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Medical students' perceptions of understanding skills needed in treating cardiac patients through simulation-based encounters in a clinical skills curriculum

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Abstract

Context: Simulation-based education can enhance medical students' understanding of clinical concepts as they learn the key elements needed to treat patients with various medical conditions. The integration of simulation programs into medical school curricula increases students' exposure to this type of learning.

Objectives: To determine the effectiveness of simulation activities on medical students' perceptions of understanding cardiac rhythm identification and the pharmacology skills necessary to manage a stable patient with cardiac arrhythmia.

Methods: A retrospective secondary data analysis was conducted utilizing a quasi-experimental one-group pretest/posttest study of a convenience sample of 159 second-year medical students in the southeastern United States during the 2017–2018 academic year. Because this was a one-group pretest/posttest study, only second-year medical students whose data could be matched were included. A 5-point Likert scale, previously developed as part of the clinical skills course, was utilized to collect ordinal understanding of cardiac rhythm identification and the pharmacologic management of a stable patient with cardiac arrhythmia. The intervention was an 18-min simulated patient encounter involving a high-fidelity mannequin (SimMan 3G or Essential) with supraventricular tachycardia.

Results: Of the 159 students, the number of students who reported a good perception of understanding of cardiac rhythm identification presimulation activity increased from 44.0% (70) to 52.2% (83) postsimulation activity. The number who reported a good perception of understanding of the pharmacologic management of a stable patient with cardiac arrhythmia presimulation increased from 37.7% (60) to 49.1% (78) postsimulation. A Wilcoxon signed-rank test model was fitted to examine improvements in perceptions of understanding of cardiac rhythm identification and the pharmacologic management of cardiac arrhythmia. The results suggested that participation in simulation activities elicited a statistically significant improvement in the students' perceptions of understanding of cardiac rhythm identification and the pharmacologic management of cardiac arrhythmia ($p=0.000$).

Conclusions: As medical education continues to evolve, simulation-based education may be helpful in enhancing medical students' understanding of cardiac rhythm identification and the pharmacology skills necessary to manage a stable patient with cardiac arrhythmia.

Keywords: cardiac patient management; clinical skills curriculum; medical education; medical students; simulation-based encounters.

The results of the Association of American Medical Colleges (AAMC) 2011 survey on the use of simulation activities across different curricula and teaching institutions indicated that the majority of respondents utilized some form of simulation across all 4 years of undergraduate medical education [1]. Participating in medical simulation activities during undergraduate medical training is viewed by medical students as integral to the curriculum, with many believing that medical simulation is a crucial component of their overall educational experience [2, 3]. Medical simulation is an effective educational modality that affects students' ability to understand the clinical significance of patient care and impacts personal development [4]. While

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medical simulation has been utilized to enhance awareness of medical problems and the need for situational awareness, and even to teach the basic sciences, it often lacks a well-defined use and consensus as a theoretically driven intervention [4, 5]. Several studies have examined the effectiveness of simulation-based education through the lens of Kolb's Experiential Learning Theory (ELT); there is, however, still a lack of research regarding students' achievement of the fourth stage of the ELT, depending on how simulation is utilized [6, 7]. Guided by the four-step cycle of the ELT (concrete experience, reflective observation, abstract conceptualization, and active experimentation), this study focused on the fourth stage by examining students' perceptions of utilizing medical simulation to influence their understanding of cardiac rhythm identification and the pharmacologic management of a stable patient with cardiac arrhythmia [6, 7]. This study was based on the following research question: Does participating in a simulation activity influence a second-year medical student's perceived understanding of cardiac rhythm identification and the pharmacologic management of a stable patient with cardiac arrhythmia?

Methods

The Institutional Review Board of A.T. Still University approved this study as exempt on August 14, 2020. No funding was provided for this study. There was no clinical trial registry, informed consent, or compensation for this study because it was part of established curriculum activities in which participation was required for all students. For the purpose of this study, the operational definition of simulation is the artificial recreation of a patient with a specific complex medical problem with the purpose of practicing treatment and management of this condition. The simulation activity in this study included a prebriefing, a simulation encounter, and a debriefing [8]. To examine the influence of the simulation activity, same-day perceptions of understanding were evaluated pre- and postintervention to measure the degree of change in cardiac rhythm identification (Cards1_Rhythm) and the pharmacologic management (Cards2_Pharm) of a stable patient with cardiac arrhythmia. For the purpose of this study, Pre-Cards1_Rhythm refers to presimulation cardiac rhythm identification, Post-Cards1_Rhythm refers to postsimulation cardiac rhythm identification, Pre-Cards2_Pharm refers to presimulation cardiac pharmacologic management, and Post-Cards2_Pharm refers to postsimulation cardiac pharmacologic management.

