IS HIGH-FIDELITY PATIENT SIMULATION-BASED TEACHING SUPERIOR TO VIDEO-ASSISTED LECTURE-BASED TEACHING IN ENHANCING KNOWLEDGE AND SKILLS AMONG UNDERGRADUATE MEDICAL STUDENTS?

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Abstract

Introduction: Medical simulation is a technique that allows interactive and immersive activity by recreating all or part of a clinical experience without exposing the patients to the antecedent risks. High-fidelity patient simulation-based teaching is an innovative and efficient method to address increasing student enrolment, faculty shortages and restricted clinical sites.

Objective: To assess the effectiveness of high-fidelity patient simulation (HFPS) as compared to video-assisted lecture-based teaching method (VALB) among undergraduate medical students.

Methods: The study was a Randomized Controlled Trial which involved 56 final year undergraduate medical students. The effectiveness of teaching based on HFPS (intervention group) and VALB (control group), on acquisition of knowledge, was assessed by multiple choice questions (MCQs) in the first and fourth week. Similarly, the skills competency was assessed by objective structured clinical examination (OSCE) in the second and fourth week. Mean and standard deviation (SD) for total score of knowledge and skills assessments were used as outcome measures. P value < 0.05 was considered to be statistically significant.

Results: In both groups, students had significant higher mean MCQ scores at Post-tests. The intervention group had higher mean change score of MCQ marks than the control group but the difference was not statistically significant. In both the first and second skills assessments, mean OSCE scores for intervention group were higher than control group but this difference was not statistically significant.

Conclusion: There was significant gain in knowledge in both methods of teaching but did not reach statistical difference in terms of skills enhancement in the intervention group as compared to the control group.

Keywords: High-fidelity Patient Simulation, Simulation-based Medical Education, High Fidelity Simulators, Video-assisted Lecture, Undergraduate Medical Education

Introduction

David Gaba opined that simulation is a technique and not a technology which can replace or amplify real experiences with guided experiences. It replicates substantial aspects of real world in a fully interactive manner. The learning is planned, and the core of simulation is focused on education rather than technology (1). HFPS-based education has evolved as a key training tool in high-risk industries such as aviation, military, nuclear power plants, and not surprisingly, its inclusion in medical education allows efficient training without jeopardising patient's safety in the process of learning (2). From 1980s onwards, many learners have been exposed to some form of healthcare simulation during their training years in medical schools (3). High fidelity simulators are developed using advanced technology to teach therapeutic measures and diagnostic procedures. In terms of medical education, HFPS are generally reserved for the clinical years to improve clinical decision skills, teamwork, and patient safety. HFPS activity had also been incorporated into a problem-based curriculum to enhance the learning of basic sciences (4). HFPS helps aspiring health care professionals to develop medical concepts and make decision by allowing the learners to venture out and acquire new knowledge, through hands-on experience, that helps in translating general concepts into practical skills and application of management protocols. It invokes an emotional reaction in addition to the experience of most learners, that helps to translate new information into memory with eventual enhancement of knowledge and psychomotor skills (5). The deliberate learning experience helps students to respond and react to the clinical scenario and assess the situation. It stimulates students to think out of the box, hypothesise, and subsequently evolve into an effective strategy for troubleshooting of problems. HFPS promotes teamwork, communication skills, reflective learning, improved self-confidence, emotional engagement, life-long learning, as well as professional identity formation (6). Studies showed that simulation-based training is superior to lecture-based training in teaching critical scenarios due to the improvement in perceptive ability. A randomized controlled study by Lee Chang et al. showed simulation is a superior method for teaching situation awareness (7). HFPS promotes rapid transformation of knowledge into reasonable action. This cognitive component cannot be effectively assessed by written tests alone (8). In addition, it is also shown that students who work with peers are more able to retain knowledge (6). HFPS provides a feasible educational platform for undergraduate medical students to demonstrate equivalent immediate improvement of knowledge, as well as better knowledge retention in comparison to lectures (9). A recent study on HFPS demonstrated that there were larger effect sizes on improving nursing students' knowledge and performance when compared to other modalities of teaching (10). The best practice approach for HFPS in medical education, should explore the additional benefits attainable with the use of this device. Apart from using quantifiable parameters to determine the effectiveness of HFPS, there are qualitative attributes achievable through this learning exercise. Recent study demonstrated that HFPS helped students to have increased use of critical thinking, helps to create thinking skills, and increase ability to transfer knowledge (6). The effectiveness of HFPS in enhancing knowledge and skills acquisition has been showed in many studies but there is a lack of proper randomized controlled trials (RCTs) to establish a direct cause-effect relationship between HFPS-based education and facilitation of learning in undergraduate students (11-13). Factors such as less rigorous study designs, lack of randomization and the use of small heterogeneous cohorts pose a great challenge in developing a proper methodology in assessing HFPS-based education. HFPS-based teaching is a comparatively new educational tool in healthcare education and therefore, the evidence regarding its effectiveness is not well established. There is a need for uniformly graded multi-site research studies of HFPS-based teaching involving larger cohort of students with convincing use of reliable and valid tools which are essential to show evidences of improved learning outcome (14). There are limited randomized controlled studies on use of HFPS-based teaching in undergraduate medical education, specifically, in comparison to conventional teaching methods. The methods of teaching to improve situation awareness and resultant improvement of knowledge and skills have not been well studied in the medical field, and therefore, our study had endeavoured to evaluate the effectiveness of HFPS as a teaching-learning tool as compared to VALB teaching in undergraduate medical education. This article discussed the findings of a pilot study of the ongoing main research which was expected to be completed by October 2020. The aim of the study is to assess the effectiveness of HFPS as compared to VALB in teaching undergraduate medical students. The objective is to assess the differences made to the knowledge and skills acquisition following facilitated HFPS sessions as compared to VALB teaching for final year students of 2019.

