Southern African Journal of Anaesthesia and Analgesia 2014; 20(3):147–151
http://dx.doi.org/10.1080/22201173.2014.936778

South Afr J Anaesth Analg
ISSN 2220-1181 EISSN 2220-1173
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RESEARCH

Airway skills training using a human patient simulator

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Background: Airway skills education is important for the safe and effective care of patients. Interns often encounter critical airway situations. Their ability to cope derives from the recall of formal lectures and tutorials, as well as accumulated experience. We tested whether human patient simulators enabled trainees to enhance skills and knowledge in a safe and realistic environment.
Method: An airway training programme was developed using a high-fidelity lifelike human patient simulator (METI®) to simulate realistic airway scenarios. An equivalent programme using traditional methods (lectures and tutorials) contained the same information. A written assessment [(multiple-choice questions (MCQ)] and four assessment stations [objective structured clinical examination (OSCE)] were administered before and after instruction. A questionnaire documented previous exposure to the simulator, airway management techniques and devices, and participants' subjective opinions on the instruction received.
Results: Eighty-two participants were enrolled into two groups of 41. Groups were comparable in terms of previous exposure and experience, as well as in pre-training scores. Both groups showed significant improvement in post-training scores. However, subjects receiving simulator training achieved significantly higher test scores in the MCQ (median 43 out of 50, interquartile range (IQR) 42–45, versus 41 out of 50, IQR 39–43); and OSCE assessment station 3 (median 15 out of 15, IQR 13–15, versus 14 and 12–15), and OSCE assessement station 4 (median 13 out of 15, IQR 12–14, versus 12 and 10–13). The simulator group showed greater participant satisfaction (95% vs. 34%).
Conclusion: There was improved immediate retention of knowledge and performance of airway management skills using the simulator. Participant satisfaction was much better in the simulator group. The importance of psychomotor reinforcement should be borne in mind when designing simulation courses.

Keywords: human patient simulator, simulation, airway management, psychomotor skills

Introduction

Airway management problems may be particularly challenging to junior doctors.[1] Traditionally, education has been accomplished through didactic lectures and direct patient experience, with little repetitive training exercises. Thus, interns in training, often the first responders to emergencies, may be poorly equipped to handle such problems.

Patient simulators are widely employed in educational models throughout many fields of medicine, including anaesthesia and critical care education. Full-sized, computer-model driven mannequins that accurately mimic human responses to procedures, medications and other treatment modalities are among the high-fidelity simulators. They respond to real-time, real-life clinical manoeuvres, and allow trainees to experience critical scenarios in a fail-safe environment. Thus, human patient simulators (HPSs) enable trainees to sharpen their skills in a safe and realistic environment, without potential detriment to patients.[1]

We incorporated the METI® HPS (Medical Education Technology, Sarasota, USA) into our education model. This study was designed to evaluate the efficacy of the HPS in critical airway management by interns.

Method

Ethics approval was obtained from the Biomedical Research Ethics Committee of the University of KwaZulu-Natal (BE 144/09). The study site was the Simulation Laboratory, Simulated Modules in Anaesthesia and Resuscitation Training Centre, Inkosi Albert Luthuli Central Hospital, Durban. We developed an airway care skills training programme using METI's® HPS (version 6).

After informed consent, we enrolled 82 volunteer interns in training from two hospitals in the eThekweni Complex at the beginning of their two-month anaesthetic rotation. Initially, each participant completed the first part (Part A) of a questionnaire that documented undergraduate anaesthetic exposure, previous exposure to simulator and airway management techniques and devices, and their opinions on teaching previously received.

We used three different methods to evaluate the efficacy of HPS training: a pre- and post-training written test, pre- and post-training objective structured clinical examination (OSCE), and a confidential, subjective questionnaire. The study design is illustrated in Figure 1.

