Published online: 2019-11-27

Review Article

Medical simulation: Overview, and application to wound modelling and management

Dinker R. Pai, Simerjit Singh[1]

Departments of Surgery and [1]Orthopaedics, Melaka Manipal Medical College, Jalan Batu Hampar, Bukit Baru, Melaka, Malaysia

Address for correspondence: Dr. Dinker R. Pai, Department of Surgery, Melaka Manipal Medical College, Jalan Batu Hampar, Bukit Baru 75150, Melaka, Malaysia. E-mail: dinkerpai@gmail.com

ABSTRACT

Simulation in medical education is progressing in leaps and bounds. The need for simulation in medical education and training is increasing because of a) overall increase in the number of medical students *vis-à-vis* the availability of patients; b) increasing awareness among patients of their rights and consequent increase in litigations and c) tremendous improvement in simulation technology which makes simulation more and more realistic. Simulation in wound care can be divided into use of simulation in wound modelling (to test the effect of projectiles on the body) and simulation for training in wound management. Though this science is still in its infancy, more and more researchers are now devising both low-technology and high-technology (virtual reality) simulators in this field. It is believed that simulator training will eventually translate into better wound care in real patients, though this will be the subject of further research.

KEY WORDS

Simulation; wound management; wound modelling

INTRODUCTION

Pari passu with the progress of science in medical education, simulation in medical education is also progressing in leaps and bounds. Something which was hardly ever talked about even a couple of years ago has now become the new buzz word in medical education circles, and now India is also getting on the bandwagon.

Simulation has been variably defined as "the imitation of the operation of a real-world process or system over time;"[1] "an imitation of some real thing, state of affairs, or process" for the practice of skills, problem solving, and judgment."[2] The aim of medical simulation training is to imitate reality, or rather, to mimic reality to the closest extent possible so that the learner is in a state of "suspended disbelief" and he believes himself to be undergoing a real experience. Simulation has been used at its greatest effect in pilot training-indeed, it is mandatory for all pilots of commercial aircraft to undergo refresher courses on flight simulators, regardless of their real flying experience. Medical simulation has unfortunately not kept up with the development of simulation in engineering systems, flight training, etc. However, this situation is now rapidly changing.

This change has been brought about by three main reasons: firstly, a big increase in student population in medical education, both at the undergraduate and post-graduate level. Today, India has the highest number of

Access this article online	
Quick Response Code:	Website: www.ijps.org
	DOI: 10.4103/0970-0358.101280

medical colleges in the world. This unprecedented growth has occurred in the past two decades (MCI Vision 2015).[3] Approximately 33,528 graduates pass out every year from these colleges (MCI Annual Report 2009–2010).[4] This situation is mirrored in other countries as well. There has also been legislation which limits the number of hours residents can now work, reducing further the opportunity for bedside learning. The American Medical Association's Accreditation Council for Graduate Medical Education has limited the time that residents can be required to work to 80 h a week. Although this action was intended to improve patient safety, it also reduced the number of patient-contact hours needed to train residents. Many educators are turning to simulator-based training to meet that need.[5]

Secondly, there is a growing awareness of patients of their rights and reluctance to be practiced upon and the growing incidence of medical litigation leading to a reduction in the number of available patients.[6] It is common experience that litigation is also increasing in developing countries.

Finally, there has been a huge technological improvement in the quality and variety of simulators. Now, high fidelity computerised human patient simulators have been developed by various companies (e.g. SimMan by Laerdal, The METI family of human patient simulators by CAE Health Care), which mimic very realistically the response of human beings to physiological insults, whether it be an acute cardiac event, or a trauma event; indeed, any disease process that affects the cardiovascular or respiratory system can be accurately modelled. Surgical simulators have been developed to practice laparoscopic surgery using a virtual reality environment (e.g. the LapVR laparoscopic simulator by CAE Health Care), which even provide haptic feedback (a sense of tissue resistance). Other advanced simulators include ultrasound simulators, endoscopy simulators, etc. The list goes on and on.