Materials and Methods

Type of study and general design

Randomized Controlled Trial, parallel groups with 1:1 allocation. Please see Appendix II for the Flow Chart.

Inclusion criteria

All male and female final year undergraduate medical (MBBS) students of Melaka-Manipal Medical College (MMMC), Malaysia were recruited during their surgical posting after obtaining their informed consent. All the participants were between the ages of 22-25 years. Out of 56 participants, 31 (55.36%) were female and 25 (44.64%) were male.

Exclusion criteria

Students who would not give consent to participate in this study.

Study area

Clinical Skills Simulation Lab of MMMC, Melaka, Malaysia.

Study period

November, 2018 to February, 2019 (4 months).

Interventions

Description of Hi-fidelity simulator: METIman Pre-Hospital HI-Fidelity Simulator (MMP-0418) was used for the simulation sessions. It was a fully wireless and tetherless, adult High Fidelity Simulator (HFS) with modelled physiology. With a simulated patient configuration and advanced airway features based on the latest training protocols, it allowed learners to practice, gain experience and develop clinical mastery in a wide range of patient care scenarios.

Description of video-assisted lecture: The conventional educational method involved a recorded video clip demonstrating the management of tension pneumothorax by performing Needle Decompression on METIman (Pre-Hospital) following Advanced Trauma Life Support [ATLS®]: The Ninth Edition, developed by the American College of Surgeons (15).

Outcomes

The effectiveness of HFPS-based teaching and VALB teaching methods were assessed by single best answer multiple choice questions (MCQs) in the first and fourth weeks of surgical posting for assessment of knowledge. Similarly, the psychomotor skill was assessed by objective structured clinical examination (OSCE) in the second and fourth week of surgical posting. Thus, at the end of the course, all the students were expected to perform satisfactorily as regard to the diagnosis and management of tension pneumothorax.

Recruitment

HFPS-based learning of trauma is one of the preferred methods of teaching for final year medical students in MMMC. They were recruited to participate in the study during their four weeks of surgical posting in the final year.

Randomization

The students posted in Surgery (12 to 15 students in each rotation) were randomized into intervention (HFPS) and control (video-assisted lecture) groups following random sequence generation method.

