Training Astronauts to Manage Trauma (Emergencies): Integrating Human Patient Simulation into Medical Operations for National Aeronautics and Space Administration (NASA)

Hal Doerr, MD,[1] W. Bosseau Murray, MD,[2] Marsh Cuttino, MD,[3] and Timothy J. Broderick, MD[4]
[1]*Department of Anesthesia Baylor College of Medicine*
1709 Dryden Road, Suite 1700, Houston, TX 77030, USA
hdoerr@houston.rr.com
[2]*Department of Anesthesiology H-187*
Pennsylvania State University College of Medicine
500 University Avenue, Hershey, PA 17033, USA
bosseaumurray@yahoo.com
[3]*Department of Emergency Medicine, Virginia Commonwealth University, Richmond, Virginia, USA*
cmcuttin@vcu.edu
[4]*Departments of Surgery and Biomedical Engineering*
University of Cincinnati, Cincinnati, Ohio, USA
brodertj@UCMAIL.UC.EDU

Learning Objectives: 1) To recognize the value of human patient simulation in training trauma teams to care for patients in extreme environments. 2) To recognize the value of human patient simulation in conducting trauma research that can improve care of patients in extreme environments. 3) To describe the alterations in cardiovascular physiology encountered during prolonged exposure to microgravity. 4) To compare cardiovascular pathophysiology routinely encountered in terrestrial trauma patients and postflight astronauts. 5) To recognize future applications of rugged, portable simulators and accurate physiologic models across diverse operational settings.

Abstract

Many advanced medical technologies developed for National Aeronautics and Space Administration are directly applicable to the care of terrestrial patients. In fact, the majority of military and civilian trauma occurs in, or requires transport through, extreme/austere environments that are remarkably similar to the aerospace environment routinely encountered by astronauts—cramped, noisy places with limited lighting, limited power, and limited communications. A simulator that works in a spaceship will function well in such vehicles as a military transport aircraft or a civilian ambulance. Using a rugged, portable digitally enhanced mannequin in parabolic flight, we evaluated the ability of providers with various levels of medical training to perform many of the procedures that are critical to successful resuscitation of an injured patient during long-duration spaceflight. We were able to control the airway using a variety of techniques: mask, placement of an intubating laryngeal mask airway, and insertion of a standard endotracheal tube. Interestingly, regardless of the level of medical training, the intubating laryngeal mask airway was the most effective means of rapidly controlling the airway in microgravity. We successfully performed the following procedures in microgravity: assessed pupils using an eye chart, listened to breath sounds, inserted an intravenous catheter, assembled an intravenous line for use in microgravity, performed needle chest decompression, applied an automatic external defibrillator, and performed cardiopulmonary resuscitation. This research suggests that we can improve the quality of trauma care by developing medical systems, training providers, and building teams using rugged simulators in real trauma environments.

Background

Human simulation is certainly not a new phenomenon. The military has developed and used a wide variety of simulation devices throughout history. Roman soldiers first employed human simulation with their use of the maniple in combat training. Military aviation led Edwin Link to develop a rudimentary flight trainer in 1928. The seminal Link Trainer laid the foundation for modern flight simulation as well as further exploration of human simulation in the 1960s. In 1963, Dr. Nic Gravenstein at the University of Florida created the first human patient simulator to assist in anesthesiology training. Since his invention of this technology, multiple medical simulators have been spawned that include digitally enhanced mannequin, computer-based, and task trainers. Trauma training has increasingly embraced simulation during the past decade in both the military and civilian arenas.

Since its inception, National Aeronautics and Space Administration (NASA) has been at the forefront of simulation. Those of us who have followed the United States manned space program have watched with fascination and admiration NASA's amazing problem-solving skills. During the flight of Apollo 13, we observed the mission director and his group of astronauts, engineers, and flight controllers use simulation to solve what appeared to be insurmountable problems that faced the crew. Although considered a simulation leader, NASA has not had a strong medical simulation effort. In part, this is related to the lack of major medical emergencies that have occurred during previous spaceflights. In the past, rudimentary medical simulation has been included in integrated mission simulations that are designed primarily to address nonmedical operational contingencies such as spacecraft system failures. The medical component typically consisted of astronauts relaying symptoms contained on an index card to the flight surgeon seated at the console within Mission Control. All NASA pilots are required to train, maintain, and validate proficiency on flight simulators to maximize performance and minimize risk. It is increasingly recognized that medical proficiency similarly mitigates life-, limb-, and mission-threatening risk. This article explores NASA research in human patient simulation targeted to develop medical capabilities as well as initial, continuing, and "just-in-time" training for long-duration spaceflight.