Part of the pre-training evaluation was a 30-minute, 50-mark true/false test consisting of questions relevant to airway management scenarios. In addition, four pre-training OSCE stations that focused on airway scenarios, each lasting five minutes and marked out of 15, were objectively scored by senior anaesthetic personnel.

Participants were randomised every two months into a simulator group and lecture group by drawn letters and numbers. The simulator group was taught using the simulator, and the lecture group received a didactic lecture. Each teaching

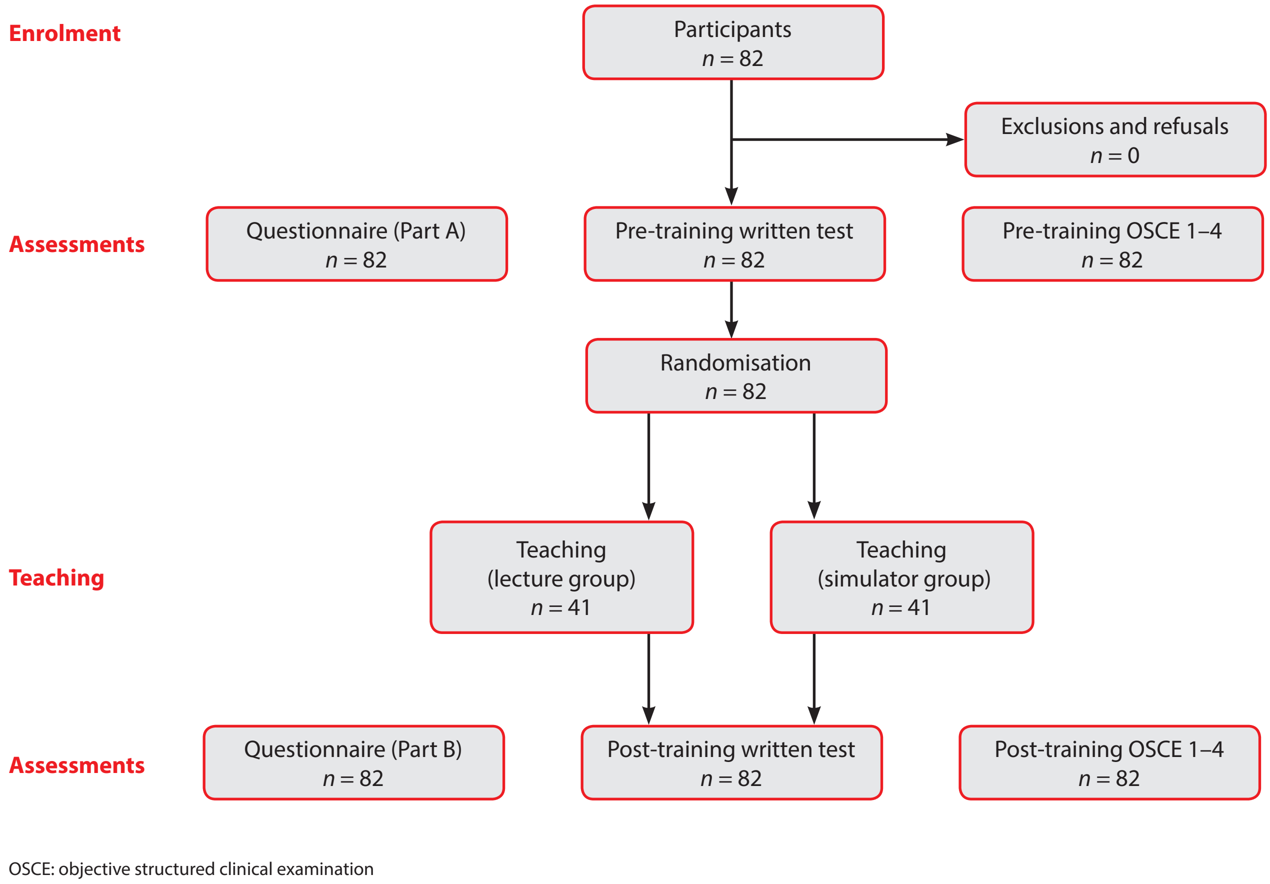

Figure 1: Study design and randomisation

session lasted 90 minutes and covered airway assessment, airway opening and maintenance, and airway complications and techniques for difficult airway management. A predesigned PowerPoint® presentation was used for the lecture group, while the simulator group instructor remained the same, using a standard approach.

