New Wide Area Virtual Environment (WAVE) Medical Education

Maj Craig Goolsby, USAF MC*; LT Ryan Vest, MC USN†; LT Tress Goodwin, MC USNR‡

ABSTRACT  Objective: Accomplish the first large-scale combat casualty training using multiple-modality hybrid simulation in the Uniformed Services University’s one-of-a-kind three-dimensional Wide Area Virtual Environment (WAVE). Methods: 91 first-year medical students (MS1) completed a WAVE training session as part of their Combat Medical Skills course. In teams of 6 students, they treated two combat casualties with blast wounds (one a SimMan 3G, and another a standardized patient) during 15-minute scenarios in the WAVE. The WAVE is a unique medical simulation environment comprising an 8,000-square-foot virtual space composed of two pods surrounded by circumferential 9 x 12-foot movie screens and a high-fidelity directional sound system. Students completed WAVE quality assurance surveys to describe their impressions. Results: 91 MS1s were trained in a 4.5-hour period (including pre- and post-briefs) without technical difficulties during this inaugural training experience. Student survey data indicated a strong desire for more WAVE training in the curriculum (2.9 on a 3-point Leikert scale), and a strong preference for training in the WAVE vs. traditional training methods (4.6 on a 5-point Leikert scale). Conclusions: The novel WAVE platform can be implemented successfully for combat casualty training and represents a significant technological advancement in simulated military medical training.

INTRODUCTION

The Uniformed Services University of the Health Sciences (USUHS), the nation’s only Federal medical school, is composed of Air Force, Army, Navy, and Public Health medical students. USUHS curriculum parallels traditional civilian medical school curriculum, but offers an additional military curriculum designed to prepare graduates for the unique challenges of combat casualty medical care. This unique military medical curriculum occurs throughout the 4 years of medical school and involves a spectrum of educational modalities from classroom-based training to field exercises. Some USUHS graduates will deploy with a military unit to a combat zone after completing an intern year. This places enhanced emphasis on learning and mastering emergency and trauma skills during the students’ undergraduate medical education.

Combat Medical Skills (CMS) is one of the major courses of this unique curriculum. Medical students complete a 9-session, approximately 30-contact-hour course during the spring semester of their first year (MS1). They learn a host of hands-on emergency trauma assessment techniques and procedures, such as performing primary and secondary surveys, applying tourniquets, and performing endotracheal intubations. Students learn through a series of readings in the Prehospital Trauma Life Support text, quiz questions, and hands-on sessions performed in USUHS’ multidisciplinary laboratory (MDL) rooms (a series of classrooms with slide projectors and tables and floors appropriate for laboratory work). The course concludes with written and practical final examinations, in which students must demonstrate competence with patient assessment and procedural interventions.

The Wide Area Virtual Environment (WAVE) at the USUHS Simulation Center is a new, one-of-a-kind medical virtual environment. The facility recreates a virtual combat environment, complete with explosions, military vehicles, and helicopter medevac flights. To prepare students for final CMS examinations, we implemented a new hybrid simulation review session in the WAVE to allow students to practice skills learned during the course in a realistic combat environment. Students cared for two patients with blast injuries—a SimMan 3G and a standardized patient—during WAVE sessions. In addition to the new WAVE session, students were able to review all procedural skills with instructors in an expo-like format in an adjacent building. This report describes the equipment used in this hybrid multimodality simulation and our initial experience implementing a new large-scale WAVE training in our curriculum.

METHODS

The WAVE is an 8,000-square-foot virtual space designed to create realistic scenarios, such as battlefields, to train medical providers (Fig. 1). 144 projectors display three-dimensional (3-D) images on eighteen 9-foot-tall by 12-foot-wide circumferential screens that immerse viewers in a virtual setting. The WAVE allows team members to interact with each other and real equipment, and gives instructors the opportunity to teach and assess teamwork skills during the training. Trainees wear 3-D glasses to view stereoscopic images that are displayed with paired Digital Light Processor projectors. The WAVE is comprised of two pods 20 feet in diameter and connected by a 15-foot corridor. A 5.1-channel sound system provides directional surround sound and realistic background
FIGURE 1. WAVE is a large-scale virtual space allowing simulation training for multiple trainees in a hyper-realistic combat environment.

noise such as explosions, gunfire, and helicopter noise. Future development phases will add debris canons and scent generators to the WAVE. Other virtual environments exist, but they are often asynchronous, computer-based avatar-type training, or specific skill training, rather than immersion into a fully virtual environment. And, although virtual environments exist for nonmedical training, and on a limited small scale for medical training, we are unaware of a facility similar to this one.

