VIRTUAL MEETING

MARCH 2, 2022

SURGEONS AND ENGINEERS: A Dialogue on Surgical Simulation

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PROGRAM BOOK

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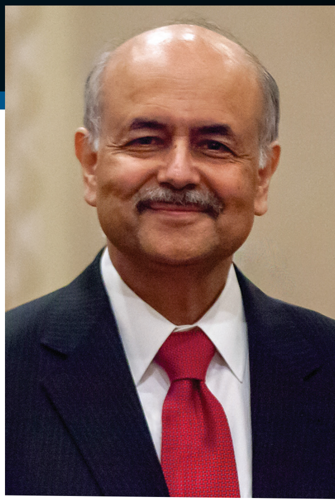
Welcome



On behalf of the American College of Surgeons (ACS) Division of Education, I would like to welcome you to the 2022 Annual Meeting, "Surgeons and Engineers: A Dialogue on Surgical Simulation." Given the success of past meetings since they were established three years ago, we are planning a full-day event this year. This will permit us to fully explore synergies between engineers, surgeons, scientists, health care professionals, and educators to advance simulation-based surgical education and the use of state-of-the-art simulations and simulators.

In view of the COVID-19 pandemic, the 2022 meeting is being offered virtually.

Thomas M. Krummel, MD, FACS, FAAP, Emile Holman Professor and Chair Emeritus, Department of Surgery, Stanford University School of Medicine, Former Co-Director, Stanford Byers Center for Biodesign, will deliver the Keynote Address. Dr. Krummel is a preeminent surgeon innovator who is nationally and internationally renowned for his leadership and many seminal contributions. A Special Panel will follow and focus on various elements of successful collaboration between surgeons and engineers. The Panelists include Ahmed Ghazi, MD, FEBU, MHPE, Associate Professor of Urology, University of Rochester; Suvranu De, PhD, J Erik Jonsson '22 Distinguished Professor of Engineering and Head of the Department of Mechanical, Aerospace and Nuclear Engineering (MANE) and Founding Director of the Center for Modeling, Simulation and Imaging in Medicine (CeMSIM) at Rensselaer Polytechnic Institute; and Amin Madani, MD, endocrine acute care surgeon, Director of the Surgical Artificial Intelligence Laboratory at the University Health Network and University of Toronto.

From the high-quality Abstracts received, the ACS Division of Education's Surgeons and Engineers Committee has selected nine Abstracts for Podium Presentations and 27 Abstracts for Scientific Poster Presentations. Following these Presentations, two parallel Interactive Discussion Sessions will be convened on Surgical Ergonomics; and Industry Discussion—Future of Surgical Simulation.

On behalf of the ACS Division of Education and the Division's Engineering Committee, thank you for attending this unique event. We look forward to continuing the productive dialogue we have initiated between surgeons and engineers aimed at fostering meaningful collaboration.

Ajit K. Sachdeva, MD, FACS, FRCSC, FSACME, MAMSE
Director, ACS Division of Education
Chair, ACS Program for Accreditation of Education Institutes

Program Objective

On behalf of the Program Committee and the Division of Education of the American College of Surgeons (ACS), welcome to the *Annual 2022 Surgeons and Engineers: A Dialogue on Surgical Simulation* meeting. The previous meetings received an overwhelming number of positive responses, so we are excited to offer a full day of activity!

The agenda for this meeting is specifically designed to convey the exciting ideas and cutting-edge innovations of a unique collaborative community of surgeons, academic and industry engineers, scientists, and surgical education leaders. By attending this meeting, it is our hope that you will gain a better understanding of the multifaceted needs, challenges, potential benefits that arise from this multidisciplinary partnership and enthusiastically contribute to promote the highest quality of surgical care through advanced knowledge and innovative education.

Through this collaboration, the Program Committee and the Division of Education have three essential goals: to bridge surgical and engineering communities, advance and support expertise and excellence in surgery, and enrich surgical simulation-based training with the most current dialogue on state-of-the-art technological and engineering advancements.

On behalf of the Program Committee, thank you for attending!

Gyusung Lee, PhD
Program Co-Chair
Assistant Director, Simulation-Based Surgical and Education Training, Division of Education, American College of Surgeons

Mandayam A. Srinivasan, PhD
Program Co-Chair
Founder, Laboratory for Human and Machine Haptics, Massachusetts Institute of Technology; Professor of Haptics, Computer Science Department, University College London, UK

With these goals in mind, the program committee has planned a premiere program to foster dialogue, enhance knowledge, build relationships, and spark ingenuity:

- Keynote Address—Our keynote speaker, Thomas Krummel, MD, has been a renowned surgeon, innovator, educator, and leader for over 35 years. He co-directed the Stanford Byers Center for Biodesign, which has taught medical technology innovations to teams of doctors, engineers, and business professionals, for nearly two decades.
- Special Panel Discussion—*Successful Collaboration between Surgeons and Engineers:* A special panel of surgeons and engineers, specifically chosen for their highly regarded expertise and experiences in surgeon-engineer partnerships, will share their knowledge and experience on this important topic.
- Oral and Poster Presentations: Our oral and poster presentations will shed light on the multifaceted collaborations between surgeons and engineers working together in research.
- Interactive Discussion Sessions: The interactive discussion sessions, which will be open to all meeting participants, are intended to address the current status of ergonomics in surgery and the industry perspective of the future of simulation education.

We are confident that you will find this meeting to be thought-provoking and rewarding, and we very much look forward to welcoming you at the meeting. Please provide us with your feedback to help ensure the success of this and future meetings.

Virtual Meeting Activities

All times listed are Central Time. All sessions will be held virtually. The schedule is subject to change.

9:00–9:15 am	**Welcoming Remarks** Ajit K. Sachdeva, MD, FACS, FRCSC, FSACME, MAMSE, *American College of Surgeons* Gyusung Lee, PhD, *American College of Surgeons* Mandayam Srinivasan, PhD, *MIT and University College London, UK*
9:15–10:15 am	**Keynote Address** ***Twenty-Year Experience Teaching Medtech Innovation to Physician/Engineer Teams: Stanford Biodesign and Fogarty Innovation*** Thomas Krummel, MD, FACS/FAAP, *Stanford University*
10:15–11:15 am	**Special Panel: *Surgeons and Engineers Successful Collaboration*** Ahmed Ghazi, MD, FEBU, MHPE*, University of Rochester Medical Center* Suvranu De, ScD, *Rensselaer Polytechnic Institute* Amin Madani, MD, PhD, FRCSC, *University Health Network, University of Toronto*
11:15–11:30 am	**Morning Break**
11:30 am–12:30 pm	**Abstract Presentation 1**
12:30–1:30 pm	**Lunch**
1:30–2:20 pm	**Abstract Presentation 2**
2:20–2:30 pm	**Move to the Interactive Discussion Sessions**
2:30–3:30 pm	**Parallel Interactive Discussion Sessions** • Surgical Ergonomics • Industry Discussion: Future of Surgical Simulation
3:30–4:00 pm	**Afternoon Break and Poster Visit**
4:00–4:30 pm	**Interactive Discussion Session Report and Q/A**
4:30–4:45 pm	**Closing** Ajit K. Sachdeva, MD, FACS, FRCSC, FSACME, MAMSE, *American College of Surgeons* Gyusung Lee, PhD, *American College of Surgeons* Mandayam Srinivasan, PhD, *MIT and University College London, UK*

**Please note: The virtual 2022 ACS Surgical Simulation Summit will take place on March 3–4.*

Gyusung I. Lee, PhD

Assistant Director, Simulation-Based Surgical Education and Training, American College of Surgeons Division of Education

Gyusung Lee, PhD, is the Assistant Director of Simulation-Based Surgical Education and Training in the American College of Surgeons Division of Education. Dr. Lee obtained his training in academic laboratories as well as in clinical environments, performed sponsored research studies both independently and within teams, and championed the development and execution of various surgical education programs.

He completed his graduate studies in biomechanics and obtained MS and PhD degrees in the department of biomedical engineering at Texas A&M University in 1996 and 2002. Dr. Lee's dissertation research was an investigation of the mechanism of secondary injuries. After graduation, his post-doctoral training in the motor control laboratory at Arizona State University involved researching how joint coordination and control strategies are affected by the aging process and by Parkinson's disease. After two years of post-doctoral training, Dr. Lee joined the department of surgery at the University of Maryland School of Medicine (UMSOM) as a faculty research associate. His primary research interest at the UMSOM was to investigate the physical and cognitive ergonomics associated with various minimally invasive surgeries (MIS), including traditional laparoscopy, Natural Orifice Transluminal Endoscopic Surgery (NOTES), and robotic surgery.

Dr. Lee served as the director of Robotic Education and Ergonomics Research at the Minimally Invasive Surgical Training & Innovation Center (MISTIC) in the department of surgery at Johns Hopkins School of Medicine (JHSOM). One of his primary responsibilities in MISTIC was to develop the comprehensive robotic surgery training curriculum. This program provided surgical trainees with basic robotic skill training in preparation for the Fundamentals of Robotic Surgery (FRS), and advanced skill training for the immediate application of the learned skills in the trainees' actual case involvement. Using this curriculum, Dr. Lee offered robotic training to Hopkins residents, fellows, and attending surgeons from the specialties of general surgery, gynecology, surgical oncology, urology, and cardiac surgery. In addition, he also created a didactic and hands-on training program for operating room (OR) staff members assisting on robotic surgery cases. Through this program, Hopkins OR staff members receive skills training on a regular basis for establishing better teamwork between surgeons and OR staff members.

As the Assistant Director of Simulation-Based Surgical Education and Training, Dr. Lee provides leadership for a broad range of innovative simulation-based education and training programs of the Division of Education. He is responsible for designing simulation-based programs, providing leadership for the simulation research and development activities, especially those of the Consortium of ACS-Accredited Education Institutes, and building and strengthening collaborative relationships with national organizations and the federal government, including the Department of Defense.

Mandayam A. Srinivasan, PhD

Founder, Laboratory for Human and Machine Haptics, Massachusetts Institute of Technology; Professor of Haptics, Computer Science Department, University College, London, UK

Prof. Mandayam A. Srinivasan is the founder of the Laboratory for Human and Machine Haptics at the Massachusetts Institute of Technology and holds the professorial chair of haptics at the department of computer science, University College London, UK. He is also Vajra faculty at the Indian Institute of Technology Madras, India. He received a bachelor's degree in civil engineering from Bangalore University, a master's degree in aeronautical engineering from the Indian Institute of Science, and a PhD in mechanical engineering from Yale University. Following post-doctoral research at the department of anesthesiology, Yale University School of Medicine, he moved to MIT and founded the Laboratory for Human and Machine Haptics, known worldwide as the MIT Touch Lab.

Prof. Srinivasan's research over the past three decades on the science and technology underlying information acquisition and object manipulation through touch has played a pivotal role in establishing the multidisciplinary field of modern haptics. He has been recognized worldwide as an authority on computation, cognition, and communication through touch interactions in humans and modern machines such as computers and robots. His pioneering scientific investigations of human haptics involving biomechanics, neuroscience, and psychophysics has led to significant advances in our understanding of how nerve endings in the skin enable the brain to perceive the shape, texture, and softness of objects through the sense of touch. His work on machine and computer haptics involving design and development of novel robotic devices, mathematical algorithms, and real-time control software has enabled touching, feeling, and manipulating objects that exist only virtually as programs in the computer. He has also demonstrated novel haptic applications such as virtual reality-based simulators for medical training, real-time touch interactions between people across continents, and direct control of robots from brain neural signals. More recently, he has been working on developing haptic aids for blind people, smartphone-based health care for underserved populations, novel robotic fingertips, and teleoperation systems for micro/nano manipulation capable of performing surgery on a single cell with micron precision.

The international impact of Prof. Srinivasan's work has been multifaceted. He has led American and European multidisciplinary teams in a number of cutting-edge technology research projects. He has authored more than 230 publications in multiple fields ranging from neuroscience to robotics that include some of the most highly cited papers on haptics. He has given more than 130 invited talks all over the world, with many keynote or plenary talks in premier international conferences. A measure of wider societal impact is that Prof. Srinivasan has been featured or quoted in print media such as the Scientific American, Time, The Wall Street Journal, The New York Times, Times of India, Pravda, and Smithsonian, as well as by worldwide radio and TV networks such as BBC and CNN in programs focused on cutting-edge research in information technology and its future prospects. Several of the technologies that were developed in his lab have been displayed as hands-on interactive exhibits in many museums such as the Boston Museum of Science, MIT Museum, and V&A Museum in London.

