Virtual Patient Simulation: Transforming Combat Medic Training

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ABSTRACT

A fundamental challenge for the United States Army is to ensure that it can effectively maintain the Combat Medic forces necessary to meet the challenges of the current battlefield and at the same time transforming Combat Medic capabilities to respond effectively in the future. One of the most important issues is how to train medical personnel in peacetime for the realities of war. In recognition that every soldier is a first responder, the Army has added a virtual capability to its medical training arena, the Medical Simulation Training Center (MSTC). This paper describes the MSTC initiative which standardizes the medical training needed by incorporating a lifelike and medically authentic simulation system designed to provide a broad spectrum of symptoms to give Soldiers the skills to save lives in combat. The new integrated training centers provide realistic wartime training utilizing physiologically-based patient simulators to ensure that they will be able to perform their duties both as a soldier and a medic. The use of simulation based training will provide medical personnel with realistic, high fidelity, mission-oriented training in critical medical skills, decision-making, and team coordination. This dynamic environment provides live, virtual, and constructive training with an emphasis on the Combat Medic Advanced Skills Training (CMAST) and Combat Life-Saver (CLS) training principles while incorporating state of the art technology. The MSTC places training emphasis on realistic simulation while adhering to the principles of tactical combat casualty care ensuring all students receive didactic, hands on, tactical, and technical medical training required to save lives during combat operations abroad.

ABOUT THE AUTHORS

Gino F. Fragomeni serves as the Systems Engineer for the Medical Simulation Training Center (MSTC) for the Program Executive Office for Simulation, Training and Instrumentation (PEO STRI). Gino is responsible for providing technical oversight and is the focal point for issues relating to the efforts of the system and integration for virtual, constructive, and live simulation. He holds a Masters of Science from the University of Central Florida and has specialized training in Systems Engineering and Simulation.

Shannon S. Swain is the program Military Analyst for the Medical Simulation Training Center (MSTC) for the Program Executive Office for Simulation, Training and Instrumentation (PEO STRI). Shannon is responsible for the daily interaction with high level officials of the Army, other government agencies and contractors to ensure the program requirements, system lifecycle, front-end-analysis, and fielding are clearly stated and understood and that the systems meet their performance requirements. He is currently a US Army Special Forces Operations and Intelligence Sergeant and Emergency Room Registered Nurse.

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INTRODUCTION

Despite the advances in medical technologies Soldiers in combat continue to die from three main causes: hemorrhage, airway compromise, and tension pneumothrax (collapsed lung). The treatment that is provided in the first ten minutes to a wounded Soldier has the greatest impact on their outcome. For this reason it is essential that Combat Medics and Combat Life Savers (CLS) receive battle focused training on the principles of combat casualty care and stay abreast of all new medical equipment and procedures. This is critical for Soldiers who are deployed for extended periods where sustainment of their medical skills can be degraded. Given the number of procedures performed, versus the number of medical personnel in the Army, coupled with the hindrance deployment plays on clinical training opportunities, it becomes necessary to foster an environment in which the medical personnel can train and renew their skills in the event they must perform in a real life situation. Furthermore, certain procedures are dangerous to perform on humans without a certain amount of practice and repetition on a training device. Enter the need for simulation. Simulations provide the medium on which these procedures can be trained. Second only to performance on live patients, which can be sporadic, stressful, and dangerous, simulations provide a medium where procedures can be learned in a stress-controlled intensive environment with minimal risk of injury to the live participant. Simulation provides the opportunity for the exact replication of a scenario, across a group of subjects, or for the duplication of a real-world patient and trauma.

OVERVIEW

The Commander, U.S. Army Medical Command in an Operational Needs Statement (ONS), dated 01 September 2005, identified a gap in Soldier-Medic training. The ONS listed the gap as the difference between current training offered and the need for battle focused training utilizing the principles of providing care in a tactical combat environment found in Training Circular (TC) 8-800.

