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RESEARCH ARTICLE

Impact of simulation-based teaching of applied physiology of the cardiovascular system on the undergraduate medical student

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ABSTRACT

Background: The undergraduate medical student, in his I year of studies, is required to know about Applied Physiology. The teaching of Applied Physiology concepts that occur in real life situations in a classroom is understandably difficult. Simulation-based teaching in medical education is an active learning format which imparts enduring knowledge. Medical simulation is an imitation of human physiological processes and changes observed in disease using a computerized model system called a human patient simulator (HPS), and the medical student acquires knowledge by practicing on them through role play, when they are given a clinical scenario. **Aims and Objectives:** To analyze if simulation-based teaching has an impact on the knowledge and skills of undergraduate medical students in Applied Physiology of the cardiovascular system. **Materials and Methods:** 150 undergraduate students of I year MBBS, of both sexes were included in this experimental study. Each student had a hands-on experience on the HPS and underwent simulation-based teaching with clinical case scenarios to facilitate better understanding of Applied Physiology of the cardiovascular system. A self-administered, pretested questionnaire was given as pre- and post-test questionnaire. The data were analyzed using SPSS version 22.0 and paired *t*-test. **Results:** Our results showed that simulation-based teaching has a significant impact on the knowledge and skills of undergraduate medical students in Applied Physiology of the cardiovascular system and both male and female students have been shown to have received the same level of impact. **Conclusion:** This study has highlighted that simulation-based teaching is an innovative method to impact the knowledge and skills of undergraduate medical students in Applied Physiology of the cardiovascular system.

KEY WORDS: Cardiovascular System; Human Patient Simulator; Physiology; Simulation; Undergraduate Medical Education

INTRODUCTION

Simulation has become one of the prominent innovations in medical education in recent times and is creating a paradigm shift in medical education toward experiential "hands-on" learning, rather than traditional didactic lectures. We have learnt over time that enduring knowledge is imparted and fostered by any active, experimental format and simulation-based medical education is one such active learning format. The sole intention of applying simulation to medical education is the fact that learning is an active process and when it is interactive and student-centered, such teaching methods fulfills the goals of better understanding, increased retention, and enhanced student satisfaction.

Simulation creates an artificial situation resembling that which occurs in real life called a scenario, to study something, through experience. Medical simulation is thus an imitation

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of human physiological processes and changes observed in disease using computerized model system which use human patient simulators (HPS) or high fidelity manikins and the medical student acquires knowledge by practicing on them through role play when they are given a clinical scenario.

Simulators are of different types. Low-fidelity simulators are static and do not provide the desired realism in the situational context of a case scenario. Moderate fidelity simulators give more resemblance of reality with such features as pulse, heart sounds, and breathing sounds but without the ability to talk and they lack chest or eye movement. High fidelity simulators combine part or whole body manikins to carry the intervention with computers that drive the manikins to produce physical signs and feed physiological signs to monitors. They are usually designed to actually resemble the real life situation as they can talk, breathe, blink respond and mimics various functions of the human body, including respiration, cardiac rhythms, and pulsation.

The simulation methodologies include case scenarios which are relevant and specific to the topic on which the instructor wants to educate the student in the session. Simulation is thus an interactive educational tool used to achieve instructional goals and to serve as an assessment device. In fact, the retention of information after a lecture with audiovisual enhancement is only about 30% while interactivity increases the retention to 75%.[1] In addition to increasing retention, simulation enhances the opportunities for the integration of basic and clinical sciences.

The undergraduate student of MBBS is required to know about Applied Physiology and the teaching of Applied Physiology concepts that occur in real life situations in a classroom is understandably difficult. Applied Physiology concepts are not so easy to understand for the students merely reading from textbooks or listening to didactic lectures. Another factor that adds to the student's inability to grasp physiological concepts may be due to the educational institutions limiting or eliminating the use of animal models in the education of medical students. Few earlier studies have shown that educational outcomes showed good results when the activities in the animal laboratories had been allowed to be replaced by simulation for demonstrating basic physiological concepts.[2] Simulation has been shown to be effective in undergraduate graduate education.[3,4] Thus, simulation, by way of artificial representation of a real time process helps us achieve educational goals through experimental learning.[5]

There are not many instances of the under-graduate preclinical student being exposed to this phenomenal innovation called simulation. To find out if the use of simulation has an impact on the students' understanding of Applied Physiology of cardiovascular system, this study was done for the MBBS – I year under-graduate students. Simulation-based teaching was done for the students by training them with clinical case scenarios to facilitate better understanding of Applied Physiology concepts, basic clinical examination skills and problem-solving ability at the bedside of the simulator.

