

Using Innovative Simulation Modalities for Civilian-based, Chemical, Biological, Radiological, Nuclear, and Explosive Training in the Acute Management of Terrorist Victims: A Pilot Study

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Abbreviations:

CBRNE = chemical, biological, radiological, nuclear, and explosive
CI = confidence interval
DOD = Department of Defense
EMS = emergency medical services
HFMB = high fidelity, mannequin-based
IV = intravenous
PPE = personal protective equipment

Abstract

Objectives: Chemical, biological, radiological, nuclear, and explosive (CBRNE) incidents are low frequency, high impact events that require specialized training outside of usual clinical practice. Educational modalities must recreate these clinical scenarios in order to provide realistic first responder/receiver training.

Methods: High fidelity, mannequin-based (HFMB) simulation and video clinical vignettes were used to create a simulation-based CBRNE course directed at the recognition, triage, and resuscitation of contaminated victims. The course participants, who consisted of first responders and receivers, were evaluated using a 43-question pre- and post-test that employed 12 video clinical vignettes as scenarios for the test questions. The results of the pre-test were analyzed according to the various medical training backgrounds of the participants to identify differences in baseline performance. A Scheffe post-hoc test and an ANOVA were used to determine differences between the medical training backgrounds of the participants. For those participants who completed both the pre-course and post-course test, the results were compared using a paired Student's *t*-test.

Results: A total of 54 first responders/receivers including physicians, nurses, and paramedics completed the course. Pre-course and post-course test results are listed by learner category. For all participants who took the pre-course test ($n = 67$), the mean value of the test scores was $53.5 \pm 12.7\%$. For all participants who took the post-course test ($n = 54$), the mean value of the test scores was $78.3 \pm 10.9\%$. The change in score for those who took both the pre- and post-test ($n = 54$) achieved statistical significance at all levels of learner.

Conclusions: The results suggest that video clinical vignettes and HFMB simulation are effective methods of CBRNE training and evaluation. Future studies should be conducted to determine the educational and cost-effectiveness of the use of these modalities.

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Introduction

Chemical, biological, radiological, nuclear, and explosive (CBRNE) incidents are low frequency, high impact events, and are encountered rarely in clinical practice. Due to their high impact nature, first responders and receivers of victims must be competent to manage these scenarios at short notice. Practical knowledge regarding recognition and triage of actual or potential CBRNE incidents is essential, as contaminated patients may self-refer from the scene and present at critical points of entry (emergency department triage or waiting area, ambulance entrance to trauma or critical care rooms). Furthermore, during a large-scale event, first responders/receivers may encounter unstable, contaminated victims who require resuscitation. Resuscitative efforts in this setting, initially were termed "dirty resuscitations" by the military,⁴⁻⁵ and must be performed while wearing bulky, personal protective equipment (PPE) that present additional challenges.

Educational modalities must recreate these clinical encounters and environments to enhance CBRNE medical preparedness. The US military has recognized this need and utilized non-traditional, educational modalities such as high-fidelity, mannequin-based (HFMB) simulations and video clinical vignettes for their CBRNE training. Some published data regarding HFMB simulation suggest that it is useful in training military clinicians responsible for treating chemical warfare victims.⁶ Additionally, the US Department of Defense (DOD)-sponsored Chemical Casualty Care Course distributes an educational CD-ROM that contains a series of military-based videos demonstrating encounters with potential victims of a chemical weapons attack.⁷

Recognizing the need to recreate similar encounters, a CBRNE training course for civilian first responders/receivers was created utilizing HFMB simulation and video clinical vignettes. Evaluative pilot data that support its effectiveness as an educational intervention are presented.

Methods

Educational HFMB simulations and video clinical vignettes were incorporated into the creation of a CBRNE training course. The purpose of the course was to train first responders/receivers in the acute management of contaminated patients including recognition, triage, and resuscitation. The course was designed as a one-day, seven-hour course structured similarly to an advanced cardiac life support (ACLS) or pediatric life support (PALS) courses. The course provided a one-hour introductory session to explain a symptom-based triage algorithm that was distributed to the students in card format.⁴ This was followed by small group stations (biological, chemical, cyanide vs. nerve agent, radiation dispersal device/suicide bombing blast, dirty resuscitation, and decontamination) that incorporated HFMB simulation and video clinical vignettes to reinforce each symptom-based algorithm.

