REVIEW

A structured literature review on the use of high fidelity patient simulators for teaching in emergency medicine

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High fidelity simulators are commonly used educational tools, mainly in anaesthesia. This literature review examines the use of simulators for teaching in emergency medicine and covers some of their advantages and disadvantages, and evidence for their use.

Simulation has always had a place in medical education, from its simplest form of using actors as patients, to practising surgical techniques on cadavers. Human manikins can be used to create a physical "patient" on which to learn, demonstrate, and test resuscitation skills. High fidelity simulator manikins can be used for physiological modelling and can recreate breathing patterns, heart sounds, pulse pressures, and airway problems. They can then be placed in an artificial environment replicating the workplace. Using the parallel with professional flight simulators, learners can be completely immersed in a setting that is relevant and practical to them, whether operating theatres, ward cubicles, or resuscitation areas. This can allow repeat exposure to accurate simulation of real situations.[1]

The reason why any simulated patient encounter can be such a useful educational tool is neatly summarised by Issenberg *et al*:

> ''Unlike patients, simulators do not become embarrassed or stressed; have predictable behaviour; are available at any time to fit curriculum needs; can be programmed to simulate selected findings, conditions, situations, complications; allow standardised experience for all trainees; can be used repeatedly with fidelity and reproducibility; and can be used to train both for procedures and difficult management situations.''[2]

The use of simulators in medicine is fast growing. According to a survey by Morgan and Cleave-Hogg in 2002 the number of worldwide high fidelity simulators rose from 29 in 1997 to 207 in 2001.[3] In this survey, albeit with only a 38% response rate, most of these simulators were found to be used for teaching technical skills, airway management, induction of anaesthesia, monitoring of patients, physiology and pharmacology, advanced cardiac life support and also rare event and crisis management. This was taught to a mix of both undergraduate and postgraduate students.

The main instigators of the use of high fidelity simulators in medicine have been anaesthetists. As a specialty, they have been keen to recreate intensive care units or the operating theatre environment to teach or practice advanced airway and other technical skills, or crisis management. Gaba *et al* started using simulators in this way in the USA in the late 1980s.[4] The development of their anaesthetic crisis resource management course has dramatically altered the perception and handling of critical procedures in the anaesthetic arena. Other applications have been error management, safety culture, and teamwork, improving performance in complex systems, and supporting methods for demonstrating and documenting competencies.[5]

It is clear that many of the skills being taught with the help of simulators are transferable to emergency medicine (EM). This literature review attempts to uncover the literature base that is available to develop simulator based teaching for EM personnel.

METHODS

A search was conducted on Medline from 1951 to Jan 2005, Embase from 1974 to Jan 2005 using Dialog Datastar and the Cochrane library database. The search terms used were: simulat$ and medical education. The results were limited to human and English language articles. This resulted in a total of 590 papers. The abstracts for these were then analysed. Papers that were not directly relevant to whole body, high fidelity simulation and education were discarded. Of the remaining abstracts, the actual papers were analysed, and more were discarded as they were considered irrelevant to the use or potential use of simulation in EM. Finally, 28 papers were included in this review.

Direct relevance to emergency medicine

Only 11 papers were found with a direct relevance to simulator training in EM. These consisted of eight descriptive studies with small scale analysis of outcomes and three review articles. Table 1 summarises the themes covered in these papers with a brief description.

The remaining papers contained views about the potential application of simulator training to EM, although not directly discussing that environment.

Advantages to simulation

Advantages of simulation education are clearly open to bias from positive reporting. Most of the

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Abbreviations: ACRM, Anaesthetic Crisis Resource Management; EM, emergency medicine; EMCRM, Emergency Medicine Crisis Resource Management

