Human Patient Simulator based CBRN Casualty Management Training

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ABSTRACT

Chemical, biological, radiological and nuclear (CBRN) emergency are becoming an impending threat. Effective preparedness needs to be raised for prompt response of CBRN incidents. During mass casualty incidents the strategy of the first responders must be beyond the triage, evacuation and medical first aid. Response process is advanced by the presence of CBRN contaminants and it becomes more complex when the rescue operations have to be performed immediately after the incident. Methodological approach is required to identify and decontaminate the CBRN victims. To manage CBRN emergencies, skill based training of appropriate degree is a key to the right level of preparedness. Intervention by first responders requires specialised inputs in knowledge, skills and aptitude. In India, CBRN defence training has traditionally been a military oriented domain, involving the quick reaction team, quick reaction medical team, rapid action medical team, etc. The training concept discussed in this study contemplates around standardised simulated CBRN casualty referred to as CBRN human patient simulator (HPS), which conceptualised in the division of CBRN Defence, Institute of Nuclear Medicine and Allied Sciences, Delhi. HPS provides an opportunity to learn about the health impact of CBRN contaminants and practise medical management. Simulation as training and planning tools, offers repeatability, controllability, possibility for evaluation and provides a platform to learn from costly mistakes. Group training and demonstrations conducted on the HPS offers an additive benefit to enhance performance as a team and also help to reduce errors. This paper provides the information on the potentials of simulation based training of emergency response teams in the management of CBRN victims.

Keywords: CBRN; Mass casualty incident; Human patient simulator; Hazard mitigation; Moulage kit

1. INTRODUCTION

There is a significant concern increased in the recent times about the use of chemical, biological, radiological and nuclear (CBRN) agents by terrorists, non-state actors or hostile rogue nations[1,2]. The existing diagnostic and remedial measures need to be optimised to curtail health effects of the use of CBRN weapons of mass destructions (WMDs), which can result in huge number of casualties[4-7]. Medical preparedness is an important link in disaster management. As a result; there is a common consensus amongst various CBRN training institutions to devise ways to enhance efforts to upgrade medical preparedness for effective management for handling such emergencies[8]. The frequency with which CBRN emergencies occur is too limited to allow training during actual patient care but when they occur, their severity and criticality demand immediate and full attention to the patient's care. Medical simulation creates a real time scenarios, in which person undergoes straining session that can be shown in detail like the health effects of such exposures and the way to treat/manage them. Trainees can proficiently master the skills relevant to clinical practice without undue risk

the life of emergency victims[9,10]. It also permits errors of either diagnosis or treatment and observe the consequences that may follow thereafter. There is a potential for significant learning from errors in simulation, and this learning can be successfully implemented during the real time incidents, without any harm to either victims or medical responders.

The four major categories of medical simulation systems are: PC-Based interactive systems, virtual workbenches, human patient simulator (HPS) and total immersion virtual reality[11-13]. HPS provides innovative solutions against the challenging CBRN defence problems by combining the skills and expertise of doctors, paramedics and scientists. The standard protocol includes protection, hazard mitigation, test and evaluation, training and medical planning[14-17].

Training on HPS provides an opportunity for the first responders and combat medics to exercise their ability to manage a mass casualty incident (MCI) resulting to better management of the causalities. The training intends to institutionalise proficient disaster management skills. During training, the healthcare professionals or paramedics are required to provide effective medical response to a simulated MCI victim. Institute of Nuclear Medicine & Allied Sciences (INMAS), Delhi, has

been consistently imparting trainings in medical management of radiation injuries. Since 1st July 2010, it has been declared as a single window for CBRN emergency management training to military, paramilitary and elite forces. This review reports the evaluation of HPS as an integral part of training imparted to the CBRN responders at INMAS, Delhi.

2. HUMAN PATIENT SIMULATOR

Human patient simulator is an interactive mannequin that is basically meant for medical simulation in case of CBRN emergencies. It is almost full-sized 'patient' with life-like features as airways, pulmonary system, cardiovascular system, trauma patient monitoring, etc.

Preparing a training module for medical management of CBRN casualties is a complex activity because the scenario involves strange medical crisis, physical conditions, extenuation, etc. The necessity of decontaminating to the victims prior to initiating specific treatment and the criticality involved in physically safeguarding paramedics from secondary cross-contamination has influenced the need for preparedness of the medical professionals for specialised training[18,19].