With the increased focus worldwide on patient safety, many countries are now making certification on simulators mandatory before performing procedures on actual patients. Even in India, the MCI 2015 Vision document says that a mandatory and desirable comprehensive list of skills has been planned and would be recommended for Bachelor of Medicine and Bachelor of Surgery (MBBS) graduate. Certification of skills would be necessary before licensure. Clinical skills centres would need to be set up in all medical colleges.[3] The Educational Technology Section of the 2004 AEM Consensus Conference for Informatics and Technology in Emergency Department Health Care concluded that there should be increasing use of web-based, virtual reality and human patient simulation in educating emergency medicine trainees. The authors postulate the philosophy of "see one, simulate many, do one competently, and teach everyone."[7]

There are now many articles on how simulation can be used in medical training. The traditional model of surgical apprenticeship hinges upon learning by doing. Learning is an opportunistic process, grafted onto clinical practice. A key challenge for surgical training is to provide conditions for effective learning without putting patients' health at risk. Simulation presents an attractive solution, offering a safe, simulated clinical environment where the training agenda can be determined by the needs of the learner, not the patient. Repetitive practice and failures are permissible.[8]

Evidence is now available to suggest that simulation training actually improves clinical performance. In a review of simulation articles, it was found that four (3%) journal articles provided evidence for the direct correlation of simulation validity with effective learning.[9]

Another study showed that the use of Virtual Reality surgical simulation to reach specific target criteria significantly improved the operating room (OR) performance of residents during laparoscopic cholecystectomy.[10]

Simulation in wound management is still relatively in its infancy when compared to the use of simulation in other areas of medical education. There are not many articles that deal with simulation in wound care. It is however reasonable to believe that the use of simulation in wound management will result in improvement in wound care. Simulation in relation to wounds can be divided into use of simulation to study the effect of projectiles on tissue (wound modelling) and the use of simulation in the management of wounds. The purpose of this article is to outline the present status of simulation related to wounds, in terms of their creation and management.

WOUND CREATION

Moulage is the art of creating mock injuries to simulate wounds. Theatrical makeup and common everyday materials are used to make very realistic moulage [Figure 1]. Moulage is commonly used in mass casualty and disaster drills to add realism to the simulation. There are a number of resources which teach how to moulage different injuries.[11] It is reasonable to believe, though not proven, that the use of moulage would create a more realistic environment to enhance learning in mass casualty and other trauma situations. As far back as in 1964, omissions and deficiencies in disaster ability were dramatically and conclusively revealed by use of what appeared to be a "live" disaster setting with smoke, fire, explosions; adverse weather and light conditions; realistically simulated "casualties" especially prepared not only to look but also to act the part.[12]

WOUND MODELLING

Another area where simulation is used in wounds is to simulate the effect of injuring agents on the body so as to understand the various forces that are at work on the tissues during the causation of an injury. This would help in accurate wound assessment and anticipation of likely tissue damage if the causative agent is known. Work has mainly been done on cavitating injuries produced by high-velocity projectiles. Because gelatin and glycerin soap have approximately the same density as human tissue, the gunshot effects in them are comparable with those in human tissue. The experiments with these substitutes make it possible to understand what happens to the human body as the result of, for example, a penetrating gunshot.[13] Some other authors have used transparent gel candles [15% kraton (polymers) in 85% white paraffin oil] for the same purpose.[14] A synthetic skin–skull–brain model has been developed to simulate gunshot wounds to the head in such a realistic manner as to reconstruct the specific physical characteristics of a given trauma, including its progressive formation. This model uses a silicon cap containing synthetic fibres for artificial skin, a layered polyurethane sphere for the skull (containing the outer and inner tables as well as the diploe), a periosteum of latex and the brain itself is simulated with ordnance gelatin. This model reacts realistically when struck by gunfire.[13]