At the time the ONS was written there was no dedicated resource for the combat medic skills after Soldiers completed Advanced Initial Training (AIT). The ONS also noted that valuable lessons learned from Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) was not passed on uniformly to Soldiers. Because sustainment training for Soldier-Medics was not standardized and the need for battle focused training existed, the Program Executive Office Simulation Training & Instrumentation (PEO STRI) was tasked to execute the implementation of The Medical Simulation Training Center (MSTC) program. The MSTC was created as a virtual simulation training facility where Soldiers could obtain sustainment and validate their medical skills. The MSTC affords commanders the flexibility to validate assigned Soldier medical skills prior to deployment and allows them the greatest flexibility in creating training relevant to the Contemporary Operating Environment (COE) and the unit's Mission Essential Task List (METL). The MSTC also provides an arena where lessons learned from current military operations are implemented and Soldiers can be educated on new battlefield procedures and equipment.

TRAINING METHODOLOGY

The MSTC is based on a training methodology that provides comprehensive training in several formats such as classroom settings, practical hands-on training, simulation, trauma lanes, and distance learning. This is accomplished in a training facility where Soldiers can obtain sustainment training and validate their medical skills in accordance with TC 8-800 and support critical training tasks associated with the Tactical Combat Casualty Care (TC3) and the Combat Life Saver (CLS) courses. The primary focus is on providing TC3/Combat Medical Advanced Simulation Training (CMAST) to the 91W/68W Military Occupational Specialty (MOS) and CLS training to non-medical personnel. It also includes: Emergency Medical Technician (EMT)-B Refresher, Soldier's Annual Combat Medic Skills – Validation Test (SACMS-VT),

and Basic Life Support (BLS) for the 91W/68W MOS qualification (see Figure 1).

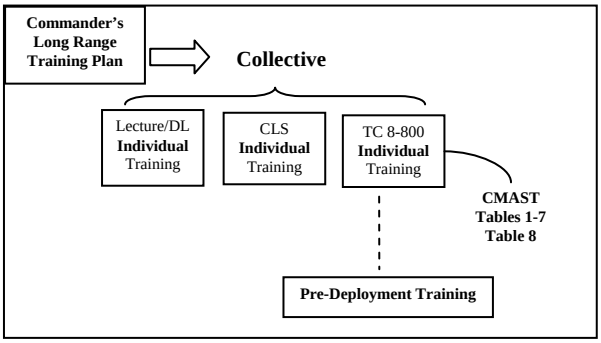

Figure 1. Training Methodology

The MSTC has the ability to support all aspects of training, from individual skills to unit collective training, using combat medics and CLS personnel in their respective roles during casualty care. Battlefield medics provide "Care-under-fire" at the point of injury to prevent death from the three major treatable causes: hemorrhage, airway compromise, and tension pneumothrax (collapsed lung). There can be multiple patients in any given scenario, with various degrees of injury, to necessitate triage and prioritization of care, based on the units' desired end-states. This methodology is accomplished utilizing a complementary mix of virtual and live simulation including computer based training.

DESIGN AND IMPLEMENTATION

The MSTC is designed primarily as an installation resource to ensure optimum utilization and is geographically situated in locations that have a high density of Active Duty 91W/68W populations or in areas that will ensure maximum coverage of the Reserve Component and National Guard forces. There are 18 MTSC sites located world wide. To facilitate implementation sites were broken down into the following priority levels.

- Priority 1 sites: FT Bragg, Ft Drum, Ft Hood, Ft Lewis, Kuwait, and Iraq.

- Priority 2 sites: Ft Bliss, Ft Riley, Ft Stewart, Ft Carson, Ft McCoy, Camp Shelby, Ft Campbell, Ft Wainwright, Schofield Barracks, Vilseck-Germany, Camp Stanley-Korea, and Ft. Dix.

There is also a deployable capability to accommodate training of all components on a regional as well as worldwide basis.

Organizational Structure

The MSTC program is the responsibility of the United States Army Medical Center & School (AMEDDC&S) and the charter group appointed by the Commandant. The AMEDDC&S provides oversight to ensure all instructions adhere to AMEDDC&S standards. The operations at each MSTC are controlled by the site director through a locally appointed oversight committee consisting of installation representatives from tenant units and installation activities. The acquisition of the MSTC is managed by PEO STRI to ensure integration of facilities and the various live, virtual, and constructive simulations. The PEO is also responsible for life cycle support of the sites and the cadre of one Lead Instructor/Manager, three civilian instructor/operators and one administrative technician which are provided for each of the sites to perform the course instruction and on-site management.

