

MEDICAL READINESS TRAINING - JUST IN TIME

Medical Readiness Trainer Team, Emergency Medicine Modeling and Simulation

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Rapid development of biomedical sciences, new diagnostic technologies, and a wide range of new drugs that arrive on the market in an uninterrupted stream, demand continuously high awareness of the occurring changes. Furthermore, without continued stimulation, even the already acquired diagnostic acumen wanes and manual skills falter^{1,2,3}. Unsurprisingly, providing intellectually stimulating continuing medical education to medical personnel in remote regions continues to be one of the greatest challenges of modern medicine^{4,5,6,7,8,9,10}. While computer technology improved access to medical education, the advantages of a modern teaching hospital in the immediate neighborhood can be only distantly approximated^{11,12,13,14,15,16,17}.

Numerous studies highlight the problem of “skills erosion” among medical personnel who do not have the periodic access to allow sharpening their expertise in manual dexterity, rapid and correct diagnosing, triage, and even proficiency in medical leadership^{18,19,10,21}. More disturbingly, studies show that under acute and stressing circumstances, the lack of training or insufficiently maintained skills may lead to increased morbidity and mortality^{22,23,24,25,26,27,28,29,30,31}.

There are a great many similarities between a rural medicine doctor faced with a medical emergency, and a Naval medical officer or Corpsman at sea or in the field^{32,33,34}. This

“environmental similarity” provided conceptual foundation for a pioneering teletraining experiment utilizing the latest computer training concepts.

The experiment was conducted jointly by personnel from the University of Michigan Emergency Medicine Modeling and Simulation Research Laboratory, the Bureau of Medicine and Surgery, and from US Navy Telemedicine Department. The centerpiece of the experiment was the Human Patient Simulator (HPS, Medical Education Technologies, Inc., Sarasota, Fl.), a training device originally developed for training of anesthesia personnel. The HPS (Fig. 1) used during the work consists of a computer-operated, life-size manikin capable of reproducing virtually all forms of disease and injury encountered by an emergency/trauma physician. It offers a highly realistic platform for training diagnostic skills, procedures, drug treatment, and medical leadership and administrative skills^{35,36,37}. The device reproduces exact physiological signs of a human in medical distress, allows monitoring sounds of the chest and heart, permits analysis of blood gases, maintenance of airway, reduction of internal bleeding, administration of drugs and I.V. fluids, defibrillation, plus a host of other procedures commonly encountered in an emergency room or a ship’s sickbay. All vital signs of the patient are faithfully reproduced on a standard ER monitor, and the instruments (e.g., laryngoscopes, needles, chest tube, etc.) are the same as used on the clinical floor. As stationary devices, HPS units are currently used in training (primarily for anesthesia techniques) by a number of medical schools in this country and abroad^{38,39,40,41,42,43}. Both the US Navy and the US Army are exploring their potential as well. Despite significant acquisition costs, HPS units have been proven to provide highly efficient training platforms^{37,38,41,43,44,45}

Modern HPS platforms are mobile and, with proper procedures, the preparations to transport an HPS, even over very long distances, can be a comparatively simple 1-2 hour exercise. The

logistics of on-site preparation are equally simple even when large numbers of trainees are anticipated⁴⁶. Deployment of the HPS human trainers is, however, a more complex evolution. All major medical training centers, military and civilian, place rigorous time demands on their teaching staffs. Teaching routines are complicated even more by clinical duties of the staff (particularly in the case of ER/trauma personnel). Essentially, their availability for travel to remote regions to provide high quality training is limited to very sporadic events. Hence, routine training by such personnel is virtually unattainable away from their parent institutions. While the advent of Human Patient Simulators provided a part of the solution to the “remote region training dilemma”, the problem of linking a very distant, forward-deployed HPS to an expert medical “coach” located at a major Naval or civilian (typically university) hospital continues to pose a formidable obstacle. Thus, if a "remote control" solution could be devised, the training potential offered by HPS technology would increase tremendously for isolated medical practices. In order to conduct an exercise demonstrating feasibility of the recently developed solutions to the remote HPS control issue, the Medical Readiness Trainer Unit of the University of Michigan⁴⁷ joined forces with senior naval medical experts from the Bureau of Medicine & Surgery.

The multidisciplinary Medical Readiness Trainer (MRT) Unit of the University of Michigan comprises of highly regarded specialists in clinical emergency/trauma medicine, biomedical science, information technology and telemedicine, virtual reality, and computer engineering⁴⁷. Whenever needed, the Unit can freely draw upon the intellectual resources of the University of Michigan Health Care System, the College of Engineering, and the Advanced Information Technology Center of the Media Union at the University of Michigan. The broad spectrum of knowledge within the Unit gives it a singular advantage of highly efficient, solution-based

approach to the complex issues facing modern, technology-based medical training. The senior physicians from the Bureau of Medicine & Surgery provided the necessary expertise on medicine-at-sea, and assisted with the development of appropriate Navy-oriented training context of the exercise.

