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Original Article

Usage of High-Fidelity Simulation among Preclinical Medical Students in the Auscultation of Respiratory System

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Abstract

Background: High-fidelity simulation has emerged as an effective educational tool in preclinical medical training, particularly for skills related to the auscultation of the respiratory system.

Objectives: The study aimed to evaluate the impact of simulation on improving auscultation skills in respiratory system examinations among preclinical medical students and to gather views from facilitators and students on the simulation-based teaching and learning process.

Methods: An experimental pre-post study was conducted in a simulation lab of a teaching hospital between March and April 2018 among preclinical MBBS students. A total of 146 students were taken in batches of 50 to the clinical simulation lab. Following exposure to a simulation-based teaching module, they were subjected to post-intervention skill assessments on the high-fidelity simulators. The pre- and post-scores were compared to measure the impact of the teaching module using paired t-tests. The students' perspectives of the current module were compared using the Chi-square test (significance at $p<0.05$) and interpreted with the help of a pre-validated, researcher-made questionnaire.

Results: Pre- and post-intervention scores in the ability to identify breathing sounds (2.05 ± 0.85 and 2.98 ± 0.14) and added sounds (0.40 ± 0.74 and 1.96 ± 0.23) were statistically significant ($p<0.001$).A statistically significant difference in identifying differences in vesicular/bronchial and vesicular breathing and between wheezing and BA/COPD breathing was observed ($p<0.001$).

Conclusion: The medical students perceived high-fidelity simulation-based medical education as a beneficial teaching modality that improved performance. However, more research is required to determine the utility of this modality in a developing country like India.

Keywords: Auscultation; Clinical Competence; High-Fidelity Simulation Training; Medical Education; Respiratory System; Simulation Training

Background

Lung sounds are assessed as part of a standard clinical examination. Despite the advancement of numerous new procedures for detecting lung pathology in recent years, auscultation of the chest remains a useful clinical tool. It is still the most prevalent method for evaluating the lungs. Medical simulation has grown significantly in importance as a tool for clinical evaluation and education over the last 15 years (1).

Preclinical medical students must learn to recognize normal clinical findings during a respiratory system evaluation. The quality and outcome of learning and/or evaluation in simulation events can be improved by accurately reproducing realistic lung and heart sounds (1). Medical simulation has become popular as a valuable tool for both teaching and clinical evaluation (2, 3).

While simulation technology-which includes multimedia computer programs-is relatively new to the medical field, other fields have long used it. The use of flight simulators by astronauts and pilots, military personnel in war games and training exercises, business executives in management games, and nuclear power plant personnel in technical operations are a few examples (2). Simulation offers several potential uses at every stage of an individual's professional growth, as well as in assisting professional practice and ongoing professional development (3).

McGaghie et al. (4), in their meta-analysis, found simulation-based medical education with purposeful practice to be better than traditional clinical medical education for meeting specified clinical skill acquisition goals. McKinney et al. (5), in their review, showed that simulation-based medical education was an effective instructional technique for teaching cardiac auscultation. They also proposed that future research should examine key instructional design characteristics and determine the relative effectiveness of simulation-based medical education compared to other educational treatments. Preclinical students could learn about normal clinical respiratory system examinations, such as the auscultation of normal breath sounds from healthy subjects. However, there is a barrier to learning the nuances of abnormal breath sounds, a part of their syllabus during the preclinical phase. Simulation-based instruction becomes critical in their learning curve since the latter cannot be replicated in a healthy individual.

All medical schools aim to equip doctors with the knowledge, abilities, and professionalism required to provide high-quality patient care. Research on medical education aims to improve the efficacy, economy, and efficiency of the enterprise. The immediate and long-term objectives of medical education research are to demonstrate how educational initiatives support the evaluation of physician competency in clinical settings, simulation labs, and classrooms. The ultimate goal of medical education research is improved patient outcomes that are directly linked to educational experiences, which makes this scholarship eligible for translational science designation (4).

