Multiple Hospital In-Situ Mass Casualty Incident Training Simulation for Emergency Medicine Residents: A Sarin Bomb Scenario

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ABSTRACT

INTRODUCTION: We simulated an on-site, multi-hospital mass casualty incident (MCI) to educate emergency medicine providers in the principles of trauma resuscitation and collaboration with administration and staff during an MCI.

METHODS: We implemented high-fidelity manikins, inflatable manikins, and actors to simulate a sarin gas bombing. Learners triaged patients at a decontamination tent using the simple triage and rapid treatment (START) tool, or they participated in a simulation in a resuscitation bay.

RESULTS: Forty participants anonymously rated the learning impact of the exercise, the clinical relevance to emergency medicine, and the effectiveness of the faculty facilitation and debriefing on a 1–5 Likert scale. The average responses to all questions were 4.45 or greater, and 98% of respondents recommended adding the scenario to the standard curriculum.

DISCUSSION: We successfully executed a novel, multi-hospital, MCI drill that was rated to be a better alternative to sequential simulation in a simulation center.

KEYWORDS: simulation, mass casualty incident, sarin, emergency medicine, toxicology

INTRODUCTION

Disasters are defined as events which exceed the capacity of the local community to mount an adequate response.[1] Disaster preparedness, specifically regarding mass casualty incidents (MCIs), has been a topic of much discussion over the past 20 years, especially in the light of the COVID-19 pandemic. Chemical, biological, radiological, nuclear, and explosive (CBRNE) modalities are all scenarios for which healthcare providers must be prepared. Potential sources for civilian exposure include terrorist attacks, military attacks, inadvertent discharge from domestic stockpiles, and industrial events. Terror incidents have increased dramatically over the last decade (Global Terror Database) with increasing numbers of mass shootings, recent emergence of targeted automobile ramming mass casualty (TARMAC) attacks, and with infamous events such as the Oklahoma City bombing and 9/11 attacks still so recent in history.

Historically, hospitals have been poorly equipped to deal with massive influxes of patients, particularly with regard to weapons of mass destruction (WMDs).[2,3] Adequate response to an MCI involves every aspect of hospital operations, from providers in the Emergency Department (ED) to housekeeping staff, security, and supply chains. Since these are high-acuity, low-frequency events, there are few opportunities for providers to practice. Simulation drills are thought to provide a way for providers to practice MCI response and increase competency in this skill set, though formal evaluation of its effectiveness should be explored futher.[4,5,6]

This exercise focused on the presentation and management of trauma patients exposed to sarin gas in a terrorist bombing. This scenario was chosen due to real, large scale, and tactical attacks using nerve agents such as the Aum Shinrikyo release of sarin in the Tokyo subway system, nerve agent attacks against the Kurds in Iraq and most recently with the sarin attacks of civilians by the Syrian government.[7,8] This unique, in-situ MCI simulation was simultaneously conducted at two academic hospitals during the normal hours of resident didactic conference. Goals of the exercise were to provide Emergency Medicine (EM) residents and other healthcare workers in the department the familiarity and hands-on exposure to the decontamination equipment and methods, to increase confidence and ability using an all-hazards approach to identify and treat victims exposed to a CBRNE incident, and to foster communication and teamwork among various healthcare workers when available resources are overwhelmed. The authors believe this mass casualty scenario could similarly be implemented both at similar institutions on site as well as within a simulation center to prepare healthcare workers for a mass casualty event.

METHODS

Development

We created this 2-hour session to be part of the EM Resident Simulation Curriculum. The MCI simulation was created, in part, to fulfill the ACGME requirement for EM residents to participate in such training for graduation. The simulation scenario consisted of 6 separate individual patient simulation scenarios as well as a mass casualty triage intake simulation. EM faculty, including expert simulation faculty, created these scenarios through an iterative collaborative process. They were reviewed by the simulation staff for revisions as well.

