Optimization of Simulation and Moulage in Military-Related Medical Training

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ABSTRACT

Preparation of Special Operations Forces (SOF) Medics as first responders for the battle space and austere environments is critical to optimize survival and quality of life for our Operators who may sustain serious and complex wounding patterns and illnesses. In the absence of constant clinical exposure for these medics, it is necessary to maximize all available training opportunities. The incorporation of scenario-based training helps weave together teamwork and the ability to practice treatment protocols in a tactical, controlled training environment to reproduce, to some degree, the environment in and stressors under which care will need to be delivered. We reviewed the evolution of training scenarios within one Pararescue (PJ) team since 2008 and codified various tools used to simulate physical findings and drive medical exercises as part of scenario-based training. We also surveyed other SOF Medic training resources.

KEYWORDS: *Pararescue; training, scenario-based; SOF Medics; simulation; moulage; training, military-related medical*

Introduction

Preparation of SOF Medics as first responders for the battle space and austere environments is critical to optimize survival and quality of life for our Operators who may sustain serious and complex wounding patterns and illnesses. In the absence of constant clinical exposure for these medics, it is necessary to maximize all available training opportunities. The incorporation of scenario-based training helps weave together teamwork and the ability to practice treatment protocols in a tactical, controlled training environment to reproduce, to some degree, the environment in and stressors under which care will need to be delivered. All protocols are practiced as established by the *Pararescue Medical Operations Handbook*.[1]

Scenario-based training at the unit level is the most readily available and least expensive training; using role players or simple mannequins allows the medics to practice and repeat protocols in the context of operations training. Mannequins found in simulation laboratories are expensive, complex, and computerized and contain software. They are impractical in these settings due to the lack of skilled personnel dedicated to the operation and maintenance of this equipment, as well as the impracticality of moving this equipment over rough terrain and by air. An article in the *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine* noted similarly that "[m]uch emphasis has been put on increasing the fidelity, but as the simulators become increasingly advanced, their mobility decreases and the demand for experienced operators and instructors increases. So do inevitably the costs."[2]

Military medics are adult learners who learn by different methods compared with earlier stages in their formal brick-and-mortar didactic-style education.[3] A 2009 report in the *Mount Sinai Journal of Medicine* stated that "clinical medicine is becoming focused more on patient safety and quality than on bed-side teaching and education . . . [and as a result, a] disconnect still exists between the classroom and clinical environment."[3] Therefore, as the link widens between classrooms and the battlefield or remote outposts, it is necessary to train medics via various simulation techniques. Presently, the best simulation medium for military medical providers is not known because most of these simulations lack the ability to drive medics to properly diagnose a patient.

Until now, the clinical and training value of getting the diagnosis correct has been the focus, not the ability of the medic to make decisions based on patient assessment or to accurately learn and rehearse appropriate skills. After almost a decade of training medics during Operation Enduring Freedom and Operation Iraqi Freedom, the lack of such data and guidance prompted us to determine the optimal means to train medics, with a concentration in the use of moulage (i.e., mock injury) techniques to compensate for lack of a clinical setting and, furthermore, simulate realistic scenarios. This was observed among one PJ team from 2008 to the present by using simulation techniques to standardize or, alternatively, display practices during medical exercises and evaluations to reduce proctor inputs.

Materials and Methods

We reviewed the evolution of training scenarios within one PJ team since 2008 and codified various tools used to simulate physical findings and drive medical exercises as part of

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scenario-based training. We also surveyed other SOF medic training resources. The techniques generally involve low levels of technology, taken from theatrical makeup courses, yet proved to be easily reproducible. When possible, commercially available rubber injuries with Velcro straps were used because they are recognizable as the injuries they represent (e.g., open fracture and burns).

Each finding was shown and explained to the PJ before training so each individual would know what the moulage represented. The objective was that if they were close enough to elicit a visual or tactile recognition resembling the injury or finding, it would imprint the basis of the diagnosis for recognition in a real-world situation. The ideas were compiled, listed, and photographed for this article. We did not look at training decay because the value was determined in debriefs after combat deployments and mission report reviews to determine that treatments were rendered per protocol based on the diagnosis.