Keynote Speaker

Thomas M. Krummel, MD
Emile Holman Professor and Chair Emeritus, Department of Surgery, Stanford University School of Medicine
Former Co-Director, Stanford Byers Center for Biodesign

For more than 35 years, Tom has served in roles as surgeon, innovator, educator, and leader. He orchestrated the resurgence of Stanford Surgery as Chair from 1998-2014. Simultaneously, he co-directed the Stanford Byers Center for Biodesign for nearly 20 years. The Biodesign program is designed to teach medtech innovation to teams of doctors, engineers and business professionals through interdisciplinary research and education at the emerging frontiers of engineering and the biomedical sciences. More than 4.3 million patients have been treated with tools and technologies originating in this program. There are now 18 similar programs on 3 continents and 259 graduates. Dr. Krummel is chair of the board of directors at Fogarty Innovation; a not-for-profit medtech educational incubator, a venture partner at Santé Ventures, serves on the board for Morgridge Institute for Research at the University of Wisconsin, and the past president of the International Scientific Committee at IRCAD, University of Strasbourg, France. Tom also serves as a consultant to the medical device industry, contributing as founder, advisor or member on boards of directors and scientific advisory boards of more than 20 successful early stage medtech device start-ups.

Panelists

Suvranu De, ScD
J. Erik Jonsson '22 Distinguished Professor of Engineering
Head, Department of Mechanical, Aerospace and Nuclear Engineering
Director, Center for Modeling, Simulation and Imaging in Medicine (CeMSIM)
Rensselaer Polytechnic Institute

Dr. Suvranu De is the J Erik Jonsson '22 Distinguished Professor of Engineering at Rensselaer Polytechnic Institute, where he serves as Head of the Department of Mechanical, Aerospace and Nuclear Engineering (MANE) and founding director of the Center for Modeling, Simulation and Imaging in Medicine (CeMSIM). Dr. De's research is at the intersection of virtual reality, noninvasive neuroimaging, and artificial intelligence. He is a member of numerous editorial boards and national technical committees and is an elected Fellow of four professional societies: the American Society of Mechanical Engineers, the American Institute for Medical and Biological Engineering, the International Association for Computational Mechanics, and the United States Association for Computational Mechanics.

He is a recipient of multiple awards including the ONR Young Investigator Award (2005), Rensselaer School of Engineering Research Excellence Award (2008), the James M. Tien '66 Early Career Award for Faculty (2009), the Rensselaer School of Engineering Outstanding Research Team Award (2021 & 2012), the J. Tinsley Oden Medal of the U.S. Association for Computational Mechanics (2019) and the ASME Edwin F. Church Medal (2021).

Ahmed Ghazi, MD, FEBU, MHPE

Associate Professor of Urology
George W Conner Dean Teaching Fellow

Dr. Ahmed Ghazi is an Associate Professor of Urology at the University of Rochester he specializes in the minimal invasive treatment of urological cancers. To further enhance his educational background, he completed the George Corner Deans Teaching fellowship, Harvard Macy Institute program for Health Professions Educators and a Masters in Health Professions Education at the Warner School of Education. He founded and led a research laboratory staffed with biomedical engineers that combine 3D printing, and hydrogel polymer technologies to fabricate realistic procedural models that replicate the texture, appearance and tissue reaction of human organs. He collaborates with educators nationally, and internationally, in a variety of disciplines to enhance role of simulation in surgical education.

Dr. Ghazi received awards at international scientific conferences and grants including a Clinical and Translational Science Award, NIH, STTR grant (academic PI), and PI of a NIH, NIBIB grant evaluating impact of his simulations in improving surgical performance and their translational impact on patient outcomes. Dr. Ghazi believes in a reciprocal relationship between research, teaching & surgery, where each informs & strengthens the others. He strives to produce academically rigorous research that is theoretically sound and translates directly into a safer surgical environment.

Amin Madani, MD, PhD, FRCSC

Endocrine and Acute Care Surgeon; Director, Surgical Artificial Intelligence Research Academy, University Health Network, Toronto, ON; Assistant Professor, Department of Surgery, University of Toronto; Founder and Chair, Global Surgical Artificial Intelligence Collaborative

Dr. Amin Madani is an endocrine and acute care surgeon, as well as the director of the Surgical Artificial Intelligence Laboratory at the University Health Network and University of Toronto (Toronto, Canada). His research focus is in surgical expertise and the use of technology to optimize performance in the operating room. He uses qualitative methodologies to investigate mental models, intra-operative decision-making and other constructs of expertise. This work serves as the basis for engaging in the design and development of new innovations to improve surgical performance, including platforms that incorporate artificial intelligence, computer vision, augmented/virtual reality, and simulation. Dr. Madani collaborates with a multidisciplinary group of engineers, computer scientists, game developers and educational psychologists, who use a team-based approach to develop technology-enhanced learning environments and assess their impact on performance and patient outcomes. Examples of these projects include developing artificial intelligence algorithms for providing real-time guidance to surgeons during surgery, augmented reality simulation platforms to teach and objectively measure intraoperative decision-making, and telestration devices to facilitate coaching and accelerate the acquisition of surgical expertise. His team also develops VR team-based simulations with a focus on using machine learning-derived metrics for decision-support.

Abstract Code   Abstract Category

O-1 Promoting Technology and Collaboration

Interprofessional Training In Virtual Reality

William Yi, MD FACS (presenter); Caoimhe Duffy, MD, MSc; Daria Harlamova, MS; Kristoffel Dumon, MD FACS; and Joshua Atkins, MD PhDS
University of Pennsylvania, Philadelphia, PA

Introduction: Team based simulation has been shown to improve communication, teamwork among clinicians, and ultimately patient outcomes. Difficulties in gathering multiple clinicians in the same space and at the same time for this type of training has been a major barrier to its implementation. These difficulties have only been magnified during the COVID-19 pandemic. Immersive virtual reality (VR) technology offers the potential to remedy these issues by allowing clinicians to participate in team based simulation without leaving their work environment. The aim of this project was to design a platform on which team based simulation scenarios could be built and implemented for use with immersive VR.

Technology Overview: Spatial.io is a VR meeting platform in which users can utilize a VR headset and interact through avatars in a stock or custom built VR space. The platform allows manipulatable objects to be loaded in, videos to be presented, and a host of other functionalities. We used the LiDAR scanner on an iPad Pro to create a 3D scan of the preoperative area of our hospital and uploaded this into Blender, a 3D creation suite. The scans were graphically adjusted and uploaded into Spatial.io along with objects such as scalpels and stethoscopes which were created in Blender. We then designed an immersive VR team based simulation that mirrored an in-person simulation we have run in the past, post-thyroidectomy neck hematoma.

Potential Application in Surgical Simulation and Education: The technology described here allows learners to put on a VR headset from disparate locations and take part in team based simulation. Using the process described, any number of clinical simulations can be designed, whether it be in the operating room, hospital floor, or clinic space.

Potential Opportunities to Collaborate: We are in the process of running a pilot study comparing immersive VR training against in-person training. In the future we would like to demonstrate that clinical simulation can be done with users at different institutions that may be remotely located.

O-2 Research In-Progress

Automated Surgical Tasks Classification Using Surface Electromyography

Hajar Sharif; Heidi Phillips; Jennifer Kuzminsky; Seung Byum Seo; Leslie McNeil; and Thenkurussi K. Kesavadas
University of Illinois at Urbana-Champaign, Urbana, IL

Introduction: Excellent surgical and microsurgical skills are critical to avoid morbidity and mortality in high stakes surgical patients. Gaining surgical skills requires significant practice and mentorship, yet opportunities to gain on-the-job surgical training are scarce. While administrative, legal, and ethical pressures understandably preclude exposure of surgical patients to novice surgeons on the steepest part of the learning curve, surgical training is negatively impacted. In addition, fewer medical training programs use live animal models in the delivery of medical education due to humane concerns and societal pressures and perceptions. As a result, development of non-living models and simulations is critical to advancement of surgical training in medical education. Evidence suggests that many highly technical skills may be acquired and refined outside of the operating arena through use of surgical simulations. Validation of any surgical simulation system is needed to ensure skills transfer to real-life surgical situations. Robust and quantitative skill assessment methods are required to perform such systems validation. One first step toward development of such quantitative methodology is to devise techniques that automatically differentiate among various surgical tasks using hand gestures. Surface electromyography (sEMG) signals have been widely used in hand gestures classification for different applications.

Methods: In this work, machine learning techniques have been presented and validated using experimental data to classify surgical tasks. sEMG signals were collected from the dominant lower arm of more than 40 participants performing common surgical tasks such as passing suture and tying knots on a high-fidelity synthesized tissue model. The cohort was composed of participant groups with differing levels of knowledge, ranging from pre-clinical veterinary students to expert veterinary surgeons. The collected data were classified using a 3-layer convolutional neural network.

Preliminary Results: Over 90% accuracy was obtained by applying the presented classification method on a subset of the collected data, i.e. the data from expert participants.

Next Steps: The presented method will be applied to the entire dataset to include data from novice and intermediate-level participants.

O-3 Research Abstracts

Objective Measurement of Standing Related Fatigue in Operating Room

Hamed Asadi; Dimitrios Athanasiadis, MD; Sara Monfared, MD; Dimitrios Stefanidis, MD, FACS; and Denny Yu
Purdue University, West Lafayette, IN, Indiana University, Indianapolis, IN

Introduction: Surgeons and surgical teams work in unique conditions that require prolonged standing and a limited dynamic movement around the operating table, potentially exposing them to musculoskeletal symptoms in the back and lower extremities. Medical experts and researchers have raised the attention on investigating occupational health consequences of prolonged standing during surgery. This study aimed to assess whether objectively measured shifts of surgeons' weight during an operation were associated with lower extremity musculoskeletal fatigue.

Methods: An IRB-approved study was conducted to quantify the intraoperative standing-related metric. All participants self-reported musculoskeletal discomfort using a 3-point Likert body-part discomfort survey. Standing data was recorded from laparoscopic operations using a pressure measurement system. The reaction forces were identified for each foot and were used to determine a weight shift by normalizing the difference between the right and left ground reaction forces over the total body weight. Based on reported pre- and post-operative discomfort ratings, participants were divided into fatigued and non-fatigued groups. A linear mixed-effects model was performed to determine the relationship between objective measurements and subjectively reported discomfort.

Results: A total of sixteen surgeon assessments were collected. The fatigued group had 2.84 ($p<0.05$) more shifts per minute compared to the non-fatigued group. The average body weight shifts slope overtime increased by 21% for the fatigued group

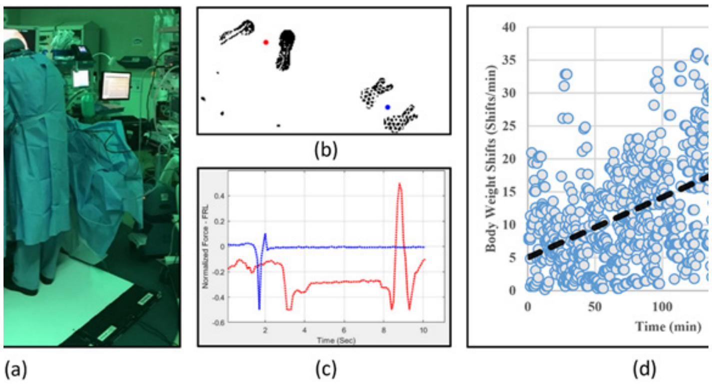


Figure 1. Pressure sensing platform, reaction forces, and weight shifts in fatigued group over time of operation

(compared to the non-fatigued group). No statistical differences were found based on age, gender, and role ($p>0.05$).

Conclusions: The results of this study showed an association of objective measurements with subjective standing-related fatigue ratings during surgical operations, indicating that the body weight shifts could be implemented as an objective variable to identify lower extremity fatigue. The future steps would be leveraging the objective measurements to develop models to predict fatigue during surgery. Beyond predicting lower extremity fatigue, this approach may also help assess the impact of interventions more effectively and efficiently.

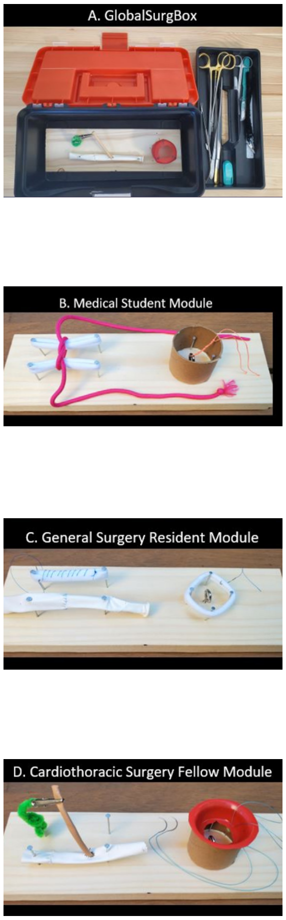
O-4 Challenges in Surgical Education

GlobalSurgBox: An Innovative, Affordable, Portable Surgical Simulator for All Trainees

Yihan Lin, MD; Anna Kathryn Gergen, MD; Michael J. Kirsch, II, MD MS; Courtney Mangham, BA; and Jay D. Pal, MD, PhD
University of Colorado and University of Colorado School of Medicine, Aurora, CO

Background: Simulator training is increasingly recognized as a critical component of a robust surgical education. Changes in surgical training environments due to work hour restrictions, operating room efficiency, and reducing errors has led to fewer learning opportunities for trainees, resulting in decreased operative exposure and hands-on skill practice. Simulation promotes practice outside of the operating room, circumventing commonly faced obstacles to achieving operative proficiency during training.

