WEDNESDAY,
MARCH 01, 2023

2023 ACS SURGEONS AND ENGINEERS:

A Dialogue on Surgical Simulation

PROGRAM BOOK

ACS Education
American College of Surgeons

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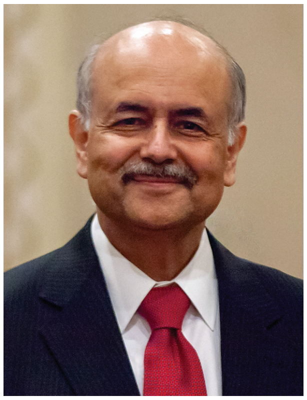
Welcome



On behalf of the American College of Surgeons (ACS) Division of Education, I would like to welcome you to the 2023 Annual Surgeons and Engineers: A Dialogue on Surgical Simulation Meeting. Given the success of past meetings for the last four years, including virtual meetings during the last two years due to the pandemic, we are very pleased to offer a full-day, in-person event this year. This will permit us to fully explore synergies between engineers, surgeons, scientists, healthcare professionals, and educators, to advance simulation-based surgical education and the use of state-of-the-art simulations and simulators.

Pierre E. Dupont, PhD, Edward P. Marram Chair and Chief of Pediatric Cardiac Bioengineering at Boston Children's Hospital and Professor of Surgery at Harvard Medical School, will deliver the Keynote Address entitled "Therapeutic Principles for Bridging the Surgeon / Engineer Culture Gap in MedTech." A special panel on how to build better surgical simulators will feature a surgeon educator, an academic engineer, and a simulator industry representative. The panelists include Gladys Fernandez, MD, Director of Education, Interim Associate DIO, GME, Assistant Program Director of Surgery, and Clerkship Director of Surgery at Baystate Health; Thenkurussi (Kesh) Kesavadas, PhD, Vice President for Research and Economic Development Executive Council at the University of Albany; and John Lenihan, MD, Chief Clinical Officer at Surgical Science.

From the high-quality abstracts received, the ACS Division of Education's Surgeons and Engineers Committee has selected nine abstracts for podium presentations and twenty-seven abstracts for poster presentations. Following these presentations, a workshop session will be convened on surgical simulation.

On behalf of the ACS Division of Education and the Surgeons and Engineers 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

Welcome from Program Chairs

On behalf of the Program Committee and the Division of Education of the American College of Surgeons (ACS), we welcome you to the *2023 ACS Surgeons and Engineers: A Dialogue on Surgical Simulation Meeting.* Previous meetings have received an overwhelming number of positive responses, so we are excited to offer a full day of activity, especially as an in-person meeting!

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. It is our hope that by attending, you will gain a better understanding of the multifaceted needs, challenges, and 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.

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:** *Therapeutic Principles for Bridging the Surgeon / Engineer Culture Gap in Med Tech*, Pierre E. Dupont, PhD, Boston Children's Hospital, Harvard.
- **Special Panel Discussion:** *How to Build Better Surgical Simulators*, a special panel of a surgeon educator, an academic engineer, and an expert from the surgical simulator industry.
- **Oral and Poster Presentations:** Our oral and poster presentations will shed light on the multifaceted collaborations between surgeons and engineers working together in research.
- **Afternoon Session:** Our afternoon session, which will be open to all meeting participants, will include a workshop on what, why, and how completing a Cognitive Task Analysis (CTA) is an essential step for simulator development.

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 us to ensure the success of this and future meetings.

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 Dept.
University College London, UK

Agenda

All times listed are Central Time. The schedule is subject to change.

Wednesday, March 1

8:00–8:15 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*
8:15–9:25 am	**Keynote Address** **Therapeutic Principles for Bridging the Surgeon / Engineer Culture Gap in MedTech** Pierre E. Dupont, PhD, *Boston Children's Hospital, Harvard*
9:25–10:35 am	**Special Panel: How to Build Better Surgical Simulators** Ahmed Ghazi, MD, FEBU, MHPE, *University of Rochester Medical Center* Kesh Kesavadas, MS, PhD, *VP for Research and Economic Development, University of Albany* John Lenihan, MD, *MultiCare Tacoma General Hospital* Gladys Fernandez, MD, *Baystate Simulation Center*
10:35–10:50 am	Morning Break and Exhibitor Visit
10:50 am–12:00 pm	Abstract Presentation 1
12:00–1:00 pm	Lunch and Exhibitor Visit
1:00–2:30 pm	**Cognitive Task Analysis Workshop, An Important Step for Simulator Development—What, Why, and How?** David Hananel, BSEE, BACS, *University of Washington* Victoria Roach, PhD, *University of Washington*
2:30–3:30 pm	Poster Presentation
3:30–3:50pm	Afternoon Break and Exhibitor Visit
3:50–4:30 pm	Abstract Presentation 2
4:30–4:45 pm	Suggestions for the 2024 Meeting
4:45–5:00 pm	**Closing** Ajit K. Sachdeva, MD, FACS, FRCSC, FSACME, MAMSE, *American College of Surgeons* Mandayam Srinivasan, PhD, *MIT and University College London* Gyusung Lee, PhD, *American College of Surgeons*
5:00–6:00 pm	Networking Reception

** Please note: The 2023 ACS Surgical Simulation Summit begins on the following day, March 02-04.*

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 Division of Education at American College of Surgeons. Dr. Lee obtained his training in academic laboratories as well as in clinical environments. Throughout his career, he has performed sponsored research studies both independently and within teams and championed the development and execution of various surgical education programs.

Dr. Lee 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. His dissertation research was an investigation of the mechanism of secondary injuries. After graduation, he completed his postdoctoral training in the motor control laboratory at Arizona State University, where he researched how joint coordination and control strategies are affected by the aging process and by Parkinson's disease. After his two years of postdoctoral 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 then 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 OR staff members assisting 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 Ph.D. degree in Mechanical Engineering from Yale University. Following postdoctoral 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.

Professor 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 have 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. 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 healthcare for underserved populations, novel robotic fingertips, and teleoperation systems for micro-/nanomanipulation capable of performing surgery on a single cell with micron precision.

The international impact of Professor 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 over 230 publications in multiple fields ranging from neuroscience to robotics that include some of the most highly cited papers on haptics. He has given over 130 invited talks all over the world, with many keynote or plenary talks in premier international conferences. Professor Srinivasan's work has attained broader social impact as well; he has been featured or quoted in print media such as *Scientific American, Time Magazine, The Wall Street Journal, The New York Times, Times of India, Pravda, and the Smithsonian Magazine*, as well as by worldwide radio and TV networks such as the 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 the V&A Museum in London.

Keynote Speaker

Pierre E. Dupont, PhD

Staff Scientist, Cardiovascular Surgery; and Chief, Pediatric Cardiac Bioengineering, at Boston Children's Hospital; Boston, MA

Pierre E. Dupont is Chief of Pediatric Cardiac Bioengineering and holder of the Edward P. Marram Chair at Boston Children's Hospital. He is also a professor of surgery at Harvard Medical School. His research group develops medical robots, implants, and imaging technology. He received the BS, MS and PhD degrees in Mechanical Engineering from Rensselaer Polytechnic Institute, Troy, NY, USA. After graduation, he was a Postdoctoral Fellow in the School of Engineering and Applied Sciences at Harvard University. He subsequently moved to Boston University, where he was a Professor of Mechanical Engineering and Biomedical Engineering. He is an IEEE Fellow, a former Senior Editor for *IEEE Transactions on Robotics*, and a member of the Advisory Board for Science Robotics.

Panelist

Kesh Kesavadas, PhD

University of Albany

Kesh Kesavadas, PhD, was the founding director of the University of Illinois Urbana-Champaign's Health Care Engineering Systems Center (HCESC), the largest endowed center in the University of Illinois system. In the center he managed research, IP and commercialization, data warehouse management (HIPAA), regulatory affairs, IRB and human subject protocols, student exchange, graduate programs, external partnerships, government relations, and more. HCESC has 186 members and affiliates. The Center collaborated and funded research in engineering, social and behavioral sciences, education, applied health sciences, medicine, and veterinary medicine. Twenty research laboratories and institutes, and affiliated hospitals, including Mayo Clinic, are supported through the program.

A professor of Industrial and Enterprise Systems Engineering, Computer Science, Electrical and Computer Engineering, and a member of the inaugural faculty of the Carle-Illinois College of Medicine, Dr. Kesavadas was named a distinguished University Presidential Executive Leadership Fellow in 2019. Dr. Kesavadas previously served as a faculty member at the University at Buffalo, where he advanced his research interests in medical robotics, virtual reality/augmented reality in healthcare, manufacturing automation and design of systems. Dr. Kesavadas received his B.Tech degree in Mechanical Engineering from the University of Calicut, India in 1985, his M.Tech degree in Aircraft Production Engineering from the Indian Institute of Technology, Madras in 1987, and his Ph.D. in Industrial Engineering from The Pennsylvania State University in 1995.

John Lenihan, MD

MultiCare Tacoma General Hospital

John Lenihan, MD, is an OB-GYN physician who has specialized in minimally invasive Gynecologic surgeries for over 40 years. He was a very early adopter of laparoscopic hysterectomies, performing his first cases in 1991, and he performed one of the first robotic hysterectomies in the USA in June 2005. He has lectured at many professional society and international meetings on robotic surgery and was an original Intuitive Surgical GYN Epicenter Surgeon. He also has a strong background in aviation and simulation, having graduated from the U.S. Air Force Academy and serving 23 years in the U.S. Air Force. He was on faculty at the University of Washington School of Medicine as a Clinical Associate Professor and has published many peer-reviewed journal articles as well as authored several book chapters on robotic surgery.

Dr. Lenihan left his clinical practice in 2018 to join Mimic Simulation in Seattle, WA, which was acquired by Surgical Science in January 2021. His current role is a Clinical Consultant to Surgical Science and other surgical robotic companies, and he is helping them to develop the next generation of robotic and minimally invasive proficiency-based surgery simulation training curriculums.

Gladys Fernandez, MD

Baystate Simulation Center

Gladys Fernandez, MD, completed undergraduate Bachelor's degrees in Chemistry, Anthropology, and Sociology at Florida International University in Miami, Florida and then received her Medical Doctorate from Tufts University School of Medicine in Boston, Massachusetts. She completed surgical residency at Baystate Medical Center in Springfield, Massachusetts where she has remained in several roles dedicated to undergraduate, graduate and continuing medical education. At present, in the Department of Surgery, she is Assistant Program Director in Surgery at UMMS-Chan-Baystate Medical Center and Clerkship Director for Undergraduate Medical Education. Institutionally, she is Interim Associate Designated Institutional Official for the Office of Healthcare Education and Medical Co-Director of the Baystate Special Pathogens Unit, a designated state Ebola Treatment center. Within the institution managing hospital-based simulation programs, she is the Director of Simulation Education for the Baystate Simulation Center and Goldberg Surgical Skills Laboratory, a Level I ACS-accredited Comprehensive Education Institute. She holds positions on the ACS Education Institute's Curriculum Committee (newly appointed Vice-Chair), the ACS/ASA Education Collaborative Group (member) and the ACS Simulation Surgical Educator Certification Advisory Committee (member).