Results

While information was gathered, photographs were taken in an attempt to standardize, or alternatively display best practices as used by SOF medical instructors and trainers during medical exercises and evaluations, and to reduce proctor inputs. The following photographs are broken down into two main categories: (1) signs and symptoms, and (2) skills sustainment. Signs and symptoms photographs are used to drive the medic toward making the correct diagnosis and treatment of injuries sustained. Skills stations are designed for the military medic to practice and perform the task hands-on, albeit in a controlled environment. As part of a larger medical scenario or as a standalone exercise, this ensures all essential steps are performed in a checklist-based approach. This allows the medic numerous opportunities to perform the task, become familiarized with gear, and accurately learn these procedures, in addition to making decisions based on assessment of the patient, and thus perform the appropriate hands-on skills. Providing refresher classes to junior medics before a trauma assessment increases the individual's exposure to such material and ensures medics receive adequate training.

A related observation we have made is that if the medic is trained in a stressful scenario and cannot recall the treatment protocol very well, the result has been a nervous medic who incorrectly performs protocols and procedures. Conversely, if the medic has proven competency through testing and standalone skills performance, and stress is incrementally added, the correct performance of the protocol under such conditions is reinforced. Stressors added can be more than tactical-related scenarios; they may incorporate various environmental factors (e.g., darkness, cold weather, and rain). This incremental approach allows for some subconscious, automatic performance of the protocol and enables maximal alertness for situational awareness.

Discussion

Special Forces Medics (18D), PJs, Special Amphibious Recon Corpsman, and Special Operations Combat Medics have limited medical training. Additionally, due to various medicolegal challenges,[5] many medics are unable to practice clinical

SIGNS AND SYMPTOMS

Figure 1 *Simulated vomit with airway obstruction is depicted with stew in a role player's mouth. In past medical exercises, the vomit may have been noted by the instructor verbalizing, "blood and mucus," "dirt," or "vomit in the mouth," whereas now, the medic will no longer have to rely on the proctor's verbal inputs. Instead, the medic would respond to what they see and feel, as one would in a real situation. Therefore, the medic responds to the visual cue and must clear the airway.*

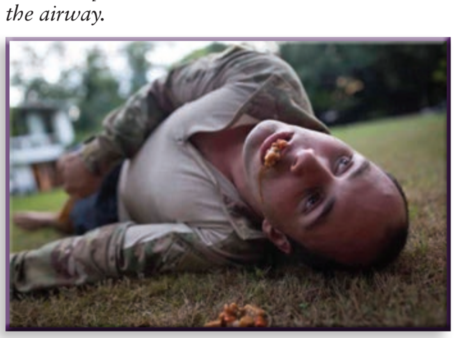
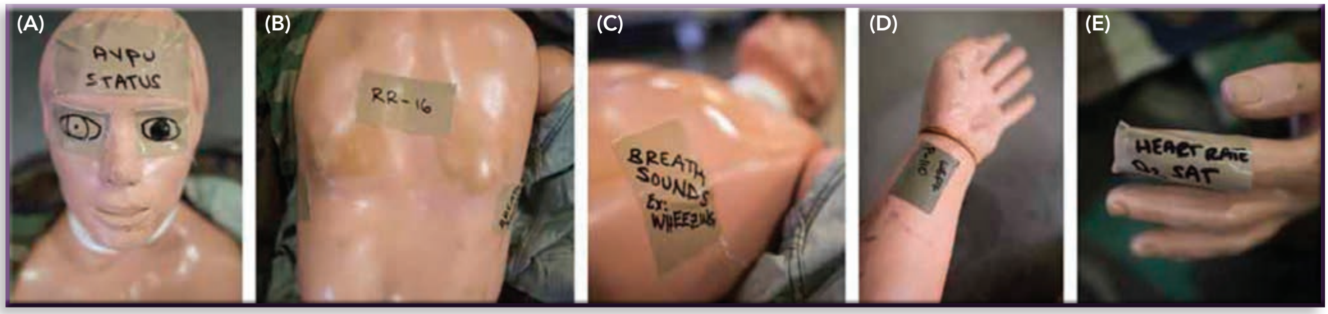