Current Challenges: Despite recognition of the importance of simulation in improving technical skills, implementation of these platforms are often limited by affordability, portability, and accessibility. Many platforms are high-fidelity platforms, which traditionally offer the benefit of close similarity to operating room environments or tissues. Unfortunately, this also leads to significant barriers of cost, limiting the number of simulators available to residents, and added difficulty in replenishing materials used for the simulator. These barriers become even more pronounced in low-income countries with limited healthcare



resources, as the current era of simulation-based training often requires substantial investments of time, money, and teaching personnel.

Need of Innovation: To overcome these barriers, we developed the GlobalSurgBox: a portable and inexpensive surgical simulation trainer that individual trainees can own, and can be easily adapted to any level of training. The GlobalSurgBox was specifically designed to help overcome resource and time constraints, allowing easy assembly, distribution, and implementation in any resource setting. The GlobalSurgBox was designed as a compact and portable trainer that fits within a 12.5-inch toolbox and costs approximately $25 to create. All of the materials can be found at online retailers and local home improvement stores. We have successfully trialed this simulator in two training programs, the University of Colorado Hospital general surgery training program, and the Tenwek Hospital in Kenya. We hope to continue working on modules for further implementation in more settings globally.

O-5 Research In-Progress

A Soft Robotic Simulator for Transseptal Puncture Training

Nicholas A. Thompson; Abraham G. Kocheril, MD; Elizabeth T. Hsiao-Weckler, PhD; and Girish Krishnan, PhD
University of Illinois, Urbana, IL, OSF HealthCare Cardiovascular Institute, Urbana, IL, University of Illinois, Urbana, IL

Introduction: Transseptal puncture (TP) is the technique used to access the left atrium of the heart from the right atrium via the interatrial septum in increasingly common catheter-based procedures such as atrial fibrillation ablation. Through repetition with actual patients, experienced TP operators develop manual skills to manipulate the TP catheter assembly inside the right atrium to their target on the fossa ovalis. To create low-risk training opportunities for new operators, we have developed a Soft Active Transseptal Puncture Simulator (SATPS), designed to match the dynamics, kinetostatics, and visualization of the heart during TP.

Methods: Safely navigating a patient's heart with a TP catheter includes three critical steps: (i) identifying and avoiding accidental puncture of the aortic mound during transit from the superior vena cava to the septum, (ii) using a combination of visual and haptic cues to correctly locate the fossa ovalis, and (iii) applying the correct force on the catheter during tenting and puncture. We sought to capture these steps in the SATPS by integrating bioinspired actuators, stretchable materials with similar mechanical properties to heart tissue, and visual simulation tools.

Preliminary Results: The SATPS includes three main subsystems: (i) A soft robotic right atrium actuated using fiber-reinforced elastomeric enclosures (FREEs) mimics the dynamics of the heart felt through the catheter assembly. (ii) A replaceable, puncturable fossa ovalis simulates the tissue properties of the real fossa to provide accurate kinetostatic force feedback during tenting and puncture. (iii) A simulated intracardiac echocardiography environment gives the user live visual feedback representative of an ultrasound monitor during an actual TP procedure.

Next Steps: The SATPS is undergoing face and content validation by experienced clinicians. Tuning the FREEs' pneumatic pressure during clinician review will allow for immediate re-evaluation of atrial dynamics. We will incorporate design improvements based on quantitative validation results and clinician feedback

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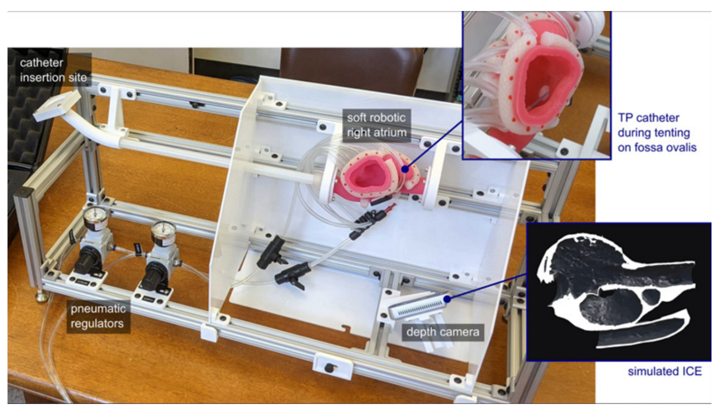

O-6 Challenges in Surgical Education

Expanding Functionality and Application of Current Examination and Diagnostic Breast Trainer for the Cost-Effective Simulation of Nipple Discharge

Hannah Chong, OMS-IV; Tariq Al Shanteer, BSBME, CHSOS; and Susan Davis Carter, MD, FACOG , FACS
Rocky Vista University, Parker, CO

Background: Breast cancer is the most common cancer among women and is the second most frequently diagnosed cancer worldwide. Education and awareness for both clinicians and patients play a critical role in early diagnosis and prevention.

Current Challenges: Current examination and diagnostic breast trainers have capabilities for nodules and cysts of various sizes, however very few have the capability to express fluid upon palpation and be readily reset after multiple iterations. Furthermore, fewer models offer the capabilities to simulate the expression of various fluids within the same model, confining current task trainers to the presentation of one type of nipple discharge per model. This limits the spectrum of presentations that can be simulated with a breast trainer, excluding the opportunity to educate learners about complex breast presentations with different discharge such as serous, white, yellow, or green discharge, milk, or blood.

Need of Innovation: Our model utilizes parts from an IV kit, suture, endotracheal tube, and a 20ml syringe to combine two existing breast models, the Gaumard Scientific Advanced Patient Care Breast Palpation Bra 20/4 and the Health Edco Interchangeable Nodules Breast Self Examination Model into a single model that can express any type of fluid upon the performance of a breast examination. These modifications have the possibility of being readily applied to other existing models creating a cost-effective solution that can be duplicated for various educational applications. Pilot experiments integrating our model into existing medical school curriculum revealed positive feedback from both faculty and students. This model has the potential to be expanded upon with the addition of a pressurized pump and modified parts of a central line kit to create a single model with the capability of switching between three different discharge types without additional set-up.

Materials Used:

- SafeDAY IV Administration Set with Universal Spike, Back-Check Valve, Roller and Slide Clamps, SafeDAY Valves 87" and 14" Above Distal End, Sliding SPIN-LOCK Connector, 105"L, 15 Drops per mL, 18.5 mL Priming Volume
- Undyed PGA Braided Suture, Size 4-0, 18", PS-2 Needle, 3/8 Circle Reverse Cut 19mm
- Endotracheal Tube Flexicare® Ventiseal Cuffed 6.5 Mm
- Sterile BD™ Luer-Lok™ Syringes, 20mL

O-7 Research Abstracts

Evaluation of Exoskeleton Implementation in the Operating Room

Jackie Cha, PhD; Dimitrios Athanasiadis, MD; Hamed Asadi, PhD; Sara Monfared, MD; Dimitrios Stefanidis, MD, PhD; and Denny Yu, PhD
Clemson University, Clemson, SC, Indiana University School of Medicine, Indianapolis, IN, Purdue University, West Lafayette, IN
Clemson University, Clemson, SC, Indiana University School of Medicine, Indianapolis, IN, Purdue University, West Lafayette, IN

Introduction: Musculoskeletal symptoms and injuries adversely impact worker health and performance in the operating room (OR). Though the ergonomic risks in surgery are well-recognized, their mitigation is especially difficult due to the demanding work and restrictive work environment (e.g., sterility) that must prioritize patient safety. The study's aim was to assess potential benefits of exoskeleton technology when used by OR team members.

Methods: After Institutional Review Board approval, and consent from the patient and participating OR team members, participant posture angles and muscle activity were collected during laparoscopic or open procedures. Measurements were recorded in cases where a passive arm-support exoskeleton (Levitate AirFrame TM) was worn by participants and in cases that it was not worn. The exoskeleton was fitted and was worn under the sterile surgical gown. Participants were equipped with inertial measurement units and surface electromyography (EMG) sensors on their upper body. Posture angles and muscle activity metrics were calculated and compared between the baseline and exoskeleton conditions using differences Wilcoxon tests.

Results: Twenty-seven total cases were collected, 12 with and 15 without the exoskeleton. One surgical nurse, one attending surgeon, and five trainees participated in the study. Two participants were female, and all were right-hand dominant. Decrease in percent time in demanding postures for the right (7%, p=0.03) and left (17%, p=0.19) shoulders were observed with the exoskeleton. There were also significant decreases in metrics representing static (0.34%, p=0.02) and dynamic (0.87%, p=0.02) demands on the left trapezius; however, there were increased signs of fatigue in the right deltoid (17% decrease of EMG median power frequency) with the exoskeleton.

Conclusions: The use of an exoskeleton during a variety of operations led to lower posture angles of the shoulders anddecreased muscle fatigue while muscle activity of the armsincreased. While exoskeleton technology has the potential to reduce musculoskeletal symptom and fatigue indicators, training on using the exoskeleton by OR personnel may be needed to minimize increased load on the arms and improve surgical team members' health and safety.

O-8 Research In-Progress

Multi-Care Team Training for Obstetric Abdominal Trauma: Developing a Cost-Effective Simulator

Stacy Forbes, OMS-III; Tariq Al Shanteer, BSBME, CHSOS; Kelsey Link, MS; and Susan Carter, MD, FACS Li Fellander-Tsai, MD, PhD
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Introduction: The Rocky Vista University Healthcare Simulation Center was approached by a regional Level II Trauma Center to develop a multi-care simulator to assess an expansion of the emergency department. The Trauma Center aimed to involve multi-care teams including obstetric and surgical physicians, nursing staff, EMT/Care Techs, and supervisory positions. Numerous obstetric-inclusive and surgical-inclusive simulators exist in the marketplace to stress specific disciplines yet it is challenging to find a cost-effective model that demands multi-system care. In order to create a unique team training scenario with materials commonly found in a simulation center, the most effective components of previously purchased simulators were combined to create an obstetric abdominal trauma simulator.

Methods: Supplies included a female task trainer torso (Laerdal® - Resusci Anne™), large and small bowel, liver, static great vessels, bladder, gynecoid bony pelvis, blood pump system (Strategic Operations®), placenta (Gaumard®), and inflatable baby (Laerdal® - NeoNatalie™). Abdominal musculature and skin were assembled from leftover silicone products.

Two versions of a gravid uterus were created, first by suturing silicone muscle tissue with tubing to connect the uterus to an external blood pump and second by using the NeoNatalie™ inside a waterproof roll top bag from a sporting goods store to simulate amniotic sac and fluid.

Preliminary Results: Two multi-care teams participated in the obstetric abdominal trauma simulation on separate occasions. Feedback was overwhelmingly positive. Participants ranked the simulator as realistic and a valuable component of their experience. Team training identified several areas of system improvement for the Trauma Center.

Next Steps: Acquiring data and feedback from multiple healthcare facilities will allow a greater confidence in the effectiveness and usefulness of the obstetric abdominal trauma simulator in training scenarios. Additional multi-care teams will be recruited to participate in the simulation, with specific evaluation of team behaviors and outcomes.

O-9 Research Abstracts

Automating Context Dependent Gaze Metrics for Evaluation of Laparoscopic Surgery Manual Skills

Shiyu Deng, MS; Chaitanya Kulkarni, MS; Shawn David Safford, MD, FACS, MBA; Sarah Parker, PhD; Laura E. Barnes, PhD; Tianzi Wang, MS; Jacob Hartman-Kenzler, MS; and Nathan Lau

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Introduction: Research has found that feedback gaze behaviors can differentiate performance between experts and novices in the technical surgical skills. However, gaze behaviors revealing feedforward control are absent in research. This study compared feedforward and feedback gaze metrics in assessing skill levels in the peg-transfer task.