Random sequence generation

We used computer generated random sequence from randomizer.org. The independent randomizer was a biostatistician who did not participate in the delivery of interventions. The allocated interventions were then sealed in a sequentially numbered, opaque envelope.

Type of randomization

We used block randomization of a block size of two to assign the students into intervention and control groups.

Implementation

A biostatistician generated the allocation sequence. One independent investigator enrolled the participants and another independent investigator assigned the participants to interventions.

Blinding

The outcome assessor and biostatistician were kept blinded to allocation.

Data collection procedure

In the first week, all the students appeared for a Pre-test (MCQ) to assess the participants' initial background knowledge. This was followed by a Post-test (MCQ) on the same subject at the end of the last simulation session in the fourth week to assess their gain in the knowledge. The MCQ answer sheets were scanned by Konica Minolta FM (172.17.5.12) scanner and graded by using Optical Mark Recognition (OMR) software (Remark Office OMR, version 9.5, 2014; Gravic Inc., USA). For the assessment of skills, all participants from both groups were subjected to an OSCE on Needle Decompression in the management of tension pneumothorax which was performed on METIman hi-fidelity simulator in the second and fourth week. We had used a validated OSCE checklist to assess the participants' performance score on Needle Decompression. Both Pre-test and Post-test knowledge assessments comprised of 20 MCQs which were to be completed in 20 minutes. We had used single-best answer A-type as per the guidelines prepared by National Board of Medical Examiners (16) in preparing these MCQs. For each correct response a score of one point was awarded. No negative marking was awarded for incorrect response. Before the main study, a pilot study involving 30 students was conducted to explore the time management, feasibility, acceptability and validation of the questionnaires (OSCE and MCQ). It was done to review the results of the analysed items to evaluate the quality of the MCQ. We had checked the difficulty index for item difficulty as well as bi-serial correlation for item discrimination. The value between 30 and 95 in difficulty index and the bi-serial correlation value > 0.2 were accepted as the desired standard in the study. OSCE checklist was validated by using the content validity, and referring to the extent of which the items in the checklist adequately covered the specific domain of interest (17). We had included ten reviewers from the field of surgery, medicine and medical education using four-point scale (1= not relevant, 2 = not important, 3 = relevant, 4 = very important) to determine if the items in the questionnaire were relevant or important. Scale-level content validity index (SCVI), and item-level content validity index (ICVI) and mean ICVI were calculated. Our SCVI and ICVI were kept at 0.943 and 0.9 respectively as per the standard recommendation (18).

The students who gave consent to participate in the study were enrolled in the study. They were briefed about the sessions and expected learning outcomes. Each session was conducted with a group of 12 to 15 students which were further sub-divided into intervention and control groups consisting of 6 to 8 students in each group. In the first week, initial background knowledge was collected as Pre-test (MCQ) from the participants about tension pneumothorax and its management following the ATLS protocol. This was followed by a theoretical briefing from an independent investigator on pathophysiology and clinical presentation of tension pneumothorax and its steps of management following the ATLS protocol. This briefing was done as an interactive lecture to both groups. In the second week, the students were randomized into intervention and control groups following random sequence generation method. The intervention group then participated in a real-time facilitated simulation session on the diagnosis and management of tension pneumothorax (Needle Decompression) in an Accident & Emergency setting. It was demonstrated on the high fidelity simulator (METIman Pre-hospital) by an independent investigator followed by hands-on training. For the control group, a recorded 20-minute video clip of the identical facilitated simulation session on the diagnosis and management of tension pneumothorax (Needle Decompression) was shown by another investigator. The video demonstration session was followed by interactive discussion with the same facilitator for 30 minutes. On the same day, each group then participated in an OSCE-based skills assessment of Needle Decompression on METIman HFS. The OSCE questionnaire was designed to complete the session within 20 minutes. Both groups were debriefed at the end of the OSCE sessions in order to achieve the learning outcomes. In the fourth week, the same groups again participated in the OSCE-based assessment on identical simulation sessions to test their short to medium term retention of skills, followed by Post-test MCQ and final debriefing. All the assessments were done by the same outcome assessor who was blinded. All the participants in both the groups were assessed twice (2nd week and 4th week). There were no additional hands-on practise sessions for the participants during the study. The students in the control group along with the students who did not consent for this research study, were provided with access to the same HFPS sessions at the end of the course to ensure parity between the groups for their professional development of knowledge and skills. Similarly, the students in the intervention group along with the students who did not consent for this study, were provided with access to the same video-assisted lecture sessions at the end of the course to ensure parity between the groups.