Figure 2 *Subcutaneous emphysema is represented by a plastic bag of rice taped to the chest. Subcutaneous emphysema, once palpated, will create a tactile memory and set in motion various maneuvers to manage thoracic trauma. Palpation of the rice in the plastic bag produces a sensation such that this finding should be recognized in real-world missions. It is more probable that a medic who feels or sees findings and is trained to react to those findings will achieve clinical fidelity than a medic processing an instructor's verbalized physical finding, then reacting.*

Figure 3 *Broken ribs. Tongue blades broken in half and taped to the chest with overlying tape so the sharp edges of the tongue blades do not cut the examiner. The simulated break is unmistakable on palpation. Bending and breaking tongue blades, but not separating the broken ends, approximate tenting of the skin from broken ribs or other bones. As a result, the medic will feel the tenting of the skin (i.e., tape, in the simulation) and the bone ends. Placing two or three broken ribs with additional ribs taped two or three a few inches apart, simulates the floating rib fractures of a flail chest; however, paradoxical motion cannot be simulated.*

Figure 4 *By placing duct tape on mannequins or using nonpermanent marker on the skin of role players, findings such as level of consciousness can be indicated where one would find the corresponding diagnostic sign or symptom. The mannequin should be dressed in a uniform, which requires the medic to do a full examination. Using a felt-tip pen or marker on duct tape on the forehead to state the level of consciousness, the medic is directly engaged, making an appropriate diagnosis during his inspection of the head during MARCH (massive bleeding, airway, respirations, circulation, head).* **(A)** *The alert, voice, pain, unresponsive (AVPU) status is noted on a label on the forehead and represents a blown pupil and normal pupil.* **(B–E)** *Vital signs and physical findings are displayed, including* **(B)** *respiratory rate on sternum,* **(C)** *breath sounds on anterior axillary line,* **(D)** *pulse information on wrist, and* **(E)** *heart rate and oxygen saturation on index finger. If a unit is low on funds or uniforms, uniforms with Velcro down the pants and arms may be used to dress such role players and mannequins to reduce waste. Mannequins may also be used to increase the number of patients or as necessary if role players are not available. If the mannequin is deceased, the pulse and respirations are marked as absent, unresponsive is marked on the forehead, and fixed and dilated pupils are drawn on the eyes. We use these findings during debriefs to have the medic reiterate the four key findings of absent vital signs: pulseless, apneic, unresponsive, and bilateral fixed and dilated pupils.*



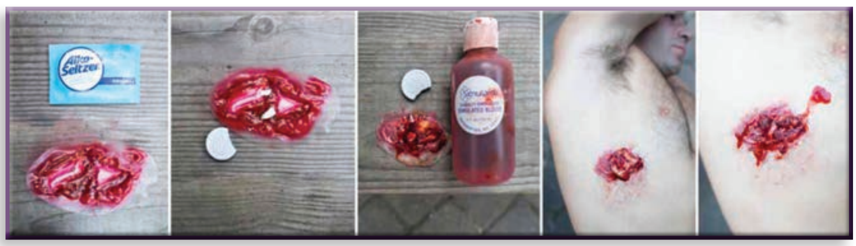


Figure 5 *Sucking chest wounds created by using moulage glue to make a crater. As the medic arrives, water can be poured on antacid tablets, causing the wound to bubble, simulating findings of a sucking chest wound. We also find it helpful to show videos of real examples of this wound during the brief or debrief on the same training day.*

Figure 6 *Oatmeal with gray food coloring and streaks of red create a consistency for brain matter. It is best to secure with plastic wrap or tubular retainer net (e.g., Spandage; Medi-Tech International, http://medi-techintl.com/). When the oatmeal is at room temperature, red streaks are added and the oatmeal is placed in a small plastic bag, which is then placed on the head and secured. Additionally, this substance can be placed under plastic wrap, directly on the role model's scalp.*