3. CBRN PATIENT SIMULATION TRAINING CENTRE

A simulation training centre has been set up at the Division of CBRN Defence, INMAS, Delhi, to impart learning of the physiological functions, familiarisation with medical examination techniques, mastering basic life support techniques, while attending victims of CBRN based MCI. The simulation offers identification and addressing of rare and complicated clinical CBRN emergencies that are not usually encountered during medical practices. The training concept includes a standardised simulated victim suffering in a typical CBRN Emergency. The medical simulation technology training is primarily being conducted on the HPS with the help of moulage kit (Fig. 1). This kit provides material needed to create different types of wounds and rashes on HPS skin. Moulage kit includes synthetic life like wounds that accurately replicate muscle, tissues and subcutaneous fat, etc.

To create beta burns induced by radiation on HPS skin, we use a light coating of petroleum jelly sprinkle with talcum powder and red powder, to create small pox, we use melt pound of flesh and then leave it to cool until its thick consistency

Figure 1. Basic components of moulage kit.

occurs. After performing treatment on HPS, created smallpox and radiation burns can be removed with the help of soap and water or cold cream. For creating skin rashes due to anthrax we take a stipple sponge and dip it into the Ben Nye Crème CL-14 Blood Red and apply the stipple sponge to the HPS's arm and make it into a rash. With 'pound of flesh' or Ben Nye Scar Effects Gel, we make a doughnut type asymmetrical circle. After adding more colours to the outer edges, spread it with fingers, to make the rash look more inflamed and rose (swollen). Pro Colour Ring Bruise #505-B or the Ben Nye F/X Wheel EW-1 can also be used to bruises brown colour for the darker colour. The simulator is a digitally enhanced mannequin that is sophisticated with mathematical models of human physiology – cardiovascular, respiratory, neurological and pharmacologic that imitates human response in multi-layered, real-time ways that are vital to a truly objective learning experience. The patient simulator blinks, breathes and have heart beat, pulse and respiratory sounds etc. Training with HPS allows us to prepare and identify opportunities to improve, standardise the medical management strategies and better serve the victims and community. Monitors are attached to display vital signs which can provide virtual simulation of almost every major physiological function (Fig. 3). HPS can be used for creating scenarios from simple physical examination to interdisciplinary major trauma management.

Figure 3. Monitor displaying vital parameters after sarin gas attack.

3.1 Training Set up

HPS has unique capability to display symptoms indicative of CBRN agents. Trainees can readily visualize the result of their decisions and actions. Errors can be created deliberately to arrive at best options as well as numerous alternative options. Identical situations can be prescribed to different teams of trainees and responses can be evaluated for comparative analysis that can also decode advance training needs of responders.