Dr. Fernandez has dedicated her education and research endeavors toward curriculum development and implementation, assessment and remediation practices, macrosystem simulation, and faculty development in feedback and debriefing.

Oral Presentation Abstracts

O-1 Research in Progress

Eye-Tracking and Artificial Intelligence Technology for Enhanced Surgical Training: Assessing the Role of Joint Visual Attention in Resident Competency for Minimally Invasive Surgery

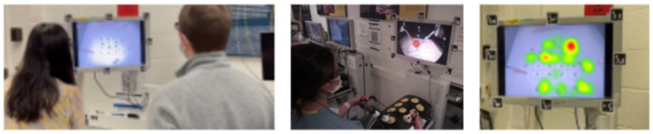
Noor Alesawy; Taylor Kantor, MD; and Vitaliy Popov, PhD
University of Michigan, Ann Arbor, MI

Introduction: The highly symbiotic relationship between attending and trainee surgeons is crucial for minimally invasive laparoscopic and robotic surgery training because it requires residents to find a delicate balance between managing the high cognitive load of the surgical operation coupled with visuo-spatial coordination with the attending surgeon. We draw on previous efforts examining eye-tracking affordance for assessment and training, known as Joint Visual Attention (JVA - when individuals are looking at a common target jointly). Our hypothesis is that higher levels of JVA can be detected in residents with higher assessment competencies, thus, JVA may be used as a surrogate marker of resident "readiness" or preparedness.

Methods: Residents and attending surgeons at the University of Michigan were asked to wear eye-tracking glasses to record visual attention during Fundamentals of Laparoscopic Surgery (FLS). JVA is measured by computing the number of times that participants' gazes are in the same radius in the scene within a 2 second time window then compared with a scoring system developed to analyze competency of the FLS task performed and resident training logs documenting total number of prior practice attempts.

Preliminary Results: The PI team has done substantial prior work on the project including a series of simulation and operating room observations with eye tracking data collection, and an interview study understanding both surgeons' needs and challenges with intra-operative coordination, teaching, and learning. If validated in the simulation training setting, this technology could further be utilized in a series of minimally invasive surgical procedures.
Next Steps: Our ultimate goal is to improve patient safety and health outcomes by training surgeons around complex real-world team situations by employing innovative technology and novel assessment methods. This has exciting possibilities for surgical education, as the

Figure 1: A panel of screenshots from the pilot study at the CSC showing overlaid attending point of gaze (green) and residents' gaze



O-2 Promoting Technology and Collaboration

Using Virtual Reality Performance Data to Power and Inform Intraoperative Performance Analysis

Anand Malpani, PhD; Jeff Berkley, PhD; and Mark Brentnall
Surgical Science, Mimic Technology, Seattle, WA

Background: Virtual reality (VR) simulation-based training has proven benefits. Automated metrics for skill assessment is one of its advantages. However, VR training is less effective without targeted, deliberate practice and personalization for the learner. At the same time, sensor technologies and artificial intelligence are being validated to automate performance analysis in the real world setting of the operating room (OR). The rich information available within VR simulators, when combined with intraoperative analytics, can transform surgical performance review.

Technology Overview: Beyond summative performance metrics, data extracted from the VR environment can provide additional information. Such data includes 2-D or 3-D images, pixel labeling of objects within these images, motion information about virtual objects like instruments and needles, events like collisions and drops, and more.

Potential Application in Surgical Simulation and Education: We present two ways VR simulation data can boost intraoperative analysis of surgical performance. Firstly, the increasingly realistic modeling of graphics and physics provides a sandbox for generating data that can train machine learning algorithms to analyze real world data from the OR. This is called "synthetic data" in the broader AI community. For example, automatically annotated image datasets can be exported from a VR simulation scene, instead of relying on human annotations of instruments, anatomy, and other objects. Secondly, the increasing breadth of surgical skills training provides a programmable tool to tailor the learning of the user by using their performance analytics from the real world (OR). For example, an intraoperative analysis showing poor performance on a skill, say sharp dissection, would generate a personalized recommendation of sharp dissection VR exercises for lab training.

Potential Opportunities to Collaborate: Researchers interested in developing AI for surgical video analysis can partner up with those developing VR simulation to validate the use of synthetic data in for applications like anatomy detection in images. Likewise, researchers studying intraoperative surgical performance data can collaborate with researchers interested in enhancing the VR simulation experience to enable closed-loop training (from OR to VR to OR).

O-3 Research Abstracts

Justification of Shoulder and Back Support Exoskeletons for Minimally Invasive Surgeons and Operating Room Nurses to Reduce Musculoskeletal Symptoms

Alec J. Gonzales; Dechristian Barbieri, PhD; Alfredo M. Carbonell, II, DO FACS; Anjali Joseph, PhD, EDAC; Divya Srinivasan, PhD; and Jackie Cha, PhD
Clemson University, Clemson, SC; Prisma Health-Upstate, Greenville, SC

Introduction: Due to the physical demands of their daily duties, many surgical care team members, especially surgeons and nurses, experience musculoskeletal symptoms (MS). Subsequently, technological interventions such as exoskeletons have been evaluated to help mitigate the development of MS. In order to identify where exoskeleton support may be the most beneficial, it is important to understand the varying work demands of these surgical team members. Considering these dynamic work demands, the goal of this study was to identify where exoskeleton support may have the largest influence on reducing high work demands in surgical teams.

Methods: Seven minimally invasive bariatric surgeons and seven operating room nurses completed surveys to understand MS prevalence. The participants completed the International Physical Activity Questionnaire (IPAQ), an adapted Nordic Musculoskeletal Questionnaire, and answered questions regarding tasks that lead to pain.

Results: IPAQ metabolic equivalent (MET) results show surgeons (116.4 MET-min/week), and nurses (190.9 MET-min/week) were classified as having low levels of overall physical activity. For surgeons, the most common area of MS was reported in the neck and shoulders while nurses most commonly reported MS in the shoulders and lower back. Surgeons' self-reported that the tasks that contributed to areas of pain were leaning forward during surgical procedures and awkward postures that stem from manipulating laparoscopic tools. Nurses' self-reported pain was attributed to patient positioning, lifting, and pulling.

Conclusions: Based on self-reported pain and task results, surgeons may benefit from back- and shoulder- support exoskeletons while nurses may benefit from back-support. However, due to the different areas of pain, and dynamic work tasks, it is still unclear which exoskeleton support is most needed for surgeon populations. Future steps would be to objectively quantify which exoskeleton would be most helpful to justify the implementation of exoskeleton use for minimally invasive surgeons and operating room nurses.

O-4 Promoting Technology and Collaboration

Transdisciplinary Development of a Virtual Reality Training System for Retropubic Sling Teaching

Lauren Siff, MD, FACOG, FACS, FPMRS; James Thomas, PhD; Jason Arhin; Sandun Bandara; Milos Manic, PhD; and Lewis Franklin- Bost, MBA, IDSA, FAIMBE
Virginia Commonwealth University, Richmond, VA

Background: Retropubic Mid-Urethral Slings are surgically placed by estimating insertion angles using external anatomic landmarks, sensing subtle tactile changes through tissue, while passing trocars in the neurovascular-rich retropubic space. The "Blind" nature of this technique, even in experienced surgeons' hands, can result in up to 13% complication rate. Surgeons are typically trained via an apprenticeship on live patients; static models, or, if available, cadaver labs which carry expense, often require travel, time away from work, and are technically limited by the distortion of anatomy after multiple uses. To develop a new innovative training method, a transdisciplinary team of surgeons, engineers, physical therapists, and programmers was assembled within Virginia Commonwealth University. Our resulting unique Sling VR system with haptics feedback and competency scoring addresses challenges in surgeon training.

Technology Overview: Our objective was to develop a low-risk, cost-effective method to teach surgical procedures that require learning by feel and high-volume pattern recognition. An initial clear development plan was developed including required expertise, resource availability, and communication schedule. Computer scientists developed artificial intelligence algorithms for deidentified MRI and CT images to provide high accuracy of anatomy in a 3D VR model. The system detects the surgeons' relative position to the pelvis, bladder, and major blood vessels. A programmer and motor control scientist (PT) from our LEVR (Launching Excellence in Virtual Reality) center integrated high-resolution haptic and visual alerts to provide the surgeon with real-time feedback when approaching at-risk anatomy and generate a competency score. Multiple surgeon trial sessions provided feedback during the iterative development steps.

Potential Application in Surgical Simulation and Education: This will be the first non-cadaveric, non-static model available in the field. It can aid in developing trainee competency, improving patient safety and decreasing perioperative complications.

Potential Opportunities to Collaborate: Efficient communication and coordination across multiple specialties, university departments, and colleges has enabled development of an operational prototype system for demonstration and broader surgeon evaluation. The system has implications to other urogynecologic transvaginal operations and potentially additional "blind" procedures.

O-5 Research Abstracts

Objective Metrics Based on Hand Rotation for Vascular Suturing Skills Assessment

Amir Mehdi Shayan; Simar Singh; Jianxin Gao; Richard Groff, PhD; and Ravikiran Singapogu
Clemson University, Clemson, SC

Introduction: Suturing is a basic yet vital part of vascular surgery that requires excellent cognitive, sensorimotor, and technical skills critical for managing delicate vasculature. This study explores the value of rotational motions along the hand-roll axis for skills assessment on a radial suturing task patterned after the Fundamentals of Vascular Surgery curriculum. 99 subjects at various skill levels completed four trials with 12 interrupted sutures per trial in two conditions (superficial and deep) on a clock face pattern affixed on a bench-top suturing simulator.

Methods: The dataset consisted of 4675 sutures [393 trials: 146 from attending surgeons and fellows, 122 from residents PGY1-5, 125 from students]. Four gyroscope-based suturing performance metrics were used: 1) average number of rotational hand motions, 2) average range of rotations, 3) log dimensionless jerk (LDLJ), 4) spectral arc length (SPARC). All metrics were computed from the roll axis of the gyroscope data during active suturing cycles of each trial. Segmentation of each suture cycle was done automatically from needle entry to exit based on the feedback of a camera placed at the simulator bed.

Results: Mann-Whitney U tests were used to investigate if metrics demonstrated significant differences between skill levels (Table I). All four metrics were able to differentiate between surgeons and students. The number of rotational hand motions metric showed a significantly greater economy of rotational motions between surgeons vs. residents and between residents vs. students. The range of rotational hand motions metric was able to differentiate between both the surgeon and resident groups vs. students. LDLJ demonstrated significantly better rotational smoothness for surgeons in comparison to residents and students, respectively.
SPARC showed a significant difference between students vs. the other two groups.

Conclusions: Overall, metrics quantifying hand roll during suturing used in this study demonstrated the ability to differentiate between surgeons/fellows, residents, and students. As such, there is value in using gyroscope-based metrics for suturing skills assessment which holds promise for finer grade comparisons between surgeons, residents, and medical students.

