Simulation Training in Trauma

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School of Medicine

Trauma simulation training has become a key component in the education of practitioners caring for acutely-injured patients.

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Abstract

Trauma care is the classic high-acuity event for which simulation training has the potential to greatly improve outcomes. While not a new concept, the variability and availability of training modalities in trauma continues to rapidly multiply. Spanning the continuum of fidelity, simulation extends from simple trauma scenario discussion, to advanced virtual reality experiences. The choice of simulation is largely dependent upon the desired outcome, which is broadly divided into either task-oriented or non-technical skill acquisition.

Introduction

Infrequent, high-acuity events, such as those involved with caring for injured patients, require rapid identification and management of life-threatening injury via a thorough, systematic, and expeditious approach. These characteristics of trauma care make it a near-ideal setting to benefit from simulation training, which is inherently low-risk and repeatable.[1] Trauma care has been at the forefront of simulation training for many years. For more than 40 years, the Advanced Trauma Life Support (ATLS®) course has employed a variety of simulation modalities to streamline and improve trauma care worldwide.[2] Since that time, a variety of strategies, techniques and courses aimed at trauma-specific training have emerged, and now provide a plethora of learning opportunities for trauma providers. From low-fidelity trainers, such as tube thoracostomy mannequins, to high-fidelity simulators with immediate and realistic feedback, to virtual reality constructs that provide an immersive experience, there are a wide range of available simulation methodologies directed at improving trauma care and reducing errors at every stage of the process.

Standardized Patients

Standardized patients are either volunteers or paid participants that function as a real patient during simulation exercises. Participants assess the patient and appropriately manage simulated injures. This method of simulation is widely utilized by medical schools and has been embraced by the National Board of Medical Examiners.[3] Inexpensive and often easily recruited, standardized patients offer many benefits to trauma simulation training. Live human interaction is one of the chief benefits to standardized patient encounters, and has been shown to greatly improve learning and retention, secondary to increased participant engagement.[4,5] An added benefit of simulated human patients, is that they also may provide feedback for the learners from a layman's perspective.

Non-technical skill training is an area of simulation particularly suited to standardized patient encounters. The American College of Surgeons utilizes

standardized patients, complete with simulated blood, open fractures and other injuries, during ATLS® courses. After dressing in appropriate garb and moulage, they are given scripts related to their assigned traumatic event, and answer questions of the participants accordingly.

Low-Fidelity vs. High-Fidelity Simulators

Simulation training exists along a continuum, from low to high. Low-fidelity simulations are typically more artificial, less-complex and less realistic. Low-fidelity trainers generally omit factors that participants may experience in real-life. A scenario read aloud for participants to discuss is an example of a low-fidelity educational method. Another example includes a tube thoracostomy task trainer without physiologic simulated feedback. To contrast, a high-fidelity simulation may include standardized patients or a complex synthetic mannequin with physiologic feedback to participant actions. Low-fidelity training modalities can be extremely effective, and "low" should not convey a sense of inadequacy. Conversely, a high-fidelity simulator, while complex, may not afford benefit in all situations. Each simulated task requires careful thought and choosing of the appropriate simulator.[6]

Trauma training typically employs both low- and high-fidelity training modalities. Low-fidelity simulators, geared toward finite educational goals, form the basis for many task trainers. Popular low-fidelity methods include task trainers, such as those designed to teach central venous access, cricothyroidotomy, intubation and focused assessment with sonography in trauma (FAST). These are often inexpensive to purchase and maintain, and may even be homemade, and are thus frequently utilized for a variety of teaching scenarios where concise goals are sought. The TraumaMan© (Simulab Corporation, Seattle, WA) simulator is one such trainer designed for tube thoracostomy, needle thoracostomy, criothyroidotomy, tracheostomy, pericardiocentesis and diagnostic peritoneal lavage (DPL) that has been shown to be comparable to live tissue models.[7] Ultrasonographic evaluation after injury is a growing field of study, and several trainers exist, including SonoSim® (SonoSim, Santa Monica, CA), to improve image acquisition time and accuracy during FAST examinations.[8]

High-fidelity simulators are also frequently utilized in trauma training. The ability to incorporate more of the real-life patient experience allows high-fidelity simulations to invoke higher order thought processes and management of the entire patient or patients. The Apollo© (CAE Heathcare, Sarasota, FL) and SimMan 3D© (Laerdal, New York, NY) are two mannequin simulators that provide a wide variety of physiologic input which favor full-scale trauma simulation scenarios. These types of simulators have features that incorporate all body systems so that the facilitator can customize each patient encounter. For example, the simulator may be tachycardic, hypotensive, and with an altered mental status secondary to hemorrhage from a penetrating wound to the thigh. With tourniquet application, intravenous access gained and blood product resuscitation the simulator will respond just as a live patient. If other injuries are not identified, the simulator may mimic a transient responder, and prompt additional interventions. The ability of high-fidelity simulators to incorporate nearly all facets of caring for real trauma patients, make them highly effective educational tools.[9] In addition to technical skill training, high-fidelity simulators offer the benefit of teaching non-technical skills and team training.[10]

Virtual Reality

Immersive, highly visual and often 3D, virtual reality simulators closely replicate real-life with incorporation of physical interfaces and haptic feedback. Virtual reality simulators are technically advanced, and available in a range of sizes and shapes. Some incorporate gaming-industry headsets and cellular phones, while others involve large-scale simulators resembling carnival rides. The field of virtual reality training in trauma is growing exponentially. Downloadable apps are currently being developed that, with the addition of a $20 headset, can provide an immersive trauma scenario experience.[11] Additionally, virtual reality simulations have the ability to connect multiple users at multiple locations to increase availability to centers with limited resources.[12]

Cadaver Training

Cadavers have long-been employed to teach anatomy and surgical technique and continue to be an excellent training tool. The Advanced Surgical Skills for Exposure in Trauma (ASSET™) course currently utilizes fresh cadavers to address difficult and rarely performed trauma surgical exposures.[13] Recent advancements in technology have allowed cadavers to more closely replicate living human tissue. Perfused cadaver models replicate bleeding tissue, and therefore closely mimic traumatic injuries.[14,15]

Although useful as a trauma training analog, access to these models is expectedly limited.

