O-11

Research In-Progress

Low-Cost, Patient-Derived, and Insufflatable Modular Abdominal Simulation Environment (MASE) for Surgical Testing

Kent K. Yamamoto, BS; Olufemi Oladokun, MD; Danyi Chen, BS; Layla Triplett, Med; Kerry Gao, BS; Katharine Jackson, MD, MBBS; and Sabino Zani, MD, FACS

Duke University, Durham, NC; Duke University School of Medicine, Durham, NC

Introduction: Laparoscopic abdominal surgery requires navigating unique technical challenges with precision, dexterity, and a thorough understanding of anatomy. There is a need for higher-fidelity training models to assist in improving trainee competence. With a variety of models ranging from benchtop to live animal models, limitations such as realism, accessibility, and scalability must be considered. To address this need, we developed MASE - a high fidelity, low-cost abdominal simulator for surgical training, designed and assembled using medical image processing and rapid prototyping. This model resulted in a patient derived life-size abdomen model with a chest cavity, pelvis, and phantom skin that can insufflate under standard insufflation parameters to accommodate laparoscopic and robotic surgery.

Methods: MASE was designed using a combination of CT-derived, 3D-printed anatomical landmarks and silicone to simulate skin and the abdominal wall. The entire construct is mounted on an acrylic base and housed within an acrylic frame, spanning from the costal margin to the pubic symphysis. The model was designed to simulate laparoscopic access via a Veress needle or "OptiView" trocar placement at Palmer's point, allowing for realistic pneumoperitoneum. The initial and maximum height of the MASE pre-/post-insufflation were measured within 5 trials. The MASE was also tested using the da Vinci Single Port (SP) robot's insufflation port.

Preliminary Results: Within the 5 trials, MASE successfully maintained an average inner pressure of 11.2 ± 0.75 mmHg and increased in height from 90.986 ± 0.46 mm to 190.086 ± 2.64 mm post-insufflation. The platform successfully supported fundamentals of laparoscopic surgery (FLS) tasks including intracorporeal knot tying and peg transfer with both laparoscopic instruments and the SP Robot.

Next Steps: Future work includes integrating both the retroperitoneal space and previously developed dynamic rib cage model, and embedding both synthetic and ex-vivo tissue models within the MASE to increase fidelity further.

a) Rib Cage Model | Flexible Hinges | CT-Segmented Pelvis and Spine

b) Peg Transfer | Suturing

c) da Vinci SP | Insufflated MASE