Table 1 Use of simulators in emergency medicine

Airway	Use of a simulator to teach airway skills to EM trainees. Simulator found to be ideal for teaching specific practical airway skills and demonstrating physiological responses in management of emergency airway[6]
Trauma	Use of a simulator within an ATLS course for teaching surgical airway and management of a pneumothorax[7]. Used as an adjunct to learning trauma skills after an ATLS course[8]
Crisis management	EMCRM course based on the ACRM course. Thirteen residents piloted the course, which concentrated on leadership and teamwork skills as well as anticipation and communication. Extremely positive response to the course in the small sample. The authors summarise that there should be further development and investigation of simulator based crisis management training for emergency medicine.[9] Another pilot programme combined EM scenarios with the principles of the ACRM course. The paper highlights the proof of concept simulation workshop that was developed, and heralds the use of multiple simulators for teamwork education[10]
Medical error	Pilot study of 15 EM residents qualitatively assessing the use of simulation as an educational technique. Medical error was examined through cognitive forcing techniques. Students rated the technique as second only to direct patient care as a learning experience[11]
Ethics	Within the EMCRM course, a simulator was used to provide a scenario of an ethical dilemma to assess the professionalism of EM residents against performance checklists. Although the participants all worked in EM, the study was not specific to the use of simulators for EM, but was successful in demonstrating this use of simulation[12]
Team performance	A prospective, blinded controlled observational study on EM teams, determining if simulation based team training improves clinical team performance. Although no statistically significant results were found, there was a trend towards improvement in the quality of team behaviour as measured by a validated behavioural rating scale[13]
Review	Reznek *et al* highlight the likely future use of simulation and virtual reality in EM education. They summarise: ''it will be important for academic emergency physicians to become more involved with this technology to ensure that our educational system benefits optimally''.[14] McLaughlin *et al* proposed a 3 year EM curriculum for a US residency programme using human simulation for both teaching and assessment of the core competencies of patient care, interpersonal skills, communication, professionalism, and practice based learning.[15] In a review article building on discussions from members of the Educational Technology Section of the 2004 Academic Emergency Medicine Consensus Conference for Informatics and Technology in Emergency Department Health Care, Vozenilek *et al* produce a recommendation that: ''emergency medicine residency programmes should consider the use of high-fidelity patient simulators to enhance the teaching and evaluation of core competencies among trainees''. This is based on strong face validity of the concept and the consulting members believing that EM is ''uniquely positioned to take a leading role in the development, application and evaluation of simulation based training''[16]

ATLS, advanced trauma life support; EMCRM, emergency medicine crisis resource management; ACRM, anaesthetic crisis resource management.

papers reviewed on simulation were understandably from centres with a simulator. Many of these are academic departments, and it was often stated that the funding for the simulator at came least partly through these departments. Authors commentating on the use of simulators for education cite similar reasons for their benefits, which are summarised in table 2.

Disadvantages to simulation

Many papers had no negative comments on the use of simulation. The disadvantages that were found are outlined in table 2.

DISCUSSION

Much of the advantages and disadvantages examined above are personal opinion from the authors of the papers reviewed. There is some evidence on simulation as an educational tool but there are few rigorous trials of different educational interventions, which makes assessing the impact of new tools very difficult. However, it is still important that any new educational technology does have relevance in actual clinical practice.

Of the papers reviewed, most of the trials were observational studies or self report satisfaction questionnaires involving small numbers of subjects. Evaluation of simulation as an educational tool showed the following common

Table 2 Advantages and disadvantages of educational use of simulators

Advantages	
Safety and error management	Provision of a safe environment for training that does not expose patients or trainees to risk[3 5 17–19]
Planning training	Simulator based clinical training can be planned and designated with predesigned clinical encounters within a systematic curriculum rather than relying on random case availability[3 5 19]
Teamwork and behavioural skills	Multidisciplinary team training and specific behavioural skills can be taught using simulated environments[5 19 20]
Analysis of training	The component parts of learning a skill can be analysed by trainees and trainers. A simulation can be frozen to allow discussion, and then repeated or alternative techniques demonstrated[17 18 21]
Rare event training	Unlimited exposure to uncommon but critical or fatal events that require a rapid clinical response. Crisis intervention skills can also be taught[9 11 17–19 22–24]
Technology	New technology can be tested and learnt how to be used without affecting patient safety. Over-reliance on technology as a substitute for clinical examination can be taught[17 21]
Educational theory	Simulation training is compatible with Kolb's theory of experiential learning and allows the opportunity for reflection in a structured environment. It also focuses on learner centred training[11 17 25 26]
Disadvantages	
Cost	High capital costs. Cost benefits are indirect, intangible, and long term[5]
Infrastructure	Lack of trainers and curricula[5]
Technical difficulties	Difficulty in evaluating some findings in physical examination, for example, patient skin colour[17 21] Computer anomalies affecting scenario programming[27]
Attitude of learners	Participants will always approach a simulator differently to real life. Two common changes in attitude can occur: (a) hypervigilance, which causes excessive concern because one knows an event is about to occur; and (*b*) cavalier behaviour, which occurs because it is clear no human life is at stake. These effects may co exist and counterbalance[17 28]
Evidence	There is a limited amount of good quality evidence on the effect of simulation based training[18]

