Benefits of computer screen-based simulation in learning cardiac arrest procedures

Elodie Bonnetain,[1] Jean-Michel Boucheix,[1] Maël Hamet[2,3] & Marc Freysz[2,3]

OBJECTIVES What is the best way to train medical students early so that they acquire basic skills in cardiopulmonary resuscitation as effectively as possible? Studies have shown the benefits of high-fidelity patient simulators, but have also demonstrated their limits. New computer screen-based multimedia simulators have fewer constraints than high-fidelity patient simulators. In this area, as yet, there has been no research on the effectiveness of transfer of learning from a computer screen-based simulator to more realistic situations such as those encountered with high-fidelity patient simulators.

METHODS We tested the benefits of learning cardiac arrest procedures using a multimedia computer screen-based simulator in 28 Year 2 medical students. Just before the end of the traditional resuscitation course, we compared two groups. An experiment group (EG) was first asked to learn to perform the appropriate procedures in a cardiac arrest scenario (CA1) in the computer screen-based learning environment and was then tested on a high-fidelity patient simulator in another cardiac arrest simulation (CA2). While the EG was learning to perform CA1 procedures in the computer screen-based learning environment, a control group (CG) actively continued to learn cardiac arrest procedures using practical exercises in a traditional class environment. Both groups were given the same amount of practice, exercises and trials. The CG was then also tested on the high-fidelity patient simulator for CA2, after which it was asked to perform CA1 using the computer screen-based simulator. Performances with both simulators were scored on a precise 23-point scale.

RESULTS On the test on a high-fidelity patient simulator, the EG trained with a multimedia computer screen-based simulator performed significantly better than the CG trained with traditional exercises and practice (16.21 versus 11.13 of 23 possible points, respectively; $p < 0.001$).

CONCLUSIONS Computer screen-based simulation appears to be effective in preparing learners to use high-fidelity patient simulators, which present simulations that are closer to real-life situations.

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[1]Laboratory for the Study of Learning and Development (Laboratoire d'Etude de l'Apprentissage et du Développement [LEAD]), National Centre for Scientific Research (Centre National de la Recherche Scientifique [CNRS]), UMR 5022, University of Burgundy, Dijon, France
[2]Department of Anaesthesia Resuscitation, Dijon National University Hospital, Dijon, France
[3]Department of Anaesthesia Resuscitation, University of Burgundy Medical School, Dijon, France

Correspondence: Elodie Bonnetain, LEAD, CNRS, UMR 5022, University of Burgundy, Esplanade Erasme, BP 26513, 21065 Dijon Cedex, France. Tel: 00 33 3 80 39 57 84; Fax: 00 33 3 80 39 57 67; E-mail: Elodie.bonnetain@u-bourgogne.fr

INTRODUCTION

Previous research has shown that success in cardiopulmonary resuscitation (CPR) procedures was strongly related to training.[1–10] Acquiring basic skills in CPR, such as those required for basic life support (BLS), as soon as possible during medical studies is a crucial learning goal to ensure the effective functioning of the chain of survival support both inside and outside hospital. However, it is unclear how best to train medical students early and efficiently.

Recent studies have shown the benefits of high-fidelity patient simulators in training in anaesthesia and emergency procedures.[11–22] Because they provide 'realistic' and dynamic situations, training on high-fidelity patient simulators is considered to prepare trainees well for real-life work as doctors.[14,16,17,19,21,22] However, high-fidelity patient simulators are limited in the educational advantages they offer by their purchase and maintenance costs, their requirements for permanent professional teams of instructors, and the small numbers of students they can accommodate at one time. Training is usually conducted during a single session, which may not be sufficient to achieve long-term memorisation of complex procedures and specific behaviours.[8,9,23]

For a simulation session to be efficient, the steps of the procedure must be taught and memorised before training sessions with the simulator. Of course, the steps of the procedure can be learned beforehand using traditional paper or electronic documents or even simple plastic manikins. However, these formats are too far removed from the real workplace context.

In anaesthesia, Nyssen *et al.*[12,13] compared the training value of two types of anaesthesia simulators, a computer screen-based simulator and a high-fidelity patient simulator, and found no difference between the two. In learning heart sounds, de Giovanni *et al.*[24] showed very little evidence that students trained with a high-fidelity simulator were more able to transfer skills to real patients than were students in a control group trained with a low-fidelity simulator.