Intervention

The medical students participated in an assigned two-part simulation encounter with the first being cardiac-related in Week 4 of a 9-week course. Each simulation activity started with a prereading that pertained to the medical simulation scenario. After the students completed the preassessment (baseline data/pretest), two teams of

five students each entered the simulation lab, where a faculty facilitator provided a brief review orientation to the room and supplies. The students then interacted with a high-fidelity mannequin—SimMan 3G or Essential© (Laerdal Medical)—programmed on LLEAP SimDesigner© and controlled by a simulation technician (Figure 1).

For the cardiac simulation, the students were exposed to a simulated patient encounter that lasted 18 min and involved supraventricular tachycardia. The students were expected to apply the cardiac monitor, interpret the rhythm on the electrocardiogram, obtain vital signs, gather a history, and perform a physical examination under the guidance of a team leader. After the history was gathered by the students, the patient was considered stable, and the students had to treat the patient appropriately by starting an intravenous line, considering vagal maneuvers, reassessing the patient, and then choosing the appropriate pharmacologic management to treat the condition.

After each simulation encounter, both student teams came together with a faculty clinical provider in one debriefing room located in the simulation center for a 45-min meeting. Each debriefing started with student reflection, which allowed the students to talk about their feelings before and during the simulation. There was also an opportunity for each student to identify one thing they did well and one thing they could improve upon in the future. The discussion allowed for the clinical faculty member to correct any poorly executed treatments.

Research design

This quasi-experimental one-group pretest/posttest study utilized the retrospective secondary data set of a survey on second-year medical students in a clinical skills course at one osteopathic medical school in the southeastern United States. The secondary data set consisted of deidentified, paired data from a convenience sample population of 159 undergraduate second-year medical students during the 2017–2018 academic year. As part of normal curriculum activities in a clinical skills course, the whole sample population was required to participate and provide data on pre- and postexposure to simulation-based education; no demographic information was obtained. The recommended minimum sample size of 47 was calculated utilizing G*Power 3.1 software [9], with the following statistical inputs: alpha (α err prob) = 0.05; medium effect size = 0.5; and power ($1-\beta$ err prob) = 0.90. A sample size of 159 participants was obtained to increase generalizability.

The information contained in the secondary data set was collected through online surveys. The medical students completed the pre-assessment survey on computers placed in the hallway before entering the simulation scenario, and they completed the post-simulation assessment on computers at the simulation center immediately after the debriefing session (Table 1). The Medical Education Department paired the data by student names before approving access to the deidentified data; this blinded the researcher to the respondents' identities. No informed consent was obtained, because the simulation activity was a required curricular activity. The complete secondary data set was exported to IBM's SPSS Version 27 for data analysis.

Univariate analysis utilizing distribution of percentages, frequencies, and central tendencies (mean, median, standard deviation) was conducted on the participants' responses to two questions in the pre- and postsimulation data. Due to a nonnormal data distribution, bivariate analysis, utilizing a Wilcoxon signed-rank test model, was done to determine the statistical significance, if any, of the median difference between the students' pre- and postsimulation perceptions

Figure 1: Simulation activity process. Flow diagram representing the simulation activity from beginning to end.

of understanding of cardiac rhythm identification and the pharmacologic management of a stable patient with cardiac arrhythmia. Results were considered significant at $p < 0.05$.

Results

A panel of faculty members developed the measurement instrument to measure students' perceptions of understanding of cardiac rhythm identification and the pharmacologic management of a cardiac condition before and after a simulation activity. Ordinal data were collected utilizing a 5-point Likert scale (1=poor understanding, 2=fair understanding, 3=good understanding, 4=very good understanding, 5=excellent understanding). The survey had a Kaiser–Meyer–Olkin coefficient of 0.772, a Bartlett's sphericity test result of < 0.001 , and a Cronbach's alpha of 0.89.

The secondary data set was analyzed to measure differences in the median scores of the perceived understanding of the skills needed to treat a cardiac patient. The pre- and postassessment data of 159 second-year medical

students were included in this study, calculated utilizing the median and interquartile range (IQR). No demographic information was collected for original data; therefore, no demographic information was analyzed. The distribution of responses for the students' perceived understanding of cardiac rhythm identification and the pharmacologic management of a stable patient with cardiac arrhythmia before and after the simulation activity is shown in Table 2. Before the simulation activity, the majority of the students reported a good (70; 44.0%) or fair (64; 40.3%) understanding of cardiac rhythm identification (Pre-Cards1_Rhythm); on the postsimulation survey (Post-Cards1_Rhythm), the majority reported a good (83; 52.2%) or very good (38; 23.9%) understanding of cardiac rhythm identification. Before the simulation activity, the majority of the students reported a fair (73; 45.9%) or good (60; 37.7%) understanding of the pharmacologic management of a stable patient with cardiac arrhythmia (Pre-Cards2_Pharm); on the post-simulation survey (Post-Cards2_Pharm), the majority reported a good (78; 49.1%) or very good (53; 33.3%) understanding of the pharmacologic management of a stable patient with cardiac arrhythmia (Table 2).