This research was supported by a National Space Biomedical Research Institute (NSBRI) grant (SM0002) as well as a National Aeronautics and Space Administration (NASA) Small Business Technology Transfer Research (STTR) grant (NAS 9-03048). This article describes funded NASA research, but does not represent official NASA position or policy. None of the authors have any conflicts of interest to disclose.

Integration of Human Patient Simulation into NASA Medical Operations

In 2001, NASA formed the Space Medicine Workgroup to study medical risk, capabilities, and training for spaceflight. A series of medical think tanks were formed and subject-matter experts in aerospace medicine, surgery, anesthesiology, emergency medicine, and appropriate subspecialties were identified. Each group received extensive briefings on such topics as microgravity physiology, medical equipment size and weight limitations, communication constraints, and medical contingencies that have occurred during previous spaceflights. Obviously, medical contingencies change in planetary exploration because of the chronic exposure to microgravity, harsh radiation environment outside the Van Allen belt, and distance from definitive care on earth. Operations aboard the Space Shuttle and International Space Station in low earth orbit allow us to face a medical emergency using the premise of “stand and fight” or “scoop and run.” However, future planetary missions will require autonomous health care provided by the crew with limited support from the ground.

Regardless of the scope of the mission, mass and volume constraints of spacecraft mandate use of minimal medical equipment. Telemedicine can provide value despite low bandwidth, long latencies, and frequent loss of signal. Consultation with flight surgeons in Mission Control typically is provided by low-bandwidth connections that are closer to dial-up modems (kilobits per second) than high-speed cable Internet connections (megabits per second). Communication latency limits operational capabilities. On average, there is a 1-second delay in communication to the International Space Station, a few seconds’ delay to the surface of the moon, and a 22-minute delay to the surface of Mars. Intermittent loss of signal mandates use of “fail-safe” protocols in space telemedicine. With regard to time and money, evacuation of an astronaut from low earth orbit within the first 24 hours of injury would cost an estimated US $500 million. During a mission to Mars, the astronaut could be millions of miles and years away from the nearest hospital. Therefore, more resources will be dedicated toward medical care in future space exploration so as to minimize risk to life and mission.

Currently, we have physician-astronauts, but we do not necessarily have a physician on board each flight. In those missions that do not have a physician-astronaut as a member of the crew, a crew medical officer (CMO) provides limited medical capabilities. The typical CMO is a pilot or scientist with approximately 28 hours of medical training. A nonphysician CMO routinely takes the CMO training in the first 2 years of astronaut candidate training. When assigned to a mission, the astronaut then trains for an additional 18+ months on other mission-specific duties. Therefore, by the time they fly and could be called on to manage a medical emergency in this austere environment, the medically inexperienced CMOs are likely years away from a few hours of very rudimentary medical training. Is there a way to improve this medical training and capabilities? Throughout the Space Medicine Workgroup meetings, it was recognized that medical simulation was vital to improve initial, continuing, and just-in-time CMO training for long-duration spaceflight.

NASA subsequently developed digitally enhanced mannequin medical simulation training through two separate programs. The first program was supported by a grant from the National Space Biomedical Research Institute (NSBRI). The NSBRI Medical Operation Support Team was tasked to create both a ground- and flight-based integrated simulation effort to provide medical emergency training. This program offered the first integrated approach to training for the NASA medical operations team; importantly, the training included not only the astronauts, but also the flight surgeons and the biomedical engineers sitting at the console in Mission Control. The initial task was to develop a microgravity physiologic model for the human patient simulator and several curricula specific to the needs of NASA. The curricula included medical training as well as telementoring and telemedicine techniques. The effectiveness of training is based on applying “HEAT”: high-fidelity environment analog training. Therefore, a laboratory was developed to recreate Mission Control and a patient care facility.