themes: (*a*) quicker responses[22]; (*b*) less deviation from guidelines[22]; (*c*) realistic[8 9 24]; (*d*) good training experience[8 21 29]; and (*e*) learning not hindered by artificial situation[24]. Only two papers that reported negative or equivocal findings for the use of simulators in critical care areas were found. This is possibly explained by the well recognised problem of positive reporting bias.

One study on 144 medical students who were taught about three critical events either on a simulator or by educational video session showed no difference in clinical scores when testing the students.[30] Theoretical knowledge tested by multiple choice questions in anaesthesia residents was similar in comparing a lecture based course to simulator training. However, the later group achieved better clinical evaluation scores in the short term.[31]

There are still unanswered questions regarding simulation as an educational tool. Can we use simulation to teach decision making?[21] Are there effects on how knowledge and skills are acquired and retained? How are attitudes changed? Does this type of training effect patient outcome?[32] One area that this review does not cover is the use of simulators for evaluation of training or assessment. It is not known what aspects of competence can be reliably assessed by a simulator, whether good performance in a simulator is reflected in real clinical situations, and if simulation could be accepted by our profession as a method of assessment.[22 33]

CONCLUSION

There is a general positive bias in the literature regarding the use of simulators in medical education, but there is a lack of robust trials showing a clinical or knowledge advantage. However, the use of simulators by anaesthetists, who have been the main researchers and users of this technology, would suggest there is common ground that could be used for education in EM, especially advanced airway skills, crisis management, critical events, communication, and team working. It does seem that that the greatest impact for using simulators would be as a tool for teaching skills that cannot easily be taught any other way in a clinical setting, either because of their complexity or their rarity.

It is clear that more evidence of educational and clinical value is needed because of the significant capital input that is required to establish a simulation facility combined with the dedicated teaching resources needed. EM is a specialty ideally suited to some of the training benefits of simulation and now is the opportunity to decide whether to embrace it. Some would feel it a moral imperative:

> ''[There is an] ethical obligation to make all efforts to expose health professionals to clinical challenges that can be reasonably well simulated prior to allowing them to encounter and be responsible for similar real-life challenges.''[5]
>
> ''No industry in which human lives depend on the skilled performance of responsible operators has waited for unequivocal proof of the benefit of simulation before embracing it.''[28]