Table I. P-values from Mann-Whitney U test comparisons of gyroscope- based metrics.

Populations/ Metrics	Num of Discrete Rotational Hand Motions	Avg Range of All Rotational Hand Motions	Avg Rotational LDLJ-V on the Roll Axis	Avg Rotational SPARC on the Roll Axis
Surgeons vs. Residents	7.6e-05	0.065	0.0015	0.055
Surgeons vs. Students	5.6e-23	3.2e-16	0.0012	8.7e-14
Residents vs. Students	1.04e-12	4.7e-13	0.85	3.4e-09

O-6 Research Abstracts

Developing Artificial Intelligence Models for Medical Student Suturing and Knot-tying

Video-Based Assessment and Coaching

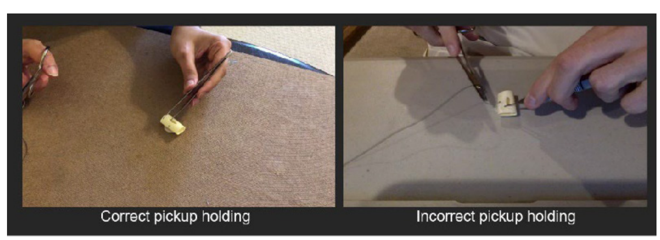
Ganesh Sankaranarayana, PhD; Babak Namazi, PhD; Madhuri Nagaraj, MD, MS; and Daniel J. Scott, MD FACS
UT Southwestern Medical Center, Dallas, Texas

Introduction: During COVID-19, the in-person suturing curriculum for our second-year medical students was adapted to an at-home video-based assessment model, which required the need for an automated assessment and feedback tool. We aimed to use artificial intelligence to develop an assessment as well as error based formative feedback tools for our curriculum.

Methods: Second-year medical students were asked to submit a video of a simple interrupted knot on a penrose drain with instrument tying technique after self-training to proficiency (performing the task under two minutes with no critical errors). Videos were manually annotated with a pass-fail grade and 9 steps of the procedure. We developed and trained two deep learning models to identify improper instrument hold and improper knot-tying. For instrument holding error, 16 frames were randomly selected from the "Needle loading and insertion" step of each video to train a Convolutional Neural Network (CNN). To identify knot- tying errors, a sequence of 64 consecutive frames (approximately 1 frame per second) from the knot-tying steps were used to train a 3D CNN. The inputs to our 3D CNN model were the calculated optical flow frames of each video.

Results: A total of 229 medical student videos were manually reviewed (150 pass, 79 fail). Of those who failed, critical error distribution was 15 knot-tying errors, 47 instrument-holding errors (Fig. 1) and 17 both errors. Task performance time in median [interquartile range] was significantly shorter for passing group at 53 seconds [43.25-64.75] as compared to the failing group at 62 seconds [51-76.5] (p-value <.01). A total of 216 videos were used to train the CNNs. A k-fold cross validation (k=10) was used for training and validation. The accuracy of the instrument holding error detection model is 88% with an F-1 score of 73%. For the knot-tying model, the accuracy is 89% with an F-1 score of 50%.

Conclusions: Using deep learning, we have developed a system for assessment and directed feedback to better acquire open surgical suturing skill.



O-7 Research Abstracts

Characterization of Surgical Movements as a Training Tool for Improving Efficiency

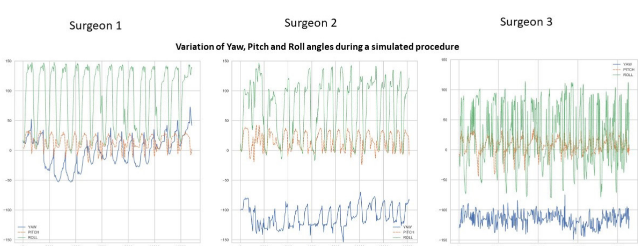
Rabin Gerrah, MD; Bunraj Grewal, BSc; and Ardeshir Kianercy, PhD
Good Samaritan Regional Medical Center, Corvallis, OR; Western University, Lebanon, OR; University of Arkansas, Little Rock, AR

Introduction: Surgical experience is often reflected by efficient, fluid and well calculated movements. For a new trainee, learning these characteristics is possible only by observation as there is no quantification system to define these factors. We analyzed the hand movement of surgeons with different experience level to characterize their movements according to experience.

Methods: Hand motions were recorded by an IMU (inertial measurement unit) mounted on the hand of 3 surgeons during a simulated surgical procedure. IMU data provided acceleration/deceleration and Eulerian angles: yaw, roll and pitch corresponding to hand motions as radial/ulnar deviation, pronation/supination and extension/flexion, respectively. These variables were graphically depicted and compared between 3 surgeons using time series analysis and dynamic time warping methods.

Results: Surgeon1 was the most and surgeon3 was the least experienced. The main motion of the hand during suturing, the roll motion, had the lowest range for surgeon1 and the greatest for surgeon3: 153, 164 and 194 degrees respectively. The video analysis revealed that surgeon1's low rolling range was complemented by maximal usage of their left hand that overall improved the economy of their movements. Acceleration in the x-axis, was highest for the experienced surgeon, 0.22 versus 0.09 and 0.07 m/s2 for surgeon2 and surgeon3.
Regularity of the movement sequences, (defined as variability between each repeating movement) was the highest for surgeon1 with no wasted moves, who also completed the task faster.
Time series analysis of the angular changes clearly signified the difference between the surgeons correlating precisely with experience.

Conclusions: Surgeon's hand movements can be easily characterized and quantified by an IMU device for automatic assessment of surgical skills. These characteristics graphically visualize the regularity, fluidity, economy, and efficiency. The characteristics from an experienced surgeon might serve as a training model and as a reference tool for trainees.



O-8 Research In-Progress

Evaluation of Mixed Reality (MR) Technologies for Remote Education and Training on Transrectal Ultrasound Biopsy (TRUS-Bx) Simulation: A Prospective, Randomized, Crossover Study

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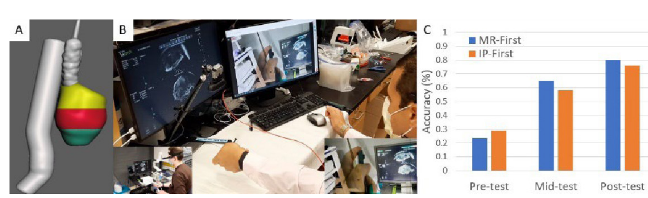
Introduction: Mixed reality (MR) superimposes two simultaneous video feeds enabling remote instruction directly onto a trainee's view. Prior comparative studies have demonstrated the potential for MR in surgical training. Using a validated transrectal ultrasound biopsy (TRUS-Bx) hydrogel model, we sought to evaluate the efficacy of MR-based remote instruction relative to that of in-person (IP) instruction.

Methods: 19 pre-clinical medical students were recruited to complete a TRUS simulation crossover study where guidance was randomized into either MR-first or IP-first groups. The students reviewed pre-learning material prior to TRUS-Bx. Each student completed a pre-test, two training sessions utilizing one modality, mid-test, two training sessions of the opposite modality, and post-test. During test sessions, participants independently measured the prostate and obtained 14 biopsies on a hydrogel model with individually colored biopsy regions. Accuracy was defined as the percentage of core with the corresponding color for the given biopsy region. During training sessions participants were guided through a TRUS-Bx on single- colored models. MR sessions utilized Zoom to transmit the ultrasound view to the instructor and Vuzix smart glasses to display the superimposed view of the surgical field with the remote instructor's guidance to the participant [Figure 1A-B]. This allowed the instructor to directly annotate on the ultrasound view while guiding trainees with the merged surgical view. Post-training surveys assessed trainee perceptions of the session.

Preliminary Results: Pre-test core percentages were similar between groups (MR-first: 23.6%, IP-first: 29.0%). Performance on the mid-test following the first two training sessions showed significant improvement (MR-first: 64.8%, IP-first: 58.2%). Post-test core percentages also showed significant improvement in performance from both pre-test and mid-test (MR-first: 79.9%, IP-first: 75.9%) with similar net improvement in core percentages between groups (MR- first: 56.3%, IP-first: 46.9%) [Figure 1C]. Participants found remote training with MR not to interfere with learning.

Next Steps: Remote instruction using MR technology provided equivalent learning to in-person
simulation instruction. This technology has the potential for cross-institutional training.



O-9 Research Abstracts

Novel Method for Obtaining Clinical Measurements in a Virtual Environment

Olivia A. Perham, BS; Paul M. Jeziorczak, MD, MPH; Emil Maric, BA, MS; Charles Jason Aprahamian, MD FACS, and Matthew T. Bramlet, MD
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Introduction: 3D modeling and virtual reality (VR) are useful in pre-surgical planning of complex cases. As VR use cases increase, need for more detailed analysis, including measurements, increases. We deployed a novel measurement method that allowed scaling in digital environments while preserving user confidence of measurement accuracy. Comparative values were Haller index measurements for ease of measurement and bone segmentation. We compare accuracy and precision of measurements made in VR to those in the medical record.

Methods: Pre-operative CT scans of 26 pediatric patients requiring Nuss procedure had; radiologist recorded Haller indices, then rendered into 3D models, and scaled to a scanned and 3D segmented 12 inch ruler DICOM model (control measuring tool) as well as a Solidworks created 3D ruler and yardstick (higher resolution for detailed measurements). All digital models were equally scaled and placed in the same VR environment. [FIGURE 1] The DICOM source of both the clinical model and physical ruler transferred confidence to the digital ruler. As scaling was applied to the clinical model in the digital environment, the same scaling applied to the digital ruler. The transverse and anterior-posterior values were measured in virtual reality using the ruler, and Haller indices were calculated and recorded. [FIGURE 2].

Results: Data was collected, and a t-tailed independent sample t-test compared the similarity of the two groups of indices measured. The average radiologist-measured Haller index (3.97) was compared to VR-measured Haller index (4.20). Statistical analysis demonstrated a p-value of 0.56, indicating that there was no significant difference between the measurements obtained via virtual reality from those measured by radiologist.

Conclusions: This novel method provides guidance for how to develop and deploy digital methodologies for measurement in a digital 3D space. Similar to the benefit of improved mental representations of 3D models in VR, adding the ability to acquire measurements in 3D may allow for more relevant measurements unencumbered by 2D formats. Further research can be conducted to analyze whether this capability decreases operative time, or decreases complication rates.