The two objectives for the new curriculum were to create an opportunity for students to review and practice all procedural skills learned during the course, and provide a tactical environment for students to synthesize skills. The concurrent expo-style training that occurred at the same time as WAVE sessions helped accomplish the first objective. This training took place in a large warehouse-type space. Twenty instructors staffed seven stations that included procedural equipment and a variety of low-fidelity simulators and task trainers to review all procedural skills learned in the course. The WAVE experience also allowed an opportunity to practice skills, but was designed primarily to meet the second objective. We used 9 instructors in the WAVE and staging areas, plus 4 support personnel from the simulation center to operate the WAVE and SimMan 3G simulators.

We developed a new combat casualty scenario with two patients. The simulated patients were injured in an improvised explosive device attack in a deployed setting on a vehicle convoy. Explosive devices are the most common cause of death and injury in the recent wars in Iraq and Afghanistan. A Laerdal SimMan 3G was used for the first patient. SimMan sustained a traumatic amputation of the left lower extremity, accomplished by using a 3G Amputated Leg attachment to replace the simulator’s normal left leg. The amputation attachment replicated arterial bleeding by pulsatile squirting of red liquid out the distal end. This liquid was caught on a highly absorbent liquid-proof carpet placed under SimMan to protect the WAVE floors. The simulator also had a right-sided tension pneumothorax, a depressed respiratory effort, and was comatose. Students had to perform appropriate tactical field care including immediate tourniquet placement on the left lower extremity, a primary and secondary survey, airway support with either bag valve mask and an airway adjunct or intubation, a needle decompression of the right chest, spinal immobilization, and preparation for rapid evacuation.

CMS assistant instructors acted as the other casualty. This patient sustained a pelvis fracture, left lower extremity fracture, and was hypotensive with an altered sensorium. Students had to complete a primary and secondary assessment, place a pelvis binder, start a large-bore peripheral IV (using a Laerdal Multi-Venous Training Arm placed near the patient actor), provide spinal immobilization, and place a lower extremity splint (Fig. 2).

The students had an afternoon available for this training. Careful planning allowed us to schedule 91 students for the training during a 4.5-hour period. Students signed up for WAVE time on a Google document. When the teams of 6 students arrived, they completed a pre-brief that described safety considerations in the WAVE, the improvised explosive device attack on a vehicle convoy scenario, and allowed
First-year medical students practice an IV start on a task-training arm while caring for combat casualties in the WAVE. The students were told a medevac call had already been placed and to expect the helicopter to arrive to pick up their patients 15 minutes after their training began. They also completed an anonymous pretraining survey that asked about prior deployments, virtual reality training, and feelings about their current level of training. The students were not told about the numbers of injured casualties or types of injuries to expect.

Students then waited immediately outside the WAVE for the previous group to finish. They donned 3-D glasses and were plunged into an urban combat scene modeled after Baghdad. They could see two injured casualties; hear screams from the patient actor, and noise from gunfire and explosions. The students had to make rapid decisions about how to divide their team and treat the casualties. They typically broke into small teams of three and began assessing and treating their patients. Two instructors supervised the students in each pod, providing real-time education as needed during the case. We set the sound volume to offer realistic background noise while allowing instructors to communicate with students without pausing the training. At 13 minutes into the scenario, the students could hear a helicopter growing louder. The helicopter circled around the battlefield and landed signaling the end of the case.

Following the scenario, students were escorted to a small classroom where an instructor led a lessons-learned discussion for about 10 minutes. This time was also used to reset the pod the students had just left—this included staff filling the blood reservoir on SimMan and allowing the patient actors a break. While this pod reset, another group of 6 students completed the training in the adjacent pod.

**RESULTS**

91 MS1s were successfully trained during the first large-scale training in the new USUHS WAVE. The training ended within 10 minutes of the planned 4.5-hour window. No significant technical issues complicated or detracted from training. Our pre-survey questions indicated 12 students had previously used some type of virtual reality training (either medical or nonmedical) and only 6 students had been previously deployed to a combat zone.

Anonymous quality assurance surveys indicated strong satisfaction with the training (Table I). 89 students completed the post-training surveys. Students reported feeling more prepared to take care of combat casualties (4.1 on a 5-point schedule) and overwhelmingly recommended more WAVE training (2.9 on a 3-point scale). The students also greatly preferred (4.6 on 5-point scale) training in the WAVE.