Facilities

Because of the urgent need of the MSTC program, PEO STRI had a challenging effort to provide facilities at the 18 sites. Careful consideration was given to ensure that the facilities would support the installations after Base Realignment and Closure (BRAC) and ongoing realignment actions to include consideration to ensure maximum coverage of the Reserve and Guard forces. Due to funding requirements each facility had to be completed under a $750,000 limit that was utilized to ensure rapid execution. Each site had the option to upgrade an existing facility or construct a new facility that did not exceed the funding. Each site was given a suggested Floor Plan (see Figure 2) that would support the requirements for the MSTC.

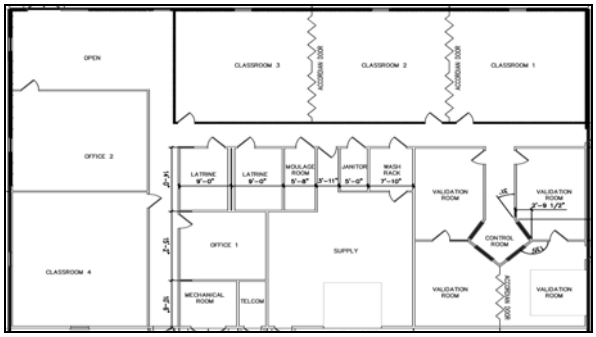

Figure 2. Suggested Floor Plan

The suggested Floor Plan was given as a guide to ensure a structural layout that would enable training to be conducted using multiple approaches, such as classroom setting, use of computers, special effects, virtual patient simulators, skill lanes, distant learning and the use of emerging technologies.

Virtual Patient Simulation

The MSTC initiative standardized combat casualty care by incorporating a lifelike and medically authentic simulation device designed to provide a broad spectrum of symptoms. The objective of this design was integration of a physiologically-based patient simulator in a realistic training environment. Under the acquisition strategy performed by PEO STRI a combined solicitation for commercial training devices to include: breathe/bleed simulators, a new equipment training course, human weighted mannequin trainers, airway management task trainers, and intravenous (IV) arm task trainers was announced. This solicitation was prepared in accordance with the format in Federal Acquisition Regulation (FAR) Subpart 12.6. The primary requirement each virtual patient simulation had to meet was to provide patient care training that simulated what an individual would see in combat. After a rigorous selection process the Medical Education Technologies (METI) Emergency Care Simulator (ECS) was chosen to be the standard device used at the MSTC sites (see Figure 3).

Figure 3. METI Emergency Care Simulator

The requirements for the virtual patient simulation were based on Key Performance Parameters (KPP) that supported the goal of improving and enhancing the combat medic's ability to treat and manage casualties. Additionally, the simulation had a requirement to be operated from a local control center capable of communication, monitoring, and surveillance at all stages. The ECS was chosen against multiple proposals based on detailed criteria (see Table 1).

Table 1. Virtual Patient Simulation Criteria

The Breathe/Bleed Simulator shall be a full-sized, human-like mannequin, with anatomically correct features, which is computer controlled.
It shall have pupils that depict the following conditions: blown; dilated and pin-point
The simulator shall be water resistant
The simulator shall be delivered with a moulage kit, with the ability to simulate the following: amputation; gunshot wounds, chemical/biological casualties; abdominal evisceration; open and closed head wounds; penetrating wounds and fractures.
The Airway will accurately represent the human airway to include tongue, teeth, vocal cords, epiglottis, vallecula, oropharynx, and nasopharynx. The simulator shall simulate difficult airways to include swollen tongue and laryngeal spasms. It shall allow training in the proper use of the following airway adjuncts: Naso-Pharyngeal Airway; Oropharyngeal Airway; Combi tube; Endotracheal (ET) tube and Laryngeal Mask Airway. The simulator shall allow for the simulation of Surgical Cricothyroidotomy procedure. The airway shall facilitate oropharynx suctioning of the patient
The simulator shall simulate respiratory patterns from apnea to tachypnea. It shall simulate breath sounds to include absent, clear, rales, rhonic, wheezes and stridor in all four quadrants. It shall simulate bi-lateral tension pneumothorax and allow treatment with needle decompression and chest tube. Needle decompression sites shall allow multiple punctures with a minimum of ten (10) punctures at each site prior to requiring replacement parts. The simulator chest wall shall rise and fall when all types of ventilation are correctly administered.
The simulator shall simulate pulses in the following sites: carotid, femoral, brachial, radial and pedal. The pulse strength shall mimic blood pressure in a clinically accurate manner. The simulator shall simulate venous and arterial bleeding at any point on the exterior of the body. The bleeding shall be controllable and adjustable for flow rate.
The simulator shall allow insertion of an IV in the arms and hands with an initial flash cue.
The simulator shall be computer driven. The computer shall have a scenario authoring tool.
The simulator shall be capable of being networked to an industry standard network.
The simulator shall be provided with initial consumable parts necessary for continuous training that will support the training of 80 students.

