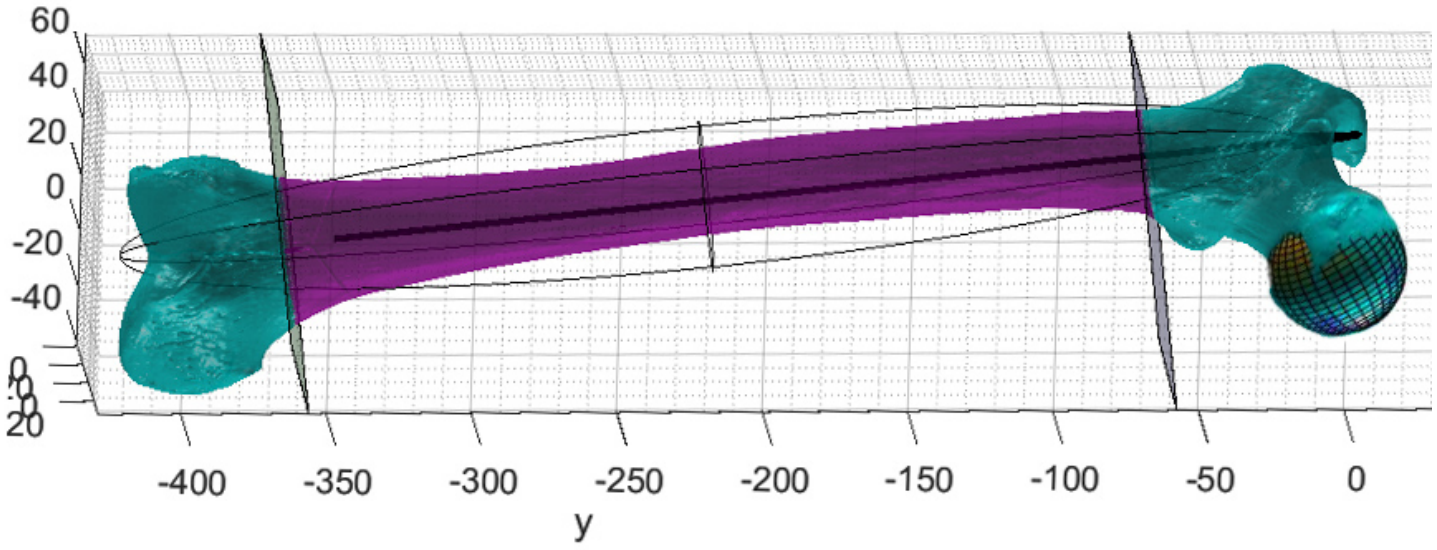


Presenter #5 Leanne DeMay

Evaluating Bilateral Asymmetry in the Proximal Femora of Homo sapiens and Pan troglodytes

Capstone Committee: Ernesto Salcedo (chair), Caley Orr (mentor), Anna Warrener

ABSTRACT:
Human handedness is disproportionately strong in relation to non-human primates (NHP) and is thought to reflect left-hemispheric specialization for functions unique to humans. Human footedness is also fairly strong and broadly parallels handedness. Morphological correlates of footedness are not fully understood, but some researchers have noted right-left asymmetries in human proximal femora. It is currently unknown whether other primates exhibit similar hindlimb asymmetries. Thus, whether femoral asymmetries in humans reflect a unique tendency toward footedness is uncertain. To begin to fill this gap, here we quantified aspects of proximal femoral morphology to evaluate and compare right-left asymmetries in humans verses chimpanzees. We analyzed 3D surface models by measuring neck-shaft angle (NSA), transepicondylar axis anteversion (TEA), horizontal femoral offset (HFO), and femoral head diameter (HD) in the right and left femora of individuals. Humans and chimpanzees appear to both be asymmetric between their left and right femur for different measurements. For absolute difference, humans are more asymmetric for HFO while chimpanzees are more asymmetric for NSA. Raw difference shows that humans and chimpanzees differ from one another for TEA, with humans showing a left preference and chimps showing a slight right preference. Overall, humans and chimpanzees are more similar in femoral asymmetries than assumed. Our results suggest that femoral asymmetries are either not a strong reflection of hindlimb preference or that chimpanzees show stronger lateralization than expected and humans are not unique with regard to "footedness."