Equipment/Environment

We conducted the simulation training exercise at two urban EDs during resident simulation conference day. The format of the scenario was virtually identical at each site. Three simulated patients presented into a trauma bay normally designed to care for two critically ill patients with a unique trauma and symptoms consistent with organophosphate poisoning from a sarin gas exposure (**Table 1**). Each hospital site had one high-fidelity Laerdal Sim Man 3G simulator and two standardized patients. All standard equipment in the resuscitation bays was available to include simulator telemetry output on a connected laptop screen, the installed resuscitation bay telemetry monitors, crash carts, bag valve masks, ECG machine, intubation equipment, thoracostomy kits, and all other commonly used medical equipment stocked in the resuscitation bay. Participants were limited in their ability to order labs and diagnostic imaging to simulate the reality of a hospital whose resources were overwhelmed due to a mass casualty incident. Eventually a "Chem Pack" containing mock vials of 2-Pam and additional atropine was made available to use. A laptop computer was positioned within the resuscitation bays to provide updates about the mass casualty incident. We also erected a decontamination tent at the entrance of the ambulance bay at each hospital for the triage simulation scenario. Inflatable, low-fidelity manikens were used for triage and decontamination at this site.

Personnel

Two simulation technicians were on site to operate the high-fidelity simulators. An EM faculty member was present for each simulation in the resuscitation bays, as well as one at the triage tents to conduct the scenarios and document when critical actions were met by the residents. Supporting nursing staff and ED techs also participated in patient care during the simulation. Nursing placed IVs, administered fluids, and verbalized administration of medications and blood when requested by the team. A supervising EM faculty member and hospital environmental safety officer was present at each site to orchestrate the overarching movement of trainees, personnel, and equipment. The standardized patients consisted of simulation staff for the individual scenarios. Volunteer scribes and medical students were integrated with the inflatable manikins at the triage site.

Implementation

We assigned EM residents of all training levels (years 1–4) to either a triage team or one of three treatment teams that would be caring for a single patient encounter. We briefed them to the goals of the simulation day in a conference room prior to moving to the ED for the exercise. A pre-recorded dramatization of a news report was then played, outlining that an explosion had occurred in the downtown train depot, and residents were brought to the treatment areas to begin the simulation.

We escorted the residents assigned to the triage team to the decontamination tents to receive patients. A faculty moderator and hospital environmental safety officer instructed them as to how to don personal protection equipment (PPE) prior to beginning the scenario, in order to realistically

Table 1. Simulation Cases

	Presentation*	Diagnosis^	Critical Actions+
AEC Patient 1	33yo unresponsive patient with shortness of breath, nausea, vomiting and diarrhea	Hypoxic respiratory failure with tension pneumothorax	Recognize unprotected airway and intubate Needle decompress the chest followed by placing chest tube
AEC Patient 2	24yo pregnant patient with abdominal pain, vaginal bleeding, cough and shortness of breath	Hemorrhagic shock due to placental abruption	Recognize shock, transfuse patient Assess fetal heart tones and emergently consult OB/GYN
AEC Patient 3	55yo heart failure patient with shortness of breath, cough and penetrating trauma to the lower extremity	Hemorrhagic shock and pulseless limb	Recognize shock, apply tourniquet and transfuse patient
TMH Patient 1	8yo patient with decreased mental status, dyspnea, vomiting, diarrhea and has significant abdominal bruising	Hypoxic respiratory failure and possible intra-abdominal injury	Recognize unprotected airway and intubate Recognize and test for possible intra-abdominal injury
TMH Patient 2	24yo asthmatic presents after being knocked down by blast complaining of head pain and shortness of breath	Blast injury with ruptured tympanic membranes and possible intracranial injury	Recognize TM rupture Evaluate and test for brain injury Treat dyspnea with bronchodilators
TMH Patient 3	ED nurse caring for patient develops shortness of breath	Secondary exposure to sarin resulting in healthcare worker	Recognize secondary exposure Decontaminate patient before treatment

* Contact corresponding author for detailed simulation script.
^ All patients will have a diagnosis of organophosphate toxicity with varying degrees of severity.
+ All patients require administration of atropine and 2-PAM in treatment of organophosphate toxicity.

create a treatment scenario in which PPE of this nature is required. The standardized patients and inflatable manikens presented to the triage team with a brief script of their symptoms. Based on the presentation, the team applied SMART-TAG© TSG Associates LTD per triage guidelines to prioritize patient care. Twelve simulated patients comprised an equal number of green, yellow, red, and black tag designations were to be appropriately treated and those requiring further management were then sent through the decontamination process in the tent where ED nurses and techs were stationed to assist. EMS participated in the drill by bringing two patients by ambulance to the ambulance bay decontamination station.