All participants underwent post-training written and OSCE tests, similar in structure and duration to the pre-training tests. OSCE stations 1 and 2 were the same in the pre- and post-training.

All participants then completed Part B of the questionnaire. This documented their opinions on the anaesthetic training, the completion of the course goals, and comments on simulation as an adjunct to training. In addition, participants evaluated various aspects of their learning and performance by scoring six questions between "0" and "5". The questions were on the gaining of new facts, understanding of issues, application of knowledge, analysis of data from monitors, diagnosis and planning management, and the enhancement of confidence and ability.

Statistical analysis

Chi-square tests were used to compare both groups in terms of previous exposure. Mann-Whitney *U* tests were used to compare pre-training and post-training assessment scores between the groups. The Wilcoxon signed-rank test was employed to assess within-group changes. Alpha was set at 0.05 to detect a score difference greater than 10% with 80% power.

Results

Eighty-two participants voluntarily enrolled in our study, and were randomised equally into two groups (simulator and lecture). Results from Part A of the questionnaire (Table 1)

Table 1: Intergroup comparison of pre-training (Part A of the questionnaire)

Pre-training	Lecture group ($n = 41$)	Simulator group ($n = 41$)	*p*-value
Months of internship training completed	12.4 (3–23)*	12.5 (3–23)*	0.239
Undergraduate anaesthetic experience (in weeks)	3.0 (1–8)*	3.3 (1–10)*	0.132
Previous exposure to simulation	12 (29.3%)	18 (43.9%)	0.169
Previous exposure to airway management devices	38 (92.7%)	35 (85.4%)	0.289
Previous exposure to airway management techniques	34 (82.9%)	35 (85.4%)	0.762
Previous exposure to ATLS/ACLS/PLS	4 (9.8%)	5 (12.2%)	0.724
Previous intubations performed	33 (80.5%)	32 (78%)	0.785

ACLS: Advanced Cardiac Life Support, ATLS: Advanced Trauma Life Support, PLS: Paediatric Life Support
*: The results are quoted as means, with the ranges (minimum to maximum) indicated in brackets

indicated that the two groups were similarly matched in terms of all of the criteria that were explored in Part A.

The simulator and lecture groups were equally matched with respect to the distribution of participants from both of the hospitals.

Post-training test scores were higher than the pre-training test scores for both the written test and each of the four OSCE stations, for both groups combined (Table 2). The pre-training written and OSCE scores did not differ between the lecture and simulator groups (Table 3).

The written scores of the simulator group were higher than those of the lecture group (Table 4). There were no differences between the two groups for OSCE 1 and OSCE 2, repeat stations from the pre-training OSCE. Participants who were allocated to the simulator group performed better than those in the lecture group for OSCE 3 and OSCE 4.

In Part B of the questionnaire (Table 5), participants' satisfaction with the overall anaesthetic training and their assessment of the achievement of course goals favoured the simulator group. All of the participants reported that the simulator was a useful adjunct to the didactic lecture format.

Compared to the lecture group, the simulator group had statistically significant higher scores in respect of the gaining of new facts, the application of knowledge, analysis of data from monitors, diagnosis and planning management, and the enhancement of confidence and ability. There were no differences in between-group scores with respect to the understanding of issues.