Figure 1: Moulage by author (DRP) showing bleeding thigh wound and evisceration on METIMan (CAE Health Care) mannequin

PHYSIOLOGICAL ASSOCIATIONS OF WOUNDS

High fidelity simulators are now available which can mimic the physiological effects of wounds on the body. The aim of management of a wounded individual in the Emergency Department is mainly to correct and prevent the life-threatening physiological derangements associated with the wound like airway obstruction, hypovolemia, respiratory distress, etc. As such, the management of the wound itself becomes secondary most of the time. These physiological derangements can be mimicked extremely realistically by these high fidelity systems, examples of which are the METI family of mannequins from CAE Health Care or the SimMan family from Laerdal. These simulators are used the world over to train emergency medical care providers, medical students, post-graduates and practicing physicians and surgeons in emergency trauma management [Figure 2]. Military specific simulators (e.g. CAEsar from CAE HealthCare) are now in advanced stages of development to train soldiers with non-medical backgrounds at the "point of injury."

WOUND MANAGEMENT

There are a few articles on the emergence of simulation in wound management, which deal essentially with teaching learners local wound management. This

Figure 2: St. John's ambulance team (Malaysia) demonstration of trauma scenario on ECS (METI) simulator

includes wound dressing techniques, performance of local surgery like escharotomy or wound debridement. Wound management simulators can be divided into basic part task trainers which use low-technology solutions that are cheap and high-technology virtual reality simulators which, of course, will be much more expensive. The low-technology solutions are discussed first, followed by the high-technology virtual reality solutions.

Simulated wounds have been created on animal models like pig trotters to teach the technique of wound debridement. A simulated wound covered with thick slough can be created on a pig trotter by excising an area of skin and then applying a layer of hydrocolloid paste (e.g. ADAPTTM, Hollister) on the denuded area. A layer of toothpaste may then be applied and covered with a piece of GLADÔ Wrap to simulate the application of EMLA cream. A small curette is then used to debride the wound as in a human patient, after washing away the layer of toothpaste (=topical anaesthetic). Similarly, one can create an eschar on a pig trotter skin. An area of skin is marked out and then coagulated with diathermy. This simulates eschar seen in human patients. Escharectomy is then performed.[15]

Another study has created a simulated abscess in chicken breast by injecting mock purulent material under the chicken breast skin. The author felt that this new simulation model may be an effective tool to teach skin abscess management. Physicians who evaluated the simulated abscess found that it replicates the classic palpable fluctuance and ultrasound findings of an actual abscess, and it can be surgically incised and drained in a similar fashion.[16]

Yet another researcher has used an orange to simulate debridement-the student is required to remove the peel and the white fibres (representing slough) off the orange without puncturing the inner orange itself.[17]

Burn wounds offer a challenge to learners in terms of local wound care, and as a result are often mismanaged. To overcome this, realistic chest wall burn moulage has been developed which also permits escharotomy. This helps train burn care trainees in the management of such wounds, specifically to perform escharotomy. The mannequin also responds physiologically to the escharotomy by an improvement in respiratory excursions.[18]

A major technological development has been that of a thigh wound virtual reality model by Delp *et al*. They have used the data from the Visible Human Project[19] as the basis of reconstruction of the thigh anatomy, on which they superimposed wound models of bullet wounds gleaned from data available in the literature. Functional consequences of the injuries were also modelled, which provided both short-term consequences as well as long-term disability of the simulated patient. The user could interact with the virtual thigh model using virtual surgical instruments from a virtual tray to stop the bleeding, assess muscle bleeding and contractility, perform debridement, align bone, etc. The overall effect on the patient's physiology was also calculated and displayed in terms of vital signs readouts, which changed depending upon appropriate treatment, e.g. control of bleeding, etc. This system is being further refined to include force feedback.[20]

