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Mastery learning of Toxicology life support skills by FMT residents using simulation technology in India

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ABSTRACT

Modern Medicine has been at the forefront in the use of patient simulation for research, training and performance assessment. With simulation, no patients are at risk for exposure to novice caregivers or unproven technologies. It becomes very important in field of toxicological emergencies, due to its acute onset of presentation, rapid progression of symptoms, early deterioration of vitals and adverse outcomes in morbidity and mortality of patients in extremes of ages. Our observational study suggests that Forensic Medicine and Toxicology (FMT) residents have limited exposure to critically ill patients of trauma and toxicology and the budding forensic professionals lack the skills to manage them. Simulation has the potential to fill this educational void in managing clinical forensic and toxicological emergencies. The following review will attempt to answer this call by quantifying the effect of simulation-based educational interventions on retention of knowledge and clinical performance, as applied to acute care toxicology.

BACKGROUND

Simulation has been used as a teaching tool for nearly 40 years in fields as diverse as aviation and military training. However, integration of this technology into the arenas of medical education and assessment is a relatively recent development.[1] Vision 2015 document of MCI emphasizes adoption of Contemporary Education Technologies- Skills lab, E-learning, Simulation.[1] Simulation benefits learners in getting hand's on experience without causing any harm to actual casualty.[2] Today's learners have had wide exposure to communication technology through high-speed computers, the Internet, and smartphones. Given this exposure and the learners' expertise in its use, they are receptive and generally excited about educational experiences involving simulated situations because they offer a more active process and employ state-of-the-art technology.[3] The purpose of medical simulation is

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to emulate real patients, anatomic regions, and clinical tasks, or to parallel real-life situations in which medical care is provided.[4] The widespread adoption of simulation technology marks a divergence from the traditional 'see one, do one, teach one' method of medical training, which for centuries has relied upon real patients. Multiple factors have contributed to this revolution in training. Changing patterns in healthcare delivery have resulted in shorter hospital stays and clinic visits.[5] Furthermore, the increasing drive to reduce medical errors and improve patient safety has fueled the impetus to incorporate simulation technology into training and assessment programs.[5] Limitations on trainee work hours have contributed to decreased clinical experience.[6] This has resulted in reduced patient availability for learning, decreased exposure to critically ill patients, and decreased time for clinical faculty to teach.[7] In addition, technological advances in diagnosis and treatment, such as newer imaging modalities and life-saving procedures, require development of skill sets that differ from traditional approaches.[8] Concurrent progress in simulation technology that enables increasingly realistic models offers advantages for such skill acquisition.[9] Simulation in toxicology education can teach the skills needed to manage rare or critical events, such as cardiopulmonary arrest or associated trauma.[10] Toxicology Trainees can make errors and learn to recognize and correct them in the simulated environment without fear of being penalized or causing harm to patients. And finally, ethical questions arise concerning the appropriateness of using real patients as training resources.[11] Much of this debate centers on sensitive tasks (i.e., pelvic examinations in females) or those that involve potential risk of harm to patients (endotracheal intubation or other invasive procedures). All of these factors driving the increased use of simulation are part of a paradigm shift toward outcomes-based medical education.[12] The consensus calls for research to explore the methods of assessment and the correlation of simulated assessments with clinical performance.[13] One reason for greater use of simulation in teaching in Clinical toxicology is that changes in health care system have shortened hospital stays and brought sicker patients into the hospital, leaving fewer opportunities for learners to gain hands-on experience in managing toxicological emergencies. Simulation is currently used as an assessment tool to provide ongoing feedback during training (formative assessment) and is gaining popularity as an adjunctive method for demonstrating competency (summative assessment).[14] Recent literature demonstrates increased retention of knowledge and skills after simulation-based training in the areas of resuscitation in intoxicated, associated trauma, airway management, procedural training, team training, and disaster management in mass casualty due to poisoning.[15]

Conceptual Background

Mannequins come in various shapes and sizes and can serve different purposes, including replication of the clinical deterioration and imitation of an adult in distress secondary to exposure to fatal poisoning. Fidelity describes the extent to which the appearance and behavior of the mannequin imitate the appearance and behavior of an actual patient.[16] Simulation is especially effective in developing skills in procedures that require eye–hand coordination and ambidextrous maneuvers, such as securing airway in compromised airway due to vomiting and aspiration in intoxicated state, vascular access in cardiovascular collapse, shock and cardiac arrest and the use of laryngoscopes for endotracheal intubation in respiratory Asphyxiants & laryngeal angioedema due to anaphylactic reaction after exposure to toxins derived from insects, reptiles and fishes.[17] Simulation training prepares learners to deal with unforeseen medical events in unknown poisoning, improves teamwork and communication skills among bedside doctors and nurses, and increases confidence and performance of healthcare providers in managing fatal toxic exposures.[18] These case scenarios were created as part of our MCI Curriculum for MD & DNB Simulation teaching & training in emergency medicine, internal medicine, forensic medicine, anesthesia & critical care. Studies indicate that simulation improves learning. These simulation cases were based on an actual patient seen in our Indian Hospital setup and highlights specific teaching points and potential pitfalls in treatment algorithms. The simulation venue offers a unique opportunity to address team dynamics as well as provide a forum for didactic learning as it is often difficult to debrief a critical case while working in real time patient care settings.[19]

