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Using a 3D Printed Model to Create a Surgical Disaster Simulation for Resident Training: How We Did It

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INTRODUCTION

The use of simulation continues to become a major part in training surgical residents. Most simulations in orthopedics focus on developing technical skills.[1] There is a gap in non-technical skills training focusing on communication, teamwork, decision making, situational awareness, and managing stress.[2] Lapses in technical and nontechnical skills have been reported as contributing factors to surgical errors, with increased incidence of errors in emergent settings.[3]

Senior orthopedic surgery residents were provided with a simulation designed to stress communication skills and operative management during an unexpected surgical emergency.

This simulation was created by members of the Departments of Orthopedic Surgery and Anesthesiology at the University of Kansas Medical Center, and our simulation institute (Zamierowski Institute for Experiential Learning (ZIEL)) to train both technical and nontechnical skills. The surgical simulation was presented as the removal of a soft tissue tumor of the lower extremity. Unknown to the residents, during the dissection the surrounding tissue would begin to simulate a massive hemorrhage, causing hemodynamic instability. This intraoperative emergency required them to manage the operative field appropriately and communicate effectively with the operating room (OR) team. This scenario created ample need for teamwork and communication between the orthopedic and anesthesiology residents, and the nursing team. This afforded the residents an opportunity to manage an emergent OR situation prior to completing residency and beginning independent practice.

The educational objectives of this simulation were to:

1. Demonstrate appropriate management of sustained intraoperative hemorrhage.
2. Perform effective interprofessional communication.
3. Express increased confidence in ability to manage intraoperative 'disaster'.

SIMULATION

Tumor Model. The model used for the simulation was designed using a 3D printer. This was a new addition to our simulation, facilitating preparation and reproducibility of the model (Figure 1). The tissue of the model was comprised of a gelatin solution, with a plum at the center serving as the tumor. Four sets of tubing were placed at various depths in the model that would be turned on as the resident reached the specific depth, increasing the amount of bleeding in proportion to the dissection depth (Figure 2). In previous years during assembly of the model, the different tubing depths would shift as the gelatin was poured, creating variability between different models. This led to development of a 3D printed to model with side mounts for tubing to assist in reproducibility and assembly of the models.

Figure 1. 3D printed model with color coded guideposts glued in place.

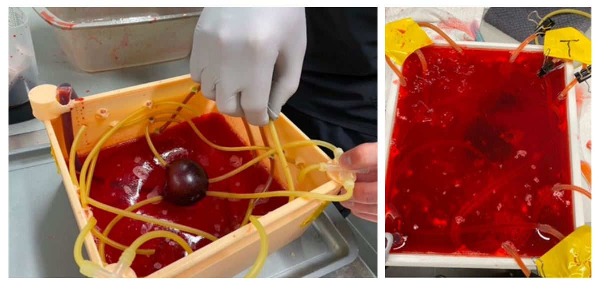

Figure 2. [Left] Placement of the tumor (plum) and the remaining vessels through their guideposts prior to pouring the second layer of gelatin. [Right] Final model after pouring of gelatin layer. Corners of model are labeled corresponding to the tubing depth.

Setting and Participants. The simulations were performed in the simulation center. The simulated operating room was set up with the model draped and prepped before the resident entered the OR (Figure 3). For the simulation, three Embedded Simulation Persons (ESPs) were involved. A medical student as the first assist and operating room volunteers as the surgical scrub technician and circulating nurse.

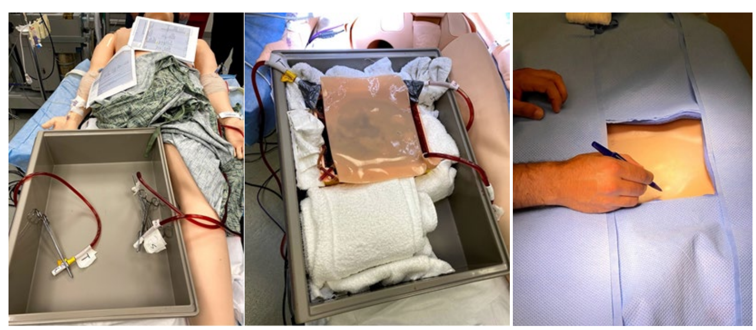

Figure 3. [Left] Container for placement of model to catch overflow artificial blood. Primed tubing from blood pump ready to be connected to the model. [Center] Model connected to blood pump, placed in container, and stabilized with towels. Artificial skin placed to complete preparation of model. [Right] Model draped and marked in preparation for start of simulation.

The anesthesiology and orthopedic residents were given history and physical exam notes, similar to a note that would be found in the electronic health record. The notes contained relevant information for the residents. Prior to beginning the simulation, they were informed that they would have access to anything they would have in a fully functional OR, including blood products. The ESPs were informed of the massive hemorrhage and were used to relay information regarding the tissue depth of the resident so the various blood pump lines could be turned on at the proper time. All vital signs, the blood pump for the model, and communication with the assistants were managed from a one-way mirror control room in addition to various cameras around the room for observation. Orthopedic and Anesthesiology faculty were present to observe the simulation and debrief the residents.

Simulation Debrief. Following each simulation, the two residents and the observing attending physicians participated in a debrief session. The session was used to discuss the thoughts and emotions experienced by the residents and to examine their team communication experience. Much of the discussion centered around communication and teamwork, with experienced attendings offering comments on strengths and opportunities for improvement. Technical skills also were discussed with instruction regarding massive hemorrhage management from the surgical and anesthesia perspective. At the final debriefing session, all learners were offered feedback on communication by the scrub technician and circulating nurse involved in their simulation.

DISCUSSION

Our goal was to provide senior residents with an opportunity to experience a high-stress scenario and manage a surgical emergency in a simulation environment as this is an important part of their training before entering into practice. The value of this simulation was to allow instruction of residents' non-technical skills, particularly focusing on areas of improvement in communication and teamwork during times of high-stress intraoperative events.

The use of 3D printing was an important aspect of this simulation. Models built for initial simulations had inconsistencies in the tubing, caused by shifting during assembly. This led to models not bleeding as intended which ultimately led to variability in the experience that the residents received. By printing the model container with guideposts for the tubing, models were able to be reproduced with minimal variability for each learner experience. Additionally, the models were able to be preserved for later use. After printing, each model was coated in FlexSeal®, which allowed for quick cleanup and storage of the model to be used again in subsequent simulations. The ability to reuse models has reduced the cost of the simulation.

CONCLUSIONS

In summary, simulation training is becoming an increasingly common and useful tool to train surgical residents. Our hope is to provide other programs an outline of how we have implemented a simulation designed to stress non-technical skills using a reproducible 3D model. This simulation provided trainees a simulated surgical emergency that provides a rare learning opportunity for resident surgeons and anesthesiologists. Further developments will continue to enhance the teaching of non-technical and technical skills during a surgical emergency for training physicians.

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