The second effort was supported by a NASA Small Business Technology Transfer Research (STTR) grant. Medical Education Technologies, Inc. (METI, Sarasota, FL) used the STTR to create a flight-ready human patient simulator that could operate in the analog environment of the NASA parabolic flight laboratory commonly referred to as the “vomit comet.” The KC-135 aircraft provides brief periods of microgravity and is routinely used for microgravity training and research. The parabolic laboratory also provides an opportunity to prepare the METI Emergency Care Simulator (ECS) for use during future spaceflight.

Astronaut Microgravity Physiology Model

Microgravity exposure causes significant physiologic adaptations and abnormalities even in healthy young astronauts. Many of these abnormalities, and particularly those related to the cardiovascular system, are similar to abnormalities routinely encountered in earth-bound trauma patients. By understanding and combining the pathophysiologic entities commonly encountered in trauma patients, we can develop a powerful model that we can use to train providers as well as develop operational medical capabilities for spaceflight. During spaceflight, the cardiovascular system is reset by the lack of gravity. The lack of gravity results in an initial cephalad fluid shift and centralization of blood volume. Microgravity changes the neurohumoral milieu (chronically elevates catecholamines) and autonomic tone (altered parasympathetic/sympathetic balance resulting from sympathetic “downregulation”) that result in increased venous compliance and peripheral blood pooling. These phenomena lead to fluid third spacing and diuresis. The diuresis that begins on mission day 3 significantly contracts intravascular volume. The volume depletion is worsened by space motion sickness, an extremely common problem during the 1st week of flight. As the heart does not have to work against gravity, relative cardiac atrophy occurs during long-duration spaceflight, even with vigorous intermittent exercise. Finally, the attenuation of aortic, cardiopulmonary, and carotid baroreflex responses to hypotension suggests an injured astronaut would not respond appropriately to further hypovolemia and/or vasodilation.

Although astronauts typically develop “bird-legs” and a “puffy face” that have little functional significance during spaceflight, the orthostatic intolerance that frequently develops on landing illustrates how these covert physiologic derangements threaten astronaut health and performance. The typical returning astronaut is deconditioned, relatively tachycardic, hypotensive, and hypovolemic. A terrestrial patient correlate would be a previously healthy young trauma patient who has required 6 months of bed rest (cardiovascular unloading similar to microgravity) in an intensive care unit (elevated catecholamines secondary to chronic illness, confinement, and stress) for complications of severe injuries that include parapalegia (loss of vascular tone). Although the “pseudonormalized” physiology of the patient and astronaut appears normal, both have altered physiology and limited physiologic reserve that become apparent even with minor stress. For example, vital signs that are normal in the supine position quickly deteriorate with changes in position or minor exertion. Obviously, major physiologic stresses of hemorrhage, anesthesia, and surgery pose significant risk to both these patients.

Astronauts may suffer from deranged physiology for 3 or more months after return to earth. Longer-term derangements include volume depletion; skeletal, vascular and cardiac muscular atrophy; lack of recruitment of volume from capacitance vessels; pseudonormalized hemodynamics; parasympathetic/sympathetic dysregulation; catecholamine receptor downregulation with corresponding dependence on catecholamines to maintain cardiovascular tone; relative lack of response to exogenous catecholamine administration; and heart rate-sensitive (dependent) cardiac output. As a general guideline, the astronauts should "earn their anesthetic" during this critical period. For example, the anesthesiologist should start with perhaps a quarter of the dose of etomidate, evaluate the response, and then iteratively administer small additional doses as necessary. If anesthesia and surgery are required soon after return from spaceflight, multiple invasive monitors are recommended as anesthesia could potentially push the ejection fraction down to the 10% range. Indirect adrenergic agents such as ephedrine are not recommended; norepinephrine is a reasonable vasopressor to use (less coronary vasoconstriction than epinephrine); beta-blockers should be avoided.

Modification of Human Patient Simulator for Parabolic Flight

The second effort by NASA was the creation of a modified ECS simulator with enhanced capabilities to teach medical skills in a microgravity environment (Figs. 1-3). The first step was to review the 300-plus-page NASA medical procedure manual jointly developed by the United States and Russia. This manual outlines the medical diagnostic capabilities and treatment modalities provided in the present Medical Pack. From the manual we extracted and summarized all the diagnoses and procedures that could be incorporated into a curriculum using a full human patient simulator. Obvious examples included diseases that had their major manifestations as cardiorespiratory disturbances such as all types of shock, tension pneumothorax, and cardiac rhythm abnormalities. Diseases with signs and symptoms not amenable to demonstration with a simulator were not included, such as mental disturbances, fractures, and stomach upsets. A literature review was also performed to identify diseases that had occurred in personnel functioning in isolated environments for prolonged periods such as prior space flights, submarine environments, and the Antarctic.