The Virtual Reality Medical Center (VRMC) conceptualised and developed a unique injury simulator as an adjunct to current combat medic training. This initial technology, called Injury Creation Science (ICS), very realistically simulated a number of battlefield injuries such as amputations, eviscerations, blast injuries, punctures and burns. Since the initial prototypes, VRMC has developed this technology into wearable "part-task trainers" that simulate injuries as well as allow combat medics to practice actual medical procedures common to the battlefield. The procedures currently available or under development include treatment of pneumothorax, hemoperitonium and gunshot wounds to an artery. By integrating medical science with cutting-edge simulation and training technologies, realistic prosthetic tissue, wounds and part-task trainers have been developed for the training of trauma care clinicians.[21]

One of the major issues with wounds is the risk of hospital-acquired wound infections, which are usually preventable by simple personal hygiene techniques. Unfortunately, many hospital workers are either unaware of them or unwilling to follow these steps. Training of all hospital staff to prevent cross infection is therefore high on the agenda for most hospital administrators, impinging as it does on patient safety. If the movement of bacteria that cause wound infection, and their removal from hands and other inanimate hospital objects could be seen, then it would be a very useful training tool and could markedly increase staff compliance with hygiene measures. This is exactly what was done in one study wherein ultraviolet polyethylene microspheres were able to simulate the spread of bacteria through direct and indirect contact on different surfaces and had the ability to be washed off under specific hand washing guidelines. The authors felt that due to the positive results, the use of microspheres as a simulator of bacterial presence and spread should be explored further in order to improve hand washing techniques and compliance.[22]

A simulation-based training system for surgical wound debridement has been developed and comprises a multimedia introduction, a surgical simulator (tutorial component) and an assessment component. The multimedia training component describes varieties of wound categories (e.g. burns, lacerations, etc.), methods of debridement (e.g. sharp, mechanical, etc.) and equipment/materials used in the procedure. This module provides the pedagogical context for skills training and assessment, linking together all of the required elements for mastering the procedure. A software virtual agent is included and performs the role of an instructor by providing verbal guidance and assessment feedback. Designed to be comprehensive in order to reduce the need for a more senior instructor, the software addresses the patient's condition, initial description of the injury, and provides instruction on operation of the simulator. Specific instructions cover the removal of foreign objects with forceps, scrubbing with a brush, rinsing with saline solution and the maintenance of sterility. The simulator includes two PCs, a haptic device and mirrored display. Debridement is performed on a virtual leg model with a shallow laceration wound superimposed. Trainees are instructed to remove debris with forceps, scrub with a brush and rinse with saline solution to maintain sterility.[5]

In conclusion, simulation has now come to stay in the field of medical education. Increasing sophistication in simulation technology has been also used in simulation of wounds, both in wound modelling and wound management. The available simulators include low-technology solutions and high-technology virtual reality simulators, all of which train learners in the art of wound management. However, this technology is yet to be validated in wound management to see if simulator training can result in better management of wounds in actual patients. Future developments would include research on application of simulator training to real patient care, and the development of better technology to make virtual reality simulators even more realistic by the improvement of design, graphics and haptic feedback.