Table 2: Pre-training scores versus post-training scores for both groups together

	Written (X/50)	OSCE 1 (X/15)	OSCE 2 (X/15)	OSCE 3 (X/15)	OSCE 4 (X/15)
Pre-training	36 (25–43)	7.5 (2–13)	11(4–15)	8 (2–13)	10 (2–15)
Post-training	42 (34–48)	13 (12–15)	14 (9–15)	14 (7–15)	13 (6–15)
p-value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

X: marks out of

* The results are quoted as medians, with the interquartile ranges indicated in brackets

Table 3: Intergroup differences with respect to the pre-training scores

	Written (X/50)	OSCE 1 (X/15)	OSCE 2 (X/15)	OSCE 3 (X/15)	OSCE 4 (X/15)
Lecture group	35 (25–43)	7 (3–13)	11 (4–15)	8 (3–13)	10 (4–10)
Simulator group	36 (29–42)	8 (2–12)	11 (4–15)	6 (2–12)	10 (2–15)
p-value	0.608	0.146	0.605	0.185	0.373

X: marks out of

* The results are quoted as medians, with the interquartile ranges indicated in brackets

Table 4: Intergroup differences with respect to the post-training scores

	Written (X/50)	OSCE 1 (X/15)	OSCE 2 (X/15)	OSCE 3 (X/15)	OSCE 4 (X/15)
Lecture group	41 (25–46)	13 (12–15)	13 (9–15)	11 (7–13)	11 (6–13)
Simulator group	44 (29–48)	14 (12–15)	15 (10–15)	15 (11–15)	15 (11–15)
p-value	< 0.001	0.730	0.085	0.030	< 0.001

X: marks out of

* The results are quoted as medians, with the interquartile ranges indicated in brackets

Table 5: An intergroup comparison of responses to Part B of the questionnaire

	Lecture group (*n* = 41)	Simulator group (*n* = 41)	*p*-value
Assessment of overall anaesthetic training			
Very good (*n*)	14 (34.1%)	39 (95.1%)	< 0.001
Good (*n*)	26 (63.4%)	2 (4.9%)	-
Poor (*n*)	0 (0%)	0 (0%)	-
Very poor (*n*)	1 (2.4%)	0 (0%)	-
Assessment of achievement of course goals			
Very good (*n*)	1 (2.4%)	29 (70.7%)	< 0.001
Good (*n*)	39 (95.1%)	12 (29.3%)	-
Poor (*n*)	1 (2.4%)	0 (0%)	-
Very poor (*n*)	0 (0%)	0 (0%)	-
Assessment with respect to			
Gaining new facts	4 (2–5)*	4 (1–5)*	0.01
Understanding issues	4 (2–5)*	4 (2–5)*	0.07
Application of knowledge	3 (1–5)*	5 (3–5)*	< 0.001
Analysis of data from monitors	2 (1–5)*	4 (3–5)*	< 0.001
Diagnosis and planning management	3 (1–5)*	4 (2–5)*	< 0.001
Enhancing confidence and ability	3 (2–5)*	5 (2–5)*	< 0.001

* Participants scored each area between "1" and "5". The results are quoted as medians, with the ranges (minimum to maximum) indicated in brackets

Discussion

There were two main conclusions to our study. Firstly, interns performed better in the written test and OSCE evaluations, and secondly, greater participant satisfaction was demonstrated when airway management was taught using simulation, rather than a didactic lecture.

Simulation is a widely used educational tool to enhance the training of medical personnel across many levels and fields of medicine. Simulators range from very basic to high-fidelity systems, which can simulate complex physiological conditions and respond to real-time interventions, making them uniquely suited to critical care and anaesthetic education. Didactic lectures and discussions play an important role in the improvement of knowledge, but the effective teaching of clinical skills requires more direct teacher-student interaction. High-fidelity simulators allow students to learn in a fail-safe environment, to attain unlimited exposure to rare events, provide immediate feedback and experience a team approach to care.[2,3]

Chopra et al[1] illustrated that some simulation exercises resulted in faster and more accurate responses up to four months after training, compared to standard didactic teaching. Other authors have questioned whether or not training with human patient simulation translates into improved patient safety and outcome.[4] Of all of the critical care and anaesthetic skills, those involving the airway tend to be the most troublesome for young physicians to learn, and for their instructors to teach. This is likely to be because of the complexity of airway emergencies, combined with general unfamiliarity with different airway techniques. Thus, the incorporation of simulation into airway educational programmes makes sense.