Table 1: Survey questions.

Variable	Label measurement	Variable measure	Measurement level	Variable value
Cards1_Rhythm	Rhythm identification	Please rate your understanding of cardiac rhythm identification.	Ordinal	1=Poor 2=Fair 3=Good 4=Very good 5=Excellent
Cards2_Pharm	Cards pharmacology	Please rate your understanding of the pharmacologic management of a stable patient with cardiac arrhythmia.	Ordinal	1=Poor 2=Fair 3=Good 4=Very good 5=Excellent

Table 2: Distribution of students' responses to perceived understanding.

Response	Pre-Cards1_Rhythm		Post-Cards1_Rhythm		Pre-Cards2_Pharm		Post-Cards2_Pharm	
	n	%	n	%	n	%	n	%
Excellent	4	2.5	6	3.8	4	2.5	8	5.0
Very good	18	11.3	38	23.9	13	8.2	53	33.3
Good	70	44.0	83	52.2	60	37.7	78	49.1
Fair	64	40.3	31	19.5	73	45.9	19	11.9
Poor	3	1.9	1	0.6	9	5.7	1	0.6
Total	159	100	159	100	159	100	159	100

Precardiac simulation data analysis results showed a median (IQR) of 3.0 (1.0) for the students' perceived understanding of cardiac rhythm identification and 2.0 (1.0) for the students' perceived understanding of the pharmacologic management of a stable patient with cardiac arrhythmia (Table 3). Postcardiac simulation data analysis results showed a median (IQR) of 3.0 (1.0) for the students' perceived understanding of cardiac rhythm identification and 3.0 (1.0) for the students' perceived understanding of the pharmacologic management of a stable patient with cardiac arrhythmia (Table 3).

Among the 159 participants, the simulation encounter elicited an increase in the perception of understanding of cardiac rhythm identification in 59 participants between the pre- and posttests; only five participants reported a decrease in perception between the two time points, while 95 participants reported no difference. The results suggested a statistically significant median increase between the pre- and postsimulation perceptions of understanding of cardiac rhythm identification among participants who reported an improvement in perception ($Z=-6.599$, $p=0.000$) (Table 3).

Among the 159 participants, the simulation encounter elicited an increase in the perception of understanding of

the pharmacologic management of a stable patient with cardiac arrhythmia in 96 participants between the pre- and posttests; only three participants reported a decrease in perception between the two time points, whereas 60 participants reported no difference. The results suggested a statistically significant median increase between the pre- and postsimulation perceptions of understanding of the pharmacologic management of a stable patient with cardiac arrhythmia among participants who reported an improvement in perception ($Z=-8.748$, $p=0.000$) (Table 3). The pharmacologic management of a stable patient with cardiac arrhythmia was the only variable with an observable increase in median scores in perception between the pretest (2.0) and posttest (3.0).

Discussion

The current findings suggest that the role of simulation activities is increasing. The increase in this study's osteopathic medical students' perceptions of their understanding of cardiac rhythm identification and the pharmacologic management of a patient with cardiac arrhythmia cannot be

Table 3: Wilcoxon signed-rank test (n=159).

Variables	Median	Interquartile Range	Percentile			Model	Rank	n	Z	Asymptomatic significance (2-tailed)
			25	50	75					
Pre-Cards1_Rhythm	3.00	1	2.00	3.00	3.00	Post_Cards1_Rhythm - Pre_Cards1_Rhythm			-6.599 ^b	0.000
Post-Cards1_Rhythm	3.00	1	3.00	3.00	4.00		Negative ranks	5 ^a		
							Positive ranks	59 ^b		
							Ties	95 ^c		
							Total	159		
Pre-Cards2_Pharm	2.00	1	2.00	2.00	3.00	Post_Cards2_Pharm - Pre_Cards2_Pharm ^g			-8.748 ^b	0.000 ^g
Post-Cards2_Pharm	3.00	1	3.00	3.00	4.00		Negative ranks	3 ^d		
							Positive ranks	96 ^e		
							Ties	60 ^f		
							Total	159		

^aPost_Cards1_Rhythm < Pre_Cards1_Rhythm. ^bPost_Cards1_Rhythm > Pre_Cards1_Rhythm (based on negative ranks).

^cPost_Cards1_Rhythm = Pre_Cards1_Rhythm. ^dPost_Cards2_Pharm < Pre_Cards2_Pharm. ^ePost_Cards2_Pharm > Pre_Cards2_Pharm.