Figure 7 *Escharotomy model.[4] Escharotomy and burn models can be handcrafted to allow the medics to perform tasks typically only available on cadavers. Creating this model is time consuming; however, the task of knowing when and how to properly perform an escharotomy in accordance with the Advanced Tactical Paramedic guidelines is an important task that could save functionality of a patient's limb.*

Figure 8 *A piece of crumbled of 2 × 2 gauze under Tegaderm dressing (3M, http://www.3m.com) to replicate the feel of a gunshot wound. This ensures that the medic palpates the entire body during an initial blood sweep and secondary assessment, guaranteeing they feel for injuries. That the medic must confirm a wound exists and properly treats it will help minimize proctor input.*

Figure 9 *An empty intravenous (IV) solution bag taped to the arm allows the medic to start an IV and inject replica/dummy medications. It is not practical to start an IV line on all role players because medications or "training" medications cannot be injected. By adding patient scripts and cues, a unit can use its own members, or request tasking a different unit to provide patients. By allowing participants to act out what they need reduces additional interactions between the evaluator and the medic. When using role players, having a "safe" word for these participants instead of the medic asking if performing an IV, nasopharyngeal airway, and so forth is acceptable to that role player, the medic can then perform the task without hesitation on the set-up IV bag. We see IVs as a stand-alone exercise that should be practiced among teammates monthly. To overcome the loss of ability to draw and administer medications per protocol, we use empty IV bags and practice bones for interosseous (IO) administration in a simple manner.*

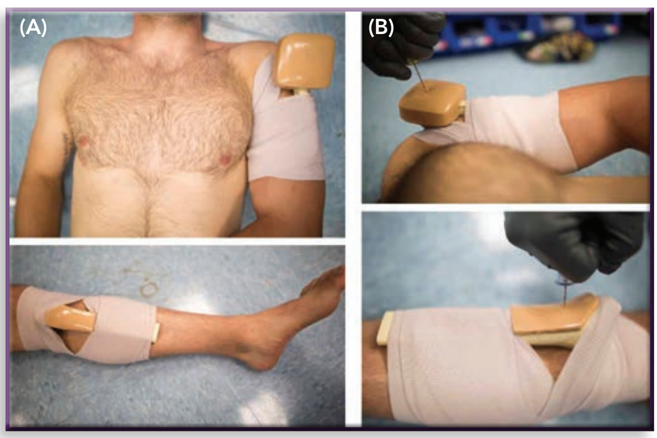


Figure 10 *IO bone trainers are taped in place on* **(A)** *the humerus and* **(B)** *the tibia to drive the intraosseous needle.* **(C)** *Alternatively, have the medic identify the site and angle of the needle on the role player and then insert the IO needle into the model placed next to the role player. Similarly, humeral head and tibial plateau practice IO bones are taped in place, allowing the medic to drive the IO needle into the practice bone. The line can then be connected to the IO or an empty bag.*

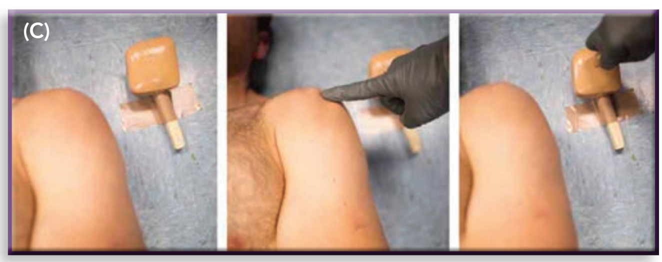


Figure 11 *Dummy or expired medications used as saline vials with the pertinent labels force the medic to draw up medications in the same concentrations as supplied. An empty IV bag is taped to a patient's (i.e., mannequin or role player) arm. This allows the medic to "start" an IV into the bag, then inject replica and dummy medications. Forcing medics to fully draw up medications, clean off vials of medicine, and then perform IV pushes or drips (from the normal saline vials marked with the proper "dose" of the medication) yields a truer sense of the amount of time as well as the hand-eye coordination and memorization of the tasks performed. Simply having medics verbally state, "I would then give [correct dose] of [medication name]" does not help the medic learn where medications are packed, if they are ready for quick administration, if these tasks can be performed efficiently in the dark while wearing night-vision goggles, or the amount of time it takes from initiation until proper documentation.*