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REFERENCES

1 **Riley RH**, Gauze AM, Chinnery C, *et al*. Three years of ''CASMS'': the world's busiest medical simulation centre. *Med J Aust* 2003;**179**:626–30.
2 **Issenberg SB**, McGaghie WC, Hart IR, *et al*. Simulation technology for health care professional skills training and assessment. *JAMA* 1999;**282**:861–6.
3 **Morgan PJ**, Cleave-Hogg D. A worldwide survey of the use of simulation in anesthesia. *Can J Anaesth* 2002;**49**:659–62.
4 **Gaba DM**, Howard SK, Fish KJ, *et al*. Simulation-based training in anesthesia crisis resource management (ACRM): a decade of experience. *Simulation Gaming* 2001;**32**:175–93.
5 **Ziv A**, Small SD, Wolpe PR. Patient safety and simulation based medical education. *Med Teach* 2000;**22**:489–95.
6 **Ellis C**, Hughes G. Use of human patient simulation to teach emergency medicine trainees advanced airway skills. *J Accid Emerg Med* 1999;**16**:395–9.
7 **Block EF**, Lottenberg L, Flint L, *et al*. Use of a human patient simulator for the advanced trauma life support course. *Am Surg* 2002;**68**:648–51.
8 **Marshall RL**, Smith JS, Gorman PJ, *et al*. Use of a human patient simulator in the development of resident trauma management skills. *J Trauma* 2001;**51**:17–21.
9 **Reznek M**, Smith-Coggins R, Howard S, *et al*. Emergency Medicine Crisis Resource Management (EMCRM): Pilot study of a simulation-based crisis management course for emergency medicine. *Acad Emerg Med* 2003;**10**:386–9.
10 **Small SD**, Wuerz RC, Simon R, *et al*. Demonstration of high-fidelity simulation for team training for emergency medicine. *Acad Emerg Med*, 1999 6, **4**:312–23.
11 **Bond WF**, Deitrick LM Arnold DC, *et al*. Using simulation to instruct emergency medicine residents in cognitive forcing strategies. *Acad Med* 2004;**79**:438–46.
12 **Gisondi MA**, Smith-Coggins R, Harter PM, *et al*. Assessment of resident professionalism using high-fidelity simulation of ethical dilemmas. *Acad Emerg Med* 2004;**11**:931–7.
13 **Shapiro MJ**, Morey JC, Small SD, *et al*. Simulation based teamwork training for emergency department staff: Does it improve clinical team performance when added to an existing didactic teamwork curriculum? *Qual Saf Health Care* 2004;**13**:417–21.
14 **Reznek M**, Harter P, Krummel T. Virtual reality and simulation: training the future emergency physician. *Acad Emerg Med* 2002;**9**:78–87.
15 **McLaughlin SA**, Doezema D, Sklar DP. Human simulation in emergency medicine training: A model curriculum. *Acad Emerg Med* 2002;**9**:1310–18.
16 **Vozenilek J**, Huff JS, Reznek M, *et al*. See one, do one, teach one: Advanced technology in medical education. *Acad Emerg Med* 2004;**11**:1149–54.
17 **Flanagan B**, Nestel D, Joseph M. Making patient safety the focus: Crisis Resource Management in the undergraduate curriculum. *Med Educ* 2004;**38**:56–66.
18 **Østergaard D**. National Medical Simulation training program in Denmark. *Crit Care Med* 2004;**32**:S58–60.
19 **Schafer III JJ**. Simulators and difficult airway management skills. *Paediatr Anaesth* 2004;**14**:28–37.
20 **Wantman A**, Chin C. Use of simulation in paediatric anaesthesia training. *Paediatr Anaesth* 2003;**13**:749–53.
21 **Hammond J**, Bermann M, Chen B, *et al*. Incorporation of a computerized human patient simulator in critical care training: a preliminary report. *J Trauma* 2002;**53**:1064–67.
22 **Chopra V**, Gesink BJ, De-Jong JG, *et al*. Does training on an anaesthesia simulator lead to improvement in performance. *Br J Anaesth* 1994;**73**:293–7.
23 **DeVita MA**, Schaefer J, Lutz J, *et al*. Improving medical crisis team performance. *Crit Care Med* 2004;**32**:S61–5.
24 **Lighthall GK**, Barr J, Howard SK, *et al*. Use of a fully simulated intensive care unit environment for critical event management training for internal medicine residents. *Crit Care Med* 2003;**31**:2437–43.
25 **Kolb DA**. *Experiential learning: experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice Hall, 1984.
26 **Gordon J**, Oriol NE, Cooper JB. Bringing good teaching cases ''to life'' – a simulator based medical education service. *Acad Med* 2004;**79**:23–7.
27 **Black AMS**. The 'METI' simulator at the Bristol Medical Simulation Centre. *Br J Anaesth* 1999;**83**:526.
28 **Gaba DM**. Improving anaesthesiologist's performance by simulating reality. *Anaesthesiology* 1992;**76**:491–4.
29 **Cleave-Hogg D**, Morgan PJ. Experiential learning in an anaesthesia simulation centre: analysis of students' comments. *Med Teach* 2002;**24**:23–6.
30 **Morgan PJ**, Cleave-Hogg D, Mellroy J, *et al*. A comparison of experiential and visual learning for undergraduate medical students. *Anaesthesiology* 2002;**96**:10–16.
31 **Good ML**, Gravenstein JS, Mahla ME, *et al*. Can simulation accelerate the learning of basic anaesthesia skills by beginning anaesthesia residents? *Anaesthesiology* 1992;**77**:A1133.
32 **Schwid HA**, Rooke GA, Michalowski P, *et al*. Screen based anaesthesia simulation with debriefing improves performance in a mannequin-based anaesthesia simulator. *Teach Learn Med* 2001;**13**:92–6.
33 **Forrest F**, Taylor M. High level simulators in medical education. *Hosp Med* 1998;**59**:653–5.