MATERIALS AND METHODS

This study was an experimental study conducted for 150 medical undergraduate students of ages 18-19 years, studying I year MBBS, over a period of three months- 1st March 2015 to 1st May 2015, in the premises of SRM Stratus Center for Medical Simulation, SRM Medical College Hospital and Research Centre, Kattankulathur, Chennai, Tamil Nadu, India.

Institutional Ethical Committee clearance (814/IEC/2015) was obtained before the study.

Written informed consent was obtained from all participants before the study. The data were collected from all the participants regarding age and gender and recorded in excel spread sheet. A self-administered pretested questionnaire was used for the study. 10 questions, based on Applied Physiology on the cardiovascular system using Likert scale were included in the pre- and post-test questionnaire.

In the simulation center, the students were first briefed about the objectives of the session. Each and every student had a hands-on experience on the HPS, which was used to demonstrate pulse, normal heart sounds, blood pressure recording, heart sounds and breath sounds.

Each student had a hands-on experience on the technique to palpate the peripheral arterial pulsations of the carotid, brachial, radial, femoral, popliteal, and dorsalis pedis arteries on the HPS. They were also made to auscultate the heart sounds and breath sounds. Hands - on practice sessions - were also allowed for each student to record blood pressure. They were taught how to attach the electrocardiogram leads on the HPS and analyze the heart rhythms like normal sinus rhythm and arrhythmias like ventricular fibrillation on the cardiac monitor.

After the students understood the basic concepts of a basic general clinical examination, they were given problem-solving situations in the form of case-scenarios. The case scenarios relating to circulatory shock such as hypovolemic shock, neurogenic shock, obstructive shock, and septic shock were clearly narrated into a microphone, from the sound-proof audio-visual room. Each of the participants could speak into a microphone and were encouraged to ask questions about the case scenario, which were answered appropriately by the instructor. All through the session there was active interaction between the student and the instructor. Audio and video recording of the practice sessions were done, which could be later used for debriefing each student individually.

At the end of the sessions, the posttest questionnaire and feed-back forms were administered.

Statistical Analysis

The entire data were entered in Microsoft Excel and analyzed using SPSS version 22.0. Frequency and percentages among descriptive statistics were used to describe the data and paired *t*-test has been used for the analysis. $P = 0.05$ was considered to be statistically significant.

To document the impact of simulation-based teaching among the study group, the scoring was done based on the options the student selected for each of the 10 questions (Annexure). Scores ranging from 1 to 4 were given based on the type of statement. A score of four was given for strongly agree, 3 for agree, 2 for neutral, and 1 for disagree.

For example, the statement "CO = Afterload X HR" is wrong and hence if the response was "disagree," it was given a score of 4, followed by "neutral" with a score of 3, "agree" with 2 and "strongly agree" with 1. The statement "CO = SV X HR" is correct and hence "strongly agree" was given score of 4, followed by "agree" with 3, "neutral" with a score of 2 and "disagree" with 1.

RESULTS

The general characteristics of the participants were that of the total study participants, 56% (84) were males and 44% (66) were females. The age distribution was that 82.7% (124) were 18 years of age and 17.3% (26) were 19 years of age (Table 1).

To analyze if there is any impact of simulation-based teaching, the hypothesis tested is "simulation-based teaching has an impact on the knowledge and skills of undergraduate medical students in Applied Physiology of the cardiovascular system."

Paired *t*-test has been used for the analysis and $P = 0.05$ was considered to be statistically significant. Since, the *P* value (<0.001) is <0.05, there is statistically significant difference between pre- and post-test scores. Hence, the hypothesis is accepted and simulation-based teaching does has an effect (Table 2).

To analyze if there is gender difference regarding the impact of simulation-based teaching, null hypothesis implies that there is no difference between male and female in pre-/post-test scores, while the alternate hypothesis implies that there is difference between male and female in pre- and post-test scores.

Independent *t*-test has been used to test the difference in pre- and post-test scores between male and females. There is no significant difference in pre- and post-test scores between males and females who showed *P* values of 0.39 and 0.58, respectively (Table 3). Hence, both the male and female students have been shown to have received the same impact when simulation-based teaching was used.

The confidence interval (CI) for pretest is 20.88-21.55 and posttest is 36.28-36.71. The CI for pretest for female is 20.862-21.896 and male is 20.640-21.527. The CI for posttest for female is 36.202-36.919 and male is 36.177-36.704 (Table 4).