The ECS is well suited for the MSTC because it's simple to operate and the system can be up and running in less than 15 minutes. It has flexible software that operates on a Macintosh platform and has a simple scenario interface (see Figure 4). The ECS requires only one operator at the laptop, making it practical for a single unassisted instructor to deliver training at multiple sites/rooms. The current configuration comes with the following 12 Prepackaged Scenarios:

- Inferior myocardial infarction
- Anterior myocardial infarction
- Unstable angina with cardiac arrest
- Severe young asthmatic
- COPD exacerbation with respiratory failure
- Asthmatic with pneumothorax
- Splenic rupture with pneumothorax
- Subdural hematoma with coma
- Congestive heart failure with pulmonary edema
- Pneumonia with septic shock
- Stab wound to the chest
- Organophosphate exposure

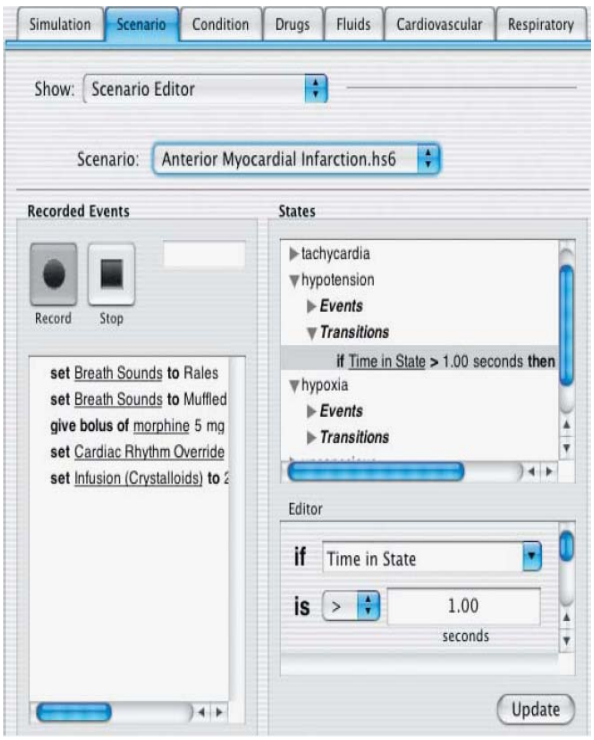

Figure 4. Scenario Interface

To maximize training, the hardware and software supportability for the ECS needed to optimize the use of open architecture, common hardware, software, communications interfaces, and logistics support. The MSTC concept was designed to maximize the use of existing Commercial-Off–the-Shelf (COTS) and/or industry standard equipment. Additionally, verification and validation of the software, including physical models, and behaviors had to be incorporated into the life cycle of the MSTC developmental effort. The software and hardware configuration of the ECS had to come fully-documented and the design had to provide adequate data security, virus protection, and minimize the effects of electromagnetic interference.

Live/Virtual /Constructive Environment

Each MSTC is designed to support three training approaches: Live Simulations, Virtual Simulations, and Constructive Simulations. Use of this approach coupled with computer/web based training provides an environment with a progressive and comprehensive learning experience in a "crawl, walk, run" fashion. Depending on the training requirements, the participant is introduced to or refreshed on the tasks they will perform in a combat environment. The virtual or constructive simulation environments also provide a multi-media teaching capability during the "crawl" phase. Then the participants are "walked" through the actual administration of the procedure or treatment with partial task trainers or limited live simulations. The final "run" phase culminates with a simulated exercise (see Figure 5) where participants are forced to combine their knowledge with their psycho-motor skills to provide patient care in individual and collective training environments.