Methods: Medical students practiced the peg-transfer task, which was video-recorded with eye-tracking data. The final dataset consisted of 499 practice trials from 9 participants. The feedback metrics were fixation rates on (1) objects, and (2) tool-holding-an-object. The feedforward metrics were fixation rates on areas (1) of objects traversed 0.12-0.6s later, and (2) outside tool-holding-an-object. These two are feedforward metrics because the former suggests looking ahead and the latter suggests looking for information beyond the immediate moving items. Cluster analysis with the 4 metrics was used to group the trials into different skill levels. A random forest model was trained to predict the skill level using the metrics as predictors of the clusters. About two and one third of the data were used for model training and testing, respectively.

Results: Within-cluster-sum of squared errors suggested 3 clusters, identifying 3 skill levels amongst the practice trials. Between the 3 skill levels, ANOVAs indicated significant differences in fixation rates on areas of objects ($F_{2,496}=383.1, p<.001$), tool-holding-an-object ($F_{2.496}=86.1, p<.001$), objects traversed 0.12-0.6s later ($F_{2,496}=445.1, p<.001$), and outside tool-holding-an-object ($F_{2,496}=32.4, p<.001$). The correspondence between the clusters and skill levels was confirmed by differences between cluster completion times ($F_{2,496}=6.9, p=.001$). For the skill level with shortest completion time, trainees exhibited highest scores for all gaze metrics. The random forest model predicted skill level with 4.8% out-of-bag error. The Mean Decrease Accuracy plot indicated that fixation rates on objects, and objects traversed 0.12-0.6s later were the most important for predicting skill levels.

Conclusions: Feature importance in random forest model suggested that fixation rates on objects and objects traversed 0.12-0.6s later were almost equally important. This study provided the first evidence that feedforward can be as sensitive and capable as feedback gaze metrics at assessing surgical skills.

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A Call for Abstracts will be announced in late summer 2022.

Abstract Code | Abstract Category

P-01 | **Research In-Progress**

Are Metrics That Quantify Suturing Skills Different for Performance by Pronation Versus Supination?

Amir Mehdi Shayan; Simar Singh; Jianxin Gao; Zhanhe Liu; Richard Groff, PhD; and Ravikiran Singapogu, PhD
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Introduction: Suturing is a basic and critical aspect of surgery. Surgeons intuitively know the importance of wrist-roll in suturing. Specifically, surgeons must decide whether to use supination (forehand) or pronation (backhand) to suture as a function of their spatial configuration with respect to the anatomical site requiring suturing. To study the importance of wrist-roll, we explored a multimodal assessment of suturing skills by extracting several metrics from sensor data. This study examines the relationship between dominant rotational movement during suturing (pronation vs. supination) and metrics used to quantify suturing skills (duration, tool-tip motion smoothness, needle motion, and force).

Methods: The suturing platform has markings printed in a radial pattern indicating twelve suture areas to be completed in each trial. In this pilot experiment, we collected data from 4 subjects (two attending surgeons [deemed experts] and two non-clinicians [deemed novices]). All subjects completed trials under different conditions, including superficial and deep suturing, resulting in 174 total sutures. For all the sutures, skill metrics were computed. Further, each suture was classified in terms of dominant movement, i.e., supination or pronation.

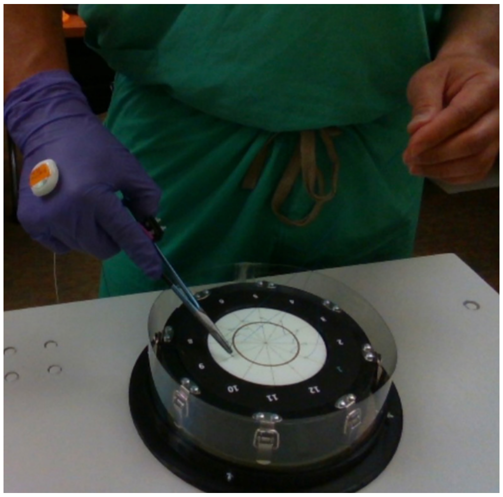
Preliminary Results: Mann-Whitney U statistical significance tests were used to compare various metrics for experts' supination to experts' pronation, as well as for novices. In this intragroup comparison, more metrics demonstrated significant differences between pronation and supination for experts than novices. Additionally, we compared expert performance with novices, resulting in significant statistical differences in most metrics (Table 1).

Next Steps: In general, the metrics used in this study demonstrated the potential to differentiate between experts and novices in various suturing scenarios. Moreover, this research showed the potential for further analysis from a larger set of data from attendings, residents, and medical students. These data could ultimately enable the presentation of objective and meaningful feedback for assessing and improving suturing skills, specifically with regard to the wrist-roll technique.

Conclusions: This work marks a promising methodology to develop automated programs for performing surgical subtasks, but further work is needed to enhance simulation complexity and computational performance. Ultimately, advancements in computer vision will allow for the translation of virtual algorithms in the physical world.

Table 1. P-Values When Comparing Suturing Quantification Metrics for Pronation vs. Supination

Metrics/Sutures	Expert supination vs. Novice supination	Expert pronation vs. Novice pronation	Expert supination vs. Expert pronation	Novice supination vs. Novice pronation
Duration	**0.000**	**0.001**	**0.011**	0.217
Tool-Tip Motion Smoothness (LDLJ From EM Sensor 1)	**0.000**	**0.001**	**0.001**	0.547
Tool-Tip Motion Smoothness (From EM Sensor 2)	**0.000**	**0.001**	**0.001**	0.612
Needle Swept Area	0.206	0.389	**0.001**	0.090
Needle Sway Length	0.183	0.608	**0.004**	0.142
Peak Downward Force	**0.000**	**0.001**	0.655	**0.035**
Tangential Force Peak to Peak	**0.000**	**0.000**	0.662	0.788
Orthogonal Force Peak to Peak	**0.000**	**0.000**	0.785	0.508



P-02 | **Challenges in Surgical Education**

Low-Resource Surgical Simulation Curriculum: Lessons Learned from a Novel Paradigm in Surgical Education during a Challenging Pandemic

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Background: Residency programs are required by the Accreditation Council for Graduate Medical Education (ACGME) to have a dedicated standardized simulation program. Several anatomical models have been used to meet this requirement from very expensive, sophisticated models to low fidelity, low-cost ones; however, not all programs have access to high-end simulation devices on which to train residents.

Current Challenges: The ongoing COVID-19 pandemic, along with the strict protective and social distancing measures that are associated with it, resulted in a major setback in surgical simulation education in many residency programs, thus potentially compromising surgical hands-on education. In conjunction with the overall decrease in operative volume in most hospitals in the country due to cancellation of elective cases, resident training experience has been limited.

Need of Innovation: With the decrease in operative volume and the concomitant decrease in simulation educational funding, surgery residency training curricula need an innovative and inexpensive approach to ensure adequate hands-on training of all residents. This study presents a pilot surgical simulation curriculum based on low-resource, low-fidelity anatomical models in an academic institution during the COVID-19 pandemic. The models developed used colored felt, cardboard and glue to replicate skin, fascial layers, blood vessels, and mimick normal anatomic findings. Standard surgical instruments, sutures, and laparoscopic box trainers were used. The Table summarizes the human-hours (hours needed for one person to develop and build the model), financial cost for assembly of the anatomical models, and training duration required to implement a simulation session, for each of 5 common surgical operations. Resident feedback was very positive on a 5-point Likert scale (average > 4.5). With the increasing difficulties in providing high-quality surgical simulation, a change of paradigm is needed to support novel low-cost curricula that can evolve into a feasible module of education for surgical trainees.

Human-hours, Financial cost, and Session duration associated with low-resource simulation training

Simulation Session	Human-Hours (hours)	Financial Cost (US dollars)	Session Duration (minutes)
Laparoscopic cholecystectomy	0.5	$ 2	20
Intestinal anastomosis	0.25	$ 1	30
Vascular anastomosis	0.1	$ 1	20
Open inguinal hernia repair with mesh	0.5	$ 2	30
Thyroidectomy	0.5	$ 5	30

P-03 Research Abstracts

The Fundamentals of Vaginal Surgery Pilot study: Developing, Validating, and Setting Proficiency Scores for a Vaginal Surgical Skills Simulation System

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Introduction: Currently there is no standardized, widely implemented basic skills program specifically for vaginal surgery. Our aim was to develop a vaginal surgical simulation system; evaluate robust validity evidence for the simulation system and its related performance measures; and establish a proficiency score.

Introduction: Currently there is no standardized, widely implemented basic skills program specifically for vaginal surgery. Our aim was to develop a vaginal surgical simulation system; evaluate robust validity evidence for the simulation system and its related performance measures; and establish a proficiency score.

Methods: In this three-phased pilot study, we developed the Fundamentals of Vaginal Surgery (FVS) simulation system - consisting of (1) the FVS Trainer, a task trainer; (2) six validated tasks to be performed on the trainer; and (3) performance measures to determine proficiency. In Phase I, we developed the task trainer and selected surgical tasks by performing a needs assessment and hierarchical task analyses. In Phase II, we conducted a national survey of vaginal surgeons to collect validity evidence relevant to the simulation system. In Phase III, we compared performance of Novice (1st, 2nd year residents) and Experienced (3rd, 4th year residents; fellows; faculty) surgeons. Performance measures were analyzed to set a proficiency score that would discriminate between Novice and expert (faculty) vaginal surgical performance.

Results: The FVS simulation system was developed in Phase I. In Phase II, survey responses of 48 participants (27 faculty surgeons, 6 fellows, and 14 residents) were evaluated. The task trainer and surgical tasks were deemed representative of intended surgical field and supportive of typical surgical actions (mean scores 3.8-4.4 / 5). In Phase III, we analyzed performance from 23 participants (15 (65%) Ob/Gyn residents, 3 (13%) fellows, and 5 (22%) Urogynecology faculty). Experienced surgeons scored significantly higher than Novice surgeons (median 467.5 IQR(402.5-542.5) vs median 261.5 IQR(211.5-351.0), P<.001). A proficiency score threshold at 400 results in 0% (0/6) novices attaining the score, with 100% (5/5) experts exceeding it (Figure 1).

Conclusions: We present validity evidence which supports the use of this novel simulation system for basic vaginal surgical skills. A proficiency score of 400 was established to discriminate between novices and experts.

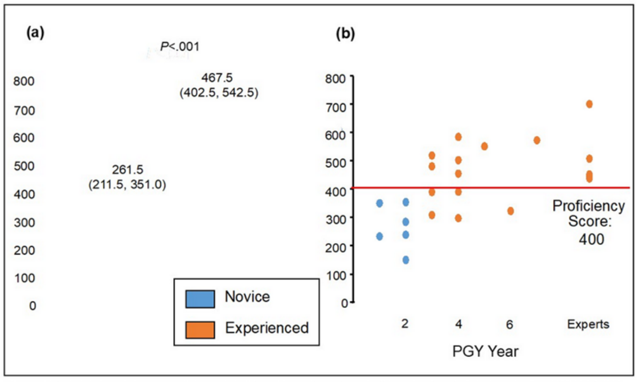

Figure 1. (a) total task performance score between Novice and Experienced groups (b) total task performance scores for each participant. Red line represents the proficiency score. Novice group: post-graduate year (PGY) 1-2. Experienced: PGY 3-7 and faculty.

P-04 Research In-Progress

Going Public in 3D Printing

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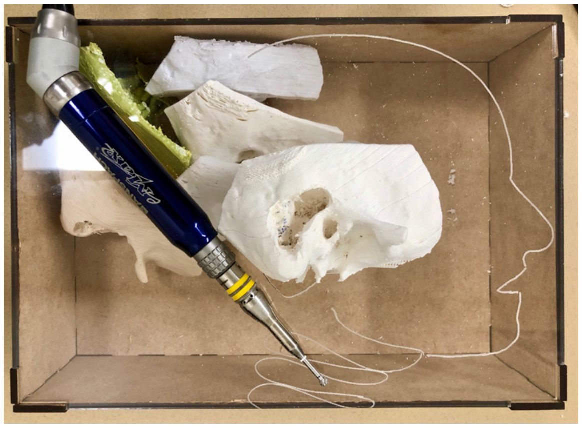
Introduction: 3D printed surgical simulators are key technologies in medical education. Unfortunately, many training programs cannot access them without equipment, expertise, and funds. Can a new public collaboration meet the need? We are testing the feasibility of engaging volunteer hobbyists in the 3D printing community to mass produce and globally distribute inexpensive, multi-color, multi-material surgical models with acceptable fidelity and validity.

Methods: We initiated a donation-based pipeline of temporal bone models to meet the educational needs of otolaryngology training programs. Open source temporal bone renderings were converted to ready-to-print files. The files were optimized for reproducible manufacturing using free software and consumer-grade fused deposition modeling equipment. Volunteers are invited to print the files on their own machines using their own materials, and then donate them to our project. We will post-process, combine, and ship the models in bulk internationally to hospitals and medical schools, sometimes in comprehensive "dissection kits."