A spreadsheet was developed with the identified signs, symptoms, and treatment modalities in the first column and, in matching rows, an attempt was made to classify the present simulator as capable of providing the necessary training or readily capable of being altered or upgraded to provide the capability. A final column indicated the value that this specific modality would provide to the astronaut's curriculum. Clinically useful diagnostic items that were identified included pulse volumes that would be linked to the blood pressure (e.g., being able to practice diagnosing and differentiating a "weak, thready" pulse from a normal volume pulse). The ability to provide more signs of a tension pneumothorax (such as distended jugular venous pressure and tracheal shift) was deemed to be important because an astronaut in microgravity can be propelled against an object that could fracture a rib. Needle decompression of the chest is a simple therapy that also is also needed urgently during an outer space excursion.

The Glasgow Coma Scale score was also identified as an important capability for an astronaut training simulator. The "voice" and "eye" signs are already available to a large extent, and adding the "response to stimulation" was seen as necessary to provide the

Figure 1. The Crew Medical Restraint System restrains the ECS mannequin while Dr. Hal Doerr performs an intubation during a period of microgravity. Dr Timothy Broderick floats in to provide assistance and cricoid pressure.

Figure 2. Drs. Marsh Cuttino (left) and Hal Doerr (right) intubating the ECS mannequin airway with a laryngoscope while in microgravity.

Figure 3. Astronaut Scott Kelly quickly establishing an airway in the floating ECS mannequin using an intubating laryngeal mask airway with assistance from Dr. Tim Broderick.

complete Glasgow Coma Scale score assessment. As cardiovascular problems encountered by astronauts included runs of "stable" ventricular tachycardia, it was determined that the capability of the simulator to provide a full 12-lead electrocardiogram would improve the practice of collecting a physiologic signal, sending it to Mission Control for analysis, and implementing any required electrical therapy and medications based on their recommendations. The simulator hardware was also modified by increasing structural support ("ruggedizing") of the mannequin, modifying the pneumatic system to NASA flight standards, and waterproofing the electricity supply and computer/electronics system. The requirements for a microgravity astronaut human patient simulator do not differ to any great extent from a simulator required by a trauma team interested in providing enhanced capabilities to a resuscitation team in an isolated or austere environment.

NASA Medical Human Patient Simulation

Given the portable patient simulator, microgravity physiologic model, and medical operational constraints as described, we developed a simulation scenario to evaluate the simulator and Mission Control interaction with medical providers' care at a simulated remote landing site. The scenario involves a scheduled Soyuz spacecraft reentry at the end of a 6-month International Space Station mission. A ballistic reentry with a hard impact (the Soyuz is designed to land on solid ground using a parachute) results in seat separation. The 47-year-old male astronaut is thrown forward into the instrument panel, which is only inches away from his face. Findings included extensive facial contusions, crepitus over the nasolabial third of the right zygomatic arch, significant epistaxis, severe right periorbital swelling and contusions, left pupil normal (round, reactive to light) and right pupil "blown" (round, fixed, dilated), and waxing/waning level of consciousness.

The landing site and Mission Control medical operations team was tasked with effective management of the simulated critically ill astronaut. As previously mentioned, when the HEAT is turned up, the simulation is remarkably realistic and can provide great insight into medical operational systems and capabilities. The team must decide to stand and fight (i.e., treat at landing site with limited expertise and resources) or scoop and run (i.e., transport an unstable, hypovolemic, head-injured patient to a higher level of care via 9 hours of flight). In addition to evaluation of current treatment recommendations, this exercise evaluated issues such as team communication, remote physiologic monitoring (e.g., verbal and digital vital sign signal transmission), and international language/cultural barriers.