Live-Tissue Training

Despite technological advancements leading to the development of complex and interactive high-fidelity and virtual reality simulators, they lack the realism that can be portrayed with live tissue models. Learner engagement is a key concept when debating the effectiveness of simulation in education, and live tissue has been shown to increase engagement substantially.[16] Start-up costs are high, and facilities are few, however the benefits of live tissue training cannot be overlooked. The Advanced Trauma Operative Management (ATOM™) course utilizes live tissue to train surgeons and surgical residents during a 1-day course designed specifically to address operative penetrating trauma. Studies aimed at assessing the effectiveness of the course show improved knowledge retention and confidence in approaching life-threatening penetrating injury.[17,18]

Trauma Non-Technical Skills

While many of the above methods are designed with specific tasks in mind, non-technical skills training in trauma is of equivalent importance. Most errors in the care of trauma patients are not technically-oriented, and arise from improper triage, indecisive team leadership and failed recognition of evolving life-threatening injury.[19] Several long-standing courses offered through the American College of Surgeons, including ATLS®, are specifically designed to improve recognition of serious injuries. Courses are offered to physicians frequently at several institutions across the state in an intense 2-day format. Less robust, Trauma Evaluation and Management (TEAM®) courses provide medical students a short, 90-minute overview of how to identify and treat common potentially lethal traumatic conditions. For those already in practice, the Rural Trauma Team Development Course (RTTDC™) improves care through a 1-day course aimed at improving care at rural facilities. This course addresses the importance of communication and role definition through interactive lectures and simulated scenarios.

Effective leadership appears to be a defining characteristic of successful trauma resuscitation.[20,21] For this reason, trauma team simulation curricula have focused on developing leadership qualities. A typical trauma team simulation follows crew resource management techniques taught most notably in the airline industry, where lectures are combined with practical stations and interactive discussions, all guided to improve leadership and closed-loop communication.[22] Team simulations frequently utilize high-fidelity mannequins to present physiologic and traumatic maladies to a multidisciplinary team. Virtual reality and live tissue simulations provide increased levels of engagement and are increasingly utilized for trauma team and leadership training. Additionally, standardized patients may be utilized via Objective Structured Clinical Examination (OSCE) methods. Video-based debriefings are frequently utilized and provide insight for participants to improve non-technical skills.

Emergency Medical Services Simulation

With changing paradigms regarding domestic terrorism and increasing frequency of mass casualty and disaster events, a focus on community readiness has emerged. Preparing emergency medical services (EMS) for large-scale events requires extensive planning and preparation to adequately manage patients during surge scenarios. To do this, simulated exercises have become more commonplace. Often involving multiple facets of emergency care, such as police, fire, ambulance, and hospital personnel, these sometimes massive simulation events have proven vital to the success of municipalities in addressing rare, high-acuity events like mass shootings.[23]

Simulation scene training for EMS has historically been focused on logistical simulation. However, evolving methods have begun to incorporate existing infrastructure, such as actual helicopters and ambulances to create mock scenarios targeted toward scene-specific issues, such as early identification and management of life-threatening injuries. Utilizing existing elements decreases costs and provides true-to-life practicum for participants who work within the exact environment in which they trained.[24] Utilizing high-fidelity mannequins during scene simulation adds an element of complexity that affords increased realism and scenario dynamics. Video monitoring of the events may be employed to provide instructors and participants the ability to view and debrief, adding educational value.

Technical procedure simulation has shown clear benefits for a variety of medical specialties. EMS procedural simulation is frequently performed with both low- and high-fidelity trainers. Some centers have the unique ability to expand procedural training to live tissue. However, local political climates and budgets may

preclude its use. Emergency life-saving procedures, such as cricothyroidotomy and tube thoracostomy, are well-suited to live tissue training for EMS providers.[16] The ability of high-fidelity and virtual reality simulation to replicate the austere EMS environment, has resulted in a shift toward more high-tech training methodologies.[24-26] Virtual-reality environments afford manipulated conditions that may be easily repeated to the desired task at hand.[27] Fully-immersive technologies allow for simulated medical care within the treatment bay of a realistic ambulance or helicopter while underway – adding in complexities such as wind, elevation and noise – which create lifelike training environments.

Simulation Challenges

Trauma simulation training has become a key component in the education of practitioners caring for acutely-injured patients. While a steady stream of technological advancements improve trauma simulation, modalities will continue to be challenged by innate shortcomings, such as realism and authenticity.[9] Additionally, high levels of learner engagement, and long-term knowledge retention with simulation have not been consistently demonstrated in the literature. Finally, start-up costs can be quite high, and thus prohibitive to smaller centers.

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Disclosure

None reported.

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