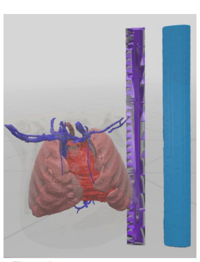

Figure 1

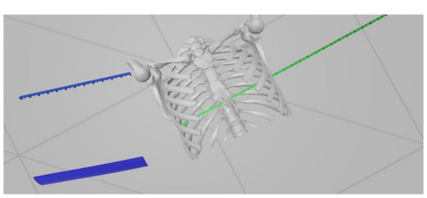

Figure 2

P-02 Challenges in Surgical Education

Leveraging Eye-Gaze Data to Augment Surgical Faculty-Resident Postoperative Case Video Analysis

Vitaliy Popov, PhD; Jingying Wang, MS, PhD; and Xu Wang, PhD
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Background: Learning how to do minimally invasive surgeries is a cognitively demanding task that requires a high degree of visuo-spatial coordination between attending (trainer) and resident (trainee) surgeons. There is a well-documented body of literature that shows the ability of eye-tracking to produce robust quantitative data and serve as an objective measurement method, with possible applications in surgical training and skill assessment.

Current Challenges: Evidence-based guidance for trainee skills assessment and high-quality feedback based on operative case video analysis is surprisingly limited, given the foundational role of this activity in surgical education. Importantly, it remains an open question how instructors can best leverage operative case video analysis, including artificial intelligence approaches, to help trainees develop professional vision and reflect on their own performance.

Need of Innovation: In this study we aim to develop a multimodal dashboard that enables attending surgeons to easily provide verbal feedback to residents. Additionally, we will combine video feed, conversation transcript, and eye-gaze data to help surgeons easily navigate a surgery recording and provide analytics to help residents reflect on their performance. The PI team has done substantial prior work including a series of operating room observations with eye tracking data collection, and an interview study understanding both surgeons' needs and challenges with intra- and post-operative coordination, teaching and learning. The research study so far includes cholecystectomy surgeries with further extension to extra-peritoneal inguinal hernia and appendicitis surgeries. Our long-term goal is to develop human-AI collaborative techniques that enable expert surgeons to create scalable training modules and enable resident surgeons to monitor their own progress from novice to expert. This concept (offering trainee-specific, data-driven assessment and feedback) has a strong path forward to not only impact the way laparoscopic resident training is carried out across institutions, but also be translated to develop data-informed training programs for other surgical procedures and approaches as well as other domains such as operating room resuscitation, emergency medical services (EMS), and ICU-based emergencies.

P-03 Research Abstracts

Effects of Optical See-Through Head-Mounted Display Use on Performance and Situation Awareness During Simulated Laparoscopic Surgery Tasks

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Introduction: This study investigated the influence of using optical see-through (OST) head- mounted displays (HMDs) as a replacement of the conventional monitors for an extended duration, as required for laparoscopic surgery, on performance and situation awareness.

Methods: Twenty-four first- and second-year medical students (15 female and 9 male) completed three experimental sessions for the three different display combinations. The experiment scenario included two displays (surgical field and patient vitals) in three different combinations (both displays in the HMD, mixed displays (one on HMD and one on a conventional monitor), and both on conventional monitors). Participants were asked to monitor patient vitals for two adverse events, hemorrhage and tension pneumothorax, while performing a 1-hour laparoscopic suturing task, and select intervention accordingly.

Results: The suturing task performance was significantly worse when using the mixed displays compared to conventional monitors ($p = 0.021$). The performance when both displays were on the HMD was not statistically different compared to the other two display combinations. The reaction time to respond to the occurrence of tension pneumothorax was significantly faster when both displays were on the HMD compared to mixed displays ($p = 0.008$) and conventional monitors ($p = 0.024$). The level 1 situation awareness for the presence of the tension pneumothorax event was significantly worse when both displays were on the conventional monitors compared to both on the HMD ($p = 0.016$) and mixed displays ($p = 0.011$). Both reaction time and situation awareness showed no statistically significant difference when participants were presented with the hemorrhage event.

Conclusions: For this study, the OST HMD did not have a negative effect on the task performance, it also improved the reaction time to adverse events and situation awareness in some conditions compared to conventional monitors. Further research is needed to determine the optimal conditions that could improve the situation awareness.

P-04 Promoting Technology and Collaboration

The Use of Extended Reality Technologies to Enhance Engineering Medicine (EnMED) Training and Education

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Background: EnMed is an innovative engineering medical school created by Texas A&M University (TAMU) and Houston Methodist Hospital (HMH) to be physicians and engineering based medical problem solvers, or "physicianeers." Students receive a Medical Doctorate and Master of Engineering in a fully integrated four-year curriculum. Given the unique nature of this course, there is an emphasis placed on exploring cutting-edge education technology platforms to accelerate training. Extended reality (XR) platforms such as virtual reality, augmented reality, and mixed reality are gaining prominence as the next generation of Web3 enablers. Here, we explore the effectiveness of a variety of XR platforms in enhancing the EnMed education.

Technology Overview: We evaluated a variety of XR platforms on a cohort (n = 25) of EnMed students. These technologies include, but are not limited to: Varjo XR-3, Microsoft Hololens, Meta Quest 2, FundamentalVR surgical simulation suite (HapticVR) and their CollaborationVR platform, Touch of Life Technologies VH Dissector platform, and the Elucis platform developed by Realize Medical.

Potential Application in Surgical Simulation and Education:
The above XR platforms will be evaluated as an integrated component to each of the 3 phases of EnMed students' curriculums.
(1) In pre-clerkship, the Touch of Life Technologies VH Dissector platform will supplement *Medical Gross Anatomy* coursework, aiding students in contextualizing anatomical structures in 3-D spaces. (2) FundamentalVR's surgical simulation suite with HapticVR will better prepare clerkship students on surgery rotations, allowing them to develop advanced understanding of orthopedic, endovascular, and robotic surgery cases in cases. (3) The Elucis platform by Realize Medical will allow EnMed students to build 3-D medical models in 3-D to characterize novel technologies developed in students' Innovation Immersion Experiences (IIE) — EnMed students' engineering corollary to traditional clinical rotations.

Potential Opportunities to Collaborate: We are open and willing to engage other medical school programs and student cohorts to assist in validating the results of our XR program.

P-05 Challenges in Surgical Education

Teaching the Surgeons: A Novel VHA-Based 3D Printing Fellowship for General Surgery Residents

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Background: Three-dimensional printing (3DP) has been utilized at the Point of Care (POC) in many capacities, one of which is the field of surgical planning. 3DP has been applied broadly in the field of surgery in the following categories: anatomic models, surgical instruments and implants and prostheses. Broadly, 3DP has been utilized successfully in surgery due to its ability to allow for rapid transformation or conversion of anatomical images into physical objects.
Surgical applications with 3DP fall into three broad time points: pre-operatively (pre-procedural planning), intra-operatively (incisional or marking guides) and post-operatively (case review and simulation).

Current Challenges: Despite the broad surgical application of 3DP technology, there are no known formal training pathways in 3DP for surgeons outside the VA system nor within it.

Need of Innovation: The Veteran's Affairs Health Care System (VHA) has created the Office of Advance Manufacturing (OAM) to aid in the diffusion and successful application of 3DP at POC. Part of this effort has been to establish broad and focused educational offering to aid in the successful surgical application of the technology. OAM has funded the first piloted training program (academic year 2021-2022) for a dedicated 3DP fellowship for general surgery. The goal of the program was "to provide to surgical trainees an extensive exposure to 3D Printing as it applies in the clinical environment".

Supporting objectives: 1. recognize the essential materials in the 3DP Process, 2. understand the common types of 3D printers, 3. appreciate the essential steps in 3D model segmentation, 4. recognize the positive and negative aspects of patient imaging approaches as it pertains to 3D model creation and 5. apply the essential steps in communicating with surgeons regarding potential and actualized 3D printed models. Learner and program assessments have been undertaken on this inaugural fellowship class.

P-06 Research Abstracts

They want Clinical Context and Protocols: Analysis of Engineers' Feedback from a National Segmentation Boot Camp Experience

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Introduction: Segmentation is a key step in the creation of patient centered pre-surgical models. As part of our system wide efforts to provide broad exposure to this critical step, we undertook a national segmentation boot camp (SBC) in April 2022. We surveyed learners as it pertains to the quality of design, conceptual framework, quality of instructors and quality of course experience. We sought to understand differences in reaction to this training event as it pertains to engineers (E) and non-engineers (non-E).

Methods: An anonymous program survey was distributed to all participants of a national two- day SBC. Key questions utilizing a 5-point Likert scale (5=strongly agree) as it pertains to quality of design (stated learning objectives, guidelines for daily activities, aligned activities, delivery methods and technology support), conceptual framework (clinical areas presented and potential future content), quality of instructors and quality of course experience (challenging the learner, appropriate workload, cadaveric lab time, presentation evaluation, software hand- on sessions, safe/effective practice and over all course rating) were asked. Of note, minimal content addressed clinical scenario linked to the segmentation task nor ideal protocol workflow. All participants self-designated if they were engineers (E) in the organization or not (NE). Student's t-test was utilized.

Results: A total of 31 participants (79.9 % of total attendees) responded to the SBC survey. Of these, seventeen (54.8%) self-identified as engineers. There was no statistically significantly difference as it pertains to the quality of the course design, quality of instructors and quality of course experience. E compared to non-E were more likely to react negatively to a lack of clinical scenario (mean Likert score of 3.6 ± 1.4 vs. 4.5 ± 0.8 p=0.03) and minimal segmentation protocols presented (3.8 ± 1.0 vs. 4.6 ± 0.6;p=0.01) respectively.

Conclusions: Our analysis of learners attending a national SBC, self-identified engineer attendees seem to desire clinical context and segmentation protocols when training on segmentation cases. This data should inform educators at the point of care within the 3D Printing space to modify future curricula.

P-07 Research Abstracts

Assessing the Accuracy of Robotic Bronchoscopy in Localizing and Targeting Small Pulmonary Lesions

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Introduction: Guidelines expanding lung cancer screening eligibility are expected to result in 4 million Americans being diagnosed with a new pulmonary nodule annually, wherein 160,000 will require definitive diagnosis via biopsy. Although screening allows for early detection of suspicious lesions, definitive diagnosis remains challenging. Evidence estimates success rates for electromagnetic-navigational bronchoscopy (EM-NB) at 39% for lesions ≤2cm located in the outer third of the lung. Emerging evidence suggests robotic bronchoscopy (RB) has improved overall accuracy. However, there remains an urgent need to quantitatively evaluate the accuracy of RB in localizing and targeting small peripheral pulmonary nodules.

Methods: A prospective, single-blinded, randomized-controlled study that quantitatively compared the accuracy of RB against EM-NB during lesion localization and targeting was performed. The dependent variable was accuracy. Accuracy was measured as a rate in terms of localization and targeting success, distance from the center of pulmonary targets (<1cm), and according to anatomic location. The independent variable was navigation system, RB was compared to EM-NB using 1:1 randomization. Differences in accuracy in terms of distance from the center was assessed using Wilcoxon-Rank-Sum. Kruskal-Wallis was used to assess differences in accuracy according to anatomic location. An adjusted regression model was used to assess accuracy in terms of distance and time across navigation systems.