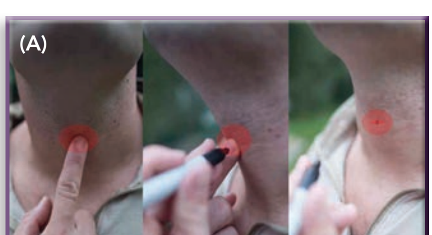


Figure 12 *Surgical cricothyrotomy.* **(A)** *When performing this procedure in training, have the medic identify the cricothyroid membrane on the role player with a dot or a line with a felt-tip marker, which provides benefit to the medic even if no incision as made, because they identify the appropriate landmarks quickly, then perform the cricothyrotomy into the model created by* **(B)** *taping the top and bottom of 8 in. of vent tubing (representing the trachea) to the ground or floor, covered by thin neoprene (representing skin) or* **(C)** *using a commercial device. The ridged tubing simulates the airway, while the neoprene simulates the skin and subcutaneous tissue.* **(D)** *The most realistic method used involves a swine trachea from a slaughterhouse which is then covered by sheepskin incorporated into a model created by the Air Combat Command/SGR Medical Modernization and Planning HQ. Sheepskin is the most realistic approximation to human skin and one of the most representative and complete models used by medics to enhance this skill. Therefore, the combination of anatomic localization on the role player and performance of the skill allow for the cognitive and psychomotor integration of this invasive skill into the scenario.*

Figure 12 *Cont.*

Figure 13 *Foley catheter.* **(A)** *Recently, the focus of extended care has brought to the forefront the need for placement of Foley catheters to accurately measure urine output of critically injured or ill patients. It is possible to have the medic perform a Foley catheter insertion by securing an endotracheal (ET) tube to the upper thigh (typically with tape or elastic bandage) of the role player so the top lumen is near pubic bone and bottom is at the top of thigh.* **(B)** *If the medic determines that the patient requires a Foley catheter, he or she can simulate inserting it using a sterile technique by treating the bottom of the ET tube along the medial thigh as if it were the penis. The catheter should be inserted so the balloon goes distal to the superior lumen, then the balloon can be inflated and the catheter taped into place. While the medic is performing other tasks, or has moved between patients, an instructor can occasionally inject liquid with the appropriate shade of yellow into the catheter so the "urine output" can be measured. If the scenario involves a patient with crush syndrome or rhabdomyolysis, the instructor can use dark soda in lieu of lighter-colored liquids.*

Figure 14 *Chest tube.* **(A)** *Demonstrate the incision line on role player, then* **(B)** *perform the procedure on a box covered with neoprene. In this case, the incision is anterior of where it would be desired and feedback can be given, and the correction could be made. This can be a stand-alone anatomy drill where the medic can mark various landmarks on a training partner. If the patient requires a thoracostomy or chest tube, the medic should draw an incision line on the role player with a felt-tip marker. If in haste, a chest tube can be secured by multiple chest seals, duct tape, and staples, or by suturing. If unable to make the model, taping the chest tube to the patient's chest emulates what the patient will look like with another tube coming out of the body.*

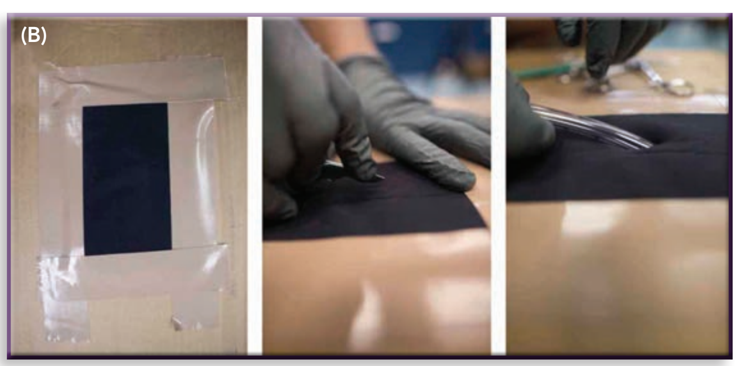


Figure 15 *Practice suturing on pig feet. If unavailable, an instructor can make an incision in the center of duct-taped neoprene or cloth to a table on four sides to allow the student to practice suturing.*