New computer screen-based multimedia simulators have fewer constraints than the high-fidelity patient simulators described above. They are less expensive, do not require the presence of a permanent professional team of instructors and can be used by students either in multimedia rooms (at the university) or at home on their own computers. As a result, their use could be highly recommended in institutions with large numbers of students. Such computer screen-based simulators are becoming more and more widely available in medical training establishments. They exhibit a high level of interactivity and realism and often include tutorials presented in a multitude of formats. These properties could be very useful in terms of the active learning they support and in fixing in the long-term memory the procedural knowledge that is absolutely essential if the student is to benefit from subsequent training with high-fidelity patient simulators.

In summary, high-fidelity patient simulators and computer screen-based simulators are different training devices, but could be used as complementary learning tools. In this area, as yet, there has been no research on the effectiveness of transfer of learning from a computer screen-based simulator to more realistic situations such as those provided by high-fidelity patient simulators.

In the context of training students, it might be very useful to test the extent to which skills learned on a computer screen-based simulator are transferred to a high-fidelity simulated patient. Thus, the aim of the present study was to test the benefits to medical students of multimedia computer screen-based simulation in learning cardiac arrest procedures.

METHODS

Study participants

The study protocol was approved by the local ethics committee. We enrolled 28 volunteer students in their second year of medical studies at the medical school of the University of Burgundy in Dijon, France.

Materials

The computer screen-based simulator used for the learning session in the study was the interactive multimedia software simulation package MicroSim®, developed by Laerdal Medical (Copenhagen, Denmark). It can be used on a standard personal computer with a graphic and video interface and consists of a series of teaching components, all related to resuscitation. A main screen delivers a real-time scenario (e.g. cardiac arrest). The learner is invited to play the role of the doctor and to manage the procedure via the selection (by mouse click) of actions to be performed. Feedback is systematically

given for each action and decision.[1,14,25] We used a scenario of cardiac arrest in a hospitalised patient. The scenario was adapted to facilitate the learning of BLS for students. The learner is required to manage the patient's care. He or she can complete different actions in real time, conduct physical examinations, administer drugs and fluids, perform CPR, etc. At the end of the scenario, a multimedia computer screen-based simulator (MCSS) delivers a written 'debriefing', which consists of a report of the right and wrong actions, decisions or declarative rules used.

The high-fidelity patient simulator used for the test session in the study was the SimMan® simulator developed by Laerdal Medical. The high-fidelity patient simulator (HFPS) is presented in the form of a real emergency room equipped with all the recommended equipment for resuscitation, but the patient is replaced by a manikin that closely reproduces the clinical aspects of a real patient in the same context. The control of the sequence of events of the scenario is monitored by the senior doctor-instructor, who observes from another room (separated from the manikin room by a two-way mirror).

Procedure and settings

The experiment took place during the resuscitation course, which included a series of theoretical lessons and practical exercises (Fig. 1). The 28 volunteers were randomly assigned to one of two groups of 14 participants. The experiment group (EG) undertook MCSS learning scenario first just before the end of the traditional resuscitation course and then undertook the full-scale HFPS test scenario. Meanwhile, the control group (CG) continued with traditional practical exercises and subsequently undertook the full-scale HFPS test scenario first, followed by the MCSS scenario. Thus, as the EG learned in the MCSS environment, the CG continued to learn within the framework of the traditional class environment, which included lessons and the same number of practical exercises as in the MCSS group. The only difference between the two groups before the HFPS assessment referred to the types of educational tool used for the practical training: the EG used the MCSS and the CG used traditional exercises (including paper-based as well as plastic manikin-based practical exercises and instructions about procedures, with feedback and debriefing). The criterion of evaluation was performance in the HFPS cardiac arrest test scenario.

We used a multiple-choice questionnaire to check that all participants had similar prior knowledge and similar experience in medical emergencies.

Simulator scenarios and task

Each simulation session began with activities designed to familiarise the participants with the simulator environment on which they would be tested. For both the high-fidelity patient simulator and the computer screen-based simulator, students inspected the simulator, learned how it could be manipulated, and were able to ask questions concerning the use and limitations of the simulator. Participants were requested explicitly not to discuss the simulation case with other students. For both simulators, participants were instructed to diagnose and treat the problem presented as they would in real life.