Results: Of 75 attempts, 72 were successful in lesion localization and 60 were successful in lesion targeting. The success rate for lesion localization was 100% with RB and 91% with EM- NB. The success rate for lesion targeting was 93% with RB and 80% for EM-NB. RB demonstrated superior accuracy in terms of distance from the center of the lesion at 0.62mm compared to EM-NB at 1.28mm (p=0.001). Accuracy was improved using RB compared to EM- NB for lesions in the LLL (p=0.025), LUL (p<0.001), and RUL (p<0.001). Accuracy with respect to distance and time varied according to navigation system in an adjusted model.

Conclusions: RB demonstrates superior accuracy and success rates in the localization and targeting of small peripheral lung nodules.

P-08 Challenges in Surgical Education

Laparoscopic and Robotic Training: A Need to Adapt Surgical Education to Left-Handed Surgeons

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Texas A&M University, College Station, TX; Houston Methodist Hospital, Houston, TX

Background: Dexterity-related challenges in medical training are commonly described but remain largely unaddressed in surgical education. Many left-handed learners either learn to perform clinical, procedural, and surgical skills with their right-hand or must adapt to performing the skill with their dominant hand without direct teaching.

Current Challenges: Although strategies to enhance surgical education for left-handed learners have been described, they often revolve around mentorship with a like-handed surgeon.1,2 Robotic training, an increasingly common component of surgical residency training, could prove to significantly decrease the impact of laterality on surgical education and performance. Although traditional laparoscopic training is similar to robotic in requiring learners to utilize both hands with proficiency, there remains laterality preference for the actively working hand among both right- and left-handed learners with certain tasks.3,4

Need of Innovation: Current training techniques involve simulation-based task-oriented exercises. Laparoscopic skills are assessed with standardized drills as prescribed by the Fundamentals of Laparoscopic Surgery (FLS) examination. Similarly, robotic training modules encompass simulation drills that grade learners based on metrics such as economy of motion, speed, keeping instruments in view, instrument collision, and number of movements. These drills provide actionable information about a learner's performance. With the ease of bimanual dexterity on the surgical robot and prompt feedback, there may be opportunity to translate these skills to similar minimally invasive techniques such as laparoscopy. Through discussions among residents at our program, we discovered a need for improved directed surgical education for left-handed trainees to utilize their dominant hand. By assessing for delta time between the dominant and nondominant hand, we can assess how variability in practice drills differs between laterality among left- and right-hand dominant residents on the robotic console versus during laparoscopic FLS exercises. Further studies will aim to identify actionable metrics to reduce the delta time between the dominant and nondominant hand on both the robotic and laparoscopic platforms.

P-09 Research Abstracts

Kinematic Differences Between Novice and Expert Surgeons During Simulated Midurethral Sling Surgery

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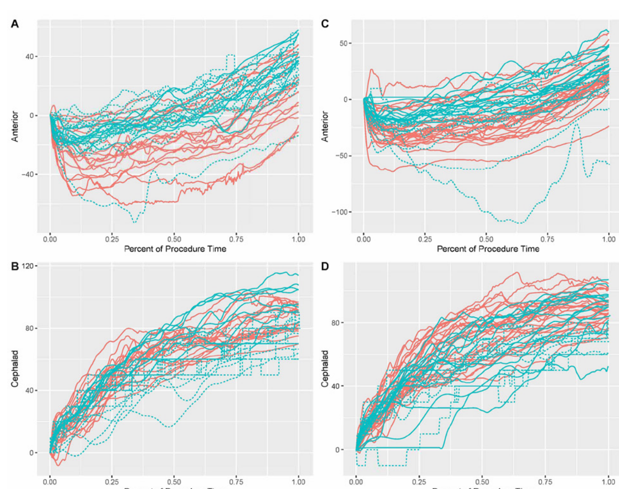
Introduction: The Midurethral Sling surgery (MUS) involves well-documented injuries to the bladder. Our objective was to investigate trocar kinematic differences between novice and expert surgeons during a simulated MUS.

Methods: Three MUS simulation models were created from MRI segmentations of women with stress urinary incontinence. Three expert and three novice surgeons performed retropubic passage of a Gynecare TVT trocar model#810041B connected to a Gynecare TVT Introducer model#810051 on the models. Reflective markers and the OptiTrak motion capture system were used to track the motions of the trocar and the model. Multibody models (MB) and motion data were used to analyze trocar kinematics and contact with pelvic structures. We performed Chi-squared tests to test the hypothesis that errors, defined as bladder contact or passage anterior to the bone, would occur more frequently among novices compared to experts. We used mixed model analysis with random effects to test the hypothesis that novices, compared to experts, would perform passes with longer trial duration and path length.

Results: Each participant performed 15 passes. Novices made more total errors (bladder + anterior), but the result was not significant (60.0% vs 40.0%, $p = 0.091$). Experts made fewer anterior passes than novices (Right: 0% vs 63.6%, $p < 0.01$; Left: 0% vs 39.1%, $p < 0.01$). (Figure 1) There was no difference between experts and novices in bladder contact (Right: 40.7% vs 21.4%, $p = 0.305$; Left: 38.9% vs 12.5%, $p = 0.360$). Experts had longer mean trial duration (9.7 vs 8.1 seconds, $p=0.085$) and path length (277.6 vs 205.4 mm, $p=0.043$) relative to the novices.

Conclusions: Novice error passes were predominantly anterior to the suprapubic bone. This simulation model can be used for surgical education in avoiding anterior passage of the trocar or contact with the bladder.



Trocar tip trajectories in anterior direction (A,C), and cephalad direction (B,D). Expert (pink), novice (green). Anterior passages are denoted by dotted lines. Left trocar passages are in panels A and B, and right passages are in panels C and D.

P-10 Research Abstracts

Estimating Surgical Instrument Position in Blind 3D Space during Simulated Retropubic Trocar Passage

Gary Sutkin, MD, MBA; Faith Mueller, MD, Md A. Arif, MS; Antonis P. Stylianou, PhD; Austin Bachar; An-Lin Cheng, PhD; and Gregory W. King, PhD
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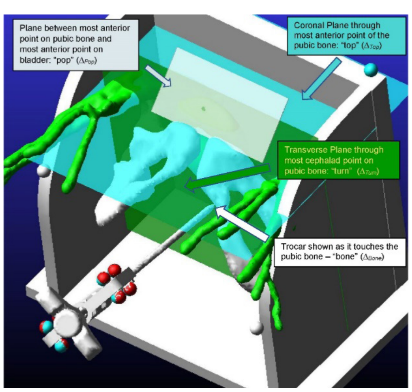
Introduction: The retropubic midurethral sling surgery involves blind passage of sharp trocars cephalad to the pubic symphysis, with well-documented injuries to the urethra, bladder, bowel, and blood vessels. Our objective was to determine if surgical novices are more likely than experts to be unaware of their instrument location in space.

Methods: Expert and novice surgeons performed bilateral retropubic trocar passes of a Gynecare TVT trocar (models #810041B-#810051) on a nontransparent pelvis simulation platform. We tracked the tip of the trocar relative to internal vital organs using 8 mm retroreflective motion capture markers on the trocar and model, and twelve OptiTrack Flex 13 cameras at a frame rate of 120Hz. Participants vocalized when they perceived the trocar tip touching the caudal aspect of the bone and crossing 3 planes (Figure 1). Two observers selected onsets for each waveform, for interrater reliability. For each trial we calculated differences (ΔBone, ΔTurn, ΔTop, ΔPop) between vocalization times and when the trocar crossed the corresponding plane (Figure 1). We performed Mann-Whitney tests to investigate differences in mean deltas between novices and experts, Chi-Square tests to detect differences in vocalizing early versus late, and Levene's test to assess the equality of variances for subject-level variation.

Results: Six subjects performed 38 trials, including 22 expert and 16 novice trials. Interrater reliability for the four vocalization onset times ranged from 0.98 to 0.99. ΔBone was significantly smaller among novice surgeons (1.210 vs. 2.824 seconds, $p<.05$). There were no significant differences between novices and experts in the remaining three deltas or in vocalizing early versus late. Levene's test revealed significant differences in within-subject variability for ΔTop ($p<.001$) and ΔPop ($p<.001$).

Conclusions: For most blind points, expert and novice surgeons were similar in their estimation of the trocar's location relative to the simulation model's suprapubic bone. We suspect the experts may conceptualize these blind planes differently.



P-11 Promoting Technology and Collaboration

Utilizing 3D Printing and Injection Molding to Create Kidney Models for Surgical Resident Training Prior To Transplant Rotations

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Background: UW Transplant faculty expressed a desire to introduce residents to kidney transplant vascular anastomosis prior to beginning their transplant rotation to improve both learning and patient outcomes. Increased warm ischemic time due to prolonged anastomoses have been found to affect early graft function and long-term graft survival (Halloran et al 1988; Hatsuse et al 1998; Hellegering et al 2012). To counteract these deleterious effects, a curricular session was implemented, tracking both time and quality of anastomoses, and collecting data about resident experience/comfortability with kidney transplants. UW Clinical Simulation Program created a novel clock face 3D—printed simulator for use in these sessions to address the educational gap.

Technology Overview: MRI images were converted to STL files by the Radius Medical Imaging Analysis team at the University of Wisconsin School of Medicine and Public Health's Department of Radiology to create a 3D printed negative mold of a solid kidney without internal structures or vasculature. This was secured within a plastic cylinder approximately three inches below the surface to create a cavity. Silicone blood vessels were created and attached to the kidney to simulate the renal artery and renal vein, while a second pair of vessels were suspended within the cylinder to imitate the recipient vessels. The objective of this session was to perform two end-to-side anastomoses while recording the time needed to complete.

Potential Application in Surgical Simulation and Education: This cost-effective method of surgical training allows for rapid-cycle-deliberate-practice by learners in order to gain proficiency in time-sensitive procedures that do not allow for a traditional teaching approach while in the operating room. With minimal investment in 3D printing technology and software, the patient imaging that is collected on a regular basis allows for rapid model creation.

Potential Opportunities to Collaborate: The process utilized with our Division of Transplantation can easily be replicated with additional partners from respective disciplines to create low-cost models to address specific learning and training objectives.

P-12 Research In-Progress

Vascular Surgery Device Innovation: Aortic Endograft Explanation

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Introduction: The standard treatment of abdominal aortic aneurysms (AAA) is endovascular aortic repair (EVAR) during which an endograft is placed within the aorta to stabilize the weakened wall and prevent rupture. 16-30% of grafts will fail which may necessitate endograft explantation. This procedure has 6.3% mortality and 31% complication rate. During the removal process, metal prongs that hold the graft apply a tearing force that damages the endothelium and can result in lethal bleeding. Current standard of care involves a syringe cut and shaved to make a cylinder. It is inserted and rotated upwards over the endograft until the hooks are covered and the graft is explanted. There is currently no off-the-shelf technology for safe endograft explantation.

Methods: Financial analysis and prototype cost estimates were conducted. The current standard of care procedure was broken down to vital steps and failure points; design criteria were developed after addressing inefficiencies and shortcomings. Materials used include 3D printers, filaments, steel wire, and ball bearings. Testing was performed in silicone tubing.
Design elements were identified to address. The prototyping process involved exploring varying mechanisms for graft removal.