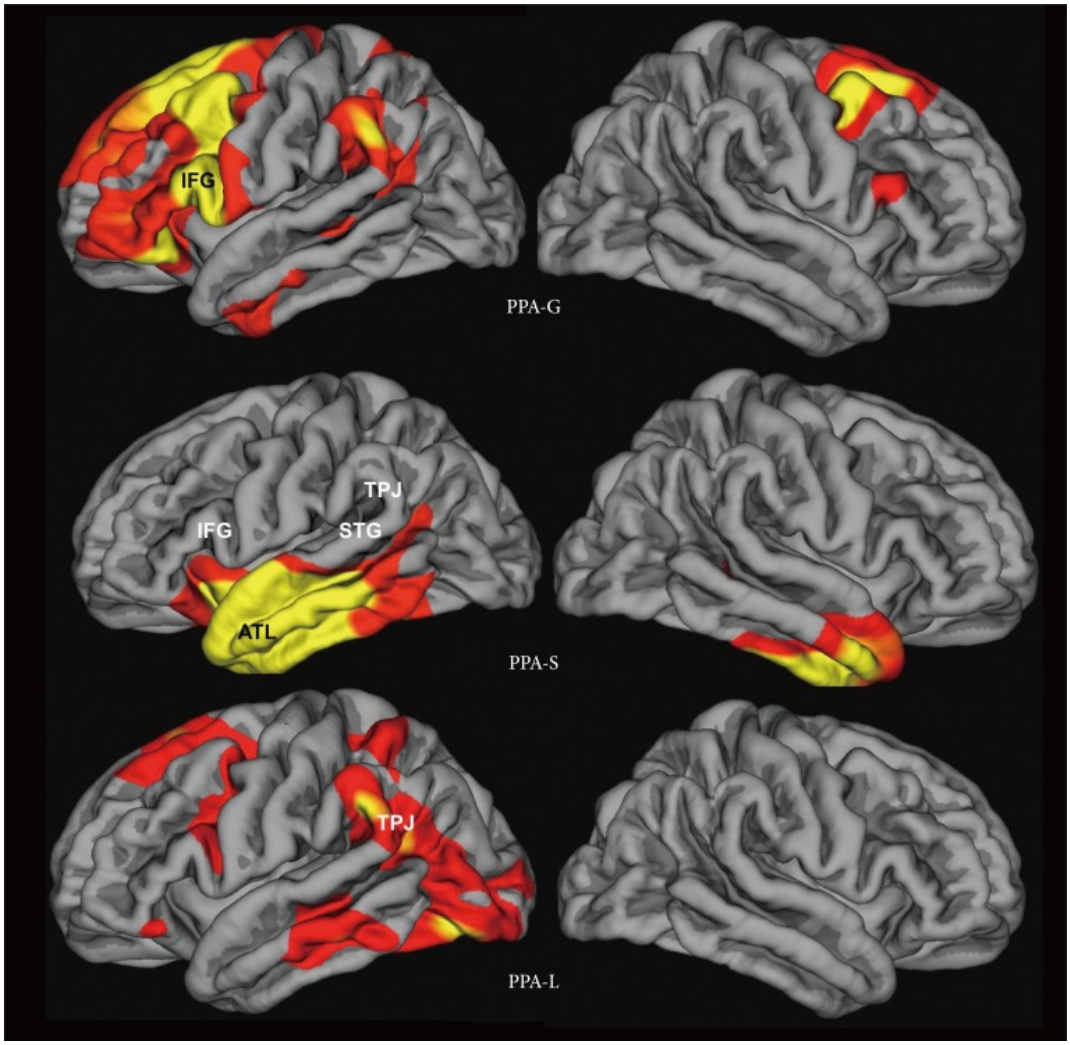


Presenter #6 Christopher O'Neill

Title

Capstone Committee: Ernesto Salcedo (chair), Peter Pressman (mentor), John Thompson