Actual medical equipment can be utilised and consequence limitations can also be understood simultaneously. The personnel can be exposed to multiple situations and the best selections can be identified with creation of real life clinical situations. The interaction among members of the teams can be analysed and extra attention can be paid to identify weak-links. In the team training methods can be evolved for effective team work, quality leadership and coordination/communication. The simulation response can be documented properly and used later for assessment and accreditation.
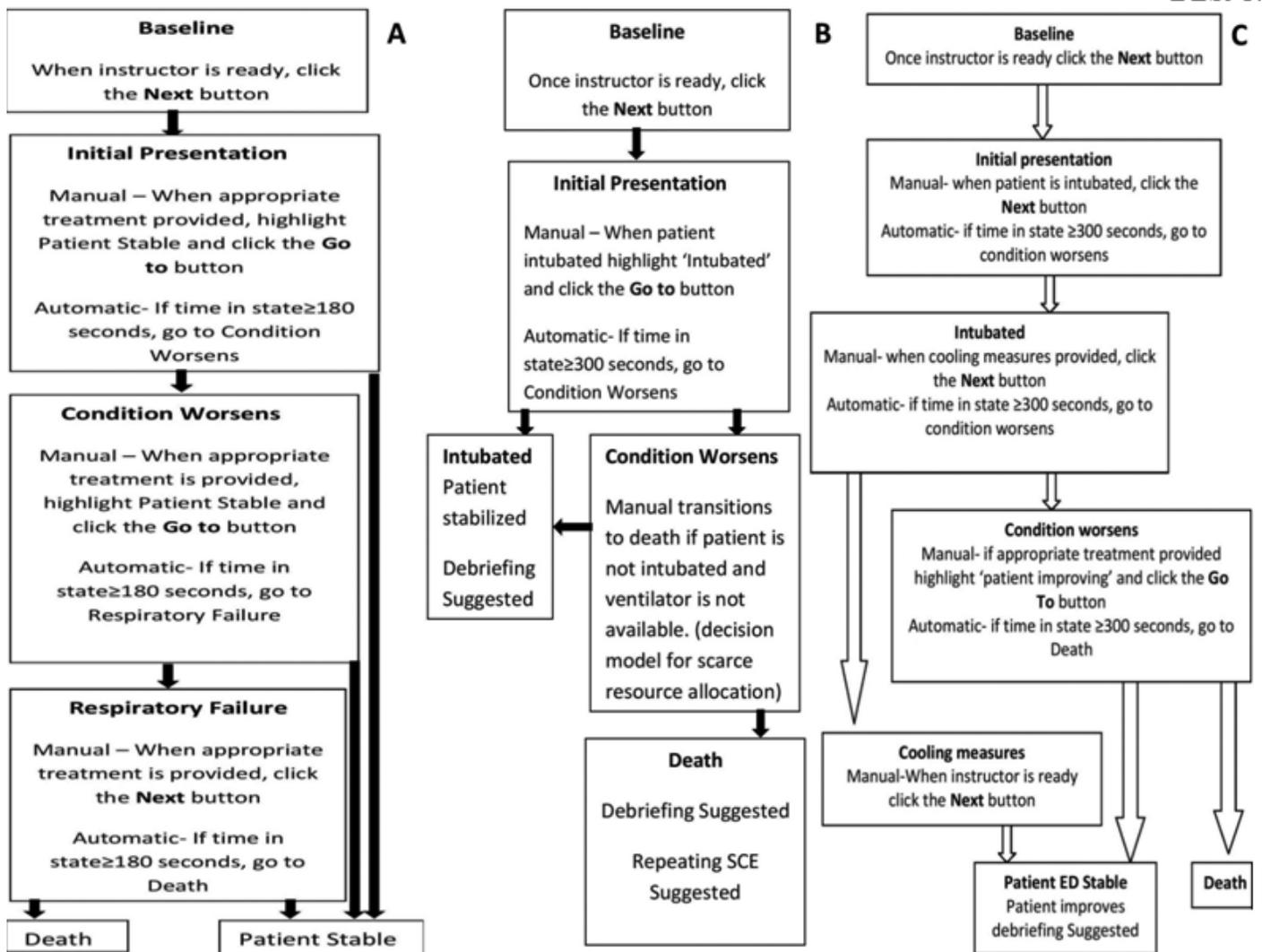
A

Baseline

When instructor is ready, click the **Next** button

Initial Presentation

Manual – When appropriate treatment provided, highlight Patient Stable and click the **Go to** button

Automatic- If time in state≥180 seconds, go to Condition Worsens

Condition Worsens

Manual – When appropriate treatment is provided, highlight Patient Stable and click the **Go to** button

Automatic- If time in state≥180 seconds, go to Respiratory Failure

Respiratory Failure

Manual – When appropriate treatment is provided, click the **Next** button

Automatic- If time in state≥180 seconds, go to Death

Death

Patient Stable

B

Baseline

Once instructor is ready, click the **Next** button

Initial Presentation

Manual – When patient intubated highlight 'Intubated' and click the **Go to** button

Automatic- If time in state≥300 seconds, go to Condition Worsens

Intubated

Patient stabilized

Debriefing Suggested

Condition Worsens

Manual transitions to death if patient is not intubated and ventilator is not available. (decision model for scarce resource allocation)

Death

Debriefing Suggested

Repeating SCE Suggested

C

Baseline

Once instructor is ready click the **Next** button

Initial presentation

Manual- when patient is intubated, click the **Next** button

Automatic- if time in state ≥300 seconds, go to condition worsens

Intubated

Manual- when cooling measures provided, click the **Next** button

Automatic- if time in state ≥300 seconds, go to condition worsens

Condition worsens

Manual- if appropriate treatment provided highlight 'patient improving' and click the **Go To** button

Automatic- if time in state ≥300 seconds, go to Death

Cooling measures

Manual-When instructor is ready click the **Next** button

Patient ED Stable

Patient improves debriefing Suggested

Death

Figure 2. Scenario algorithm used in the software to simulate CBRNE casualty in the mannequin.