Data on the effectiveness of simulation-based learning among students is scarce. In a simulated situation, distinguishing between normal and aberrant breath sounds and identifying irreproducible additional noises in respiratory auscultation becomes easier. The main objective of this study was to assess the impact of simulation on improving auscultation skills in respiratory system examination among preclinical medical students. The findings of this study are anticipated to shed light on the usefulness of simulation-based learning and strategies to improve the module based on input from students and facilitators.

Objectives

The study aimed to evaluate the impact of simulation on improving auscultation skills in respiratory system examinations among preclinical medical students and to gather views from facilitators and students on the simulation-based teaching and learning process.

Methods

An experimental pre-post design study was conducted among 146 preclinical MBBS students admitted to the course during the 2017/2018 academic year in a simulation lab of a teaching hospital and medical institute. Students from both the central board and state board of school education systems were included. Both male and female students aged 18 to 25 were included in the study. Students who did not consent to the research were excluded from the study.

The study was conducted from April 2018 to May 2018 with approval from the Institutional Human Ethical Committee (Proposal no. 18/107; Ref No. PSG/IHEC/2018/Appr/Exp/119). Before the commencement of the study, informed consent was obtained from each participant, and complete anonymity of the participants was ensured throughout the process.

The structured and validated teaching module, comprising a lesson plan, specific learning objectives, learning materials, and an assessment tool (a checklist with scores and an answer key to the questions), was briefed to all facilitators involved, and they were oriented for its execution. The assessment tool was designed based on the guidelines from standard practical manuals (6, 7). Before its use, it was peer-validated with the help of subject experts for content and pretested in a group of first-year medical students who were not included in the main study for reliability (Cronbach's Alpha: 0.741). The students involved in the study had undergone conventional practical small-group teaching classes, using live human subjects to demonstrate breath sounds and added sounds.

Written informed consent from the students was obtained, and the enrolled participants were subjected to a pre-intervention skill assessment using the designed assessment tool. The predesigned learning material, adapted from standard practical textbooks of physiology describing the auscultation of the respiratory system, was provided to them. The students were taken in batches of 50 to the clinical simulation lab. After dividing the students into smaller tutorial groups, the facilitators implemented the teaching module with deliberate hands-on practice sessions in auscultation and recognizing the unique character of each breath sound and added sounds, namely wheeze, and crepitations, using high-fidelity simulators-SIMMAN 3G and Nursing Anne. Following exposure to the simulation-based teaching module, the study group was subjected to post-intervention skill assessment on the same high-fidelity simulators. Every YES was scored 1, and every NO was scored 0 during the pre- and post-intervention skill assessment.

The pre- and post-intervention scores were compared to measure the impact of the teaching module. The students' and facilitators' perspectives of the current module were interpreted with the help of a feedback questionnaire prepared by the author, which consisted of a set of five close-ended questions with a five-point Likert scale, followed by an open-ended question to welcome additional suggestions to improve the efficacy of the module. This feedback questionnaire was checked for internal reliability (Cronbach's Alpha 0.741). Content validity was done by expert review, and the evidence of acceptability using test-retest reliability was found to be 0.8. The responses to the feedback were categorized into binary variables as favorable and unfavorable to this simulation model and compared with the responses to the conventional model using the Chi-square test.

Data were analyzed using the statistical software R 4.0.3 and Microsoft Excel. Continuous variables were represented by mean ± SD and categorical variables by a frequency table. Shapiro-Wilk's test (Table 1) was used to check the normality of variables. A paired t-test was conducted to compare the two groups. The McNemar test was used to determine if there were differences in a dichotomous dependent variable between two related groups. A p-value less than or equal to 0.05 indicated significance.

Results

The mean ± SD age of the students was 19.8 ± 1.36 years. Among the 146 students, 61.6% (n = 90) were females, and 38.4% (n = 56) were males. Regarding educational background, 61% (n = 89) were from the Central Board of Education, while the remaining 39.04% (n = 57) were from the State Board.