REFERENCES

1. Banks J, Carson J, Nelson B, Nicol D. Discrete-event system simulation. 3rd ed. Upper Saddle River, New Jersey: Prentice Hall; 2001.
2. Wikipedia, the free encyclopedia. Simulation[homepage on the Internet]. Available from: http://www.en.wikipedia.org/wiki/Simulation. [Last cited on 2012 Mar 25].
3. Medical Council of India. MCI Vision 2015, Announcements [homepage on the Internet]. Available from: http://www.mciindia.org/tools/announcement/MCI_booklet.pdf. [Last cited on 2012 Mar 22].
4. Medical Council of India. Annual Report 2009-2010. [homepage on the Internet]. Available from: http://www.mciindia.org/AboutMCI/AnnualReports.aspx. [Last cited on 2012 Mar 29].
5. Seevinck J, Scerbo MW, Belfore LA 2nd, Weireter LJ Jr, Crouch JR, Shen Y, *et al*. A simulation-based training system for surgical wound debridement. Stud Health Technol Inform 2006;119:491-6.
6. Walker E. Most Doctors Will Face Malpractice Suit, AMA Says [Internet] 2010 Aug 5. Available from: http://abcnews.go.com/Health/HealthCare/malpractice-lawsuits-doctors-common-ama/story?id=11332146#.T3a_XGFzXD8. [Last cited on 2012 Mar 30].
7. Vozenilek J, Huff JS, Reznek M,Gordon JA. See one, do one, teach one: Advanced technology in medical education. Acad Emerg Med 2004;11:1149-54.
8. Kneebone R. Simulation in surgical training: Educational issues and practical implications. Med Educ 2003;37:267-77.
9. Issenberg SB, McGaghie WC, Petrusa ER, Lee Gordon D, Scalese RJ. Features and uses of high Fidelity medical simulations that lead to effective learning: A BEME systematic review. Med Teach 2005;27:10-28.
10. Seymour NE, Gallagher AG, Roman SA, O'Brien MK, Bansal VK, Andersen DK, *et al*. Virtual reality training improves operating room performance: Results of a randomized, double-blinded study. Ann Surg 2002;236:458-63.
11. Community Emergency Response Team. Step-by-Step Moulage Instructions [homepage on the Internet]. Available from:http://www.troop502.info/moulage_tips.html, http://www.cert- la.com/education/moulage.htm. [Last cited on 2012 Apr 7].
12. Campanale RP. Surprise realistic mock disasters. The most effective means of disaster training. Calif Med 1964;101:435-8.
13. Thali M, Kneubuehl B, Zollinger U, DirnhoferR. The "skin-skull-brain model:" A new instrument for the study of gunshot effects. Forensic Sci Int 2002;125:178-89.
14. Uzar AI, Dakak M, Ozer T, Ogunc G, Yigit T, Kayahan C, *et al*. A new ballistic simulant "transparent gel candle" (experimental study).Ulus Travma Acil Cerrahi Derg 2003;9:104-6.
15. Sinha SN. Wound debridement: Doing and teaching. Prim. Intent. 2007;15:162-4.
16. Heiner JD. A new simulation model for skin abscess identification and management. Simul Healthc 2010;5:238-41.
17. Davis JT. Enhancing wound-debridement skills through simulated practice. Suggestion from thefield. Phys Ther 1986;66:1723-4.
18. Foot C, Host D, Campher D, Tomczak L, Ziegenfuss M, Cohen J, *et al*. Moulage in high-fidelity simulation-A chest wall burn escharotomy model for visual realism and as an educational tool. Simul Healthc 2008;3:1-5.
19. Ackerman MJ. The visible Human Project: A resource for anatomical visualization. Stud Health Technol Inform 1998;52:1030-2.
20. Delp S, Loan P, Basdogan C, Buchanan TS, Rosen JM. Surgical simulation: An emerging technology for training in emergency medicine. Presence 1997;6:147-59.
21. Wiederhold MD, Wiederhold BK. Using Advanced Prosthetics for

Stress Inoculation Training and to Teach Life Saving Skills. NATO Research and Technology. Meeting proceedings [homepage on the Internet]c2012. Available from: http://www.rto.nato.int/abstracts.aspx?pg=2 and RestrictPanel=0 and SearchString= and RestrictRDP=4 and Authors=.[Last updated on 2010 Apr; Last cited on 2012 Apr 10].

22. Wigglesworth-Ballard L. Use of polyethylene microspheres to simulate hospital acquired infections: A teaching strategy for healthcare students and workers. [homepage on the Internet]. Available from: www.vmasc.odu.edu/downloads/Capstone./Wigglesworth.doc. [Last cited in 2012 Apr 4].

How to cite this article: Pai DR, Singh S. Medical simulation: Overview, and application to wound modelling and management. Indian J Plast Surg 2012;45:209-14.

Source of Support: Nil, **Conflict of Interest:** None declared.