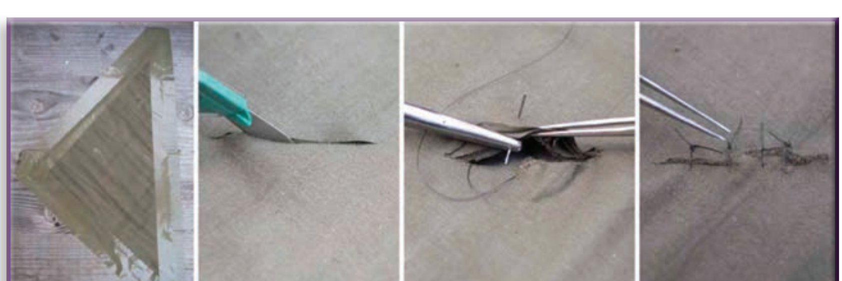


Figure 16 *The combat pill pack. As the introduction of antibiotics to the battlefield has helped to decrease the number of infections, many organizations now mandate their members carry the combat pill pack, a combination of acetaminophen, meloxicam, and moxifloxacin. All individuals should carry a small plastic bag with three pieces of candy, whereby the medic upon scene can ask if the injured has taken his or her combat pill pack. If the patient has not done so, the medic can direct the patient to consume their pre-allocated medication.*

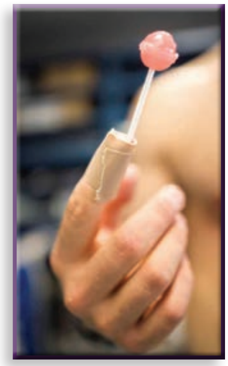


Figure 17 *Lollipop simulating a fentanyl lozenge. When indicated, the medic gives a lozenge to the patient with appropriate instructions. Patients are instructed to continue having pain for several minutes and occasionally pass out, simulating respiratory depression requiring naloxone administration and airway support, emphasizing the importance of continuous monitoring.*

medicine on patients in hospitals or in ambulances after graduation from formal military medical training. The traditional educational and assessment approach using lectures, clinical shadowing, written examinations, and objective-structured clinical examinations are not enough in totality for physicians to help address all competencies regarding education, practice, and team-based learning.[6] As a whole, medics require medical exercises that are driven by their assessment and inspection of patients rather than proctor inputs. Regardless of the type of simulation training selected by the instructor, much of the training is learner dependent, because each medical exercise requires full participation and engagement by the individual.[3] However, simulation can be extremely cost prohibitive and, therefore, not practical for use when performing frequent situational medical exercises. Moulage is commonly used during training; there is a paucity of research and guidelines regarding how to best display various signs and symptoms related to combat trauma. This is necessary to drive clinical diagnostic acumen, as well as push the trainee to perform the protocols associated with the desired learning objectives for the exercise.

Deliberate practice and mastery of basic skills must use certain commonalities regardless of the specific medical exercise created and used. All these techniques should be reviewed as standard rules of engagement before training to maximize the value of the training. Trainees must be able to correctly identify the cue stated by the instructor during their assessment of the patient, treat the patient appropriately, and view the results of their treatment repeatedly to root the pathways for diagnosis and treatment according to military medical protocols.[7] Through observation within this study, trainees may incorrectly diagnose patients during simulations because of ineffective moulage, vague instructions given to the role player or medic, vague signs and symptoms, poor coaching of the role player, the role player not staying in role, or lack of practice. Therefore, feedback must be provided immediately, and the individual being evaluated must engage in repetitive practice until the treatment algorithms are committed to memory.[7]

Equally as important, at the outset of training, instructors must identify the requisite-defined learning objectives and tasks to help guide the immediate feedback sessions.[7] As the algorithms become ingrained by repetitive practice, clinical variation and stress can be added over time. Often in the military, individual organizations slightly modify doctrinal tactics to develop their own techniques and procedures. However, in medicine, cross-talk between organizations has helped standardize treatments and protocols (e.g., Committee for Tactical Combat Casualty Care, the Joint Trauma Service [JTS]). The JTS provides up-to-date clinical practical guidelines based on feedback from theater trauma patients; this shared approach to training, as it relates to ideas and materials, would benefit all warfighters.[6]

Simulation as a teaching technique can be used so the learner can participate in mastery learning and deliberate practice, embrace outcome measurement, and address cultural barriers.[7] The use of cadavers to practice invasive battlefield procedures required of medics is the best available; human cadavers are frequently used to perform procedures on human anatomy that lack diagnostic drivers.