Simulation scenarios and video clinical vignettes used in the course were developed from background materials adapted from the (US) Centers for Disease Control and Prevention (CDC),⁸ a screen-based CBRNE victim simulator (*Bioterrorism Simulator 2002*, Anesoft Corp, Issaquah, WA), and course textbooks and CD-ROMs dis-

tributed from DOD sponsored Biological, Chemical, and Radiation Course.^{7,9-10} Utilizing the Society of Academic Emergency Medicine Simulation Interest Group Template,¹¹ a series of eight adult and pediatric HFMB simulations were created, each with primary and secondary learning objectives. Due to resource and time constraints, four were performed as HFMB simulations, and the other four cases were covered using moulaged actors or with case-based discussion. The primary objectives included: (1) recognition of CBRNE victims at critical points of entry to the emergency department; (2) avoiding contamination by triaging to appropriate areas (isolation, decontamination, dirty resuscitation); (3) timely use of antidotes; (4) appropriate handling of unstable, contaminated victims; and (5) provisions of force protection (appropriate use of PPE).

The simulations included dirty resuscitation scenarios and had defined critical actions for the treatment of unstable CBRNE victims. The specific cases covered by either HFMB or by video vignette included: (1) adult and pediatric sarin exposure; (2) adult cyanide intoxication; (3) adult plague; (4) adult and pediatric blast injuries; and (5) adult dirty bomb explosion. The critical actions defined for the dirty resuscitation scenarios included: (1) airway management; (2) hemorrhage control; (3) needle decompression of tension pneumothorax; (4) administration of antidotes; and (5) decontamination. Each of the simulations were beta-tested by faculty members prior to the course. To recreate the dirty resuscitation environment, the scenarios were conducted after the participants had donned PPE at the previous teaching station. The PPE used was recommended by the [US] Occupational Safety and Health Administration's (OSHA) *Best Practices for Hospital-Based First Receivers*.¹¹ At the conclusion of each station, faculty members in charge of the station debriefed the participants. The debriefing included meeting defined learning objectives and reinforcing necessary critical actions. The stations were designed for an average of 4-6 people, all of whom participated at the same time at each simulator station. Additionally, approximately six course faculty members (not including actors and simulator operators) were necessary to run the three high-fidelity simulation stations, (biological, radiation dispersal device/blast, dirty resuscitation (two cases run)), and the other three stations.

The course incorporated a series of 12 video clinical vignettes created for training and evaluation purposes. The video script was designed with the same primary objectives as the HFMB simulations. The settings for the videos were: (1) emergency department nursing triage area; (2) EMS command phone; (3) trauma and critical care area; and (4) "dirty resuscitation" and decontamination area. The decontamination and dirty resuscitation course stations did not utilize the video clinical vignettes for training purposes. The video vignettes were used to facilitate case-based discussion at the other stations.

The course was evaluated using pre-course and post-course tests, which utilized the 12 video clinical vignettes followed by 3-4 specific questions per vignette. The test was comprised of 43 multiple-choice questions to be completed in one hour. The correct answers were based on the

Type of learner	n	Pre-course test scores Mean \pm SD	Post-course test scores Mean \pm SD	Difference in mean score	95% CI for difference
Attending physicians	6	62.1 \pm 13.8	83.9 \pm 5.1	21.8	(9.5–34.0)
Resident physicians (PGY 2-4)	15	66.5 \pm 7.2	86.7 \pm 7.2	20.1	(16.4–23.8)
Nurses and physician assistants	18	44.9 \pm 6.4	73.5 \pm 7.5	28.6	(23.7–33.4)
Medical students	9	48.9 \pm 10.8	80.3 \pm 9.0	31.4	(26.6–36.3)
EMT-P and ED technicians	6	38.7 \pm 9.7	67.2 \pm 16.4	28.5	(9.8–47.2)

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Table 1—Test results by medical training background (CI = confidence interval; ED = emergency department; EMT-P = emergency medical technician-paramedic; SD = standard deviation)

consensus of the primary authors in consultation with recognized subject matter experts. The questions were designed so that answering one question incorrectly did not preclude getting the next question correct. The items were not completely independent of each other because they were linked to the video. The test questions emphasized the primary objectives of the video clinical vignettes and the HFMB simulations. The pre- and post-course tests were conducted without the use by the participants of the symptom-based triage card that contained the algorithms.

Descriptive statistics were performed on all pre-course and post-course test results. The results of the pre-test were analyzed across levels of learners to identify differences in baseline performance. This analysis was performed using an ANOVA with a Scheffe *post-hoc* measure of the differences between learner categories. More people completed the pre-test than the post-test. This was because some people left the course early due to clinical duties or other demands. For those participants who completed both the pre-course and post-course tests, the test results were compared with a paired, Student's *t*-test. All data were analyzed using the SPSS version 11.5 (SPSS, Inc. 2002; Chicago, Illinois) statistical software package. This project was given a waiver of Institutional Review Board review.