Preliminary Results: Market analysis identified a need for a low cost multi-use product priced under $100 on a low volume, on-demand basis. Testing criteria were the ease of removal, procedure time, and reproducibility. Modifications were incorporated based on performance in the mock aorta. One major design criterion from consulting vascular surgeons was to reduce the diameter of the graft before explantation. Our top prototype reduced a 25mm diameter graft to 7mm, and adequately fulfills the design requirements. This device is pending intellectual property protection.

Next Steps: Our study has shown that the current standard of care is inefficient in multiple steps of the explantation procedure with high mortality and no available off-the-shelf technology. We described the biodesign process for a technology assisting in aortic endograft explantation. Our prototype indicated the feasibility of use and effectiveness in endograft removal. Next steps are further device development, and in-vivo testing.

P-13 Challenges in Surgical Education

Video-based Task Deconstruction of Robotic Hiatal Hernia Repair

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Background: Robotic surgery is increasingly permeating the surgical arena and expanding the role of minimally invasive surgical approaches. Due to this, teaching robotic skills to general surgery residents is critically important. Video based learning has demonstrated significant advancements and can be used to further skills and shorten the learning curve. Studies have shown that there are specific aspects of video-based learning that are more beneficial, such as presence of narration and didactic illustrations. Video-based education addresses challenges within surgical training including increased knowledge retention within a continuously expanding field of information and a time-constrictive environment.

Current Challenges: We propose a surgical steps task deconstruction of robotic hiatal hernia repair with LINX paired with a surgical video following the same steps and using valuable video characteristics, as a standardized teaching tool. We gathered subject matter experts (SMEs) to create a list of procedural steps for a robotic hiatal hernia repair with LINX. Four SMEs developed a comprehensive ten-step task list for the conduct of the operation, beginning with a literature review and employing a modified Delphi process to reach a consensus. A surgical video was created using narration and anatomic labeling to guide the learner through the Delphi process agreed upon ten procedural steps. The goal was to create a standardized set of tasks paired with video representation to facilitate teaching robotic hiatal hernia repair with LINX to novice learners. Creation of a video-based instruction tool with consideration for important characteristics such as narration and anatomic labeling allows for standardization of the performance and teaching of the operation, facilitating formative and summative feedback and assessment for learners by the supervising surgeon.

Need of Innovation: Development of a standardized task list paired with video-based learning for a robotic hiatal hernia repair with LINX provides the structure for teaching complex robotic surgery safely and efficiently to general surgery residents. Video-based education offers significant advantages in trainee learning, performance, and experience therefore it should be an integral part of surgical education.

P-14 Challenges in Surgical Education

Task Trainer Development for Realistic Simulated Penetrating Neck Trauma in Team Trauma Training

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Background: Penetrating neck trauma injuries are seen by Emergency Department teams in 10- 15% of all trauma cases. Due to the location of important anatomical structures, neck trauma has a high rate of morbidity and mortality. Teamwork, excellent communication, and time management skills for airway management and hemostasis are essential for successful patient outcomes. These complex life-saving procedures require teams to operate effectively under crucial time constraints. This necessitates assembly of a reproducible task trainer so that trauma teams can practice proper management of this unusual but critical condition.

Current Challenges: Currently, no known simulator for penetrating neck trauma is available for retail purchase. While there are task trainers and team training exercises for neck trauma, these trainers either focus on airway management or hemostasis protocols. Additionally, there are no task trainers that allow teams to assess and manage both airways and hemostasis simultaneously.
In a recent regional multi-disciplinary healthcare team simulation competition, one scenario involved a patient presenting with a gunshot wound to the neck and difficulty breathing. A modified surgical Cut SuitTM was utilized to simulate a penetrating neck injury and allowed trauma teams to assess and manage the patient's high volume blood loss and difficult airway access.

Need of Innovation: This unique penetrating neck injury task trainer has a variety of applications for trauma and other perioperative specialties. It provides a well-received, highly realistic experience with a live actor wearing a surgical Cut SuitTM. Interprofessional education training can utilize this simulator to measure and improve team communication, leadership and roles, technique, response time, and outcome in scenarios involving airway management and mass transfusion protocols. Further application of this innovative simulator includes developing a step-by-step guide to create a penetrating neck trauma model. This task trainer provides a critical life-saving educational opportunity for healthcare professionals in managing penetrating neck trauma.

P-15 Research Abstracts

Training Impact of Simulated Laparoscopic Appendicectomies (TISLA)

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Introduction: AbstractStudy Objective:To assess the impact of Augmented Reality Training on improving completion of Laparoscopic Appendicectomies using objective performance metrics.Design:Utilising the LapAR™ by Inovus Medical Ltd (UK), we supervised surgical trainees performing several Augmented Reality simulated appendectomies interspersed with LapPass tasks*. Objective metrics measured include time to completion, distance travelled by instruments, instrument acceleration, hand dominance and instrument time in view.Comparison was made with a benchmark score set by an experienced minimally invasive surgery (MIS) surgeon. Subjective performance feedback was also provided by experienced surgeons using the work-based assessment (WBA) framework.*Activities including laparoscopically passing thread through a hoop, manipulating hoops between instruments, positioning hoops on posts, cutting simulated skin within guidelines and placing sutures laparoscopically.

Methods: Setting:A National Health Service (NHS) University Teaching hospital in South London.Patients or Participants:Surgical trainees (Senior House Officers and Registrars) qualified doctors of at least 1 year. Interventions:During the course, benchmarks of both LapPass tasks and Appendicectomies were set by each trainee in addition to an experienced MIS surgeon. Trainees were then asked to perform a series of tasks including further Appendicectomies and LapPass tasks. Following this period of intervention, trainees were set a final benchmark to compare to their original.

Results: Measurements and Main Results:We found that the performance metrics improved when comparing initial & final benchmarks. In addition, the final benchmark metrics of the trainees were compared in a standardisation exercise to the benchmark set by the experienced MIS surgeon. Of note, time to completion and distance travelled were both markedly reduced following the intervention period. WBA based review of performance demonstrated a marked improvement in surgical skill.

Conclusions: Augmented Reality task training using a high-fidelity Laparoscopic box trainer such as the LapAR™ improves objective and subjective performance in simulated appendicectomy completion. It can be inferred that this technique improves the surgical learning curve whilst safely taking it away from the live patient.

P-16 Research Abstracts

Democratizing Access to Realistic Surgical Simulation with Augmented Reality - a Health Economics Review

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Introduction: Surgical training is traditionally learned by surgeons through repeated practice on patients 3. This is a time-consuming, costly and potentially ineffective process. During COVID this situation has worsened not only due to a lack of ability to operate due to redeployment, but also there has been less opportunities for trainees. This coupled with the emergence of a litigious world 4,5, we cannot afford to be practicing on patients, and neither can we rely on studying for from a book, a video, or even a one-off course 6. Simulation centres were also closed during the pandemic, and any access to it were highly limited due to costs and lack of comparison to alternatives 7.

Methods: We implemented this strategy by providing each trainee with a "lap box trainer" which allowed them - once requested by their faculty member - to perform a set of tasks ranging from learning modules all the way to full operations such as appendectomies & hysterectomies. Objective metrics were provided to trainees, and the faculty member provided subjective comments either in real-time on live courses, or remotely and in retrospect. The overarching aim of training in this manner is to reduce operative time, reduce risk of complications and to save the money.

Results: Combining this data from Needham et al8 with health services indices, and hospital stay 9,10, we estimate a £79pp cost savings. Extrapolated across 150 acute trusts 11 undertaking 10,000 lap appendectomies per day, the total cost saving would be £777.579 in one particular operation, for one surgical speciality.

Conclusions: The pandemic allowed us to utilise technology to remain productive and to see and hear loved ones. This allowed us to incorporate video-linked supervised operative training sessions using a new Mixed-Reality (real & augmented) platform involving hardware, a native application and a cloud-based server. This solution meant that we were able to increase accessibility by keeping costs down whilst maintaining fidelity to improve surgeon ability and to save hospital money.

P-17 Research In-Progress

The Effect of Augmented Reality Training in Simulated Laparoscopic Appendectomies

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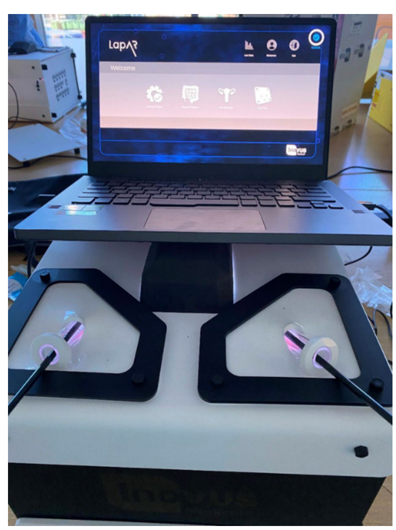
Introduction: The role of surgical innovations in training has been highlighted before, but the importance of its implementation in a timely manner was emphasised during the COVID-19 pandemic, during which many surgical trainees at all levels lacked theatre exposure due to cancellations of elective lists.

Methods: Utilising the LapAR™ by Inovus Medical Ltd (UK), we asked surgical trainees in a number of London and Manchester University NHS Trusts to perform several Augmented Reality simulated appendectomies interspersed with LapPass tasks. Objective metrics measured include time to completion, distance travelled, smoothness, acceleration, handedness and time in view. A comparison was made with a benchmark score set by an experienced minimally invasive surgery (MIS) surgeon. Subjective performance feedback was also provided by experienced surgeons using the work-based assessment (WBA) framework.

Preliminary Results: We found that the performance metrics improved when comparing initial & final benchmarks. In addition, the final benchmark metrics of the trainees were compared to that of the experienced MIS surgeon. Notably, time to completion and distance travelled were both markedly reduced following the intervention period. WBA based review of performance demonstrated a marked improvement in surgical skills.

Next Steps: Augmented Reality task training using a high-fidelity Laparoscopic box trainer such as the LapAR™ improves objective and subjective performance in appendectomies. It can be inferred that this technique improves the technical skills acquisition and refinement for surgical trainees. Further work needed with larger numbers of trainee volunteers for further validation and potential implementation. We aim to publish this data and recruit surgical residents from other health systems in addition.



P-18 **Research Abstracts**

Establishing Expert Benchmarks for Simulation Training on New Robotic Platforms: The Medtronic Hugo RAS Experience

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Introduction: All new robot-assisted surgery platforms being developed will be required to have proficiency-based simulation training available either as an embedded feature or as a stand-alone product. Previous benchmarks for virtual reality simulation metrics for commercial products have been based on expert surgeon data supplemented with engineering benchmarks which evolved organically over several years as new data was gathered. This paper reviews a methodical and efficient process utilized to establish expert surgeon benchmarks for virtual reality simulation metrics for the new Hugo™ RAS Simulator from Medtronic prior to commercial launch.