<table>
<thead>
<tr>
<th>Question</th>
<th>Average Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Feel Confident Performing a Patient Assessment (Primary and Secondary Survey) and Basic Procedural Interventions to Stabilize a Combat Casualty</td>
<td>3.8</td>
</tr>
<tr>
<td>I Think a Realistic Environment Enhances Casualty Care Training</td>
<td>4.8</td>
</tr>
<tr>
<td>The WAVE Is a Better Environment to Practice Combat Casualty Care Than the MDL (Multidisciplinary Laboratory)</td>
<td>4.6</td>
</tr>
<tr>
<td>I Feel Better Prepared to Take Care of Combat Casualties After Today’s WAVE Training</td>
<td>4.1</td>
</tr>
<tr>
<td>I Feel Less Nervous/Anxious About Being Deployed to a Combat Zone After Participating in the WAVE Training Today</td>
<td>3.4</td>
</tr>
<tr>
<td>For the Future, I Recommend: More WAVE Training, the Same WAVE Training, Less WAVE Training</td>
<td>2.9*</td>
</tr>
</tbody>
</table>

*Responses were on a 5-point Leikert scale from strongly agree (5) to strongly disagree (1). Responses to this question were on a 3-point Leikert scale from more WAVE training (3) to less WAVE training (1).
to conventional training in the school's MDL. Qualitative remarks from students were strongly positive as well.

DISCUSSION
The WAVE represents a truly unique opportunity for combat casualty training and many other types of medical training. We are not aware of a similar training facility available for large-scale undergraduate medical training. Right now, this multimillion dollar technology would likely be cost prohibitive for many institutions interested in developing similar training. Since the equipment had not been used previously for large-scale medical student training, we hoped to demonstrate that the training could be implemented successfully, and contribute a positive learning environment. Both of these goals were met.

We brought together multiple modalities of simulation (high-fidelity simulators, standardized patients, and a WAVE) into a successful training experience. Student satisfaction (quantitative and qualitative) indicated a successful educational experience with strong desire for more training of this type in the future.

Although we had a positive initial experience with hybrid simulation in the WAVE, it is important to acknowledge limitations of our experience. First, we had a voluntary group of students participate in this exercise. About two-thirds of available students chose to participate, and we assume this is a representative group of students. However, it is possible either highly motivated students or conversely poor-performing students who needed extra help may have self-selected to participate. Either group could have biased our experience. Next, there is still uncertainty about the ideal way to use simulation in medical education in general, and how effective it is compared to other modalities. Ilgen et al addressed this in a recent meta-analysis of technology-enhanced simulation in emergency medicine. They found that technology-enhanced simulation is associated with variable benefits, but that current research is limited. While we have described an initial experience and new curriculum in this article, new training modalities like WAVE require rigorous educational study before endorsing them as optimal training modalities. Finally, we have shown it is possible to use this technology for brief training of large numbers of students. However, using WAVE for more in-depth training would either limit the number of students or require more time, which may not be practical within the constraints of modern medical education.

Going forward, it is interesting to consider the incredible number of possible uses of WAVEs. They could be used to create virtual battlefields for various types of learners. Or, it could be used to recreate intensive care units, operating rooms, or emergency departments. Interactive characters on the 3-D screen could talk or react to actions by learners in the WAVE. Learners in clerkships, residencies, or fellowships could treat simulated patients in environments that mirror their normal practice environments, but without the risks to patient safety. Interdisciplinary simulation team training might be enhanced in a WAVE. This area is ripe for future research: how and when to use WAVEs, optimal curricular design, cost versus educational benefit, and translational outcomes today should all be considered.

CONCLUSION
We described the first successful implementation of large-scale medical student combat casualty training in a one-of-a-kind WAVE medical simulator. The art and science of simulated combat casualty care education continues to evolve, and this technology represents an important new frontier.

ACKNOWLEDGMENT
The authors gratefully acknowledge the support of members of the USUHS Department of Military and Emergency Medicine, particularly LTC James Schwarz (ret.), and USUHS Simulation Center who contributed their time, ideas, and effort to making this project happen.

REFERENCES
3. Vincent D, Sherbino J, Cook D; Technology-enhanced simulation in emergency medicine. The art and science of simulated combat casualty care education continues to evolve, and this technology represents an important new frontier.