We attempted to evaluate participants' previous exposure to the field in Part A of the questionnaire. Participants were at different stages of their 24-month intern training programme. It was likely that an intern at the end of his or her training would have experienced greater exposure to clinical medicine and airway management, and thus would perform better in our assessment. We did not attempt to quantify this.

It is noteworthy that as an undergraduate, the mean exposure to anaesthesia for the entire cohort was 3.14 weeks. This limited exposure to essential emergency care at different medical schools in South Africa is concerning. Although performance in the pre-training assessments for both groups was statistically similar, our study was not powered to detect differences in relation to periods of undergraduate training. As expected, a comparison of all of the pre-training and post-training assessments for the entire cohort revealed statistically significant improvements. This emphasises the value of, and need for, any form of teaching with respect to airway management.

A comparison between the groups in respect of post-training assessments clearly favoured the simulator group. Interestingly, the demonstrated significant statistical differences did not reflect the small scoring difference between the groups after instruction. This may be because both groups received some form of recognised training, thus the difference in the scores was minimised. Lack of a statistically significant difference in OSCE stations 1 and 2 may be ascribed to participants' prior exposure to the same stations in the pre-training OSCE.

Overall, there was positive feedback with regard to the utility of this exercise. All but one of the 82 participants rated the overall anaesthetic training and the achievement of the course goals to be "very good" or "good". However, participant satisfaction was greater in the simulator group, in which there were more statistically significant responses of "very good". A possible explanation for this greater satisfaction may relate to the physical performance of tasks in simulation. All of the participants who were not exposed to the simulator reported that the simulator would be a useful adjunct to the didactic lecture format. This may indicate preconceived bias in favour of simulation.

We also attempted to quantify differences between the simulator and lecture groups with respect to various aspects of learning and performance. Practical performance and the acquisition of required skills in the simulator group returned higher scores for the application of knowledge, the analysis of data from monitors, and the enhancement of confidence and ability. Even with regard to the area of gaining of new facts, where didactic lectures may have been expected to generate better scores, the simulated group returned a higher mean score. Surprisingly, there was a better median score in the lecture group for the understanding of issues. A possible explanation for this may be that there is greater emphasis in the lecture group on why various things are carried out, in comparison to the simulator group, where the focus may have been on what, as well as how, things are achieved.

While this study demonstrated an inherent improvement in knowledge in both groups, with a statistically significant improvement that favoured the simulator group, it did not test the long-term retention of knowledge in the two groups. Future studies in this regard should include a long-term evaluation of the participants.

A previous study verified the validity of using HPS through a detailed analysis of case performance compared to level of training and experience.[9] Validity has also repeatedly been shown to be a performance evaluation tool in many other studies with regard to use of a patient simulator.[5-11]

Clearly, availability and cost are the greatest limitations to incorporating high-fidelity patient simulation into any educational programme. These simulators are expensive, and typically require great commitment by centres for the development of the programmes and maintenance of the simulators. The statistical significance in this study may not reflect the required significant practical difference that warrants the major capital outlay. It was not the aim of this study to analyse the cost-effectiveness of the simulator, on its own, or against other conventional methods of teaching. However, that might be prudent, particularly in resource-constrained environments. However, Grenvik et al[2] showed that simulators may result in cost savings as a result of decreased use of operating room training and fewer malpractice suits.

Conclusion

The use of simulation resulted in improved immediate retention of knowledge and performance pertaining to airway management skills, and better participant satisfaction in interns in training, than traditional, didactic lectures.

Conflict of interest — The authors declare no conflict of interest which may have influenced them in writing this article.

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Received: 15-08-2013 Accepted: 22-04-2014