Due to limitations of cost and reality, most training exercises use role players. The use of appropriate props and moulage techniques eliminate much of the verbalization of findings and contrived nature of putting on situational medical exercises; therefore, it is possible to better approximate physical findings driving the scenario. No substitute exists for learning how to incise a human's skin, thus the use of human cadavers helps close the gap from not having suitable clinical training. Once the skill is learned on a suitable model, it can be successfully incorporated into scenario-based training to reinforce the technique. Skill stations can also be performed separately from a medical exercise, allowing the medic to continue to hone his or her skills. These stations will test the medic, ensuring he or she is adequately prepared with the required equipment to perform the task, in addition to teaching the medic the amount of time the task will take to perform correctly without distractions. Finally, we believe that practicing a protocol in its totality is necessary for adequate subconscious learning of the task in a suitable setting so that appropriate emotional contextualization will occur.

Undoubtedly, the goal within the SOF medical community is mastery of the basics, of which expert performance is contingent upon four conditions: intense repetition of a skill, rigorous assessment of that performance, specific informative feedback, and improved performance in a controlled setting (i.e., lack of real-life threat to the patient and providers), which allows for medical oversight and evaluation.[3] In our training environment, we define a controlled setting as a noncombat setting in which direct medical director observation is performed. Ideally, a controlled setting will use the photographs discussed to be briefed before the exercise, driving the medics to make the correct diagnosis and treatment of the simulated patient. A study noted that students tend to remember 90% of what they do, compared with only 10% of what they read.[3]

A study performed in Victoria, Australia, surveyed more than 200 health care professionals, including doctors, nurses, paramedics, and midwives in rural areas. Parallels can be drawn between rural healthcare professionals and SOF medics: both are expected to perform flawlessly even though certain illnesses, diseases, and surgical procedural skills may seldom be performed. SOF medics are expected to properly triage, identify, and treat wounded Servicemembers in a timely manner without consistent exposure to such egregious injuries.[8] This study demonstrated that there was a correlation between the frequency of certain skills and confidence regarding maintenance of these skills; conversely, the more complex the skill or disease state, the more likely respondents reported a need for frequent rehearsal of the skill.[8]

Research has found that simulation-based workshops, each lasting approximately 1 hour and comprising a scenario lasting 30 minutes, followed by a 15-minute debriefing session and 10-minute didactic session covering key teaching points, are beneficial teaching models. Participants at baseline felt the simulation was more valuable for medical teaching when compared with traditional-style reviews of course material.[5] Anesthesiologists and emergency medicine programs express the benefits of simulation training, particularly during critical and stressful periods of treatment, as well as better adherence to algorithms for performing intubations, resuscitations, and American Heart Association guidelines in real emergencies.[3,5]

Conclusion

The goal of simulation training to maximize its impact is to remove as many administrative interactions and notional training inputs with the instructor or role player as possible. Although the ultimate medical training is clinical rotations with access to patients, the improved simulation experience allows for improved practice of technique, aiding retention in the tactical or austere setting. This is the standard by which most medics train, thus increasing the importance of improving fidelity of the training experience. Simulation will never replace the situational context and complex interactions learned through contact with real patients.[7] However, in the SOF medical community, it remains the most commonly available source of training for our medics. Thus, it is incumbent upon trainers to make it as worthwhile and effective as possible to both support the medic and optimize patient outcome. We believe that although the techniques discussed in this article are simple and involve low levels of technology, they improve the fidelity of each exercise and move closer to achieving the desired training objectives.

Disclosures

The authors have nothing to disclose.

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