Impact of simulation-based teaching based on pre- and post-test scores of all the respondents are given in Table 2. The hypothesis tested was whether simulation-based teaching has an effect and the hypothesis is accepted, proving that simulation-based teaching does have a significant impact on the knowledge and skills of undergraduate medical students in Applied Physiology of the cardiovascular system.

Table 1: General characteristics of the respondents

Characteristics	Frequency (%)
Gender	
Female	66 (44.0)
Male	84 (56.0)
Age (in years)	
18.0	124 (82.7)
19.0	26 (17.3)
Total	150 (100.0)

Table 2: Impact of simulation-based teaching

Test	N	Mean±SD	*t*-statistic	*P* value
Pretest	150	21.21±2.07	−93.40	<0.001
Posttest	150	36.49±1.32		

SD: Standard deviation

Table 3: Gender difference regard impact of simulation-based teaching

Gender	*n*	Mean±SD	*t*-statistic	*P* value
Pretest				
Female	66	21.38±2.10	0.87	0.39
Male	84	21.08±2.04		
Posttest				
Female	66	36.56±1.46	0.55	0.58
Male	84	36.44±1.22		

Table 4: Confidence interval

	Pretest	Posttest
n=150	20.88-21.55	36.28-36.71
Gender		
Female	20.862-21.896	36.202-36.919
Male	20.640-21.527	36.177-36.704

There was no significant difference in pre- and post-test scores between males and female participants which showed *P* value of 0.39 and 0.58, respectively (Table 3). Hence, both male and female students have been shown to have received the same level of impact when simulation-based teaching was used.

DISCUSSION

Simulation creates an artificial real life situation, to study something through experience. Simulation is an innovation in medical education in recent times which is creating a paradigm shift toward experiential "hands-on" learning rather than traditional didactic lectures. The retention of information after a lecture with audiovisual enhancement is 30% while interactivity increases the retention to 75%.[6] There has been increased retention and student satisfaction reported in earlier studies, when the old "See One, Do One, Teach One" method is shifted to a "See One, Practice Many, Do One" model of success.[7]

HPS is of different types based on their resemblance to reality into low-fidelity, medium-fidelity, and high-fidelity simulators.[8-10] Based on the information received from centers around the world, there has been extremely overwhelming student satisfaction reported with the use of simulations and simulation-based teaching has proven time and again to be beneficial to the learners.[11-13] HPS is now being widely used in education and training of medical students as it has been included in their curricula.[14,15] Simulation has been shown in earlier studies to improve the understanding of cardiovascular and respiratory physiology.[16-18]

In this study, it has been proven that simulation-based teaching has a significant effect on the knowledge and skills of undergraduate medical students in Applied Physiology of the cardiovascular system and that both male and female students have received the same impact when simulation-based teaching method was used.

One of the major challenges to medical simulation, in general, is the fact that it is weak in methodology. Most of the published work is descriptive and the assumption that such learning is directly transferable to the clinical context is often untested.[19]

LIMITATIONS

The limitations of this study lies in the fact that similar to the earlier published studies, it is weak in methodology and requires further studies to document the retention of learnt skills. This can be overcome by assessing the students knowledge and skills of the students after a time interval.

CONCLUSION

Current generations of students have grown up in an electronic and interactive world. To keep pace with their learning styles, medical education needs to advance, and incorporate active learning strategies and simulations into all aspects of the curriculum, including the basic sciences. This experimental study has proven beyond doubt that simulation-based learning has an impact in their understanding of the concepts of Applied Physiology of the cardiovascular system of the I year medical under-graduate students.

The number of teaching modules available to the medical educator continues to expand and prove its effectiveness. In the future, simulation will only be limited by the imagination of the educator and the students. As a part of our future plans, simulation-based teaching modules incorporating innovative ways to present case scenarios relating to other systems of the human body such as the endocrine, renal, and the central nervous system are in the anvil.

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ANNEXURE

Sr. No.	Questionnaire (Based on Likerts Scale)	Responses			
		a	b	c	d
1	Cardiac output=Afterload×Heart rate				
2	End-diastolic volume determines the preload				
3	Giving carotid massage increases the HR				
4	Cardiac output=Stroke volume×Heart rate				
5	Diastolic BP is determined by cardiac output				
6	CPR improves perfusion of the brain				
7	Ejection fraction=Stroke volume/End-diastolic volume				
8	Patient in hypovolaemic shock should be covered with blankets				
9	Cardiac tamponade causes obstructive shock				
10	Hb level is a reliable parameter in early stages of shock due to blood loss				

HR: Heart rate, BP: Blood pressure, CPR: Cardiopulmonary resuscitation