Advantages of simulation training in toxicological emergencies

- Realistic learning as an active participant
- Trainer provides real-time Prompt feedback
- Deliberate practice
- Curriculum integration

- Outcome measurement
- Simulation fidelity
- Skill acquisition and maintenance
- Mastery learning
- Transfer to practice
- Team work
- Debriefing and reflection after learning
- Tangible outcome measures
- High-stakes testing
- Range of difficulty and complexity
- Opportunity for repetitive 'hands-on' practice
- Crisis resource management skills
- Educational and professional context

Goals of study: The goal is to have participants manage and stabilize a patient suffering from Common types of Poisonings in India while simultaneously caring for overdosed patients in the Hospital due to medication errors by patient, bedside nurses or doctors due to communication gap.

Purpose of study: The purpose of this training is to prepare FMT residents and students to appropriately care of a poisoned patient in emergency and intensive care units.

Simulation as an educational and assessment tool in toxicology: Simulation, as an educational tool, mirrors, anticipates, and amplifies real-life situations with guided and interactive experiences.[20] Simulation has the added benefit of creating the optimal level of productive anxiety for learning.[21] Errors can occur in simulated cases without adverse outcomes or fear of retribution. These errors are more valuable to learning than successes, and raise awareness of aspects of performance that need improvement. The teacher can then deconstruct the providers' performance, correct errors, and provide immediate feedback until the trainee masters all components. An essential aspect of formative assessment is feedback or debriefing. This technique is effective in describing what was done well and where improvement is needed to develop an individualized learning plan.

Observational study material, requirements, tools and methods: The particular skills or learning objectives that are being taught dictate the type of simulator and level of fidelity that are necessary for a particular scenario. When the learning objective was to emphasize the timing and depth of chest compressions in a resuscitation scenario in an adult, a low-fidelity mannequin was used. This mannequin has limited responsiveness to learners' interventions (i.e., it cannot demonstrate a return of spontaneous circulation if chest compressions are applied appropriately). When the objective was to have learners recognize when an arrhythmia becomes a cardiac arrest through loss of the pulse, then a higher-fidelity mannequin was used. A computer-driven mannequin that can simulate physical signs of cardiopulmonary management and provide feedback for learner interventions (e.g., produces tactile pulses) was utilised for toxidrome case scenarios (Table 1). Screen-based simulation allows learners to participate in decision making scenarios at their own pace, with an instructor. Our training program covered a wide range of topics, from antidepressant overdose to opioid drug abuse and bio-toxicology by venomous snake bites.

Toxidrome Study Material

1. Simulation Cases: Common Toxidromes in India

- Cholinergic Toxidrome- Organophosphates, Nerve gases, Carbamates
- Anticholinergic Toxidrome- Atropine, Tricyclic antidepressants, Mushrooms
- Sympathomimetic Toxidrome- Cocaine, Amphetamines, Cannabis
- Sympatholytic Toxidrome- Morphine, Heroin, Fentanyl, Opioids.
- Snake bite Toxidrome- Cobra, Krait, Viper.

2. Case related Audiovisuals utilized during simulation:

- Clinical signs – Face, pupils, tongue, Limbs, trunk
- EKG – programmed into case, distributed in hard copy, and shown if prompted by participant.
- Chest & Abdominal X-Ray – programmed into case or distributed in hard copy, shown if prompted by participant.
- CT Head / Chest- programmed into case.
- Toxicology reports & relevant Laboratory reports – programmed into case and distributed in hard copy, showed when prompted by participant.

When used for medical education, Toxidrome Simulation has the following requirements:

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1. Highly motivated learners with good concentration (e.g., FMT residents, Emergency & ICU residents);
2. Engagement with a well-defined learning objective or task;
3. Appropriate level of difficulty;
4. Focused, repetitive practice;
5. Rigorous, precise measurements;
6. Informative feedback from educational sources (e.g., simulators, teachers);
7. Monitoring trainees' learning experiences, correcting errors, and engaging them in more deliberate practice;
8. Evaluation to reach a mastery standard;
9. Advancement to another task or unit.