We escorted each treatment team in rapid sequence as their assigned simulated patient arrived in the resuscitation bay. All three patients were treated simultaneously to augment the chaos of an overcrowded MCI. A pre-recorded dramatized newscast was played mid-scenario which revealed that the train bombing released sarin. We displayed this mid-scenario video directly to the residents if they had not yet identified the presenting toxidrome in their patient in a timely fashion.

Assessment

The reported results focus on the overall evaluation of the simulation program itself, rather than the individual participant. Evaluative data was gathered from all willing participants, regardless of their role in the simulation. The standard feedback form used by our department for all resident simulations was administered in a mobile phone compatible format using Qualtrics This feedback form has been used with over 800 learner encounters prior to this simulation.

Debriefing

At the end of the exercise, residents walked through the resuscitation bay as well as the disaster tent to view portions of the scenario that they did not experience. Each EM faculty preceptor spent about 15 minutes individually reviewing the critical actions with their assigned team. The participants at each hospital site gathered to debrief for 20 minutes on each scenario, specifically summarizing their scenario, the critical actions required, and any changes in how they would have managed the scenario to optimize care. We then gathered all participants from each hospital for a general event debriefing, during which the residents summarized their scenario to describe the injuries and critical actions they employed during the simulation.

RESULTS

A total of 40 participants completed the voluntary feedback form. Participants included EM residents, EM faculty, advanced practice providers, medical students, nursing staff, facilities management personnel, and prehospital providers (**Table 2**).

Table 2. Participant Responders to the Simulation Evaluation Tool

Role	%	Count
Emergency Medicine PGY 1	17.50%	7
Emergency Medicine PGY 2	10.00%	4
Emergency Medicine PGY 3	17.50%	7
Emergency Medicine PGY 4	10.00%	4
Advanced Practice Provider	2.50%	1
Medical Student	2.50%	1
Emergency Medicine Faculty	27.50%	11
Other (3 RNs, 2 prehospital providers)	12.50%	5
Total	**100%**	**40**

Table 3. Participant Ratings of Simulation Exercise on a 1–5 scale

Please Rate:	Minimum	Maximum	Mean	Std Deviation	Variance	Count
Scenario Overall	3.00	5.00	4.45	0.67	0.45	40
Relevance to training/duties	3.00	5.00	4.63	0.58	0.33	40
Faculty effectiveness at facilitation/debriefing	2.00	5.00	4.45	0.74	0.55	40

The mean rating for the scenario overall, relevance to training/duties, and faculty effectiveness at facilitation and debriefing were all rated highly on a 1–5 scale (**Table 3**). Ninety percent of respondents felt the learning objectives were clearly defined. Representing the perceived value of this training, 98% of respondents recommended this simulation should become part of the standard EM residency curriculum.

The most valuable feedback came from the free text responses to the questions, "Please give AT LEAST ONE suggestion to improve this simulation" and "Other comments or suggestions?" (**Box 1.**) While a formal thematic analysis is beyond the scope of this project, the authors noted the following feedback to consider in future events: respondents note a lack of clarity in participant role in the triage and decontamination assignments, and some reported confusion about "deconned" patients who remained fully clothed during the simulation. Unlike a typical ED patient encounter, during the simulation scenario the standardized patients and student volunteers were not undressed by the residents providing the simulated patient care. These issues could be remedied in the future by specifically addressing them in the pre-brief or by the standardized patients wearing a nude-colored bodysuit under their clothing. As for "other comments or suggestions," many residents specifically noted the high value of the debriefing exercises.

Box 1. Simulation Survey

Q1. What best describes you?
PGY 1
PGY 2
PGY 3
PGY 4
Advanced Practice Provider
Medical Student
Emergency Medicine Faculty
Other
Q2. On a scale of 1 to 5, please rate the scenario overall.
Q3. On a scale of 1 to 5, please rate the scenario's relevance to your training/duties.
Q4. On a scale of 1 to 5, please rate the faculty effectiveness at facilitation and debriefing.
Q5. Please give AT LEAST ONE suggestion to improve this simulation.
Q6. Would you recommend this simulation become part of the standard curriculum?
Yes
No
Q7. Other comments or suggestions?