ABSTRACT:
Semantic primary progressive aphasia (svPPA) is one of three variants of primary progressive aphasia (PPA), a neurological disorder that gradually impairs speech. At times, it can be challenging to differentiate between the variants when attempting to make a clinical diagnosis. However, physicians have recently observed that some patients with svPPA exhibit increased pitch variation on a motor speech task. These observations led us to compare pitch variation between the semantic and logopenic (lvPPA) variants. Patients with lvPPA and svPPA performed a motor speech task in which they repeated the syllables "Pa", "Ta", and "Ka". Pitch analysis revealed that patients with svPPA displayed greater variation of fundamental frequency compared to patients with lvPPA. Differences in pitch variation could serve as an additional diagnostic tool to distinguish between the different forms of PPA. Accurate diagnosis is important as medical treatment and speech therapy differ between the subtypes.



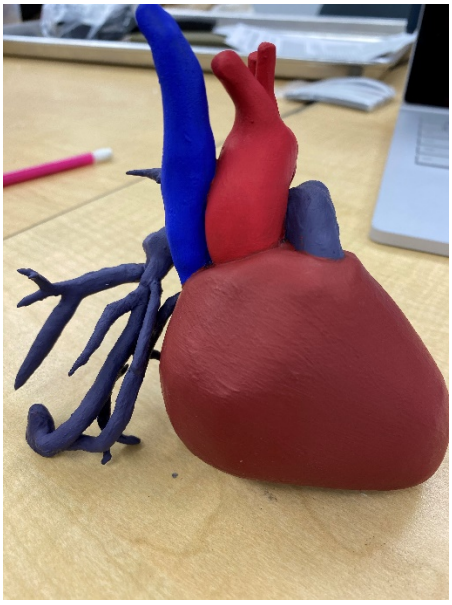
Patterns of atrophy in primary progressive aphasia (PPA) subtypes

Presenter #7 Holly Olson

A 3D Printable Model of Pulmonary Arteriovenous Malformation as a Useful Tool for Improving Patient Education

Capstone Committee: Ernesto Salcedo (chair), Paul Rochon (mentor), Jonathan Lindquist

ABSTRACT:
Pulmonary arteriovenous malformations (PAVMs) are vascular anomalies in which there is a direct connection between pulmonary arteries and veins, bypassing the lung capillary bed (1). The most common cause of PAVMs is congenital, resulting from hereditary hemorrhagic telangiectasia (HHT). HHT is an autosomal dominant disorder that causes mutations in proteins important in the vascular signaling pathway (2). Complications of untreated PAVMs include stroke, hypoxemia, dyspnea, platypnea, infections, and anemia (1,3). Treatment of PAVMs is most commonly done via endovascular embolization (1). When HHT patients develop PAVMs and come to the IR clinic for consultation, they are often anxious about their diagnosis. This anxiety coupled with the complex anatomy of PAVMs can present challenges to the physician as they discuss the anatomy, pathology and treatment of the disease. The current institutional standard for patient education uses the patient's 2D CT scans along with the physician's narrative. Patients may find this method difficult to follow because they are not trained in reading such medical datasets. We hypothesized that having a patient interact with a 3D-printed model of a PAVM would improve their understanding of the disease and of the anatomy involved. We further hypothesized that this increased understanding would decrease their anxiety regarding their diagnosis and treatment. To test this hypothesis, we segmented CT scans from a single patient with multiple, untreated PAVMs to generate a 3D model of the heart and the vasculature in the upper torso. This model included a PAVM chosen for its distinctive feeding artery that exited the pulmonary trunk into a fistula and a distinctive vein exiting the fistula and entering the left atrium. The 3D model was then sculpted, artistically adjusted, and enhanced to provide anatomically accurate representation of the chest anatomy applicable to this disease. Finally, the model was 3D printed. The use of a 3D model has the potential to decrease patient anxiety prior to the treatment of their PAVM and improve their knowledge on the anatomy and pathology. The effects of HHT patient interaction with the model on the patient's anxiety levels and understanding of the disease remains to be investigated.