Preliminary Results: In phase I (proof-of-concept), 10 volunteers enthusiastically participated in the project, and 5 training programs requested prints for 45 residents and 30 medical students in Thailand, Vietnam, Czech Republic, and the United States. To date, 4 models have been made by 1 volunteer and shipped to residents in Vietnam and Arizona.

Next Steps: Our goal in phase II (recruitment pilot) is to serve 25 sites with approximately 15 models each, for a total of 375 models by December 31, 2021. We estimate 3 prints will be donated per volunteer, requiring 125 volunteer hobbyists, plus additional volunteers to support logistics. Work is underway to share the files on common public 3D printing forums and to recruit volunteers



P-05 Research In-Progress

Customizing Virtual Reality Cardiac Auscultation Training Employing Upper Limb Ergonomics

Jackson Rushing; Priya Kartick; Alvaro Joffre Uribe Quevedo; Norman Jaimes; Bill Kapralos; Fahad Alam; and Adam Dubrowski
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Background: Introduction: Virtual reality (VR) applications enable the development of replicable, immersive, interactive, and engaging simulations for the training of cognitive and/or psychomotor aspects of medical practice. Current consumer-level VR allows for seated and standing interactions that are mapped to virtual spaces (e.g. operating room, or a bench). However, in general, VR lacks relevant customizations that acknowledge the user variability with respect to ergonomics. For example, upper limb interactions are critical to improving the realism and effectiveness of reach and grasp in training. Here, we present a VR cardiac auscultation simulation for auscultating a virtual patient. The trainee placement varies based on their upper limb reach to ensure a comfortable distance from the virtual patient.

Methods: The auscultation training simulator was developed using the Unity game engine, SteamVR, VR controllers to calibrate the upper limb length, and the HTC Vive trackers to manipulate the virtual stethoscope. The trainees examine the patient by placing the virtual stethoscope over the aortic, pulmonic, tricuspid, and mitral areas on the virtual patient's chest as presented in Figure 1.

Preliminary Results: Participants new to cardiac auscultation (n=10) performed three examinations. Results show that with the current arrangement, tracker occlusion can occur between the trainee and the HTC Vive base stations when holding the HTC Vive tracker. While participants were within comfortable reach, the tracking issue produced 25 faulty interactions between the stethoscope and the auscultated area, thus affecting completing the examination.

Next Steps: We have demonstrated shortcomings of our current solution with respect to tracking occlusion. Additionally, our approach allowed placing trainees within comfortable range by using their upper limb ergonomics.Future work will explore alternative solutions to SteamVR in addition to hand tracking and custom-made user interfaces and the effects on usability, presence and performance within the virtual auscultation.

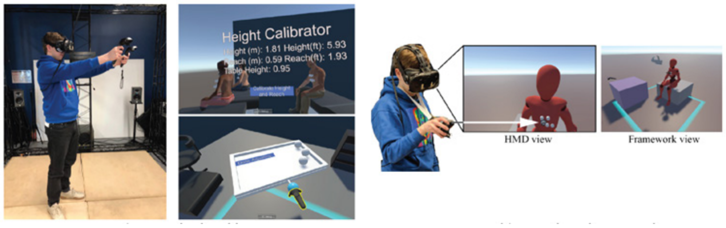

Figure. Calibration and cardiac auscultation examination
a) Upper limb calibration b) Virtual cardiac auscultation

Conclusions: Surgical skills simulation workshops can improve medical student confidence levels and competency in core surgical skills, while fostering interest in a surgical career. Medical schools and teaching hospitals should consider utilising it as a practical method for surgical education delivery to help prepare students for surgical rotations as a junior doctor. Further studies are required to assess the long-term impact of a SSSW on future career choice, competency and confidence levels.

P-06 Resaerch

Simulating the Surgical Environment: The Benefits of Exposure to Surgical Skills for Medical Students

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Introduction: Current models of surgical education in medical schools produce variable results, with some junior doctors expressing low levels of confidence and competency in surgical skills prior to internship. The aim of this study is to investigate whether the implementation of a 'Surgical Skills Simulation Workshop' (SSSW) can improve medical student confidence levels, competency and interest in pursuing a surgical career

Methods: 32 final year medical students across two university medical schools were enrolled in a SSSW which consisted of four, three-hour workshops covering suturing, hand-tying and laparoscopy. Student competency, confidence levels and future interest in a surgical career were assessed through pre-and-post workshop surveys, demonstrator assessments and student self-assessments.

Results: Upon completion of the SSSW, all 32 final year medical students demonstrated a significant improvement in competency and confidence levels with all three core skills; suturing, hand-tying and laparoscopy ($p<0.01$). Students showed the largest confidence increase with hand-tying (Pre: 2.75 vs Post: 7.97, $p<0.01$), followed by laparoscopy (Pre: 3.13 vs Post: 7.91, $p<0.01$) and suturing (Pre: 5.13 vs Post: 8.31, $p<0.01$). In regard to internship preparedness, only 6 students (18.7%) believed their medical school had adequately prepared them for surgical rotations, with 18 students (56.3%) feeling unprepared and 8 students (25%) indifferent. Additionally, 26 students (81.3%) expressed they were more likely to pursue a surgical career after having attended the SSSW compared to 19 students (59.4%) prior to the SSSW.

P-07 Research In-Progress

Using Digital Biomarkers to Measure Fluctuations in Instructors' Cognitive Load Between High-Fidelity Simulations and Debriefing Sessions

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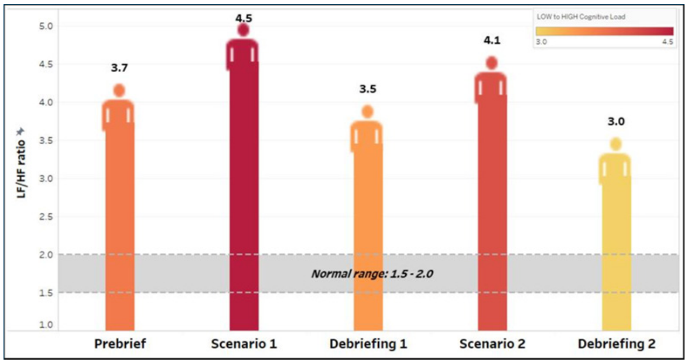
Introduction: Facilitating simulation training requires instructors to perform multiple tasks throughout the session. These activities generate a substantial cognitive load to instructors. If the mental demand exceeds an instructor's cognitive capacity, it may negatively affect performance. The aim of this study was to analyze cognitive load fluctuations among simulation instructors during high-fidelity Interprofessional training sessions.

Methods: Data were collected from instructors (simulation fellows). Each session was composed of 5 phases: prebrief, scenario 1, debriefing 1, scenario 2, and debriefing 2. Participants wore a chest strap that collected Heart Rate Variability (HRV). Low frequency/ high frequency (LF/HF) ratio was used as a proxy for the cognitive load. LF/HF ratio was calculated using a 1-minute time window. Friedman's two-way analysis of variance was performed.

Preliminary Results: Five fellows debriefed 15 sessions. Eleven had 1 debriefer and 4 had 2 debriefers (co-debriefing), totaling 19 measures over the 5 phases of the session. The median of the LF/HF ratio in each phase were: prebrief = 3.7 (2.8-6.1); scenario 1 = 4.5 (2.8-6.1); debriefing 1 = 3.5 (2.6-4.9); scenario 2 = 4.1 (3.4-5.2); debriefing 2 = 3.0 (2.2-4.4). There was a statistically significant relationship between the simulation phase and LF/HF ratio ($p = 0.001$). Post-hoc pairwise comparisons showed that debriefing 2 posed the lowest LF/HF ratio compared to scenario 1 ($p = 0.001$) and scenario 2 ($p = 0.048$). Grouped analysis for prebrief vs scenario vs debriefing showed that instructors presented the lowest LF/HF ratio during the debriefing phase: 3.1 (2.6-4.9), compared to prebrief: 3.7 (2.8-6.1); $p=0.028$ and scenario: 4.3 (3.0-5.5), $p=0.017$.

Next Steps: The cognitive load during all phases was higher than the normal range (i.e LF/HF ratio: 1.5-2.0). The use of co-debriefers or cognitive aids can be used to avoid cognitive overload and potential negative impact on performance. The next step consists of assessing the relationship between cognitive load and instructors' debriefing performance.



P-08 Promoting Technology and Collaboration

CrashSavers: Low-Cost Virtual Reality Hemorrhage Control Simulator

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Background: Hemorrhage is responsible for up to 40% of deaths after trauma. Hemorrhage control techniques consisting of pressure, packing, tourniquets, and foley catheter placement are among the most effective interventions in early trauma management. In many low- and middle-income countries (LMICs), there is no training in hemorrhage control for first-responders. Furthermore, many traumas occur in settings lacking trauma centers, blood banks, and extensive hospital transport times. In prior studies, untrained personnel were found to have high rates of tourniquet failure, leading to poor hemorrhage control and, likely, preventable deaths. We are designing a comprehensive training platform in hemorrhage control techniques for first-responders and healthcare personnel in low-resource settings, "CrashSavers", that is low-cost and has built-in self-assessment, obviating the need for expensive, in-person instruction.

Technology Overview: The CrashSavers platform teaches hemorrhage control using both virtual and physical components. The virtual application presents didactic materials, administers knowledge checks, and embeds virtual reality case scenarios to teach and assess clinical decision-making. The physical model of a limb with a blood flow and pressure simulator is constructed with low-cost materials and is connected to the virtual application. Combined, learners experience integrated and engaging high-quality training.

Potential Application in Surgical Simulation and Education: We present an alternative that will have broad implications in reducing prehospital morbidity and mortality from traumatic hemorrhage that can be used for a wide variety of learners - from volunteers to first-responders and hospital-based healthcare personnel in LMICs. Our simulator uses a gamification algorithm to assess user learning based on answers given in each clinical case. Only the best scores can go further and practice in the simulator, ensuring quality of the training provided.

Potential Opportunities to Collaborate: The Crashsavers team consists of trauma surgeons and engineers in Latin and North America. There is significant opportunity to collaborate to improve low-cost simulation-based education for training in LMICs. We believe our simulator will be used by people around the world, which will help us strengthen our network, get feedback and innovative ideas.

P-09 Promoting Technology and Collaboration

Novel Laparoscopic Spatial Training System

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Background: Laparoscopic simulation is an essential part of the modern surgical curriculum because it provides opportunity to learn and practice various surgical skills and tasks before exposure to patients in the operating room, thereby lessening the risk of trainee errors. The two types of simulators in common use are the low-cost physical box trainers, and the much more expensive virtual reality simulators. The American College of Surgeons developed a program called the Fundamentals of Laparoscopic Simulation (FLS) Surgical Simulator Method which includes five basic tasks performed in a box trainer. The Novel Laparoscopic Spatial Training System more effectively targets the development of the FLS core skills of two-handed coordinated movement (development of non-dominant hand), tactile perception/ force sensitivity, and three-dimensional depth perception. It is user friendly and cost effective.

Technology Overview: The Novel Laparoscopic Spatial Training System will provide enhanced training outcomes compared to the FLS system. It will expose the trainee to all aspects of laparoscopic surgery beyond the current five basic tasks performed in the FLS box trainer. The system will incorporate graduated levels of difficulty to aid in trainee skill development for easily reconfigurable tasks. It will also measure speed and precision of movement.

Electronic interactive devices in the laparoscopic box trainer can be connected to a personal computer to facilitate various learning activities. These tasks are automatically recorded and timed providing user feedback.

Potential Application in Surgical Simulation and Education:

- Improves training outcomes compared to the FLS system.
- Detailed design of the system components and models is considerable cheaper
- The design and implement several new models and tasks which more effectively target and develop the core skills of two-handed coordinated movement (development of non-dominant hand), tactile perception and force sensitivity, and three-dimensional depth perception

Potential Opportunities to Collaborate: They're opportunities to collaborate with medical schools and training institutions. There is opportunities to improve and learn new techniques in surgery.

P-10 Promoting Technology and Collaboration

Quantifying, Standardizing and Tracking Surgical Performance on an Open Simulator

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ReSuture Inc, Surprise, AZ

Introduction: For nearly two decades, various stakeholders have been calling for major revisions to the current training model. Since the establishment of the Surgical Council on Resident Education (SCORE) in 2006, important steps have been taken to make surgical training and evaluation more efficient. Restrictions on resident duty-hours, greater specialization, and subjective systems of assessment have elucidated an urgent need for better evaluation techniques.