DISCUSSION

Most of the disaster preparedness education that EM residents receive is in the form of lectures and classroom didactics.[9,10] Programs have sought to implement disaster experiences into residency curriculum in other ways, including tabletop exercises, computer-based simulations, high-fidelity simulation sessions, and virtual reality,[11,12,13] with mixed success. Simulation-based disaster exercises have been shown to be useful and to increase resident confidence in managing disaster events.[11]

Other than tabletop exercises, a review of the literature is bereft of in-situ, hospital-based MCI simulations, especially with more than one hospital involved. This is likely because of the challenging logistics and time commitment to run such an event. This simulation exercise would not have been possible without many months of preparation. Most important was advance collaboration with key stakeholders at both hospitals, including administration, EMS leadership, environmental safety, senior nursing, and ancillary staff. All told, more than 10 stakeholders and committed faculty participated in the disaster simulation at each site.

We were fortunate that on the actual date of the exercise, the weather was favorable, and the actual ED visits that morning – both hospitals combine for approximately 175,000 ED visits per year – were low enough to prevent the simulated disaster from interfering with normal ED function.

The rationale behind the in-situ design of this scenario was enhanced realism, as it was conducted in the actual workplace of the EM residents and ancillary staff. Utilizing standardized patients with injuries, along with hi-fidelity manikins that had received toxic doses of sarin gas, further served to make the entire scenario more realistic. The fact that 98% of respondents recommended this simulation become part of the standard curriculum strongly suggests that this is a preferred disaster education modality compared to classroom didactics and other methods. This response is presumed likely because of active learning and the realism of the scenario.

The secondary goal of this in-situ simulation was to stress the need for the residents to protect themselves from inadvertent exposures in an MCI, which could occur in a real biological or chemical disaster. The use of a nerve agent allowed the inclusion of worried, well-standardized patients, further simulating what would happen in an actual disaster.

Limitations

Although all participants were invited to provide feedback, most respondents who completed the evaluation form were EM residents and faculty. We suspect that this is due to their familiarity with this tool and its expectation to be completed after didactic sessions. We recognize the need to encourage all groups of participants to provide feedback at future simulated MCIs.

The risk of performing an in-situ simulation is that it can be derailed by the demand for real patient care, jeopardizing the execution of the entire scenario. We had limited time to perform the scenario for this reason. This limitation also prevents each learner from experiencing each patient scenario, which is particularly relevant when comparing the triage and simulation teams' experiences. This is partially offset by the shared experience with the group debriefing at the end of the exercise. The goal of enacting the realism of a true MCI merits the loss of specific scenario exposure. We also did not measure retention of medical knowledge learned during this exercise, so efficacy of this training program cannot be critiqued.

The larger goal is to provide trainees with a different scenario in subsequent years. We plan to include a post-simulation test to assess medical knowledge and have an objective measure of the value of in-situ, disaster-based education, rather than only a subjective one. Specifically, we could include knowledge-based, multiple-choice questions for the simulation teams on evaluation for, and treatment of, blast injuries and organophosphate poisoning, as well as proper decontamination practices. We could also include multiple-choice or free-text response questions as to what each level in the START tool represents. We do not plan to administer a pretest to gauge prior knowledge because it could potentially affect performance during the scenario.

It was acknowledged in the preparation of this drill that including additional ancillary staff (e.g., blood bank, radiology technicians, security) would provide further benefit in training for a mass casualty incident to test our facility's preparedness, but due to the complexities already required to orchestrate nursing, EMS, and residents for training, as well as to minimize further disruption of true patient care ongoing in the Emergency Department, we did not include these components in the simulation.

Although it is conceivable to compare medical knowledge across learners with a post-test, it would be difficult to power this analysis at a single institution. A post-test given 6 to 9 months after may alternatively have value in assessing the decay of knowledge.

In conclusion, this in-situ MCI simulation was perceived as such a success by faculty, administrators, and our EM residents that a different in-situ MCI was designed and scheduled for the next academic year. It is our belief that annual in-situ disaster simulations with rigorous, post-test analysis will foster teamwork, understanding of existing disaster protocols, increase knowledge retention, improve healthcare worker safety, and enable EDs and hospital systems to be better prepared for such a high-acuity and low-frequency event. This exercise demonstrated that we could successfully run scenarios with high-fidelity simulators, low-fidelity simulators, and standardized patients, just as we would in our simulation center, with significant preceptor oversight within the environment that trainees would encounter a real disaster scenario.

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