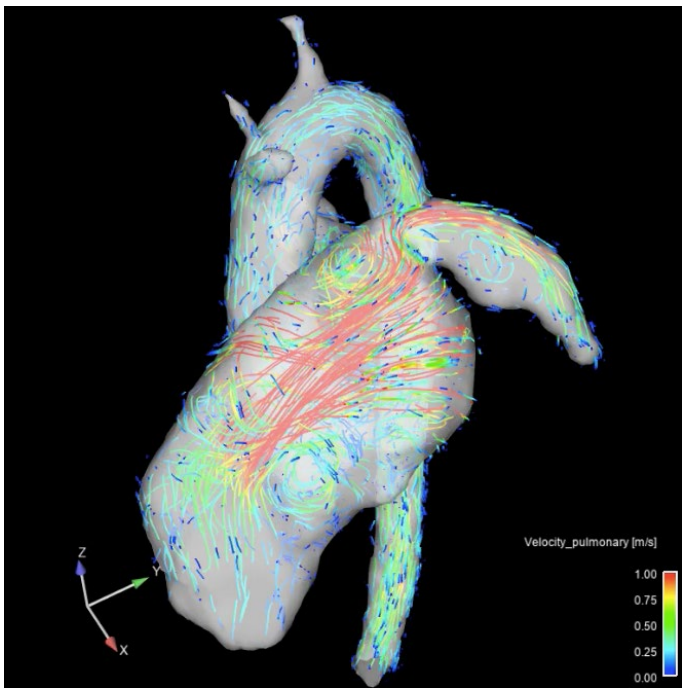
Session III: 11:30 AM – 12:30 PM

Presenter #1 Alexander Berthusen

Check That Flow Out: A Hemodynamic Comparison Study of Fick and Phase-Contrast MRI in Children with Tetralogy of Fallot

Capstone Committee: Ernesto Salcedo (chair), Alexander Barker (mentor), Michal Schäfer

ABSTRACT:
In children with tetralogy of Fallot (TOF), pulmonary flow hemodynamics is a critical metric that can be obtained by two different techniques: the Fick catheterization technique and phase-contrast MRI (PC-MRI). The Fick principle relies on accurate oxygen estimate measurements in the catheterization lab; however, previous evidence suggests Fick may not be reliable due to a number of confounds. By comparison, PC-MRI, has been shown to be more accurate for similar flow measurements. Flow hemodynamic indices were collected in 35 patients at the Colorado Children's Hospital with an average age of 7 years who underwent FICK technique catheterization and MRI Cardiac scans within a 5-month span. Seven of these patients underwent same day catheterization and pc-MRI imaging. Comparison of Qp between FICK and PC-MRI showed poor agreement with an absolute bias of .80 □ .910 L/min/m2. We found that the FICK principle gave an average Qp of 3.17 L/min/m2, while PC-MRI gave a mean Qp of 2.57 L/min/m2, suggesting PC-MRI showed an underestimate of Qp in children with TOF. By collecting the regurgitation fraction (RF) through PC-MRI analysis, we were able to separate patients based on the RF median of 40% and compared the difference in Qp between the two groups. We found a mean difference in Qp in patients experiencing a RF over 40% of 1.18 L/min/m2, while patients under the mean have a Qp difference of 0.341 L/min/m2 (two-sided t-test, p-value = 0.0126). We found that Fick-derived flow hemodynamics directly differs from PC-MRI computed values, and there is a significantly larger difference in patients with an RF above 40%. The short acquisition time and low invasiveness of PC-MRI should serve as the gold standard of collecting pulmonary flow hemodynamic indices in children with TOF.



Presenter #2 Tanner Blocks

A 3-D Printable Ultrasound Phantom For Subclavian Central Lines

Capstone Committee: Ernesto Salcedo (chair), Timothy Tran (mentor), Cory Buenting Gritton