Figure 5. Simulated Exercise

The MSTC also provides surveillance, data collection, feedback, and performance analysis capabilities to allow medical personnel to learn from their mistakes. The system measures performance and monitors diagnoses, interventions and treatments from the point of injury, through forward care modalities, to complete

post-evacuation care. It replicates battlefield injuries by type/category and monitors time within the combat casualty system. The MSTC provides scalable training from the self aid/buddy aid level, to the specialized combat medic level inclusive of all levels in between. It provides a complete training package, ultimately decreasing fatalities due to non-fatal wounds and injuries received in combat. The computer/web based, and constructive simulation systems act as enhancements to the didactic training. Classroom modality is required to promote program of instruction (POI) discussion and conduct refresher training. The use of After Action Reviews (AAR) and video critiques allow AMEDDC&S to rapidly push lessons learned and new changes in treatment and doctrine quickly to all of its medical personnel.

FUTURE CAPABILITES

Currently 18 MSTC sites are scheduled to be completed. The sites have varying floor plans that consist of a set of hardware, software, expendable supplies, and trained cadre operating in fixed facilities designed primarily to meet the medical training needs of medical personnel and Soldiers. As funding is allocated, MSTC sites will incorporate emerging technologies that enhance the Soldiers training experience and ability to care and manage casualties. Additionally other training systems that can be synchronized or interoperate with the MSTC such as Close Combat Tactical Trainers (CCTT), Laser Marksmanship Training System (LMTS), Virtual Combat Convoy Trainers (VCCT), and other Live/ Virtual/Constructive training capabilities will be explored. Additional capabilities and initiatives being implemented are:

- A Technology Transition Agreement between PEO STRI and the Research, Development, Engineering, Command Simulation and Training Center (RDECOM-STTC) for the purpose of defining technology insertion into the MSTC sites.

- The Stand Alone Patient Simulator (SAPS) is a tether-less, physiologically-based patient simulator designed to meet Army training requirements and optimized to reduce consumable costs. The SAPS has been designed to improve upon this existing technology of the ECS and overcome the technical barriers previously encountered in the medical simulation and training market by offering a comprehensive solution. The SAPS addresses the problems previously impeding training in field environments because it is self contained. This self-contained unit will allow a medic to drag, lift and carry the device as he or she might a real patient on the battlefield. The SAPS features an 8-hour internal battery instead of an external power supply, small internal air compressor instead of an external compressed air source, on-board bleeding, no external wired connections, and realistic weight and height. These features reduce the logistical support, as well as multiple types of simulators needed to effectively run a training exercise that replicates the battlefield environment.

- The Mobile MSTC (MMSTC) is a mobile version of the fixed MSTC sites that will be able to provide regional training to areas not easily served by the fixed sites. The MMSTC contains the same training aids, command and control capability, and environmental controls as a MSTC but integrated into a mobile platform.

- The Tactical Combat Casualty Care (TC3) Game is designed to provide initial, refresher, and sustainment training to medics at MSTC sites. Computer games are being adopted by dozens of different industries to conduct training, information visualization, data analysis, education and exploration. The (TC3) simulation allows combat medics to practice focused life-saving skills. The simulation immerses Soldiers into scenario-driven events to test and evaluate their knowledge of essential tactics, techniques and procedures. The medics must triage a group of patients, determining which patients require immediate care, and administer that care. Their actions must be applied in the correct order to save as many lives as possible. Consistent with battlefield procedure, the medics must drag the patients to safety, then assess all vitals, treat victims using the equipment normally available, and call for medical evacuation. Medics must also be aware of their fellow Soldiers and be ready to respond to enemy contact at all times.

CONCLUSION

The MSTC initiative standardizes the medical training needed to give Soldiers and Medics the skills to save wounded Soldiers in combat. Medical training as it

relates to decision making and team coordination under extreme conditions has been traditionally difficult to replicate. Utilizing virtual simulation, each MSTC site provides a method to rehearse in a safe environment and learn from realistic actions under combat stress. The new centers provide realistic wartime training to ensure that in the very distracting situation of war, personnel will be able to perform their duties both as a soldier and a medic/CLS. Military medical personnel need sustainment training that supports their needs in the ever changing environment in which they are expected to perform. The MSTC accomplishes this by providing the training needed by incorporating a lifelike and medically authentic simulation system designed to provide a broad spectrum of symptoms to give Soldiers the skills to save lives in combat.

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