Educational Objectives of simulation in toxicology:

1. Organize a patient care team.
2. Recognize appropriate elements of Toxidrome.
3. Recognize life-threatening complications of different Toxidromes.
4. Manage a critically ill patient with different Toxidromes.
5. Discuss the practical difficulties in using antidotes.

DISCUSSION

Two recent studies of virtual reality-based toxidrome drills demonstrate the potential of using this novel technology of simulation. First study was conducted during ISTOLS workshop on low-fidelity simulation on 1st generation manikins with hands on training of life saving skills during TOXOCON-12, annual conference by Indian society of toxicology at Sikkim Manipal Institute of Medical sciences, at Gangtok, Sikkim on 7th April 2018; by training resident doctors in critical care, emergency, forensic medicine, pharmacology and internal medicine; analyzed clinical skills during simulated toxicology casualty drills, using a virtual reality head-mounted ICU display monitors and emergency drugs cart.Another consecutive study on high fidelity bedside simulation on computerized manikins, alongwith toxicology quantitative lab, during ISTOLS Masterclass by Indian society of toxicology at Medanta-the Medicity on 24th june 2018, by training resident doctors & consultants in critical care, emergency, forensic medicine, utilized a high-resolution computer-generated scenario integrated with a human patient simulator to evaluate first responders during a simulated toxicological casualty event. These drill helped to identify several critical errors made by first responders, including incorrect triage, inability to assess critically ill poisoned victims, and failure to resuscitate intoxicated patients in cardiac arrest. Participants agreed that the virtual reality simulator was effective at conveying images of toxicology victims.

Results analysis: We observed that FMT residents who received high fidelity training on a human patient simulator performed significantly better on the advanced life support written examination as well as during a mock resuscitation. Pre-test and post-test analysis reported improvement in overall performance by doctors after implementation of simulator training sessions. Figure 1

Figure 1: showing impact of simulation teaching on scores of Post-test of FMT residents.

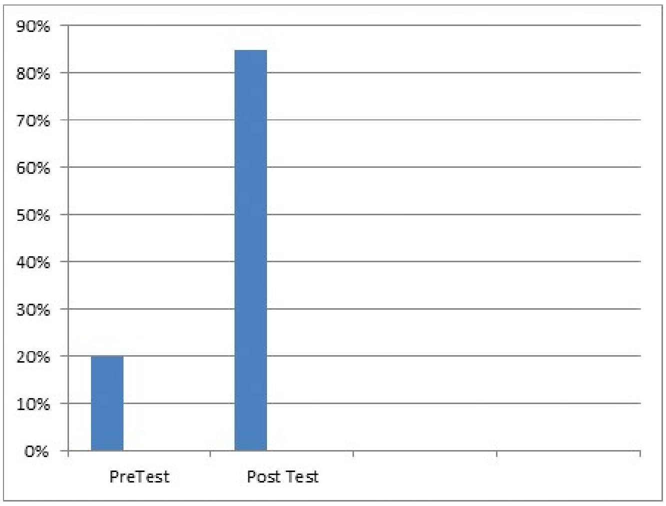

Fig 1 showing impact of simulation teaching on scores of Pretest and Post-test after simulation training of FMT residents.

Source: Simulation training assessment during ISTOLS course by IST on 24th- 25th june 2018.