3.2 Importance of HPS for CBRN Learning and Training System

• HPS represents an advanced technology, mimics a real patient and adds authenticity which leads to the better learning opportunity than a text book, indicating that students perceived a huge difference between watching and performing.

• Once the simulation session begin, trainee forget that they are working on a simulated patient and responded to the situation as if it was real.

• Patient's condition can improve or deteriorate with interventions as the scenario progresses and at any point of time scenario can be stopped and restarted to clear the doubt and confusions of the learners.

• Includes many trainees for single CBRN scenario learning.

For example: Five trainees worked together on each scenario, two inside participated and three were there as observer.

• HPS provide better opportunity to experience working as an Autonomous practitioner.

• The experience enabled to recognise the importance of a sound knowledge base to effective clinical judgement and decision making.

• Trainees get opportunity to work independently and the experience enabled them to coordinate effectively in the real time CBRN emergency.

4. DISCUSSION

During training, the mannequin will be connected with a laptop and a monitor for creating disaster scenario. Input will be provided with the help of its inbuilt software to the HPS and it will behave according to the instructions. Symptoms like vomiting, nausea, lachrymal secretion, dilation of pupil, excessive salivation and nasal discharge, increased/decreased temperature, blood pressure, heart beats etc. are introduced through digital commands. Typical of a CBRN attacks can be simulated on HPS. Later on, the trainees can perform desired activities to bring it back into normal condition.

The effects of 'Sarin' gas like constriction of pupil size, wheezing in chest and convulsion etc, can be demonstrated on HPS. The iris acts as a diaphragm, like a shutter on a camera, regulating the amount of light that enters through the pupil. The pupil appears as a black hole at the center of the iris. It

is the opening through which light enters the eye (Fig. 4). CBRN HPS is a valuable tool to meet training needs for CBRN medical management.
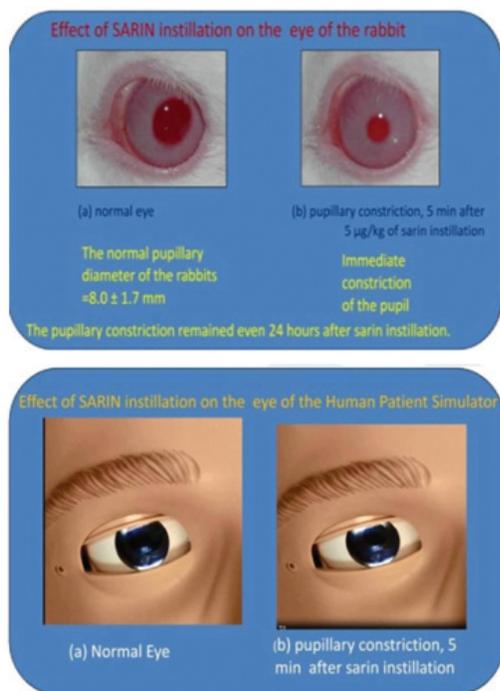

Figure 4. **Traditionally, effects of Sarin on eye of rabbit is shown by instillation it in the eye and same in HPS.**

5. CONCLUSION

The medical preparedness for handling mass casualty incidents emerging out of CBRN incidents is not limited to triage or preliminary treatments. As CBRN emergencies becomes a looming threat and medical system needs to be prepared to treat the casualties of such a mass casualty event. Obtaining specialised training about the medical aspects of CBRN agents is an important part of medical preparedness for both military and non-military medical institutions. Division of CBRN Defence at INMAS is actively working on their critical areas to develop a state-of- art CBRN simulation based training facility requisite for training of all responders /stakeholders in changing disaster dynamics. Workshops to train medical first responders and other emergency functionaries / stakeholders are held at periodic intervals, such courses are needed to be made mandatory for the medical responders and paramedics tasked with CBRN response. The ongoing training program combined with hospital drills shall provide an optimal solution for the treatment challenge and addresses the practicing needs of the training medics/ paramedics.