Technology Overview: This technology is a proposed training tool for open vascular surgery that incorporates multiple procedures of progressive difficulty into a perfused benchtop device. A novel method for manufacturing durable synthetic vasculature accurately replicates the physical properties and complex anatomical geometries of human vessels. Soft capacitive sensors collect data on surgical performance and provide quantitative feedback to residents in real time, allowing for user-specific skill tracking, as well as skill benchmarking across an online database. Procedures will range from basic anastomosis practice to complex procedures such as re-attempted Abdominal Aortic Aneurysm repair after failed EVAR.

Potential Application in Surgical Simulation and Education: The proposed technology has potential to allow for the standardization of simulation training as well as simulation-based objective assessment. Attendings will be able to assess their residents' level of technical competency before allowing them to participate in procedures. The proposed technology will remove bias and subjectivity from surgical evaluation, while also eliminating the need for attendings to be physically present to assess their residents' performance.

Potential Opportunities to Collaborate: Areas of collaboration include published research studies evaluating the effectiveness and impact of this technology, co-development for procedures outside of vascular surgery, and co-development of an online learning management system to track and store data collected from user.

P-11 Research

Medical Student Confidence and Perceived Competence when Performing a Female Genitourinary Exam using Task Trainers and Specialized Standardized Patients

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Introduction: The female genitourinary exam (FGUE) is an essential component of a complete medical education for all future physicians. For many medical students, the intimate nature of the exam can be anxiety-provoking. The purpose of this study is to investigate what factors make students feel confident and competent when performing a FGUE. We anticipated that students would increase their confidence and perceived competence from OMS-I to OMS-II, would prefer the use of specialized standardized patients (SSPs) over task trainers, and that the results would vary by student demographics.

Methods: Hard copy surveys were provided to Rocky Vista University - College of Osteopathic Medicine classes of 2023 (OMS-I) and 2022 (OMS-II) pre- and post-intervention in the Spring semester of 2020 in Parker, CO. Guidelines on a complete FGUE and educational interventions including the use of task trainers and SSPs were provided by the Department of Primary Care and the Principals of Clinical Medicine courses II (OMS-I) and IV (OMS-II). Survey responses were evaluated via Generalized Linear Mixed Models for numeric responses, statistical modeling, and descriptive statistical analyses with SAS v.9.4.

Results: The results demonstrated that the OMS-I and OMS-II osteopathic medical students of racial and ethnic minorities rated themselves as more confident and had a higher perceived competence than Caucasian counterparts. Students felt that using SSPs alone was the best mode of learning the exam compared to either task trainers alone or the combination of task trainers and SSPs together, and students' current specialty of choice did not correlate with increased confidence or perceived competence.

Conclusions: The utility of these findings will help medical educators use methods that best prepare their students for becoming successful physicians capable of performing an effective FGUE.

P-12 Research In-Progress

TIPSlite: Interactive Laparoscopy Training Wherever There Is Sufficient Internet Connectivity

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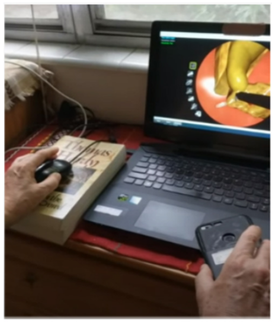
Introduction: The pandemic has reduced access to training, a familiar problem for rural, underserved locations. In response, SurfLab prototyped TIPSlite, a physical and software interactive laparoscopy training interface that can be used wherever there is sufficient internet connectivity. Reactions from surgeons are "TIPSlite is truly innovative", "responsive to the time and location constraints of medical students and physicians", and "a solution for remote, pandemic, international and continuing education outreach."

Methods: Requirements for deploying TIPSlite are a thin client (laptop) for display from the remote simulation server and an affixed upright cell phone pen providing a trocar pivot point that stays in contact to a flipped smartphone acting as a surgical instrument. Users download a thin client and a phone app (Android play or Apple store). The upright-clamped cell phone pen tip acts as a fulcrum point (trocar) and the down-flipped phone allows the full range of motion of laparoscopic surgery tools: three rotational degrees-of-freedom (up-down, left-right, axial rotation) and insertion-retraction. Disconnecting from the fulcrum by lifting the phone resets and allows switching the tool. Vibration and sound provide collision and cauterizing feedback. A computer mouse is typically used to retract tissue with the non-dominant hand. The remote server runs the Toolkit for Illustration of Procedures in Surgery (TIPS).

Preliminary Results: In a design-analysis cycle, SurfLab tested numerous prototype app and remote server options both under Apple testflight and Android. To date, 14 users have been debriefed. TIPSlite has been used at home, at work, and in a cafeteria experiencing negligible latency at 50Mb/sec.

Next Steps: Early accolades must be rigorously tested, after assuring optimal ease-of-use. Specifically, the goal is to test the hypothesis that the key benefits of TIPS training, hands-on experience of complex surgical sequences, can be experienced using TIPSlite freeing learners from difficult-to-deploy-and-maintain haptic devices and software.



TIPSlite phone-based 4-dof haptic interface (mouse for weak hand) © J. Peters.

P-13 Research

The Use of Simulation in Undergraduate Surgical Education for Sub-Saharan Africa- Opportunities for Collaboration: A Scoping Review

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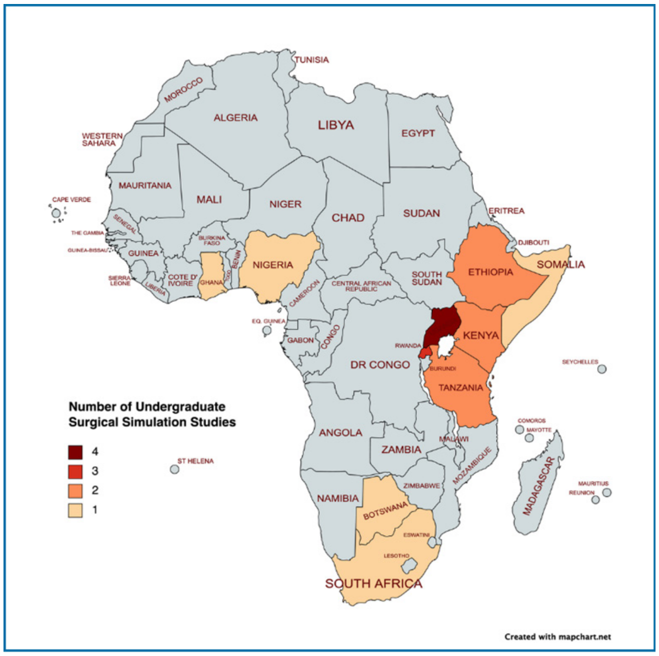
Introduction: Most surgical simulation training is applied to the increasingly complex High-Income Country educational context, and prioritized for residency training. However, prioritization of simulation in undergraduate surgical training for sub-Saharan Africa (SSA) is crucial due to the large burden of surgical disease, and low surgical provider density. This scoping review aimed to identify the application of simulation to undergraduate surgical education in sub-Saharan Africa as a first step to identifying geographic and educational gaps, and potential opportunities for collaboration.

Methods: We conducted a scoping literature search using PubMed, Embase, and African Index Medicus in August, 2021. Studies that reported data on simulation for undergraduate or internship surgical training in SSA specific to surgical clerkships, programs or procedures were included with no language or date restrictions.

Results: We identified 119 studies; 19 were included in the final analysis. Most simulations for undergraduate surgical training in SSA began recently (2017-2021), and were mostly reported from Eastern Africa (78%) (Figure 1). Medical, nursing, anesthesia, dental, and emergency medicine undergraduates benefitted from simulation, training in cohorts ranging from 5 to 198 learners. Only 25% of programs applied simulation to early undergraduate training. Most simulators were low fidelity (69%). Most programs were internal (94%) and general surgery led. Only half were planned as recurring, sustained simulation programs, and most (60%) were newly introduced. 44% of primary care and 32% of first-level hospital essential surgical procedures, as defined by the Disease Control Priority Program (DCP3), important for graduates' surgical practice, are reported as taught by simulation. Only 15% of programs included non-technical skills and 14% had engineering collaboration.

Conclusions: There is need for surgical simulation in early SSA undergraduate medical training, trans-sectoral and interdisciplinary collaboration, and expansion to other African regions. Currently, there is a lack of published experience in simulation-based teaching of 65% of the DCP3-defined essential operations.



P-14 Research

Comparative Millennial and Generation Z Endoscopic Surgical Skills

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Introduction: Having been raised in contrasting backgrounds, Generation Z has developed surrounded by the internet, social media, artificial intelligence, and video games as opposed to Millennial. This augmented exposure could provide an advantage for Generation Z individuals over Millennials in the development of finer laparoscopic surgical skills when comparing both groups' performance. This study aims to demonstrate that Generation Z students surpass Millennial in performing laparoscopic surgical tasks.

Methods: Two comparative groups participated, 43 Millennial and 41 Generation Z students, respectively. A laparoscopic surgical task was completed by each student with the time taken to complete the task measured in seconds. The data obtained were analyzed using representative statistics, such as mean x, standard deviation, and maximum and minimum time. Chi-Square test analysis was chosen as the statistical method to compare surgical skills between groups. Mobile phones were integrated into Endoscopic surgical simulators and used as laparoscopes after being connected to a computing device.

Results: Generation Z performed the laparoscopic surgical task with the following results: X2 (Chi-square test) 10.86 and α (alpha) = 0.01, and a mean time of 107.40 seconds. Meanwhile, millennial students completed the task in a mean time of 146.09 seconds.

Conclusions: Generation Z's higher performance could be explained by their precocious exposure to technological advances. Overall, technology has provided teenagers with skills such as increased hand-eye coordination and visuo-spatial cognitive abilities that could potentially be of use in medical education, specifically benefitting surgical dexterity and facility within the field.

P-15 Research In-Progress

Augmented Reality Improves Time to Completion of Laparoscopic Peg Transfer by Surgical Residents

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University of North Dakota

Introduction: Augmented reality (AR) integrates computer-generated images into a real environment. Our goal was to determine if AR is feasible for use in surgical education. Our hypothesis was that residents would perform Fundamentals of Laparoscopic Surgery (FLS) tasks quicker with AR technology.

Methods: Research subjects are surgical residents at a university-affiliated community program in a rural state. Residents were asked to perform the laparoscopic peg transfer activity with manipulation of six plastic blocks according to a pattern that was displayed either in the AR glasses, or on a laptop computer screen positioned in a way that required them to turn their their heads behind them to view the pattern. Time to completion for Laptop vs. AR, and senior (PGY 4-5) vs junior (PGY 1-3) residents were compared with paired Student's t-tests. Errors including dropped blocks were assessed using the Fisher exact test.

Preliminary Results: Twenty-four residents participated in the study, 16 juniors, and 8 seniors. Mean time to completion for all residents was 104 ± 23 (SD) seconds for the laptop group vs. 90 ± 23 seconds for AR ($p<0.001$). Four blocks were dropped in the AR group and none in the laptop group ($p=0.57$). Junior resident mean time was 102 ± 25 seconds for laptop vs 93 ± 26 seconds for AR ($p=0.06$). Senior residents were significantly faster in the AR group (85 ± 17 seconds) vs laptop (105 ± 19 seconds) ($p<0.001$).

Next Steps: Overall, resident performance was faster in the AR group, supporting our hypothesis. This finding was significant for senior residents, and there was a trend towards faster times in the junior AR group, suggesting construct validity. This study demonstrates that AR use is feasible in surgical education. This has exciting possibilities for surgery and surgical education, with future directions exploring the use of AR glasses for provision of real-time instruction and feedback.

P-16 Research In-Progress

Automated Surgical Skills Evaluation Using RGB-D data in a Longitudinal Study

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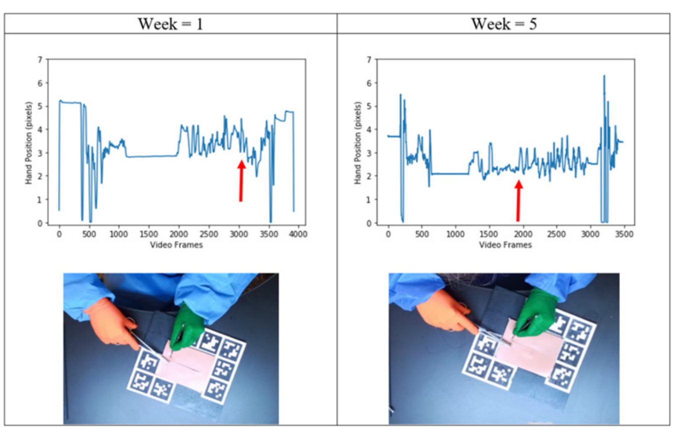
Introduction: Excellent surgical and microsurgical skills are critical to avoid morbidity and mortality in high stakes surgical patients. Gaining surgical skills requires significant practice and mentorship, yet opportunities to gain on-the-job surgical training are scarce. While administrative, legal, and ethical pressures understandably preclude exposure of surgical patients to novice surgeons on the steepest part of the learning curve, surgical training is negatively impacted. In addition, fewer medical training programs use live animal models in the delivery of medical education due to humane concerns and societal pressures and perceptions. As a result, development of non-living models and simulations is critical to advancement of surgical training in medical education. Evidence suggests that many highly technical skills may be acquired and refined outside of the operating arena through use of surgical simulations. Validation of any surgical simulation system is needed to ensure skills transfer to real-life surgical situations.