We observed a mean pre-intervention score of 2.05 ± 0.85 in the ability to identify breathing sounds, and the post-intervention score was 2.98 ± 0.14. In addition, a mean pre-intervention score of 0.40 ± 0.74 and a post-intervention score of 1.96 ± 0.23 were recorded to identify added sounds (Table 1).

Using the McNemar test, a statistically significant difference was observed in the ability to identify breath sounds, the difference in vesicular/bronchial breathing, and identifying vesicular breathing ($p<0.001$) pre- and post-intervention (Table 2).

Using the McNemar test, a similar statistically significant difference in the ability to identify added sounds and a difference in identifying wheeze and BA/COPD breathing ($p<0.001$) was observed pre- and post-intervention (Table 3).

Using the paired t-test, we determined that the distribution of ability in the identification of pre- and post-intervention breathing sounds and added sounds is statistically significant ($p<0.001$) (Table 4).

Regarding the feedback from the participants, 79.5% of the students opined that this model made their learning easier, and 78.8% agreed that this technique successfully met the given objectives. Moreover, 82.9% believed this simulation-based learning enhanced their clinical acumen. When the participants' ratings regarding the conventional and simulation-based models were compared, there was a statistically significant difference (Chi-Square Test). The simulation-based model was rated higher ($p<0.001$, Table 5).

Discussion

We conducted a study using a pulmonary auscultation manikin and employed a deliberate practice framework and hypothesis-driven approach to address the demand for teaching lung sounds auscultation. Our study was generally well-received, and it helped us assess the impact of simulation in improving auscultation skills in respiratory system examination among preclinical medical students and gather views on the simulation-based teaching and learning process among facilitators and students.

Typically, simulation is reserved for the clinical years of medical school; however, applying high-fidelity simulation (HFS) to preclinical first-year medical students proved that simulation is a viable method for integrating basic knowledge with clinical scenarios. Our study also observed that the identification of breath sounds, added sounds, and pathological conditions such as bronchial asthma and chronic obstructive pulmonary disease significantly improved in the post-intervention group. HFS is known to replicate clinical scenarios and modify patient cases to help students make informed decisions (8).

Harris et al. assessed first-year medical students' knowledge and perceptions of cardiovascular physiology and congestive heart failure treatment techniques (9). After simulation, comparing a six-question test's pretest and post-test results revealed a 22% improvement in accurate responses. Similarly, Valente et al., in comparing high and low-fidelity simulations for determining respiratory failure in emergency pediatric patients, found that fourth-year medical students usingHFS performed better and had improved confidence in determining variations in clinical conditions and memory retention (10). Nonetheless, students in the intervention group had generally positive opinions toward HFS-based learning, which are similar to those observed in the study by Joseph et al. (11).

The ability of high-fidelity simulation-based medical education (HF-SBME) to improve clinical skills and increase patient safety and comfort was viewed as the most important advantage by the students. According to a study by Joseph et al. (11), over 57.5 percent of students believed SBME would diminish their communication skills. Furthermore, 45 percent of students believed that using SBME would lower their empathy for patients. A study conducted in Malaysia also reported insignificant improvement in knowledge using SBME (12).

This study suggests that SBME is an effective instructional approach for teaching respiratory auscultation. Based on these findings, it can be concluded that nearly all of the students had successfully acquired the auscultation skills of breathing and added sounds. Similar to the present study results, Tawalbeh's study (13) on the influence of simulation on nursing students' cardiopulmonary system examination skills found that the students' skill levels were much greater after the simulation.HF-SBME in an emergency nursing setting also enhanced clinical decision-making skills (14). HFS for cardiac auscultation reduces performance anxiety among students and improves their knowledge, diagnostic capability, and ability to recognize abnormal cardiac sounds (15).

Although a regular feature in the developed world, HF-SBME has only recently gained interest in India (16). Conventionally, these results also showed that the students performed better with simulation-based education, as seen in a study conducted in Karnataka, India, among first-year medical students, which reported enhanced understanding of the clinical scenario, decision-making, communication, and teamwork skills (17).

Money is a major consideration when incorporating HFSB into the medical curriculum in a developing country like India. As a result, careful planning is essential prior to the acquisition and use of such technology.