Methods: Nine surgeons from multiple specialties who are superusers of the da Vinci® surgical system were recruited for this study. After a familiarization process, surgeons were asked to perform five sessions for each of the 49 simulation exercises (basic and advanced skills) available on the Medtronic Hugo™ RAS Simulator. A number of performance metrics for each exercise (e.g., Time to Complete, Economy of Motion, Instrument Collisions, etc.) from the simulator were exported for analysis. A standard box and whisker plot was used for each metric to identify outliers. The passing benchmark was set at 1 standard deviation above the mean value calculated from the remaining data points after excluding the outliers.

Results: A total of 1915 valid sessions (~ 58 hours of simulation time) were obtained from nine surgeons and were used to establish the passing benchmarks for each exercise. This process took just under three months.

Conclusions: This study presents an efficient method of establishing simulation benchmarks using surgeon superusers from an established robot-assisted surgery platform. Validation of these benchmarks will occur as they are utilized by academic training centers to train surgeons on the Hugo™ RAS System.

P-19 **Challenges in Surgical Education**

Intraoperative GoPro Mount: The Future of Surgical Education

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Background: Surgical residents learn to be proficient attendings through various learning activities, but perhaps the most valued opportunity is through direct observation of procedures complex operations. However, there are fundamental limitations to this approach; Residents only have so much time to spend in the OR (and viewing a 5 minute technique might take a hour of waiting), there is a limitation to the number of observers who can closely observe a procedure, and video of procedures (live or recorded) are often not from the same perspective as the surgeon performing the technique.Incorporating video analysis of residents' OR performance has been shown to be a useful tool in surgical education. A surgical team from the Department of Surgery at the University of Ontario conducted a study comparing Conventional Training (CT) (i.e. written evaluations from attending surgeons) with a new method called Comprehensive Surgical Coaching (CSC), which incorporated video feedback sessions. The surgeons found that CSC was more effective than CT for quality feedback.

Current Challenges: While video is an effective tool for surgical teaching, there lacks an effective way to integrate cameras into the workflow of the OR that effectively capture the surgeons' view. Sterile field concerns (especially when using Surgical Helmet Systems), issues with OR lights, and the camera's field of view are just a few hurdles that must be overcome when capturing a surgery.

Need of Innovation: Our team, has developed a 3D-printed camera mount for integration into a surgical helmet system. This mount enables the capturing of a surgeon's vantage point that is often difficult to achieve with other camera mounting options. our goal is to integrate this device with residency education. We aim to build a surgical library for review and encourage residents to film their cases for skillset improvement and hope to spread this system and approach to other surgical programs for their own use.

P-20 Research In-Progress

Simple Tools for Efficient Artificial Intelligence Assisted Laparoscopic Training

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Introduction: Artificial intelligence nowadays can be implemented for object recognition, motion analysis and image segmentation. Those assets could be used to enhance laparoscopic training through computer assisted laparoscopic systems.

Methods: A number of simple software tools were developed using Python, Opencv and Tensorflow. The system was able to detect 1.Camera excessive motion, 2.Target out field, 3.Tools out of field, 4.Foggy field, 5.Tools cross-handed, 6.Tools out of target. A preliminary study was performed on 10 laparoscopic videos performed by residents in general surgery. Evaluation of the results was made by comparison of computer analysis outcomes and laparoscopic surgeon rating on the same six skill points mentioned above.

Preliminary Results: Artificial intelligence system was able to detect laparoscopic performance although significantly underrated skills because several necessary surgical motions were translated as errors. Laparoscopic abilities were evaluated faster, objectively and the data results were kept for future reevaluation.

Next Steps: Completion of the system for real-time laparoscopic training analysis and assistance. Simple artificial intelligence tools can be used to improve laparoscopic performance and training.

P-21 Research Abstracts

Video-Based Assessment of Surgical Skill Using Unsupervised Temporal Attention

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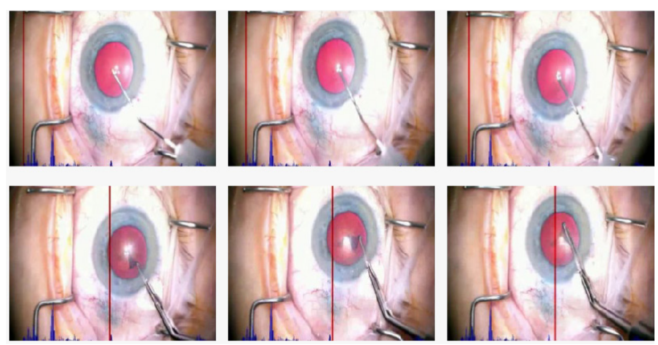
Introduction: Algorithms for video based assessment (VBA) of surgical skill should be explainable to facilitate their adoption. Our objective was to develop and validate deep learning algorithms for VBA of surgical skill that localize predictive segments of surgical activities.

Methods: We used a dataset of 99 videos of capsulorhexis for which ground truth (expert/novice) was specified by an expert surgeon using the International Council of Ophthalmology's Ophthalmology Surgical Competency Assessment Rubric for phacoemulsification. We first trained a CNN as a feature extractor from video images. We then stored the features to save memory, which would allow us to compute frame-level features for videos of any length (limited only by storage capacity). We then trained a simple long short-term memory network with temporal attention modules using the extracted frame-level features as input. The temporal attention facilitates localization of segments in the video that influenced the predicted skill. We used 5-fold cross-validation to estimate algorithm performance in terms of sensitivity and specificity, and qualitatively analyzed influential video segments identified by the network.



Conclusions: Temporal attention, normalized across the entire video, is beneficial for both performance and explainability of deep learning methods for VBA of surgical skill.

P-22 Challenges in Surgical Education

Interprofessional Curriculum for Emergency Undocking as a Part of Residency Training - Simulation Models and a Protocol

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Background: General surgery residents are increasingly expected to be proficient in robotic surgery by graduation. Robotic surgery curriculums have been incorporated into residency training to reflect this need; however, there is a dearth of literature describing emergency undocking training as a part this curriculum. For practicing surgeons, curriculums using hydrogel simulation models have been described in the field of Urology and Gynecology. Bleeding during robotic surgery requiring emergency undocking is a high-stakes situation that requires coordination of the interprofessional operating room (OR) team. It is important for surgeons to understand the emergency undocking protocol, communicate effectively with the team, manage the situation, and be confident in their abilities to do so. This requires exposure, repetition, and practice, which should begin during residency training.

Current Challenges: Though robotic curriculums have been implemented most general surgery residency programs, emergency undocking is not commonly incorporated into training. The skills required for docking the robot and performing surgery robotically can be taught with simulation and honed with practice in the OR. Situations that require emergency undocking in the operating room are infrequent, and when they do occur, they are not optimal learning opportunities for a trainee to learn how to manage the situation given the life-or-death nature of the event. Simulation models can expose residents to this high stress situation and provide practice for efficient management of the emergency.

Need of Innovation: We propose an interprofessional curriculum for teaching emergency undocking using simulation models as well as a protocol for emergency undocking to incorporate into general surgery residency robotic training curriculums. The simulation models include a high-fidelity cadaver model with a pump system to mimic a bleeding event as well as a moderate-fidelity explant model. Not only does the curriculum include resident education for simulating a skill that is not commonly encountered, but it also incorporates the other players in the OR including anesthesia, circulating nurses, and scrub technologists given the importance of all team members to work together for the best patient outcome.

P-23 Research In-Progress

Statistical Shape Modeling and Simulation for Reconstructive Breast Surgery

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Introduction: Simulation and visualization tools for communicating postoperative breast shape changes and for elicitation of patient preferences following reconstructive surgery are limited. We propose a shape simulation method on 3D surface images that allows data-driven deformable, non-rigid localized changes to breast shape.

Methods: Active Shape Models (ASM) is a statistical approach, that leverages specificity (common features) and variability (features of significant variations in the given dataset) for shape modeling. We previously developed a spherical harmonics-based breast shape model (SPHARM), which utilizes orthogonal basis functions defined on the surface of unit sphere to obtain descriptors of breast shape. In this work we utilize the descriptors from SPHARM modeling with ASM to achieve breast shape simulations. For a training set with 321 breast images (168 preoperative and 153 postoperative (30 tissue expander, 81 implant-based, and 42 autologous) reconstructed breasts), we computed the covariance matrix with SPHARM-based shape descriptors. Eigen value decomposition on the covariance matrix determines the eigen vectors and corresponding eigen values. Weight parameters (shape controls) assigned to these eigen vectors can be adjusted to allow shape simulations.

Preliminary Results: Our preliminary result showed that the first 24 eigen vectors capture 98% of the variability in the dataset. We adjusted the weights of the eigen vectors on the preoperative breast image shape to obtain a postoperative shape simulation

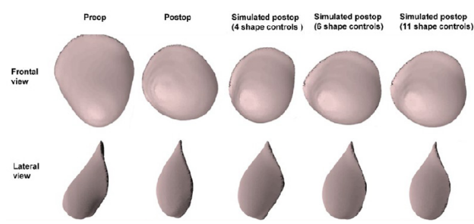

Figure 1: Simulation of postoperative results. We adjusted the shape controls on the preoperative breast image to achieve the desired postoperative shape outcome. Closest simulation to postoperative shape was obtained using 11 shape controls.

Next Steps: Mapping of shape controls to intuitive and anatomically relevant features is required for clinical implementation. For example, a specific shape control parameter would map to an anatomic feature, e.g., upper pole fullness. We will utilize synthetic breast images with known dimensions to determine the association between controls and anatomical features using regression models. This will facilitate visualization of postoperative shape simulation on the preoperative torso for clinical consultations

P-24 Research Abstracts

Development of an Affordable Abdominal Fascia Closure Model to Train Surgical Residents

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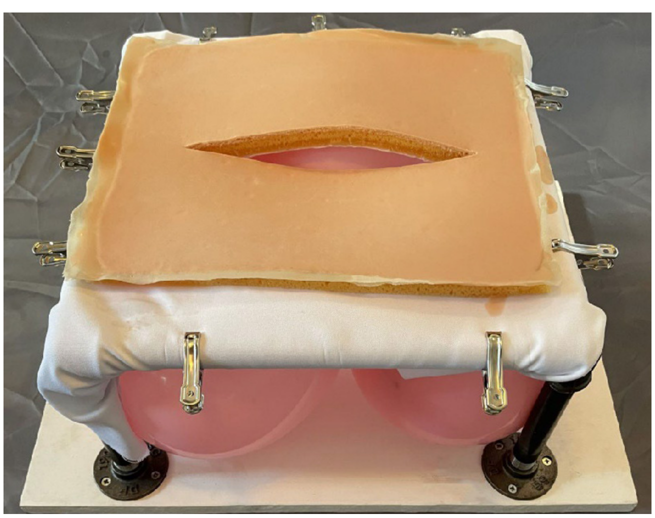
Introduction: Proper surgical technique of midline laparotomy closure is crucial to prevent fascial dehiscence, evisceration, and incisional hernia. Formal simulation training of residents in fascia closure is lacking. To address this training gap, we are developing an abdominal wall closure simulation course for our residency program. This pilot study was designed with the goal to develop a realistic, low-cost model of the abdominal wall for use in our surgical simulation center.