Statistical analysis

After checking and coding the questionnaire, we used Microsoft Excel for data entry and SPSS software (version 25) for data analysis. We calculated descriptive statistics such as frequency and percentage for categorical data, mean and standard deviation for total score of knowledge and skills assessments. Independent t-test was used to compare the MCQ and OSCE scores. All the statistical tests were two-sided and the level of significance (P value) was set at 0.05.

Results

Table 1 shows intergroup comparison of MCQ marks between intervention and control groups at pre-test and post-test. There were no significant differences of the MCQ marks between control and intervention groups at Pre-test and Post-test.

Table 1: Intergroup comparison of pre and post MCQ marks among intervention and control group

Group	n [a]	MCQ marks Mean (SD)	Mean difference (95% confidence interval)	t (df)	P value
Pre-test scores:					
Intervention	27	57.59 (11.80)	-3.10 (-8.98, 2.79)	-1.06 (54)	0.299
Control	29	60.69 (10.15)			
Post-test scores:					
Intervention	27	70.37 (12.55)	1.23 (-4.63, 7.09)	0.42 (54)	0.675
Control	29	69.14 (9.17)			

n [a]: Number of students
SD: Standard deviation
t: t-value/distribution
df: Degree of freedom

At Pre-test, the control group had higher mean MCQ marks than the intervention group but it was not statistically significant (P value = 0.299). At Post-test, the intervention group had higher mean MCQ marks than the control group but it was not statistically significant (P value = 0.675).

Table 2 shows the comparison of pre and post MCQ marks among the intervention and control group. We observed significant higher mean MCQ marks at Post-test than Pre-test in both intervention and control groups.

In the intervention group, the students had statistically significant higher mean MCQ marks at Post-test than Pre-test (P value < 0.05). Similarly, the students in the control group had statistically significant higher mean MCQ marks at Post-test than Pre-test (P value < 0.05).

Table 3 shows the change score of MCQ marks (post–pre) between intervention and control groups. There were no significant differences between the Pre-test and Post-test MCQ marks among the control and intervention groups.

Table 2: Intragroup comparison of pre and post MCQ marks among intervention and control group

Group	n [a]	MCQ marks Mean (SD)	Mean difference (95% confidence interval)	t (df)	P value
Intervention:					
Pre-test scores	27	57.59 (11.80)	-12.78 (-18.13, -7.42)	-4.90 (26)	< 0.05*
Post-test scores	27	70.37 (12.55)			
Control:					
Pre-test scores	29	60.69 (10.15)	-8.45 (-12.79, -4.10)	-3.98 (28)	< 0.05*
Post-test scores	29	69.14 (9.17)			

n [a]: Number of students
SD: Standard deviation
t: t-value/distribution
df: Degree of freedom
* Significant

Table 3: Intergroup comparison of Change score of MCQ marks (Post – Pre) between intervention and control groups

Group	n [a]	Change score of MCQ marks Mean (SD)	Mean difference (95% confidence interval)	t (df)	P value
Intervention	27	12.78 (13.54)	4.33 (-2.37, 11.03)	1.30 (54)	0.203
Control	29	8.45 (11.43)			

n [a]: Number of students
SD: Standard deviation
t: t-value/distribution
df: Degree of freedom

The intervention group had higher mean change score of MCQ marks than the control group but it was not statistically significant (P value = 0.203).

Table 4 shows the intergroup comparison of OSCE marks between the intervention and control groups. There were no significant differences of the OSCE marks among the control and intervention groups at first and second assessments.