This research has a few limitations. Since this was a single-center study, the results may not apply to other medical institutes in India. Furthermore, as this study only used SIMMAN 3G and Nursing Anne as simulators, the results may not apply to other simulations. Finally, the examiner's assessment of the student clinical examination was subjective, and more objective assessment techniques could have been used. Multi-center randomized control trials with a greater variety of simulation experiences are required to gain a better understanding.

Conclusion

The observations from the present study reinforce the need for using simulators as a teaching and evaluation tool. In addition, it is thought that implementing simulation applications that include more comprehensive physical examination skills would facilitate the integration of knowledge and skills and improve student attitudes toward holistic patient assessment.

In conclusion, more studies are still necessary to explore the potential use of HFS-based education as an effective tool to increase medical students' competence levels and to better understand its impact on patient outcomes.

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Conflict of interests: There is no conflict of interest.

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Table 1. Descriptive statistics of the study population

Breath sounds	**Pre-intervention n (%)**	**Post-intervention n (%)**
Vesicular/bronchial		
No	47 (32.19)	2 (1.37)
Yes	99 (67.81)	144 (98.63)
Places diaphragm	19 (13.01)	146(100)
No	127 (86.99)	0 (0)
Yes		
Identifies vesicular		
No	72 (49.32)	1 (0.68)
Yes	74 (50.68)	145 (99.32)
Added sounds		
Identifies wheeze		
No	113 (77.4)	4 (2.74)
Yes	33 (22.6)	142 (97.26)
BA/COPD		
No	121 (82.88)	2 (1.37)
Yes	25 (17.12)	144 (98.63)
Variables	**Mean (SD)**	**Mean (SD)**
Breath sounds total score	2.05 (0.85)	2.98 (0.14)
P-value (Shapiro Wilk's test)	0.16	
Added sounds total score	0.40 (0.74)	1.96 (0.23)
P-value (Shapiro Wilk's test)	0.12	

BA/COPD: Bronchial Asthma/ Chronic Obstructive Pulmonary Disease

Table 2. Comparison of ability in identification of pre and post-intervention of breath sounds

	Post-Intervention No	Post-Intervention Yes	P value
Breath Sound (Vesicular/bronchial)			< 0.001*
Pre-Intervention-No	2	45	
Pre-Intervention-Yes	0	99	
Breath Sound (Places diaphragm)			-
Pre-Intervention-No	0	19	
Pre-Intervention-Yes	0	127	
Breath Sound (Identifies vesicular)			< 0.001*
Pre-Intervention-No	1	71	
Pre-Intervention-Yes	0	74	

*Indicates significance at $p<0.05$.

Table 3. Comparison of ability in identification of pre and post-intervention of added sounds

	Post-Intervention No	Post-Intervention Yes	P value
Added Sound (Identifies wheeze)			< 0.001*
Pre-Intervention-No	4	109	
Pre-Intervention-Yes	0	33	
Added Sound (BA/COPD)			< 0.001*
Pre-Intervention-No	2	119	
Pre-Intervention-Yes	0	25	

*Indicates significance at $p<0.05$.
BA/COPD: Bronchial Asthma/ Chronic Obstructive Pulmonary Disease

Table 4. Comparison of ability in the identification of pre- and post-intervention sounds

Variables	Post-Intervention	Post-Intervention	P value
	Mean (SD)		
Breath sound	2.05 (0.85)	2.98 (0.14)	< 0.001*
Added sound	0.40 (0.74)	1.96 (0.23)	< 0.001*

*Indicates significance at $p<0.05$.

Table 5. Student's feedback on training module

Student's perspective	Favour Simulation model of teaching	Favour Conventional model of teaching	P value
Made their learning easy	116 (79.5%)	30 (20.5%)	< 0.001*
Met the objectives successfully	115 (78.8%)	31 (21.2%)	< 0.001*
Enhanced their clinical acumen	121 (82.9%)	25 (17.1%)	< 0.001*

*Indicates significance at $p<0.05$.