ABSTRACT:
Ultrasound guided subclavian (SC) vein central venous catheter (CVC) placement has been shown to be a safer method than using the more traditional landmark method. However, many trainees have limited experience using ultrasound for SC cannulation. Ultrasound phantoms have been shown to be effective in teaching trainees how to perform ultrasound guided procedures without the need for live patients. Unfortunately, there are currently available phantoms for SC-CVC placement are either perishable or cost-prohibitive. We aimed to create a reproducible, cost-effective SC-CVC placement ultrasound phantom. Here, we segmented the upper thoracic cage and first two cervical vertebrae from a computed tomography (CT) dataset. We then generated a printable skeletal model which we 3D printed and set into ballistics gel. Using latex tubing to accurately simulate vasculature, we developed ultrasound phantoms that simulate relevant anatomy with proper echogenicities for each structure. The model accurately simulates the anatomy relevant to the CVC procedure. This openly available 3-D print resource for ultrasound phantom construction can be an effective middle ground between expensive professional models and perishable models made from animal products or similar materials. This provides a cost-effective solution for both physicians trying to teach residents subclavian CVC placements in the clinical setting in addition to a potential solution to the financial barriers of ultrasound curriculum integration at the medical school and residency level.

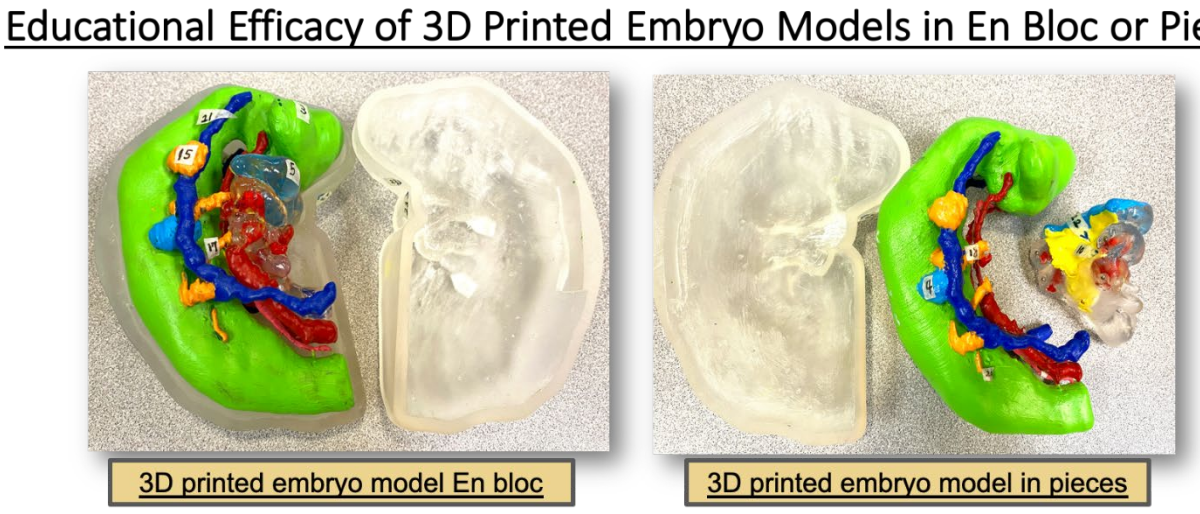
Phantom: Long axis view of subclavian vein

Presenter #3 Yu Jung Choi

"Build an Embryo": Educational Efficacy of 3D Printed Embryo Models in Pieces or En Bloc in Enhancing Spatial & Temporal Anatomy Learning

Capstone Committee: Ernesto Salcedo (chair), Lisa Lee (mentor), Jennifer Stratford

ABSTRACT:
Teaching and learning embryology is challenging, due to the rapidly changing embryonic structures across 3 spatial dimensions and a 4th, temporal dimension seen during embryonic development. Previous studies have shown that anatomically accurate 3D printed embryo models are powerful learning tools to address this challenge. However, feedback from previous student surveys indicated a desire to disassemble the 3D printed models, like Legos. The goal of the current study was to assess and compare the educational value of a new set of 3D printed embryo models that focused on head and neck development. One version of the head and neck embryonic model was printed in aggregate as a single piece (en bloc), while the other version was printed in multiple pieces to allow students to assemble and disassemble the embryonic parts. To test this model, 184 first-year medical students enrolled in an integrated gross anatomy course were recruited to complete a randomized, single-blind study. During an active learning session, control group (n=72) interacted with the single-piece 3D printed model, and the experimental group (n=76) interacted with the multi-piece 3D printed model. All participants completed a pre-quiz and a post-quiz before and after the resource exposure. The educational impact of the resources was analyzed by comparison of quiz scores, and the perceived value of the assigned resources was assessed by survey analytics. Both groups showed the positive educational effect of the 3D printed embryo models on student performance. However, the average improvement between pre- and post-quizzes was higher in the control group as compared to the experimental group. These results suggest that the multi-piece 3D printed model do not have an advantage over single-piece 3D printed models for learning the head and neck development focused subject matter. In the survey, after exploring two learning resources, 94% of the participants showed preference for interacting with the multi-piece 3D printed model even though it had little impact on learning outcomes. This study reveals the educational value of 3D printed embryo model in integrated gross anatomy and has implications in the development of educational resource for medical curricular content for subjects that are foundational but have limited contact hours.