In the first assessment, the mean OSCE marks of the intervention group was higher than the control group. However, it was again not statistically significant (P value = 0.076). Similarly, the mean OSCE marks of the intervention group was higher than the control group in the second assessment but it was not statistically significant (P value = 0.313).

Table 4: Intergroup comparison of OSCE marks among intervention and control group

Group	n [a]	OSCE marks Mean (SD)	Mean difference (95% confidence interval)	t (df)	P value
1st Assessment scores					
Intervention	4	26.50 (2.08)	3.25 (-0.47, 6.97)	1.52 (6)	0.076
Control	4	23.25 (2.22)			
2nd Assessment scores					
Intervention	4	24.25 (2.06)	2.00 (-2.44, 6.44)	1.81 (6)	0.313
Control	4	22.25 (2.99)			

n [a]: Number of students
SD: Standard deviation
t: t-value/distribution
df: Degree of freedom

Table 5 shows the comparison of OSCE marks in the first and second assessments in both intervention and control groups. We observed significant higher mean OSCE marks in the intervention group at first assessment than the second assessment (P value = 0.018). In the intervention group, the students had statistically significant higher OSCE marks at the first assessment than the second assessment (P value = 0.018). In the control group, there was no significant difference between the first assessment and the second assessment (P value = 0.613).

Discussion

There are some studies which have produced equivocal results but many studies showed a significant difference between the impact of simulation in undergraduate

Table 5: Intragroup comparison of OSCE marks among intervention and control group

Group	n [a]	OSCE marks Mean (SD)	Mean difference (95% confidence interval)	t (df)	P value
Intervention:					
1st assessment	4	26.50 (2.08)	2.25 (0.73, 3.77)	4.71 (3)	0.018*
2nd assessment	4	24.25 (2.06)			
Control:					
1st assessment	4	23.25 (2.22)	1.00 (-4.66, 6.66)	0.56 (3)	0.613
2nd assessment	4	22.25 (2.99)			

n [a] - Number of students
SD: Standard deviation
t: t-value/distribution
df: Degree of freedom
* Significant

medical education when compared to other educational methods. Our study revealed that the effectiveness of HFPS was not significant from conventional teaching methods which corroborated with the variable findings from other research studies.

In our study, there was statistically significant enhancement of knowledge in both the intervention and control groups, suggesting that each was equally effective in enhancing the knowledge of students. This is consistent with the findings of an RCT study carried out by Wang et al. (19) where both groups showed significant improvement in results on written test scores. Though the HFPS group scored higher in Post-test knowledge assessment in comparison to the VALB group, the difference in knowledge gain was not statistically significant. As regards to the difference of scores from Pre-test to Post-test knowledge assessments, the intervention group had a higher mean change score than the control group but it was again not statistically significant. Hence, HFPS did not demonstrate any tangible benefit in knowledge enhancement than the conventional lecture-based teaching method. Simulation training had shown to be a better alternative than didactic lecture for teaching management protocol of critically ill patients to medical students (20). However, a study by Couto et al. (21) showed that simulation had no meaningful difference from case-based discussion for acquisition and retention of knowledge, though it was superior in terms of student satisfaction. A systemic review conducted by Warren et al. revealed that there was limited evidence supporting the use of HFPS within nursing practitioner programs, though it increased students' knowledge, confidence, and satisfaction in comparison to other conventional teaching methods (22). In contrast, Anderson et al. opined that simulation was an indispensable alternative to hands-on experience with real-life patients in midwifery (23). In skills assessment, HFPS group scored higher than the lecture-based teaching group in both the first and second assessments. However, it was not statistically significant. Interestingly, there was a drop in the skills scores in both intervention and control groups, after a lapse of 2 weeks, reflecting decreasing retention of skills learnt with time. The better performance of the intervention group in the first OSCE assessment was most probably due to their exposure to the hands-on training just before the first assessment session. The learning and memory process consists of three stages: encoding, storage, and retrieval (24). It is possible that the experiential learning in HFPS helps students to better encode, store, and thus translate into immediate retrieval at the first instance. A memory would be evoked more effectively, if the retrieval tool was coupled to an experiential memory, as in HFPS session (25). In addition, HFPS experiences were typically brief, but emotionally intense, for learners due to the fidelity (25). With time, the initial effect became diluted, affecting the retrieval of the skills learnt. This explained the more significant drop in the skills score for the intervention group, as compared to the non-statistically significant drop of skills score in the control group. HFPS group did not show significant difference or advantage in the enhancement of skills as compared to the VALB group. On the other hand, Maddry et al. (26) demonstrated that lecture-based teaching was found to be more effective in terms of knowledge and performance than simulation-based teaching immediately after the intervention but the simulation group showed greater retention than the lecture group when tested later. Another study reviewing the effects of HFPS in students learning physiology, did not observe a longer-term learning benefits for the simulation group (6). In this perspective, our study did not register significant immediate and longer-term benefits in the acquisition of skills post HFPS as compared to VALB learning. The educators and researchers in undergraduate medical education programs need to follow the best strategic models when using HFPS teaching based on the evidences from the design and implementation of past HFPS-based education, and striving to adhere to the Standards of Best Practice (27-28). This may decide the way HFPS programme has to be implemented for maximising its educational values.