The principal goal of the experiment was to demonstrate that the Human Patient Simulator could be successfully deployed to a very remote site, and still act as a teletraining platform for intensive practice of emergency/trauma medicine skills, e.g., ATLS, ACLS, etc. The essential technological aspects of required for such operation are: 1) the remote control of all simulator functions by an expert stationed hundreds or even thousands of miles away from the simulator itself; 2) the capacity of the remote expert to view the trainees during a training session. Both problems were solved by using electronic interfaces developed by the MRT Unit and connecting the simulator-driving computer and its remote controlling device by means of standard telephone lines. Commercial Off-The-Shelf (COTS) technology provided real time video link. Functionally, this communications system allowed full control of the simulator, continuous transmission of vital signs monitor data, selectable view of the simulator, trainees, or both, and voice communications.

In the first of the exercises, the participating physicians were located approximately 700 miles apart from each other. The control group operated from the office at the Department of Telemedicine, National Naval Medical Center, Bethesda, MD. The simulator group was located at the Virtual Reality CAVE of the University of Michigan Media Union in Ann Arbor (Fig. 2). Treatment of ventricular tachycardia served as the training scenario, with the physicians in Bethesda providing instruction to the “trainee” team in Ann Arbor.

The next exercise was designed to demonstrate that an expert stationed at the simulator (i.e., at a major medical teaching center equipped with HPS platform(s)) can provide training in diagnostic and patient management skills by explaining and guiding the distant trainees through the essential “how to” skills of patient management and care. In this mode, the distant trainees can be repetitively drilled in triage, rapid diagnosis of unsuspected disorders, etc. HPS-based training aimed at the distant trainee group that has no physical access to the simulator is made possible by the HPS telecommunication links of the simulator. The the remote trainee has, therefore, full access to the same set of information that is available to the clinical expert operating the simulator, e.g., views of the vital signs monitors, blood gase status, chest and heart sounds, etc. The trainee can be then requested to provide initial diagnosis, develop initial management plan, followed by final diagnosis, recommendations for further management, transfer, and other elements leading to the definitive disposition. During this part of the exercise, the physician in Ann Arbor acted as a training expert exposing the “trainee” group in Bethesda to sudden, unexpected medical events (hypovolemic shock).

Finally, a “just in time” training scenario was devised. In this scenario, a remote expert located in Bethesda instructed a distant “junior physician at sea” (i.e., Ann Arbor) in the approaches necessary to save a critically ill patient (blunt injury caused by incorrect underway lowering of a ship’s whaler).

The entire series of exercises had no precedence in the history of medical education and training. The results provided both a proof of concept, and the validation of the usefulness of Human Patient Simulator-based teletraining and its potential versatility (Fig. 3). Importantly, the exercise demonstrated that coupling the HPS with remote computer interfacing devices offers probably the most desirable form of skills maintenance outside the “real life” emergency room or

sickbay. It provides the trainees with a high degree of realism, allows introduction of different forms of stressors (e.g., unexpected medical complications, inadequate resources, time, etc.), and forces them into the active “clinician” rather than the passive “student” pattern of behavior. The challenging, high paced, and rapidly (and even unpredictably) changing action environment of HPS-based training facilitates such transition. Importantly, though, the pace of a training session remains under full control of the remote expert who can readily adjust the level of intensity to that suitable to the proficiency (or educational comfort) of the trainees. Moreover, the scenarios can be exercised repetitively either in identical sets, or in sets that offer subtle variations and provide a didactically important element of reinforcement. The latter capacity allows the trainees to develop the capacity to think rapidly, plan ahead of the current status of the patient, and consider alternative plans of management. Finally, the exercise demonstrated that this new technology may offer other significant advantages, e.g., simultaneous training of a number of widely dispersed trainee groups, rapid access to prominent experts, and (significantly) a potential for the reduction of overall training costs.

The next phase that is currently planned involves USCGC FORWARD (WMEC911) and the Roosevelt Roads Naval Hospital in Puerto Rico, and, as a part of the UNITAS 99 exercise, will focus on collection of the preliminary quantitative data on the impact of HPS-based, remotely controlled, teletraining under fully operational conditions. Additional knowledge on both didactic and technical aspects of this form of training will be gained during the operational testing as well.