Methods: In this work, a validation methodology is presented based on examining how hand kinematic features are commensurate with experience level. A cohort of sixteen 2nd-year veterinary students participated in a longitudinal study, during which data were collected on completion of the 1st, 3rd, and 5th weeks of a suturing course.



An RGB-D camera recorded participants' lower arms during performance of suturing and knot tying tasks on a high-fidelity synthesized tissue model.

Preliminary Results: A less noisy hand position with more clear hand position cycles, indicative of better hand control, is observed after week 5 for 3 participants. The attached image shows hand position along the x-axis for one participant performing a suturing task. The arrows demonstrate snapshots of the corresponding frames.

Next Steps: Data from all participants will be analyzed using statistical methods to reveal correlations between kinematic features; i.e. instantaneous position, speed, and acceleration; and practice level.

P-17 Promoting Technology and Collaboration

High-Fidelity Simulation: A Perfused Cadaver Model to Teach and Practice Vascular Access, Control, and Repair

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Background: Increased utilization of minimally invasive and endovascular techniques as well as changes in the residency training environment have resulted in declining trainee experience with complex open surgical cases, particularly in vascular and trauma surgery. Low incidence and high mortality of major vascular injuries require trainees and practicing surgeons to improve and maintain their skills using high-fidelity simulation.

Technology Overview: Cadaveric tissue dissection is the most "realistic" model for surgical anatomy, particularly of major vascular structures. In our surgical dissection lab, we use cadavers combined with a pump system to achieve perfusion and thus maximal realism to practice access, control, and repair of major vascular structures. We trialed multiple pump systems, including centripetal, interrupted flow, and peristaltic methods prior to settling on a diaphragm roller pump design for this application. The valved and regulated design allows for establishment and control of pulsatile rate, stroke volume, and pressure using a closed-loop feedback control system. The result is realistic peripheral flow and venous return from proximal cannulation. The model uses retroperitoneal access to the aorta allowing for torso perfusion without disrupting anatomy in important junctional areas such as the groin. Figure 1 demonstrates femoral vessels before (1a) and after (1b) perfusion.

Potential Application in Surgical Simulation and Education: High-fidelity simulation for surgical and vascular anatomy is critical for trainees and surgeons in all operative specialties as well as clinicians in anesthesia (practice of airway management and vascular access), interventional radiology and cardiology, and pre-hospital personnel in both civilian and military settings. Perfused cadaver models also allow for practicing ultrasound-guided access to vessels, which is an invaluable skill for emergencies in the pre- and in-hospital setting.

Potential Opportunities to Collaborate: Successful establishment of a high-fidelity, pressurized cadaver model requires collaboration between surgeons of different specialties, engineers, and trainees. It promotes collaboration between in-hospital and pre-hospital providers as well as providers in a civilian and military environment
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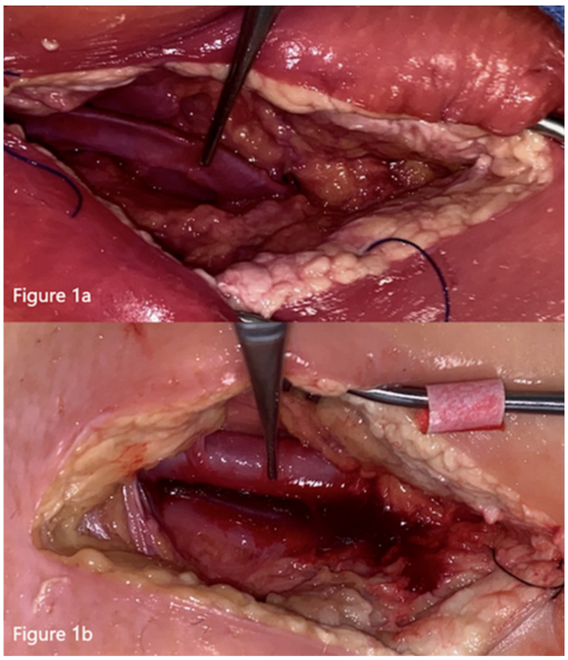

P-18 Promoting Technology and Collaboration

Virtual Reality Surgeon Training on Retropubic Midurethral Sling Procedures

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Background: The retropubic midurethral sling is one of the most common, most effective anti-incontinence surgeries. Current technique relies on estimating angles using external anatomic landmarks, sensing subtle pressure changes through tissue, and blindly passing trocars in the neurovasculature-rich retropubic space. Even in experienced hands, this can result in a 13% complication rate. Typically, training involves apprenticeship in the operating room on live patients, or expensive cadaver labs, which are limited by distortion of anatomy after multiple passes of the trocars. Given this “blind” nature, a VR training system improves surgeon visualization acuity, allows for multiple no-risk training exercises, provides real-time feedback on the proper insertion pathway, and potentially reduces complications.

Technology Overview: We present a first prototype produced by our multidisciplinary team (medical & engineering) that introduces: (1) Virtual Reality (VR) environment for surgeon training, (2) exact 3D virtual anatomical models of each patient, and (3) haptic and visual notifications regarding the progress of the procedure. The framework consists of employing AI algorithms on anonymized patient data to model the 3D virtual anatomy of each individual patient. Having constructed the main anatomical landmarks (bladder, blood vessels, pelvic bone), we integrate the model along with a 3D design of surgical tools and Operation Room (OR) settings in the finalized VR environment. Surgeon training is based on maneuvering the haptic device handle through the virtual environment (Figure 1). Haptic and visual notifications are provided to the user depending on the divergence from the optimal tool path through the anatomy.

Potential Application in Surgical Simulation and Education: This framework is generalizable for a wide range of urogynecologic procedures, such as vaginal hysterectomies and transvaginal prolapse surgeries, since it overcomes the lack of direct visibility inherent in pelvic floor operations. Subsequent iterations of the prototype will include predictive AI-driven guidance, which further enhance the dynamic and cost-effective character of the system.

Potential Opportunities to Collaborate: This collaboration between surgeons and engineers extends naturally to other subspecialties addressing blindly passed instruments requiring haptic feedback in neurovascular-rich anatomy

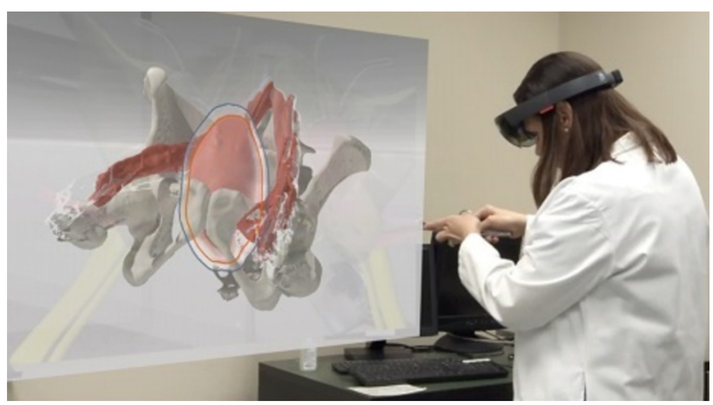

Figure 1. Virtual surgeon training for Retropubic Mid-Urethral Sling Procedures

P-19 Research In-Progress

Laparoscopic Surgery Telementoring as a Teaching Tool for Surgeons in Low- and Middle-Income Countries

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Introduction: Laparoscopic surgical education in low- and middle-income countries (LMICs) has been hindered by the limited presence of surgical mentors and basic equipment challenges. Our multidisciplinary team of surgeons, engineers, and global health experts designed the KeySuite laparoscopic system with telementoring functionality, costing < $200 suitable for surgical education and patient care in LMICs. KeySuite can be used for in-person and remote laparoscopic training of LMIC surgeons through a telementoring approach.

Methods: The KeySuite system includes a low-cost, durable single-unit laparoscope (KeyScope) and variable-sized mechanical retractors (KeyLoop) for gasless lift laparoscopy. The KeyScope has an integrated camera that can be powered by and displayed on a laptop computer. Our custom KeyScope software has video functionality for image/video capture, and the ability to allow for internet-based communication in real-time during surgery to allow for mentoring in LMICs.

Preliminary Results: KeyScope has comparable image quality to a commercially available laparoscope at shorter working distances. The custom software is designed to permit real-time, peri-operative telementoring for LMIC surgeons through interactive video sharing that can be used to observe procedures and provide feedback. The software also facilitates post-operative image and video saving and sharing for educational discussions.

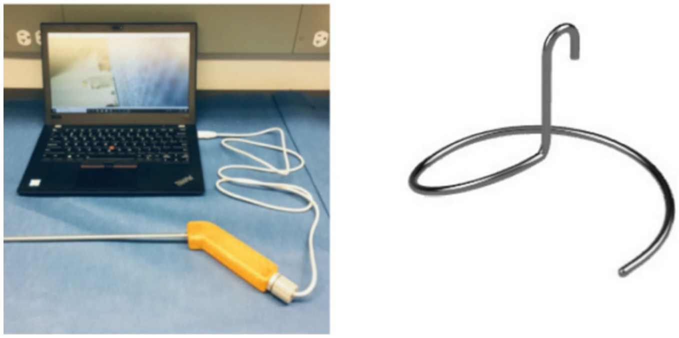

Figure. Components of KeySuite system—KeyScope connected to a laptop (left) and the KeyLoop retractor (right)

Next Steps: Surgical education in LMICs is limited by the lack of infrastructure and paucity of available mentors. Hence, KeySuite-based telementoring is a viable alternative that connects surgical mentors in the United States to surgical trainees in LMICs. Through continued device testing, we aim to commence telementoring and education of surgeons and residents in Uganda. The portable low-cost KeySuite system is well-suited to educate future laparoscopic surgeons in low-resource surgical operating rooms

P-20 Research

Efficient Assessment of Surgical Maneuvers: Human verses Machine

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Introduction: Human observers cannot detect and track technical performance the way computers can. In this study, we trained an algorithm to automatically identify gestures in surgery.

Methods: Thirteen attending surgeons and eleven medical students performed a suture task on our variable tissue simulator. They placed 3 interrupted instrument-tied sutures on two opposing pieces of material. Each participant performed the task 4 times and a total of 96 videos were analyzed. Six Surgical gestures were defined: G0 - nonspecific motion, G1 - Needle passing, G2 - Pull the suture, G3 - Instrumental tie, G4 - Lay the knot G5 - Cut the suture. For the automatic gesture recognition, a 3D Resent -18, was trained and its output was fed to Long Short-Term Memory (LSTM) unit. Networks were trained in a 5-fold cross validation manner.

Results: The system achieved a frame wise accuracy of 75.7±4.7%, frame wise F1 of 69.2±5.6, F1@10 of 64.6±3.8 and Edit distance of 55.7±2.6. All the gestures, except for G5, took the medical students significantly longer. Detailed analysis revealed that gestures G0 and G1 took the students approximately 1.9 times longer than the surgeons ($p < 0.05$), gestures G2, G3 and G4 took approximately 1.5 longer ($p < 0.05$). There was no significant difference for gesture G5.

Conclusions: It is well established that attending surgeons are faster than medical students, however this evaluation is typically provided as a global, time-based metric for the full task or procedure. In this study, using automatic gesture analysis, we were able to analyze time differences on a gesture level. We identified that two specific gestures (nonspecific motion and needle passing) accounted for the largest delays in the students' performance. Thus, automatic analysis of gestures may provide the trainees with more specific, and actionable information regarding their performance as well as reduce the time and effort required from experts for providing feedback.

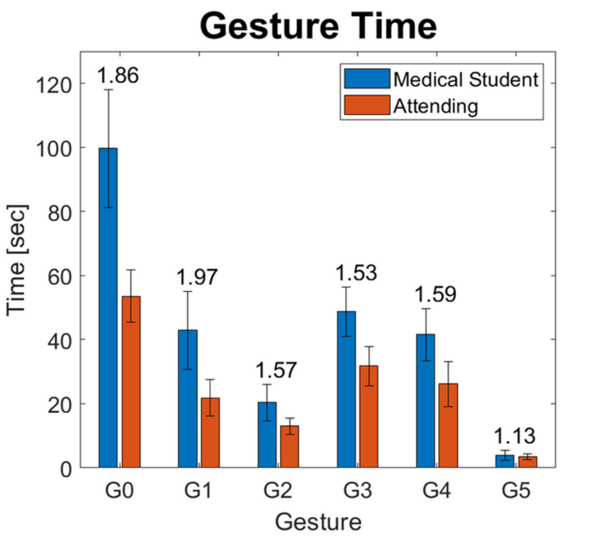

Figure 1: Total Time per Gesture by Training Level. Number above bar indicates the ratio between the gesture time of the medical student and the attending.