Computer screen-based training session for CA1

The basic cardiac arrest module (for beginners) offered by MicroSim® was chosen to define the parameters of cardiac arrest scenario 1 (CA1). Learners were given the following instruction: 'You are a student trainee in a regional university hospital in a big town. Mr SD is a 72-year-old man. His ward neighbour is calling for help [because Mr SD has felt a sudden sharp pain].'

Each participant was required to complete three sessions, separated from one another by 1 day. This

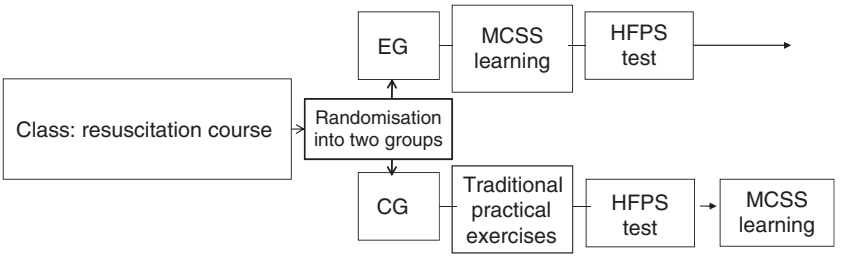

Figure 1 Representation of the stages of the experiment. EG = experiment group; CG = control group; MCSS = multimedia computer screen-based simulator; HFPS = high-fidelity patient simulator

Table 1 Expected actions in the management of cardiac arrest scenarios 1 and 2. Phase A = initial diagnostic phase (items 1–5); Phase B = cardiopulmonary resuscitation phase (items 6–16); Phase C = final phase (items 17–21)

Treatment variables: expected actions in three phases from the onset of CA		**Score**
Phase A Information required for diagnosis (5 points)	1 Check consciousness	1
	2 Check for airway obstruction	1
	3 Free airways	1
	4 Check breathing	1
	5 Check pulse	1
Phase B CPR actions (13 points)	6 Begin CPR (delay < 180 seconds), chest compressions, 30 : 2 ratio and	1
	7 Call for help (nurse)	1
	8 Call for (take) defibrillator device (from nurse, delay < 300 seconds)	1
	9 Installation of the defibrillation device (ask nurse)	1
	10 Detect ventricular fibrillation and call emergency department team (delay < 480 seconds)	1
	11 Ask colleagues to move away from patient	1
	12 When the shock is 'not recommended'	
	Check breathing	1
	Check pulse	1
	13 Restart CPR, chest compressions (for 120 seconds), 30 : 2 ratio	1
	14 Ask for a new defibrillator analysis	1
	15 Move away from patient	1
	16 When the shock is recommended	
	Deliver external electric shock	1
	Restart CPR until patient is breathing(< 10 seconds after shock), 30 : 2 ratio	1
Phase C End of CPR: planning immediate future (5 points)	17 Stop CPR when spontaneous breathing obtained = verification of breath, pulse control	1
	18 Give oxygen to patient	1
	19 Take arterial pressure	1
	20 Measure oxygen saturation	1
	21 Install scope (scope computer screen)	1
All phases	Total score	23

CA = cardiac arrest; CPR = cardiopulmonary resuscitation

was intended to enhance distributed learning, which is known to be more efficient than grouped learning, and to retain alignment with the control group sessions.[26] After each trial, the software automatically calculated the score based on the treatment variables (Table 1). The scenario was considered to have been successfully managed when the score was > 75% (18/23: this threshold was defined collectively by the team of expert doctors at the hospital) (Table 1).

Each of the three sessions finished when the learner successfully performed the scenario. Within each session, the learner performed the number of trials necessary to achieve a score of 75%.

High-fidelity patient simulator test for CA2

Each participant was placed in the simulation situation. The instruction used for cardiac arrest

scenario 2 (CA2), similar to CA1, was: 'You are a student trainee in the nephrology department. You are in the room of Mr AZ and you are going to give Mr AZ his daily treatment and check his state. Mr AZ is a 56-year-old man suffering from congestive renal failure with hypertension and high cholesterol. Mr AZ is also a regular smoker and regularly drinks alcohol.'