We observed that 94% of FMT resident benefitted from increased confidence and perceived technical and non-technical skills during toxicological emergencies following simulation based learning. These novice learners in clinical toxicology demonstrated improved triage and intervention scores after each virtual reality toxidrome drill. FMT residents who received human patient simulator training in addition to advanced life support showed significantly higher adherence to international standards as compared with those who received basic life support alone. It was observed that the prior simulation training positively impacted their clinical skills during the resuscitation, including rapid problem recognition, correct choice and dosage of specific therapy, and coordination of team efforts. The differences of percentage in doctors' responses towards life support skills with and without the implementation of simulation practice were calculated and recorded. After the implementation of simulation training, FMT residents showed more anticipation in the implementation of simulation training by hands-on practice on manikins and there was an increase from 63.89% to 89.44%. Among FMT residents, 65.35% of them liked life support skills as a subject even before the simulation training were implemented. After the application of the simulation in training, 95.49% of residents were interested to learn life support skills in managing poisoning patients. There was an increase of 30.14% of FMT residents, who had developed their liking towards life support skills in management of toxicological emergencies. We compared 'low-fidelity' versus 'high-fidelity' simulation on doctor's ability to successfully perform nasogastric lavage and endotracheal tube placement. The low-fidelity mannequin consisted of a relevant body part model that allowed for tube insertion, in contrast to the high-fidelity simulator (anatomically correct mannequin that reacts to tube insertion with physical responses such as change in vital signs, gagging/ coughing sounds, etc). FMT Residents who received high fidelity training scored significantly higher than residents trained by the low-fidelity simulator. The Forensic Mediciene and Toxicology residents were subsequently evaluated on their peripheral line placement technique on manikins. The 'trained' group outperformed the 'untrained' group on the majority of clinical aspects of venous catheterization, including fewer attempts to find the vein, identification of anatomical landmarks, and total overall performance score. The 'trained' group also scored higher on a post-test, supporting a correlation between knowledge gain and improved clinical performance. Before the training, the FMT residents used to undermine themselves: 'we know nothing about clinical toxicology.' Moreover, the FMT residents felt that they were not capable of managing without a critical care expert. After the training, it was quite evident that FMT residents have a very clear role to perform, while managing poisoning cases in emergency. Every resident learned to contribute their important role to the team work in resuscitation of a dying patient due to fatal poisoning.The participating FMT residents' positive feedback for the overall training program indicated that 95% of residents were satisfied with the training program and believed that skills learned could be applied well in their field of work. The FMT Resident's positive response directly correlated to their post-training evaluation undertaken by trainers, which positively signified effective learning of skills during the training intervention. Learning features, such as training in teams, skills training, and realistic repeated scenarios with consecutive debriefing for reflective learning, including a systems approach to human error, were crucial for enhanced teamwork during bedside toxidrome drills on high fidelity manikins. Developing clear communication and teamwork were found to be the key learning principles guiding their practice. The most important findings from the focus group discussions were the importance of team training as learning feature, and the perception of improved ability to use a teamwork approach to toxidromal diagnosis and management. Rudolph et al suggest a four-step model of debriefing: identifying performance gaps related to predetermined objectives, providing feedback describing the gap, investigating the basis for the gap, and helping to close the gap through discussion and targeted instructions.[19] Regardless of profession and job tasks in medical toxicology, 83% of FMT residents expressed enhanced self-efficacy and reduced perception of stress. 86% of FMT residents perceived that improved competence enabled them to provide efficient management for improved patient outcome. Based on above findings, we recommended simulator training to be continued and disseminated among FMT residents.Limitations of this Observational study: Information has been collected about team dynamics as well as completion of critical actions in an effort to target debriefing strategies. Perhaps in the future we can use simulation to target areas of weakness in participants and tailor clinical toxicology education to meet their needs. At present, there is a lack of evidence regarding the benefit of simulation as measured by actual patient outcomes, with the exception of resuscitation and peripheral line placement and intubation studies. Other limitations of our current simulation study include small sample size and

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lack of validated instruments to measure performance. Despite the lack of clinical evidence, the face validity of simulation is strong enough to support its implementation into toxicology life support training programs. No industry in which human lives depend on the skilled performance of responsible operators has waited for unequivocal proof of the benefits of simulation before embracing it.[20]Future Implementation of simulation in teaching toxicology: These cases have been used in-situ and would potentially be good cases to run within the hospital environment with actual bedside caregivers (nurses, technicians, resident doctors etc). Simulation training in-situ offers the unique benefit of targeting team dynamics among team member who actually work together in the clinical environment, improving patient safety, building self-confidence in participants by learning from errors and pitfalls, thus preventing medical negligence in managing poisonings and overdoses. Further research is necessary to develop validated performance assessment tools and demonstrate improvement in clinical outcomes after simulation training.

CONCLUSION

There is ample evidence that simulation-based educational interventions increase retention of knowledge for resuscitation, toxicology and trauma care, airway management, procedural skills, team-training, and disaster management due to fatal toxicological exposures. Simulation based training, by enhancing provider skills, can subsequently decrease medical errors and increase patient safety.

Table 1: Features of human patient simulator

Airway	Monitoring
Anatomical landmarks	Vital sign generation
Pharyngeal/tongue edema	Blood pressure
Trismus	Heart rate/ telemetry
Laryngospasm	Rhythm generator
Response to positioning	Respiratory rate
Sound generation (eg., Voice, cough)	Oxygen saturation
	End tidal CO2
Cardiopulmonary	
Spontaneous and assisted ventilation	Procedures
Changes in lung compliance	Bag valve mask ventilation
Accessory muscle use	Endotracheal intubation
Heart sounds, murmurs	Nasogastric tube placement
Blood pressure auscultation	Cricothyroidotomy
Palpable pulses	Thoracostomy/ needle decompression
Perioral cyanosis	Cardioversion/ defibrillation
	Chest Compression
Gastrointestinal	Pericardiocentesis / Venipuncture
Gastric distension	Lumbar puncture
Bowel sounds	Urinary catheterization
Neurologic	Software
Seizure like movements	Programmable clinical scenarios

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