Presenter #4 MariaFrancisca Zabalaga-Haberman

Twisted Development: Assessing the educational value of a 4D interactive embryonic gut tube model

Capstone Committee: Norma Wagoner (chair), Lisa Lee (mentor), Jennifer Stratford, Cory Buenting Gritton

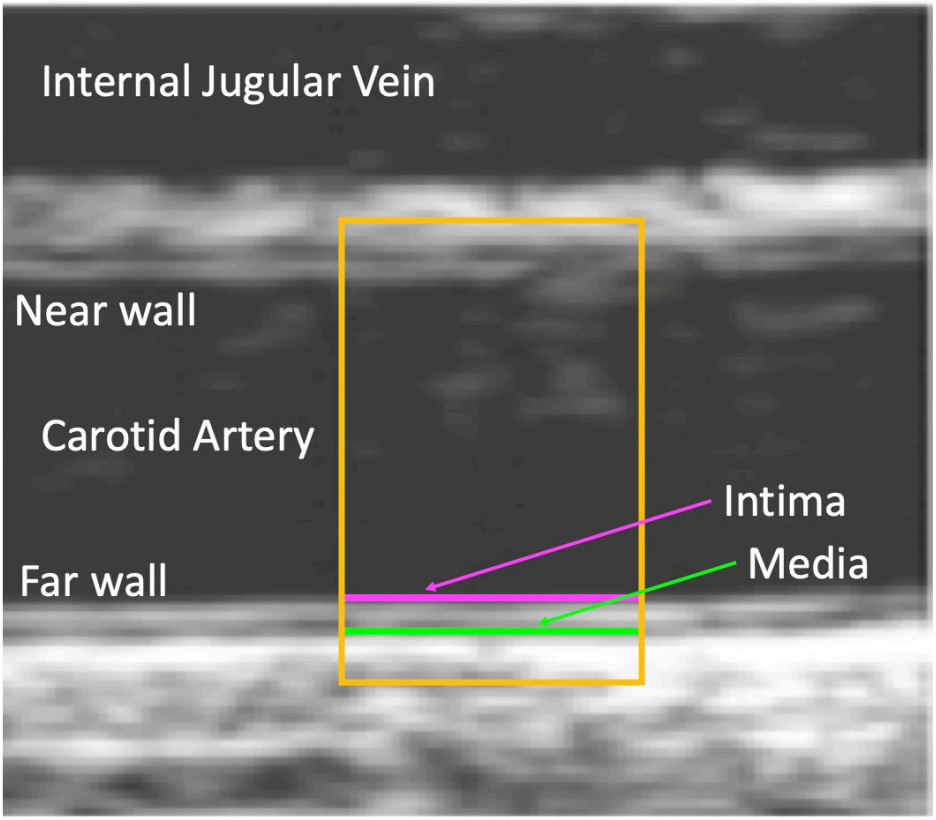
ABSTRACT:
Embryology is fundamental to anatomical understanding in medical education; however, the reduced curricular hours for embryology, and the limited visual and physical aids to demonstrate the complex changes that occur not only in 3 spatial dimensions, but also in the 4th dimension in time, increase the challenges students face to learn embryology. In the current study, interactive hands-on embryonic models which demonstrate gastrointestinal development in 4D were developed. The aim of the study was to assess the educational value and student perception of these embryonic models for the learning of embryology. In a COMIRB-except study, 156 first-year medical students in an integrated gross anatomy course were randomly assigned to experimental and control groups during an active review session; the experimental group utilized the interactive 4D embryonic models, while students in the control group utilized a series of 2D embryology textbook images depicting the same developmental process. Educational value was assessed by pre-post quiz performance comparison before and after interaction with the assigned model. Results showed improvement on post-quiz performance for both groups, suggesting that learning occurred regardless of resource type. Survey analytics showed no difference in perceived value between both resources; however, resource preference results showed a higher preference for the 4D model. Outcomes of this study suggest that an interactive embryonic model depicting complex 4D transformation may not be as effective in education as expected. For future studies, assessment of groupwork and active learning versus a more passive individualized learning with the models should be taken into consideration.