We also evaluated the ECS during parabolic microgravity on the NASA KC-135 vomit comet. Prior to flight, METI prepared the simulator for use in parabolic flight according to NASA specifications. We evaluated the ability of astronauts with diverse medical training to perform many airway and Advanced Trauma Life Support procedures that are critical to successful resuscitation of the trauma patient. We were able to control the airway using a variety of techniques: mask, placement of an intubating laryngeal mask airway, and insertion of a standard endotracheal tube. Interestingly, regardless of the level of medical training, the intubating laryngeal mask airway was the most effective means of rapidly controlling the airway in microgravity. Further procedures we performed on the ECS in microgravity included assessing pupils using an eye chart, listening to breath sounds (which is not easy in a noisy cabin), inserting an intravenous catheter, assembling an intravenous line for use in microgravity (requires a pressure bag and evacuation of air from system), performing needle decompression of a tension pneumothorax, applying/simulating use of an automated external defibrillator, and performing/evaluating effectiveness of cardiopulmonary resuscitation (probably easiest with feet on ceiling, but can be performed while freely floating with legs straddling chest of mannequin).

Conclusion

Traumatic injury in extreme environments such as space require emergency care because even small injuries are life-, limb-, and mission-threatening. The combination of environmental and trauma "skills" required for successful treatment of such injuries are successfully obtained with high-fidelity trauma simulation within the extreme environment. Similar to flight simulation, medical simulation allows effective training and development of trauma capabilities for spaceflight.

Many advanced medical technologies developed for NASA are directly applicable to care of terrestrial patients. In fact, the majority of military and civilian trauma occurs in, or requires transport through, extreme/austere environments that are remarkably similar to the aerospace environment routinely encountered by astronauts—cramped, noisy places with limited lighting, limited power, and limited communications. A simulator that works in a spaceship will function well in such vehicles as a military transport aircraft or civilian ambulance. This research suggests that we can improve the quality of trauma care by developing medical systems, training providers, and building teams using rugged simulators in real trauma environments.

Acknowledgments

The authors gratefully acknowledge the support of the National Space Biomedical Research Institute. We also gratefully acknowledge the financial and technical expertise provided by Medical Education Technologies, Inc., in support of this research. We thank the NASA Reduced Gravity Program personnel, flight surgeons, and astronauts who contributed to this research. The following astronauts provided insight and effort that was instrumental in our research success: Stephen Bowen, Yvonne Cagle, MD, Scott Kelly, Scott Parazynski, MD, David Williams, MD, and David Wolf, MD.

Bibliography

Cooper JB, Taqueti VR. A brief history of the development of mannequin simulators for clinical education and training. *Qual Saf Health Care* 2004;13(suppl 1):i11-8.

Hammond J, Bermann M, Chen B, Kushins L. Incorporation of a computerized human patient simulator in critical care training: a preliminary report. *J Trauma* 2002;53:1064-7.

Hammond J. Simulation in critical care and trauma education and training. *Curr Opin Crit Care* 2004;10:325-9.

Lee SK, Pardo M, Gaba D, et al. Trauma assessment training with a patient simulator: a prospective, randomized study. *J Trauma* 2003;55:651-7.

Marshall RL, Smith JS, Gorman PJ, Krummel TM, Haluck RS, Cooney RN. Use of a human patient simulator in the development of resident trauma management skills. *J Trauma* 2001;51:17-21.

Meier AH, Henry J, Marine R, Murray WB. Implementation of a Web- and simulation-based curriculum to ease the transition from medical school to surgical internship. *Am J Surg* 2005;190:137-40.

Murray DJ, Boulet JR, Kras JF, Woodhouse JA, Cox T, McAllister JD. Acute care skills in anesthesia practice: a simulation-based resident performance assessment. *Anesthesiology* 2004;101:1084-95.

Murray WB, Good ML, Gravenstein JS, van Oostrom JH, Brasfield WG. Learning about new anesthetics using a model driven, full human simulator. *J Clin Monit Comput* 2002;17:293-300.

Nackman GB, Bermann M, Hammond J. Effective use of human simulators in surgical education. *J Surg Res* 2003;115:214-8.

NASA Small Business Technology Transfer Research web site: http://sbir.gsfc.nasa.gov/SBIR/successes/ss/9-067text.html. Accessed: December 12, 2005.

National Space Biomedical Research Institute. Smart medical systems: development and testing of a space-adapted human patient simulator. Available at: www.nsbri.org. Accessed: December 12, 2005.

Rafiq A, Broderick TJ, Williams DR, Doarn CR, Jones JA, Merrell RC. Assessment of simulated surgical skills in parabolic microgravity. *Aviat Space Environ Med* 2005;76:385-91.