The Edgar Dale's Cone of Experience suggests that audio-visual learning methods i.e. via videos were more abstract in which learners become spectators, in contrast to "practice by doing", i.e. HFPS, with demonstration and direct purposeful experience. The real and concrete experience in HFPS helped to provide foundation for more long-term learning as compared to audio-visual learning (29). However, in our study, there was no significant difference between VALB teaching and HFPS-based teaching. The likely explanation among others, apart from the limitation of the study design, might include individual variables which include learning styles i.e. audio-visual or kinaesthetic, learning attitude, pre-existing relevant knowledge, as well as reinforcement by other learning modality i.e. interactive discussion or self-directed learning post lecture-based teaching. HFPS provided an environment where students enter a situation with a unique knowledge base and consolidate it with a new experience or information learnt in the process (30). Hence, the magnitude of enhancement in knowledge and skill acquisition among students might not be entirely linear or proportional to the single exposure of HFPS session or video-assisted lecture-based teaching. These factors might compound the interpretation of the data to achieve a valid conclusion. A recent study, however, suggested HFPS was most likely not superior to other conventional means for acquisition of knowledge (6).

Limitations

There is a possibility of inherent limitations due to biases in design, recruitment, sample populations and data analysis. Other variables like simulation course implementation, curricular integration and faculty expertise could have influenced the findings. The randomisation of a rather small sample size of 56 students might not be effective to account for these inherent individual confounders. The other confounding factors such as communication between the different groups of students before their second OSCE assessment, students' recall memory and prior preparation for the Post-test MCQ after 4 weeks need to be considered. This was a single centre study and only final year medical students had participated, and as such the validity of the findings may not be applicable to other settings.

Conclusion

High Fidelity Patient Simulation offers a novel experience for students to acquire knowledge, polish clinical skills, immerse in the thrill of critical care management, and to work as a coherent functional team. Thus, it is a potentially powerful tool in the pursue of knowledge and for the perfection of skills. The evaluation of the effectiveness of HFPS would not be complete without an attempt to gauge the overall fulfilment of the traditional measurable learning goals as well as examining the equally important soft professional attributes that could only be caught but not taught. However, an expensive high-end device as it is, would naturally invite more studies to examine its effectiveness in achieving these goals, as to determine its cost-effectiveness to deliver. Our study demonstrated its efficacy as a useful adjunct in teaching medical students, without clear indication of its edge over other conventional platform of education. Thus, more studies are needed to determine its advantage or concrete role in producing the next generation of competent doctors.

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Competing interests

The researchers had not received any specific grant from funding agencies in the public, commercial, or not-for-profit sectors or elsewhere to conduct this study and had no conflicts of interest.

Ethics approval

Ethical approval was obtained from the Ethical Committee / IRB of Melaka-Manipal Medical College (MMMC/FOM/ Research Ethics Committee - 11/2018). Informed consent was taken from all the participants. All information about the participants were kept confidential.

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