Building a Simulator with Life-like Realism for Teaching Abdominal Operations

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OBJECTIVE: The objective of this communication is to provide an evolutionary description of an attempt to replicate the success of the Rampahl Cardiac Simulator using perfused abdominal organ blocks the way that the Rampahl Simulator uses ex vivo porcine hearts.

DESIGN: This descriptive paper makes no attempt to prove the effectiveness of the described educational tool, but rather, outlines the successes and failures in development. The proven value of a perfused organ teaching tool, as the Rampahl Simulator, suggests that others can build upon the work described in this paper so that, in the future, perfused abdominal organs will be available to students of general surgery as a routine part of their pre-operative preparation.

SETTING: The Animal Resource Facility of the University of Utah, under the oversight of the University Institutional Animal Use and Care Committee (IACUC), provided the animals, operating suites and technical support.

PARTICIPANTS: During each development phase, General Surgery Residents and Medical Students from all levels participated. In addition, operating room staff with an interest in either medical school or perfusion were invited to participate.

RESULTS: The efforts described in this paper eventually resulted in a reliable teaching tool for abdominal procedures in that viability of the porcine abdominal organs for up to three hours after euthanasia was regularly achieved.

CONCLUSIONS: General Surgery Teaching Programs of a size similar to the University of Utah may have access to the resources necessary to replicate this teaching tool in a cost-effective manner. However smaller teaching programs, such as those without a research facility, may not be able to adapt the procedures described in this paper. (J Surg Ed ▮:▮▮▮-▮▮▮. © 2018 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

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COMPETENCY: Patient Care

INTRODUCTION

This report is a summary of an attempt to develop an animal teaching tool for students of abdominal operations that could be as useful, effective, and easily adaptable by some General Surgery Teaching Programs, as the Rampahl Simulator has become for Cardiothoracic Surgery. As general surgery educators accept the new reality that future students will receive a much smaller part of their technical education in the operating room, these educators are developing creative and unique educational tools to teach competence in surgical technique outside of the operating room. Quite possibly, no one has done this more successfully than Dr. Richard Feins at the University of North Carolina and the Association of Program Directors in Thoracic Surgery. The Rampahl Simulator, which they have promulgated throughout thoracic training programs, is one of the clear leader among all the educational tools that have been developed to prepare students for the operating room. By far and away, its standout feature is the astounding fidelity offered to students learning to operate on the human heart.

THE SEARCH FOR AN APPROPRIATE MODEL

First Attempt: Experience With Meat Processors and Packers

This report on an attempt replicate the simulator that has been adopted by the Association of Program Directors in Thoracic Surgery (www.tsda.org) began with local area meat packers. Dr. Feins obtains porcine hearts that are readily available to him from local businesses that process pork.

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The plan for this abdominal simulator was explained to several meat processors in the Salt Lake area: removal of the internal organs from the diaphragm to the pelvis immediately after slaughter, cannulate the organ block and perfuse it with Wisconsin solution, then transport the organs to the University of Utah. After three visits to separate businesses in the Salt Lake and Toole Valleys, it quickly became apparent that these businesses were not interested in the project. They each expressed concern with inspections from the Federal Drug Administration (FDA), but a principal impediment may have been the fact that they use the internal organs to make marketable food products. The lack of enthusiasm to supply organs on the part of the meat packers as well as the logistics of preserving these organs in transport to the University made this plan to procure organs the way that hearts are obtained for the Rampahl Simulator unrealistic.

Second Attempt: a University-based Research Project Studying Lung Injury in Premature Neonatal Lambs

An established researcher at the University of Utah, offered the use of postpartum ewes, weighing between 80 and 120 kg after he had delivered neonatal lambs by Cesarean Section. Ordinarily, they euthanized the ewes after delivery. This seemed like a steady supply of animals and there would be no need to transport organs from outside the university. The revised plan was to extend the abdominal incision from the Cesarean Section and cannulate the great vessels at the diaphragm. While the organs were being perfused, the organ block would be removed from the animal. A total of four sheep provided enough experience to abandon this plan. The abdominal contents of the sheep were so big that retraction was difficult and retroperitoneal dissection almost impossible without unacceptable blood loss. Simultaneously, another researcher offered 30-40 kg pigs after euthanasia; so, pigs replaced sheep as the source of organs. Another major advance was an observation made by the perfusionists. They suggested that there was no need to remove the abdominal organs from the euthanized animal. Therefore, the operative plan changed: after euthanasia, cannulas (aortic and caval) would be placed in the chest instead of the abdomen. This change preserved the abdominal contents in place and allowed residents to operate on perfused abdominal organs in situ, covered with blue drapes exhibiting great similarity to their operating room training environment.

Third Attempt: a University-based Research Project Studying Endovascular Hyperplasia in Gore-Tex Grafts Used for Dialysis in Renal Failure Patients Became the Source for Abdominal Organs

In this Institutional Animal Care and Use Committee (IACUC) and Institutional Review Board (IRB) approved study, experimental Gore-Tex grafts were sewn into the carotid position of pigs. After a defined period for maturation, the grafts were ready for retrieval and analysis; the grafts were removed from the pigs under anesthesia, then the pigs were euthanized. This option became the source of abdominal organs for this work. After abandoning the idea of removing the abdominal organs, the revised plan began with a median sternotomy and cannulation of the ascending aorta and the superior vena cava, leaving the abdomen untouched and ready for a variety of open and laparoscopic procedure. A brief video of the model is attached. It shows the opening of the mediastinum after euthanasia with a Lebsche Knife, the perfusion apparatus and personnel, cannulation of the aorta and superior vena cava for bypass and the final preparation ready for abdominal operations. Note the difference in the color of the blood in the arterial and venous lines. The abdominal organs in this perfused preparation extracted oxygen from the blood for up to three hours.

MATERIAL AND METHODS

The University of Utah IACUC (Institutional Animal Care and Use Committee) oversees the conduct of research for all animals and approved this simulator project (Protocol number 12-05017). University Researchers using large animals volunteered their animals upon completion of their study. Animals were between 30 and 40 kg (swine). The research projects that supplied the animals for this work were done in the University of Utah Animal Resource Center and did not involve the abdominal organs. The surgical instruments came from the main operating room after they were deemed too worn for further use. Other supplies, such as drapes, suture, and gloves were also discards from the main operating room. The cardiopulmonary bypass circuits and oxygenators were obtained from cardiac operations that required cardiopulmonary bypass stand-by but were successfully performed without bypass, such as, transcatheter aortic valve interventions or, off-pump coronary bypass. Oxygenators that had been stored in the original priming solution for up to four months worked well when put to use.

Prior to euthanasia, using Beuthanasia dosed for weight, the animal was given 10,000–20,000 units of heparin. Beuthanasia was administered intravenously. Once death occurred, the ventilator was stopped and the endotracheal tube was removed. Then, a median sternotomy was done. This provided an opportunity to practice an Emergency Room Thoracotomy. The students were briefed beforehand in the use of the Lebsche Knife and great vessel cannulation. Aortic and venous cannulas discarded from the heart room were inserted into the inferior vena cava and the ascending aorta and secured with either a Rumel Tourniquet or umbilical tape.

The cardiopulmonary bypass hardware was comprised of two Cobe roller pumps (arterial and suction), and an oxygen