Scerbo MW, Bliss JP, Schmidt EA, Hanner-Bailey HS, Weireter LJ. Assessing surgical skill training under hazardous conditions in a virtual environment. *Stud Health Technol Inform* 2005;111:436-42.

Schwid HA, Rooke GA, Carline J, et al. Anesthesia Simulator Research Consortium. Evaluation of anesthesia residents using mannequin-based simulation: a multiinstitutional study. *Anesthesiology* 2002;97:1434-44.

Incorporating Simulators into Emergency Medicine Residency Training

Neil Coker, BS, EMT-P,[1] and
Lawrence E. Kass, MD, FACEP, FAAEM[2]
[1]*Director of Simulation , Temple College, Temple, TX 76504*
neilcoker@templejc.edu
[2]*Vice-Chair for Educationand Residency Program Director, Department of Emergency Medicine, PennState/Hershey Medical Center*
500 University Drive, MSHMC-UPC, Hershey, PA 17033-0850
lkass@psu.edu

Learning Objectives: 1) To state advantages of simulation as a teaching tool for health professions education. 2) To discuss the importance of simulated clinical environments as a resource for optimizing the educational impact of clinical simulation. 3) To identify formation of multi-institutional consortia as a strategy for offsetting costs associated with developing and maintaining simulated clinical environments. 4) To describe features of a simulated clinical environment that can maintain a sense of realism while maximizing instructional effectiveness. 5) To understand the rationale for incorporating simulation technology into an emergency medicine residency curriculum. 6) To describe five aspects of education into which simulation technology can be incorporated.

Abstract

Clinical simulation is a powerful teaching tool for the education of health care professionals. In Part I of this article we describe the process of developing a clinical simulation center (as experienced by Temple College in Temple, Texas, USA), including recommendations for essential features of layout, monitoring, and recording, as well as equipment. In Part II we describe the process of incorporating a simulation center into a residency curriculum (as experienced by the residency in emergency medicine at Penn State Hershey Medical Center in Hershey, Pennsylvania, USA), including observations about its usefulness in teaching and measuring resident success in using treatment algorithms, addressing chief complaints, performing procedures, performing resuscitations, and performing crisis resource management.

Part I. Designing and Developing a Clinical Simulation Center

Clinical simulation is a powerful teaching tool in the education of health care professionals. Simulated patient contacts can complement and enhance traditional clinical experiences by:

1. Ensuring every learner sees exactly the same set of patients.
2. Permitting controlled manipulation of patient encounters with predictable results.
3. Focusing learner attention on the problem at hand rather than the distractions that occur in real life (unless the distractions are a planned part of the problem).
4. Allowing learners to experience consequences of poor decisions without risk to real patients.
5. Pushing learners up the continuum of clinical competence from novice to expert more rapidly by providing realistic practice in analyzing complex problems, synthesizing information from a variety of sources, and evaluating possible courses of action.
6. Requiring integration of knowledge, skill, and professional behavior in dynamic environments.
7. Developing communication and leadership skills by allowing learners to work together in multidisciplinary teams.

For clinical simulation to be most effective, learners must “suspend disbelief” and interact with the simulator and the environment as if they were real. An effective clinical simulation is very much like a good theatrical production. The set, the actors, and the props support the illusion of reality and allow everyone to become fully immersed in the experience. Therefore, the most effective clinical simulation facility does not simply provide access to mannequins that reliably duplicate patient signs and symptoms. It duplicates the sights, sounds, smells, and other sensations associated with the clinical environment.

Attempting to design, develop, and maintain a simulation center that reproduces the patient-care environment with high fidelity is a challenging task. Such facilities are expensive to build, equip, and operate, and anticipated utilization by a single institution frequently will be too low to justify the costs. Our experiences in designing and developing a facility at Temple College that meets the clinical simulation needs of several academic institutions and hospitals in central Texas demonstrate one strategy for overcoming these difficulties.

Temple College is a comprehensive community college with 4,000 students in Temple, Texas, a city with a population of 58,447 located 120 miles south of the Dallas-Fort Worth metroplex on Interstate Highway 35. Temple also is the home of Scott & White Memorial Hospital, Central Texas Veterans Health Care System, King’s Daughters Hospital, and Texas A&M University System Health Science Center College of Medicine’s clinical campus. Health

---

One of the authors has a financial interest in a company involved in the production of simulators.