REFERENCES

1. Amir, V.; Inbal, L. & Haim, B. Simulation-based training of medical teams to manage chemical warfare casualties, non-conventional warfare medicine. *Isr. Med. Assoc. J.* 2002, **4**, 540-544.
2. Ronen, R.; Eyal, R.; Arik, E. & Aviv, V. Training israeli medical personnel to treat casualties of nuclear, biologic and chemical warfare, non-conventional warfare medicine. *Isr Med. Assoc. J.* 2002, **4**(7), 545-548.
3. Gene, B.W. Medical simulation and training: Breakthroughs and barriers. *J. Soc. Mod. S Intl.*, 2008, **52**.
4. Fatimah, L. Simulation-based learning: Just like the real thing, *J. Emerge. Trauma Shock,* 2010, **3**(4), 348-352. doi: 10.4103/0974-2700.70743
5. David, P.; Patrick, H. & David, H. An evaluation of high fidelity simulation using a HPS in a new diploma in military medical care, JMVH, 2013, 04-10
6. Sima, G. & Rakesh, S. Standardizing CBRN 'Triage' through digital-cum-interactive approach in training platforms presented in bilingual international conference: Information technology: Yesterday, today and tomorrow, DESIDOC, Delhi, Feb, 2015, 19-21.
7. Bjorn, S. & Hakan, E. Training of public health personnel in handling CBRN emergencies: A table-top exercise card concept. *J. En. Sc., R H,* 2014, 164-169
8. Kleinert, R. & Heiermann, N. Realisation and first validation of an immersive web-based virtual patient stimulator for clinical decision in surgery. *J. Surg. Educ.*, 2015, **72**(6), 1131-1138. doi: 10.1016/j.jsurg.2015.05.009
9. Ferreira, A.D.E.S.; Pacheco, A.G. & Sim, T.C.M. A human patient stimulator with application diagnostic accuracy studies of chinese medicine. *J. Integr. Med.*, 2015, **1**(13), 9-19. doi: 10.1016/S2095-4964(15)60151-0
10. Vaughan, N.; Dubey, V.N.; Wee, M.Y. & Isaacs, R.A. Review of epidural simulators: where are we today? *Med. Eng. Phys.*, 2013, **35**(9), 1235-50. doi: 10.1016/j.medengphy.2013.03.003
11. William, M.; Nissa, M. & Matthew, L. Student perception of using a human patient stimulator for bardsic caiac assessment. *Curr. Pharm. Teach. Learn.*, 2011, **4**, 29-33.
12. Tsume, Y.; Takeuchi, S.; Matsui, K.; Amidon, G.E. & Amidon, G.L. In vitro dissolution methodology, mini-gastrointestinal stimulator, predicts better in vivo dissolution of a weak base drug, dasatinib. *Eur. J. Pharm. Sci.,* 2015, **30**(76), 203-12. doi: 10.1016/j.ejps.2015.05.013
13. Michael, M.; Katharina, S.; Deike, H. & Thomas, G. Human biological monitoring: A versatile tool in the aftermath of a CBRN incident, *Toxicol. Lett.,* 2014, **15**, 306-14.
14. Juul, G.; Michel, D.; Hans, T.E.; Rolf, B. & Kleber, A.D. Phychosocial care to affected citizen and communities in case of CBRN incident. *Environ. Int.,* 2014, **72**, 46-65. doi: 10.1016/j.envint.2014.02.009
15. Scheri, L.; Vanden, B. & Scott, B.D. Preparation for mass causality incidents. *Critical Care Nursing Clinic*, 2015, **27**, 157-166.
16. Aakil, M.; Caunhyea, M. Lib. & Xiaofeng, N. Allocation model for casualty response planning during catastrophic radiological incident, socio-economic planning sciences. 2015, **50**, 32-44.
17. Sibel, F.S. & Sezer, G. Deployment of field hospital in mass casualty incident. *Computers Industrial Eng.*, 2014, **74**, 37-51.

doi: 10.1016/j.cie.2014.04.020

18. Rachel, M.R.; Galante, J.M. & Jacby, R.C. Mass casualty disaster. *J. Emer. Med.*, 2015, **48**(6), 685-692.
    doi: 10.1016/j.jemermed.2014.12.069

19. E.L.; Sayed, M.; Tamim, H. & Mann, N.C.Description of procedure performed on patient by emergency medical service during mass casualty incident in the United States. *Am. J. Emer. Med.*, 2015, **33**(8),1030-36.

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