Results

A total of 54 participants completed both the pre- and post-course tests and their results by medical training background are listed in Table 1. The change in score achieved statistical significance at all levels of learner. For all participants who took the pre-course test ($n = 67$), the mean value for the test scores was $53.5 \pm 12.7\%$. For all participants who took the post-course test ($n = 54$), the mean value for the test scores was $78.3 \pm 10.9\%$. The pre-course test analysis for differences across learner category revealed no statistical difference between the emergency medicine attending physicians and resident-level physicians (mean score of the difference for the attending physicians $-0.41 \pm 3.7\%$;

when compared with the residents, 95% confidence interval (CI): -12.1 – 11.3). There was a statistically significant difference between the emergency medicine attending physicians and the emergency department nurses (mean score difference $18.8 \pm 3.6\%$, 95% CI: 7.5 – 30.1), the medical students (mean score difference $15.4 \pm 4.1\%$, 95% CI: 2.3 – 28.5), and the paramedics (mean score difference $18.7 \pm 4.1\%$, 95% CI: 5.6 – 31.8). Overall, it appeared that the emergency medicine attending and resident physicians were similar to each other in baseline knowledge. The nurses, medical students, and paramedics also were similar to each other in baseline knowledge.

Discussion

The evaluative data obtained from this course suggest that utilizing video clinical vignettes and HFMB simulations for CBRNE training and evaluation is effective for first responder and patient receiver education. The video clinical vignettes were used as the evaluative tool rather than HFMB simulation due to the practical ease of testing students in a classroom in a standardized manner. It was difficult to evaluate performance of individual students, because the students performed in groups during the dirty resuscitation scenarios. Furthermore, learning objectives and critical actions were developed with the assistance of subject matter experts, and recognized evaluation standards and competencies regarding dirty resuscitation have not been defined. A more rigorous testing format would include a simulation evaluation with grading of skills demonstrated by critical actions or competencies.

The advantage of employing HFMB simulation as an educational modality for CBRNE education is to gain a practical, “hands-on” competency in the skills of dirty resuscitation. The training task is similar to the real world transfer task. Training conditions are improved with repetition and problem-solving. To facilitate interaction, background materials such as the symptom-based algorithm triage card may be used as a supplement to enhance the training. Demonstrating a symptom-based presentation to students, either through mouled actors, video vignettes,

or with HFMB simulation, is crucial for improving recognition of potential presentations and understanding the appropriate response.

Another important practical use of HFMB simulation is the exposure of weaknesses in the currently proposed management of CBRNE victims. For example, during the simulations, it became clear that administration of amyl nitrite to an intubated cyanide victim was difficult, if not impossible. Placing the amyl nitrite into a bag-valve-mask set-up is not accomplished readily while wearing butyl rubber gloves. Routine intravenous (IV) access in a dirty resuscitation environment is challenging. Thus, delaying or limiting administration of IV antidotes. Additionally, awareness of the limitations of communication, patient care abilities, and work tolerance while wearing PPE are well-illustrated using HFMB simulation.

Performing HFMB simulations for CBRNE training requires significant initial capital expenditures and mechanical upkeep costs. In the long run, the cost of faculty time (in this case, six faculty per course), and trainee time may far outweigh the initial equipment expense. This is true, especially if the goal is to reach all potential first contact providers with this level of education. Additionally, HFMB simulations are limited in the number of students that can participate effectively and simultaneously, and should be monitored closely so that the learning objectives are met by all participants. Debriefing is another essential element of HFMB simulation and requires faculty to devote effort to this component.

Video clinical vignettes were utilized effectively as training and evaluation tools. These tools may be used by first responders and patient receivers for self-directed independent study. The vignettes can be used to train large audiences and provide a standardized training format that would be valuable for "just-in-time" education. These types of vignettes also may be incorporated into a screen-based simulator to add realism and context.

The data suggest that these educational modalities are effective in transmitting core knowledge about handling the initial encounter with terrorist victims. However, due to

cost and faculty-resource intensity, it is recommended that HFMB simulations be reserved for the specific first responders/receivers that are likely to be involved in dirty resuscitation. Clinical video vignette simulation can be utilized for all audiences and tailored as necessary. They both provide a standardized educational experience. Future efforts may include utilizing video clinical vignettes to prepare for mass vaccination efforts, mass antibiotic prophylaxis efforts, issues of crowd control, scene security, and emergency department and hospital security.

Limitations

The tests used had not been validated previously, but partial construct validity was noted in that those with more advanced clinical training performed better. Long-term retention testing was not performed. However, each participant received a take-home, symptom-based triage card as a real-time cognitive aid for future reference.

Conclusions

A course incorporating HFMB simulation and clinical video vignette simulation offers the ability to create a virtual environment for CBRNE training and evaluation. Course test data suggest that these are effective teaching methods for first contact providers. Future studies should be conducted to further determine the educational and cost-effectiveness of these modalities.

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