Each participant began the test scenario alone with the high-fidelity patient simulator (in the simulation room). When explicitly called by the student, the nurse entered the scenario (this role was played by a nurse-instructor from the hospital's emergency training centre). The sessions were videotaped with a super-imposed stopwatch for evaluations. After the end of the scenario, a debriefing phase was started (in the debriefing room). Debriefing was audio- and videotaped. In this research, the debriefing data correlated closely with the behavioural data for the test scenario.

Scoring and statistics

To resolve the scenario, the resuscitation procedure prescribed in recent European Resuscitation Council[27–30] guidelines had to be accurately completed. Specific and precise treatment actions were expected (Table 1).

The scoring system consisted of a list of points assigned to appropriate medical and technical therapeutic actions performed using the right procedure at the right time/rate, for a maximum of 23 points. The scoring systems for the computer screen environment and the high-fidelity patient simulator were identical. In the case of the high-fidelity patient simulator, all the data from the simulations were extracted by reviewing the video-recordings. However, points were given only when actions were correctly justified in the debriefing. Dual scoring was used. The two assessors were in close agreement for the presence and absence of a technical action and on the lead time measurements; rating was based on the grid of indicators in Table 1. Inter-assessor agreement, by chance-corrected Cohen's kappa, was 0.96. Calculations were performed using STATISTICA Version 7.1 (StatSoft, Inc., Tulsa, OK, USA). Means, standard deviations and percentages of success of all subjects for treatment scores and treatment times were calculated for both simulators. ANOVAs were used for the analysis of the effects of experimental factors on treatment scores and treatment times for the test scenario on the high-fidelity patient simulator.

Table 2 Resuscitation scores and times for each group with the high-fidelity patient simulator

	Total treatment score/23, mean (SD) %	Treatment time, seconds, mean (SD)
Experiment group	16.21 (2.11) 70.5%	410.21 (90.32)
Control group	11.13 (1.56) 48.4%	420.92 (98.73)

RESULTS

Treatment scores and treatment times for the CA2 test scenario on the high-fidelity patient simulator are shown in Table 2.

For total score, the EG outperformed the CG ($F_{1,26} = 51.96$, $p < 0.00001$, effect size $\eta_p^2 = 0.67$, effect power [$\alpha = 0.05$] = 1.00). The EG trained with the screen-based simulator performed significantly more actions accurately than the CG. Furthermore, total treatment time did not differ significantly between the two groups ($F_{1,26} = 0.09$, $p = 0.77$ [NS], $\eta_p^2 = 0.003$, effect power = 0.006).

DISCUSSION

The positive effect of computer screen-based simulation on learning CA procedures

The goal of this research was to test the benefits of a computer screen-based simulator in learning cardiac arrest procedures in undergraduate medical students (in Year 2). During a 'traditional' resuscitation course, the performances of two randomised groups, an experiment group and a control group, were tested using a high-fidelity patient simulator. The EG was trained with the computer screen-based simulator before the test. The CG used the computer screen-based simulator after the test. The nature and length of the resuscitation course for both groups were comparable before the test, except for the types of tool used, which involved a training session with the computer-based simulator for the EG and the same amount of traditional practical exercises, information and instructions for the CG.

Our results showed a significant benefit of training with the computer screen-based simulator. The mean treatment score of the EG was higher than

that of the CG and the total treatment times of the two groups were comparable. Therefore, computer screen-based simulation appears to prepare learners well for the use of high-fidelity patient simulators, which present scenarios that are closer to real-life situations.

Our results are in accordance with those of other research reported in the wider literature about the effects of computer screen-based and high-fidelity simulators in anaesthesia and CPR training.[1,2,4,5,12,15,18,24,31–35]

CONCLUSIONS

The MCSS provided this initial resuscitation instruction to an acceptable degree, and seems to provide reliable metrics for assessment purposes. Multimedia simulation also has some cost-related and logistical advantages in that learning outcomes are superior to those achieved using traditional methods. However, our results raise several questions about the efficacy of resuscitation courses and the use of simulators in the education of medical students.

The first question relates to the duration of training. In the present study, after a resuscitation course plus a mean of six trials with the multimedia computer screen-based simulator, the EG achieved a test performance with the high-fidelity patient simulator of 70%. This is a relatively good performance, given that we used a strict and rigorous grid of criteria. However, in order to optimise efficacy in resuscitation procedures, more training may be needed to obtain optimal performance.

The present study has other limitations, including the small size of the sample. However, within this experimental framework using randomised and comparable samples, clear significant differences were found between the EG and the CG.

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