Methods: We created a low-cost ($54) multilayer abdominal wall model based on commercially available materials. Using Smooth-On® silicone gel-filling technique and various fabrics and materials to delineate layers, a 12x10-inch three-layered (artificial skin, subcutaneous fat, and fascia) pad was constructed. This pad was placed on a metal frame attached to a wooden base to simulate an abdominal wall with balloons underneath to represent bowel. A midline cut through all layers simulated a laparotomy incision. Surgical faculty and senior surgical residents subjectively assessed the model. The evaluators were asked to suture and then rate the model in terms of realism and training utility. Responses were measured with a 5-point Likert scale (1 - strongly disagree to 5 - strongly agree).

Results: Four residents and fourteen attendings participated in the study. Majority of evaluators agreed that the abdominal wall model is a reasonable representation of a midline laparotomy, scores range 3-5, mean 4.28±0.57. Evaluators agreed that the fascia had realistic feel on needle insertion, scores range 2-5, mean 4.17±0.79; and that the model could be used to teach residents to close midline laparotomy, scores range 3-5, mean 4.44±0.62.

Conclusions: Our synthetic model demonstrated a reasonable realism, low cost, and ability to re-use the model multiple times. It is endorsed by faculty and residents as a tool to enhance the training of fascia closure technique.



P-25 Research In-Progress

Challenges of Ergonomics Encountered by Women in Surgery

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Introduction: Female surgeons may encounter greater ergonomic barriers while operating on patients compared to their male counterparts. Surgical instruments are generally made as a standard size. Past studies have reported as high as an 87% injury rate related to instrument design suited for those with larger and stronger hands in the field of minimally invasive surgery. Tools such as the laparoscopic stapler have been reported as too large by female surgeons who on average are more likely to receive medical attention related to wrist, thumb and finger injuries compared to men. Such findings may deter women from entering the already male dominated surgical specialties. Our study aims to investigate the role gender plays in the required pinch and grip strength associated with the usage of forceps and the Kocher clamp.

Methods: An open-ended pre survey will be sent out to third year medical students at RVU prior to a surgical rotations prep course. The pre-survey will address demographics, average glove size, and engagement in common daily activities in which grip or pinch strength may be improved. After hand measurements are taken, pinching capabilities of forceps without and with simulated tissue (introduction of torque) will be measured using a baseline LITE hydraulic pinch gauge. Grip strength required for the use of the Kocher clamp will be measured using a baseline® electronic Smedley adult hand dynamometer. At the conclusion of the prep course an open-ended post survey assessing perceived level of pinching and gripping difficulty will be sent to students. Following collection of data, a chi square analysis will be performed.

Preliminary Results: Mock table representing relationship between average glove size & pinch/ grip strength

Average Glove size	Perceived level of discomfort during pinching activity with simulated tissue	Perceived level of difficulty during pinching activity without simulated tissue	Perceived level of difficulty during gripping activity	Pinch Strength in Kg	Grip Strength in Kg
Small					
Medium					
Large					

Next Steps: Creating ergonomically friendly tools for female surgeons should be of high priority. Such steps can foster an environment in which female surgeons can perform surgery and pursue surgical subspecialties with increased confidence.

References: Sutton, E., Irvin, M., Zeigler, C. et al. The ergonomics of women in surgery. Surg Endosc 28, 1051-1055 (2014). https://doi.org/10.1007/s00464-013-3281-0

P-26 Research Abstracts

Improving Family and Child Understanding of the Nuss Procedure Through Virtual Reality

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Introduction: Virtual reality (VR) has become a popular form of gaming, but VR applications in healthcare are still novel. Discussing pectus excavatum and the Nuss procedure with a family can often be difficult for them to visualize in the conventional 2D imaging of CT. We hypothesize that utilizing VR will improve child and family understanding of pectus excavatum and lead to improved informed consent of the Nuss procedure.

Methods: After obtaining IRB approval, children in the chest wall clinic at the OSF Children's Hospital of Illinois were recruited for the study. The study was supported by a grant through the JUMP Arches program. Children provided assent and their legal guardians consented to VR modeling of their chest CT. This was converted into the VR environment utilizing Enduvo software. The Oculus Quest 2 was used in clinic and in the preoperative area as the visualization platform. A pre- and post-test survey utilizing a Likert scale to judge both understanding and engagement compared to standard pre-op discussions was given.

Results: 15 patients participated in the initial pilot study. There was a significant difference in the understanding of the procedure and the chest wall defect after review in virtual reality compared to CT scan (p-value < 0.01). Those same 15 patients were also evaluated on their ability to accurately explain pectus excavatum to those around them and again there was a significant difference after review of the virtual reality (p-value = 0.02).

Conclusions: The virtual reality platform increases both engagement and understanding when compared to traditional pre-op discussions. The use of virtual reality in clinic during preoperative discussions can help improve the informed consent process. The Oculus system is portable, can be used in the preoperative area, and does not require additional space or footprint. Further studies are need to show the utility of virtual reality in other surgical disease processes and perioperative planning.

P-27 Research Abstracts

Reimagining Inpatient Physiologic Monitoring: A Pilot of Wearable Activity Monitors After Cardiac Surgery

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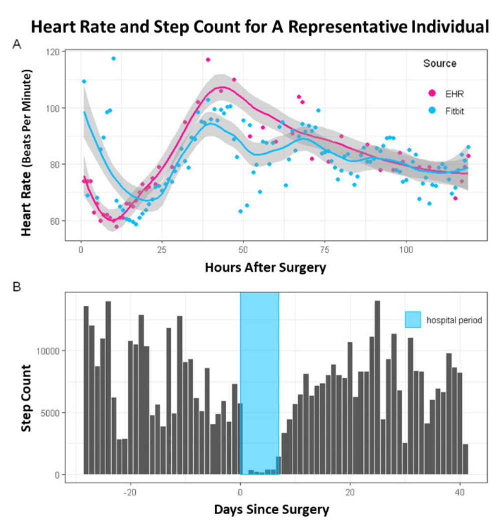
Introduction: Noninvasive wearable patient monitoring has the potential to revolutionize inpatient and outpatient surgical management. This pilot study aims to establish the feasibility of using noninvasive wearable activity monitors (wearables) to track key clinical variables in the outpatient setting.

Methods: A single-center descriptive pilot study was conducted. Preoperative cardiac surgery patients were consented, provided with a wearable, and instructed in its use. Activity monitor data was abstracted from the patient's wearable account and clinical information was gathered from the electronic medical record. Descriptive statistical analysis was undertaken to correlate hospital measured heart rate with wearable measured heartrate to validate accuracy and to analyze trends in sleep score and step count over time.

Results: 30 patients were enrolled and issued activity monitors. The average age was 54 years (range 20-85) and 36% were female. Usable data was obtained in 70% of patients. Inpatient heart rate was measured by both the hospital and the wearable device in 8 patients, and the interquartile range for the Spearman correlation was 0.4 to 0.5. There was also significant overlap in the measured heart rates. Dramatic changes occurred with patient activity.

Conclusions: This study demonstrates that wearable noninvasive activity monitors can be used to remotely monitor cardiac surgical patients. These results confirm the unique physiologic data that is available from wearables and allude to the potential for perioperative patient management.



P-28 Research In-Progress

Multi-Sensor Analysis of Surgeon's Moves and Conduct to Improve Surgical Efficiency

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Introduction: Analysis of the surgeons' kinetics and actions is often used for the assessment of surgical skills. Video analysis and electromagnetic tracking are the most used techniques for this purpose. These techniques only track the movements, are non-specific and their interpretation is time consuming. We designed a multisensorial detection system to automatically quantify the specific actions taken during a simulated procedure as a teaching tool to improve surgical efficiency.

Methods: A simulated surgical field was equipped with multiple sensors to automatically detect specific moves and surgical actions. We used video recording to validate readings from the following sensors. Hall effect sensors recorded the number of approaches and duration of presence in the field of the magnet-mounted forces. Multiple photoresistors recorded the presence and the count of the hand in three peripheral zones. Vibration sensor read the magnitude and duration of the field vibration. Time-of-flight distance sensor read the variations in the distance to the field. Data from these sensors are collected by an Arduino microcontroller to Excel spreadsheet. The model was tested on two surgeons: Surgeon A= is highly experienced, Surgeon B= is a trainee.

Preliminary Results: During an identical suturing procedure, surgeon B approached the field with the forceps 58%, held the forceps in the filed 78% and manipulated the field 96% more than surgeon A. Surgeon B also made 7 unnecessary moves that wasted time and affected efficiency. Distance and photoresistors showed surgeon A's working zone was significantly smaller than for surgeon B. The readings from the sensors had a 100% correlation with the video recordings.

Next Steps: We plan to optimize and validate this system to create a surgical skill assessment tool. As a training platform, this system potentially improves surgical efficiency and fluidity by detection, quantification and elimination of unnecessary moves and touches.

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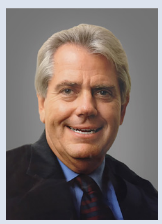

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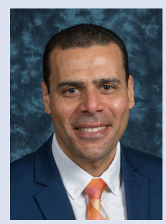

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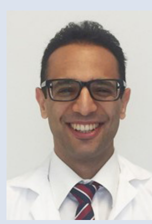

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Assistant Research Professor, Malone Center for Engineering in Healthcare, Whiting School of Engineering The Johns Hopkins University
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We would like to thank our Platinum Sponsor, **Intuitive Surgical**.

Exhibitors

Industry Sponsorship and Exhibit Opportunities

The Annual ACS Surgeons and Engineers: A Dialogue on Surgical Simulation meeting is growing. This meeting both welcomes and encourages sponsorship and exhibit opportunities are available on a first-come, first-served basis.

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The Annual ACS Surgeons and Engineers: A Dialogue on Surgical Simulation Meeting is growing. There are various levels of sponsorship opportunities available.

EXHIBITORS

Meeting participants have asked for exhibitor involvement. The Annual ACS Surgeons and Engineers: A Dialogue on Surgical Simulation both welcomes and invites exhibitors to participate in this meeting.

Please visit *www.facs.org/surg-eng* for more information.

2023 Meeting Survey

Thank you for attending

the 2023 ACS Annual Surgeons and Engineers:

A Dialogue on Surgical Simulation Meeting.

In order to better serve the surgical and engineering communities, we ask that you complete a brief survey. Please share what you found valuable about today's content, and changes or additions that would be impactful in the future.

NAVIGATE TO: *https://redcap.link/2023SurgEng*

OR SCAN THE QR CODE with your smartphone camera to access the survey

ACS Education

American College of Surgeons

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.

ACS AMERICAN COLLEGE OF SURGEONS

Notes

SURGEONS AND **ENGINEERS:**

A Dialogue on Surgical Simulation

633 North Saint Clair Street, Chicago, IL 60611-3295

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