Presenter #5 Nazeen Morelli

Cardiovascular Disease Risk Begins Early In Males With Klinefelter Syndrome

Capstone Committee: John Caldwell (chair), Jill Kaar (mentor), Shanlee Davis

ABSTRACT:
Klinefelter Syndrome (XXY) has an incidence of 1/600 births. Men with XXY have higher morbidity and mortality from cardiovascular disease (CVD). Increased carotid intima-media thickness (cIMT) is associated with CVD risk and is higher in men with XXY. cIMT has not been assessed in adolescents with XXY. This cross-sectional pilot study aimed to compare cIMT in adolescents with karyotype 47,XXY with typical males. cIMT was measured using standard ultrasound protocol in the supine position. Two sample t-tests were used to compare cIMT between controls and boys with XXY treated with testosterone to those untreated. Because our sample size for controls was limited, we also compared to published adolescent male norms using a one-sample t-test. Linear correlations assessed the relationship between cIMT and clinical biomarkers of metabolic function, including seated systolic and diastolic blood pressure (SBP, DBP), pulse pressure (PP), BMI percentile (BMIp), waist circumference (WC), fasting blood glucose (FBG) and lipid profile (total cholesterol, LDL, HDL, and triglycerides). cIMT in 25 males with XXY (age 14.5±1.5yrs, BMIp 55.3±32.6) was 0.55±0.07mm, significantly greater than expected compared to controls (0.47mm, $p=0.013$) and literature norms (0.45mm, $p<0.0001$). cIMT did not differ between testosterone treated and untreated males with XXY. FBG and PP were positively correlated with cIMT but other biomarkers did not have any relationship. In conclusion, normal-weight adolescents with XXY had higher than expected cIMT, suggesting their risk for CVD begins early despite absence of obesity, hypertension, or diabetes. cIMT did not consistently correlate with markers of cardiometabolic health.



Presenter #6 Rocío Griggs

Evaluating the Adrenal Glands During Simian Varicella Virus Infection in Rhesus Macaques

Capstone Committee: John Caldwell (chair), Maria Nagel (mentor), Cristy Niemeyer

ABSTRACT:
The adrenal glands work in conjunction with the hypothalamus and pituitary gland to regulate responses to physical and psychological stressors via the hypothalamic-pituitary-adrenal (HPA) axis. There is evidence that physical stressors such as viral hemorrhage and necrosis insult the adrenal glands during infection with Herpes simplex virus (HSV) which disrupts the HPA axis and glucocorticoid secretion which can be detrimental to survival and disease mediation. We hypothesize that the common infectious varicella zoster virus will infect the adrenal glands in a similar way to HSV-1 due to their shared herpesvirus family, transaxonally and predominantly the adrenal medulla due to the common embryonic origin of the adrenal medulla and sensory ganglia. Using a monkey animal model, we found evidence of simian varicella zoster virus in the adrenal gland of a rhesus macaque, primarily located in the adrenal cortex with some infection near the corticomedullary junction. It remains to be determined whether transaxonal transport occurred in the immunocompromised individual, as bloodstream is an alternate means of transport. Our findings show that SVV can infect and damage the adrenal cortex which secretes cortisol. This research suggests further study should consider the role of varicella virus adrenal cortex infection and damage, as a source potentiator, when considering etiology for certain conditions and diseases that may be related to adrenal function and the HPA system.