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Legends to the Figures



Fig.1 Human Patient Simulator in action. LCDR Warren Russell, M.C., U.S.N. demonstrates the technique of rapid sequence intubation in a “victim” of near drowning. As described in the text, the device faithfully reproduces all pathophysiological responses of a sick patient. Thus, in the demonstrated scenario, the trainee may face problems of severe hypothermia, laryngospasm, cardiac arrhythmia, etc. In addition, other symptoms may be added, e.g., blunt chest injury (as the original reason for falling into the water). Hence, like in “real life” clinical emergency/trauma medicine, the trainee must be constantly prepared for the unexpected, and must be able to adjust the management of the “patient” correspondingly. Improper intervention while training on the simulator may, as in the real world, lead to death.



Fig.2 Medical Readiness Trainer in operation. The HPS unit is surrounded by the fully immersive, Hyper-Rich Virtual Reality (VR) environment (CAVE), in this case depicting a patient bay of at the Department of Emergency Medicine at the University of Michigan. Other shells have been constructed, e.g., a generic operating room, a sick bay in a small warship, etc. Note scenario-relevant diagnostic tools modeled in VR, the ultrasound monitor and the vital signs monitor. A VR rendition of a light box with the scenario-relevant diagnostic quality X-ray images on the wall, and a video clip showing a physician demonstrating the technique of intubation (right) are not visible at the angle of the photograph (both are hidden behind the instrument pillar in the background). However a floating VR billboard with the electronic (web-based) patient record can be seen behind the recording nurse to the right. A wide variety of web-based teaching tools can be accessed with ease, displayed in the form of floating billboards that can be moved in and out of the trainee's field of vision as required.

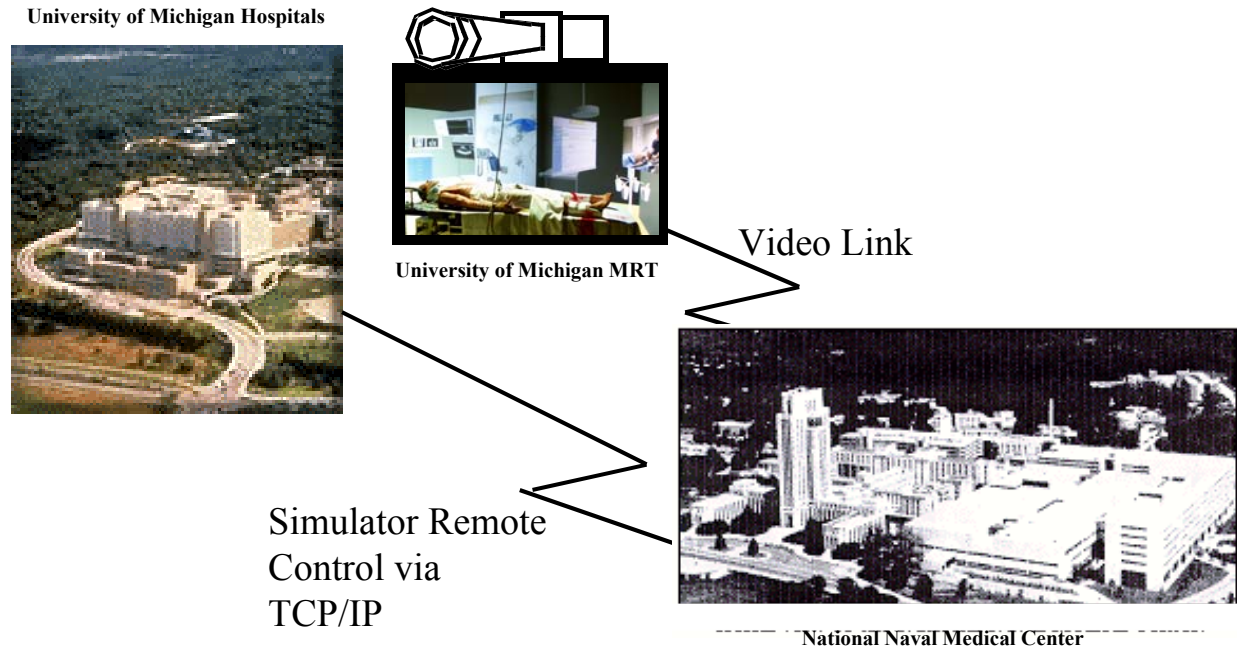


Fig.3 Schematic view of the HPS remote control system. During the exercise, the HPS located in the CAVE in Ann Arbor was under full remote control of the physicians in Bethesda. However, the physician in Ann Arbor assumed the control of the unit during the “just-in-time” segment of the program. During that segment, an emergency briefing on the symptoms and emergent treatment of chest injury was given to the staff physicians at Bethesda. The latter group acted the role of junior medical personnel faced with a sudden, life-threatening emergency at sea. Barely discernible in the picture of the CAVE (between the pictures of the two hospitals) are the X-ray light box (to the left of the life sign and ultra sound monitors attached to the central pillar), and a floating billboard containing a video clip with a demonstration of the rapid sequence intubation technique (extreme right).