P-21 Research In-Progress

Designing a Full Procedural Simulator for Central Venous Catheterization

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Introduction: Central venous catheterization (CVC) involves four key steps: preparation, aseptic technique, needle insertion, and catheter placement. Doctors who have performed this procedure less than 50 times are twice as likely to incur an error - demonstrating a need to rethink training. The state-of-the-art training method is the Dynamic Haptic Robotic Trainer (DHRT) which provides training on patient anatomical variability through simulated ultrasound, haptic feedback, and a personalized graphical-user interface (GUI). While this system has been shown to have benefits over traditional training methods, it does not address all four key steps of CVC.

Methods: A whole procedure DHRT+ prototype was created including a CVC medical kit, a false vein channel, and a personalized GUI to focus on CVC training from start (patient consent) to finish (suturing and monitoring). Two rounds of interviews were conducted on the prototype. The initial interviews with 10 experts included a pre-survey on attitudes and perceptions of simulation, a demonstration of a medium fidelity GUI prototype, a semi-structured interview, and a post survey comparing the demonstrated system to existing methods. A second set of interviews with 6 experts was conducted following the development of a high-fidelity prototype using Blender 2.79 and incorporating physical elements based on the first round of interviews using the same procedures.

Preliminary Results: Ninety percent of doctors from the initial interviews and 100% from the second round indicated that the DHRT+ would be more useful for acquiring an understanding of best practices over current training methods and either strongly agreed or agreed that the simulator was an improvement over existing methods. All of the participants indicated that they would encourage their residents to train on this simulator when available.

Next Steps: The DHRT+ system was deployed in summer 2021 to train 22 surgical residents. Prototype iterations and development are ongoing

P-22 Research In-Progress

Development of a 3D User Interface for Twin to Twin Transfusion Syndrome Surgical Simulator

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Introduction: Monochorionic diamniotic twins occur in approximately 1 in 300 pregnancies, of which 15% suffer from Twin-to-Twin Transfusion Syndrome (TTTS), with a fetus mortality rate of 85% when left untreated. Fetal laser ablation (FLA) is a minimally invasive treatment for TTTS with a 70% survival rate. Currently, TTTS training focuses on procedural training while lacking the ability to practice navigating the womb or identifying problematic vessels safely. Simulators can offer a safe realistic environment to develop the necessary skills to perform this procedure. In this paper, we present a simulator for FLA training that consists of a virtual environment and four degrees of freedom 3D printed low-cost haptic interface.

Methods: The TTTS 3D user interface (3DUI) consists of a haptic interface that captures the movements made by the trainee operating the fetoscope. The TTTS 3DUI provides vibrotactile haptic feedback cues when navigating in the virtual womb and is connected to a virtual simulator that provides spatial-visual feedback to perform the procedure. The TTTS 3DUI employed a 3D printed spherical flexure joint to map the real fetoscope movement into the simulation. The mechanism captures position and orientation information through a triple-axis magnetometer, accelerometer, and gyroscope sensor. Face validity was tested with an expert surgeon and 3 trainees.

Preliminary Results: The preliminary face validity test showed that the simulator accurately replicates the experience of performing the real-life procedure. Participants suggested the simulator has adequate realism for the training of the FLA procedure. Particularly the functionality and realism of the virtual environment were highlighted as the simulator strengths.

Next Steps: The next steps include incorporating force feedback into the simulator and increasing the number of placentas with different vessel connections in the virtual environment. In addition, we will test the content validity of the simulator using simulator-generated metrics and its capacity to help master the FLA skill..

P-23 Promoting Technology and Collaboration

Augmented Reality for Improving Operative Performance of Surgery Residents

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University of North Dakota School of Computer Science and Electrical Engineering, Grand Forks, ND; University of North Dakota School of Medicine and Health Sciences, Grand Forks, ND

Background: Recent advances made in Augmented Reality (AR) technologies are offering many potential applications in medical education and, specifically, surgical training. AR will not only further the acquisition of knowledge, but also creativity and imagination by transforming the way educational content is delivered.

Technology Overview: There is evidence in support of the potential benefits of AR in surgical training by improving task performance of required surgical skills in an efficient way. However, the research done to improve the AR technology towards this use is limited as challenges have been faced with implementation of AR into surgical training. Several types of AR glasses have been tested, and due to a number of factors the AR Vuzix system was chosen as being best suited for our application.

Potential Application in Surgical Simulation and Education: In an operating room, surgeons may have to look at multiple separate screens to see visual information regarding the procedure, leading them to stop the procedure or turn away from the patient. AR technology can provide residents with an efficient tool that projects selected required or supplementary visual information for a procedure in line with task performance, with potential to help them focus and perform more efficiently.

Potential Opportunities to Collaborate: Currently, computer scientists from the School Of Electrical Engineering and Computer Science (SEECS) at the University of North Dakota (UND) in Grand Forks, ND are working with surgeons from Altru Hospital in Grand Forks, ND and Sanford Medical Center in Fargo, ND to implement an AR-distributed platform to employ the AR Vuzix technology in training facilities where UND surgery residents perform operative procedures in cadaveric and Fundamentals of Laparoscopic Surgery (FLS) models. With continued collaboration between engineers and surgeons, we intend to transition this work into the operative setting.

P-24 Challenges in Surgical Education

Education Led Technology Versus Technology Led Education

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Background: Educational technology (ET) has offered significant educational tools for surgery. Procedure based education and training have used technology considerably. The common example is simulation. Technology of simulation and the practice of simulation have been advancing continuously and providing increasingly important and broader training. However, there is a common practice of using technology where it fits in education rather than where it is needed and for specific educational goals.

Current Challenges: ET has been implemented in fields of education with limited background and experience in the educational principles and learning theories. Many applications of technology took the form of mere tools for education such as delivering information or communicating. A common example is transforming books into digital formats or video recording educational events. While these applications are advantageous, they represent a narrow spectrum of the advantages that technology can offer to education. The main reason for this limited use is the scarcity of experience in ED among educational practitioners and the insufficiency in using learning theories to implement technology in education.

Need of Innovation: ED can be used efficiently to teach at a large scale, teach in unusual circumstances (such as the current pandemic), adapt to continuous educational demands, and achieve educational goals that cannot be met with the traditional educational approach. The application of ET must be carefully selected and designed for educationally effective use. We recommend parameters that can be used to evaluate how effective the use of technology will be. These parameters include focusing on the learning process rather than materials, meeting specific educational needs, performing complex task precisely, achieving automaticity, and using hydride learning. Ultimately, the value of ET is determined by how well it informs and facilitates learning and clinical expertise development

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P-25 Research

Self-Determination of Aptitude in Surgical Specialties: Assessing Contributing Factors to Fine Motor Skills in Preclinical Medical Students

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Introduction: It is still uncertain if particular activities or hobbies can be significant contributors to improving dexterity skills that would lead to better surgical aptitude. The main objective of this study was to investigate if students' prior exposure to activities such as painting, playing sports musical instruments, videogames or sewing would influence their surgical simulation scores. Then, to determine if their aptitude perceptions towards a surgical career was supported by their performance on the simulation.

Methods: A cohort of 40 preclinical medical students participated in laparoscopic task simulation study where they were scored on their performance on standardized tasks. They completed a pre- and post-task survey where self-rated their performance, described their participation in activities that require dexterity along with their interests in pursuing a career in surgery. Data was evaluated by modeling to detect associations between their performance and their survey responses.

Results: Findings show that the type of activity is influenced enormously by the age at which they start practicing it. Students who started painting in their life had an advantage on surgical performance in the simulator. However, the participation in sports in later life showed the opposite effect. Videogames did not show any association. Student's rating of their performance and interests in a career in surgery showed that although they can rate their ability correctly, their performance is not enough to persuade their specialty interest into or out of surgery.

Conclusions: There are activities that can provide an advantage to improving surgical skills in a simulator, but this advantage can be complex and may be related to the stage of development of the participant. Also, this study shows that medical student's interest in can be deeply engrained and that an objective assessment of their skill is not likely to persuade them in the decision to pursue a career in surgery

P-26 Research

A Gap in Literature Still Exists: A Scoping Review of the Impact of Video Gaming on the Development of Laparoscopic Surgical Skills

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Introduction: Video games (VGs) are an emerging educational training modality. However, due to methodological differences in current literature, there is a paucity of consensus on VGs' impact in laparoscopic surgery (LS). This study explores peer-reviewed articles published in the last 10 years and provides insight to VG impact in LS skill development, both technical and non-technical.

Methods: A review adhering to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (PROSPERO ID: 275417) was performed, searching electronic bibliographic databases (Pubmed, Europe PMC, Scopus, Cochrane, Science Direct, CINAHL, Embase, ClinicalTrials.gov, Academic Search Complete, Gale One File, Epistemonikos, WorldCat, and MedRxiv) from January 1, 2010 to July 15, 2021. Articles detailing the use of VGs in the context of LS among surgical residents were included. Articles not written in English and articles without the specific gaming console (e.g. Nintendo DS, Playstation 2, Xbox 360, etc.) were excluded. Eligible studies were assessed using the Joanna Briggs Institute critical appraisal tools.

Results: A total of 1,375 study participants from 19 articles were included, the majority had no prior gaming experience (66%). Most studies focused on curriculum development (68%), teaching methods (53%), and utilized haptic technology (31%), virtual reality (21%), Nintendo Wii-U (32%), or Nintendo Wii (15%). The majority of studies focused on technical LS skills, such as objective completion time (68%), object positioning (32%), and object manipulation (42%). However, very few included non-technical LS skills such as motivation/engagement (16%), problem recognition and solving (5%), teamwork (5%), communication (5%). No study focused on the impact of VGs on resident's confidence during surgery, and none focused on patient safety.

Conclusions: Surgical education has primarily focused on technical skills and manual dexterity. However, there has been a lack of focus on teamwork and problem solving skills. Further studies are needed to explore the application of gaming on laparoscopic surgical training in regard to non-technical skills such as communication, teamwork, and motivation, as well as overall patient outcome

P-27 Challenges in Surgical Education

Telesimulation Designed for Undergraduate Students of Surgery: Delivering High Quality And Accessible Clinical Teaching Strategies without Reinventing the Wheel

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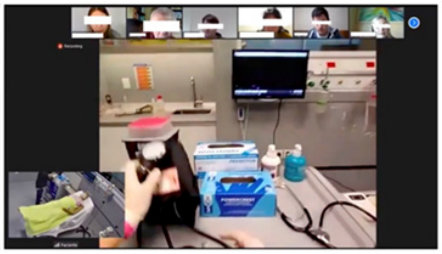
INSPIRE Simulación Femeba

Introduction: The current COVID-19 pandemic challenged clinical teaching by affecting the normal development of face-to-face activities including simulation center´s activities. Even more, simulation came up with some restraints about accessibility.

Current Challenges: Solutions are needed to help mitigate these effects, making clinical practice more accessible and affordable, especially in low and middle income countries.Idle simulation center resources and low cost avaliable software are some strengths and opportunities to reshape the way we deliver clinical teaching in a more efficient and fully interactive manner.

Need of Innovation: High-fidelity telesimulation using web meeting platforms that allow students to experience and analyze critical situations and plan solutions is possible. As a learning opportunity favors clinical teaching. As a communication and information technology, although it can achieve high fidelity and improve accessibility to simulation as a learning tool, it cannot neglect the technical and technological aspects in both sides (teachers and students) that can alter the course of it



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Meeting participants have asked for exhibitor involvement.
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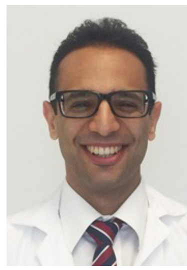

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Thank you for attending

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VISIT *https://www.surveymonkey.com/r/SIMSEM_2022*
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We offer you our sincere thanks for attending this meeting and we hope you have gained beneficial insights and inspiration from this dialogue and activity.

We welcome your input.
Please contact **Gyusung Lee, PhD**, at glee@facs.org or 312-202-5782 with any questions, comments, and suggestions to benefit the planning of future meetings.

SAVE THE DATE! MARCH 1, 2023 *Swissôtel CHICAGO, IL*

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