^fPost_Cards2_Pharm = Pre_Cards2_Pharm. ^gObservable statistically significant difference in median values.

underestimated. In this study, the students' perceptions of their understanding of cardiac rhythm identification and the pharmacologic management of cardiac arrhythmia increased after the students participated in the simulation activity. These findings are significant because the general expectation is for medical students to recognize and initiate treatment for cardiac arrhythmia immediately after graduation, on the first day of residency [10]. The current study suggests that simulation activities related to cardiac care may be an effective educational method for second-year medical students when embedded in the curriculum. Several other studies have utilized simulation to influence medical students' perceptions of understanding of the critical cardiac skills needed to provide patient care and have reported similar results [11–13]. Simulation can strongly influence medical students' perceptions of understanding, especially when it is embedded in the medical school curriculum. Whereas this study showed how influential simulation can be when embedded early in the curriculum, other studies have reported similar findings when simulation is placed later in the curriculum [12, 14, 15].

Such findings are relevant to the overall training of osteopathic medical students, which is currently based on competencies and entrustable professional activities (EPAs). The medical competencies and skills needed when entering the first year of residency for osteopathic physicians are outlined in the *Osteopathic Considerations for Core Entrustable Professional Activities (EPAs) for Entering Residency*, and they align with the competencies of the

American Association of Colleges of Osteopathic Medicine and the AAMC [10]. Simulation activities can increase students' understanding, creating a solid educational foundation from which one can see advancement from a pre-entrustable to entrustable level. Although other components of the simulation activity not directly studied may align well with many EPAs, this study's results directly correlate with EPA 10: "the ability to promptly recognize a patient who requires urgent or emergent care, initiates evaluation and management, and seek help is essential for all physicians." [10] A student's ability to recognize a patient who is decompensating and differentiate between urgent and nonurgent care are addressed in this EPA [10]. On the first day, first-year residents should be prepared to care for tachyarrhythmias (e.g., supraventricular tachycardia), as well as initiate treatment [10], which was addressed in this study. The pre-entrustable resident needs supervision to carry out specific tasks or levels of responsibility. In contrast, the entrustable resident has gained trust over time by being exposed to tasks and patients with different care needs, and the resident no longer needs direct supervision. Utilizing simulation activities early in a medical school curriculum explicitly addresses the critical skills required in EPA 10. This early use of simulation activities provides an opportunity to increase the number of exposures, leading recently graduated medical students to entrustability sooner.

The lack of evidence in the current literature that simulation affects knowledge retention of pharmacology

does not mean that simulation activities do not have a place in pharmacology instruction in a medical school curriculum. Fouad et al. [16] showed higher assessment scores with a strategically executed pharmacology curriculum utilizing simulation among 646 third-year medical students allocated into groups of seven students. The current study showed that simulation strategically placed in the curriculum increased medical students' understanding of the application of pharmacology. The current study offers a true purpose behind simulation activities, but further research is needed to evaluate what simulation activities would be best suited for medical school pharmacology education, and where.

Yang et al. [17] suggested that all simulation should be created with some form of educational theory. Kolb's ELT suggests that providing a concrete experience, offering reflective debriefing, and allowing abstract conceptualization followed by active experimentation may lead to students' increased understanding of the key concepts of medical education. This study's findings support the use of Kolb's ELT when creating simulation activities embedded in a clinical skills curriculum. In this study, the students were assessed before being exposed to the concrete experience of the simulation, which is the first step in the learning theory. The students were then assessed after the debriefing session, which allowed for reflective observation and abstract conceptualization, which are the second and third steps of the learning theory. Future studies are needed to evaluate the use of simulation weeks after the initial exposure, thereby exploring achievement of the fourth stage of the learning theory.

This study must be considered in the context of its limitations. This study utilized convenience sampling at one medical school; therefore, its findings are limited to a specific population. Because all of the study participants were medical students who were required to participate in these activities as part of the curriculum, the results may not be generalized to another medical school or a different sample. Another limitation is the use of a retrospective secondary data set, which limited the context of the results to the specific variables being studied with no considerations for confounding variables [18]. This limitation could be reduced by adding a control group consisting of students not exposed to the simulation activity or a comparison group consisting of students exposed to a different kind of simulation activity, and then comparing the data between the groups. In addition, it is important to consider the possibility of student–student communication as well as distractions in the hallway while completing the pretest survey, because these may have confounded the observed outcomes. There is also the possibility that student–student communication

postsimulation contaminated the pretest responses of the students who had not yet participated.

There are several opportunities to improve upon this study. First, there is an opportunity to redesign the study to a longitudinal study, assessing the continued effects of simulation on medical students throughout their training. A longitudinal design would allow for better understanding and reliability of simulation activities as a model for instruction and assessment specifically related to competencies or EPAs as undergraduate medical students move into graduate medical education as resident physicians. A longitudinal design may also open the opportunity to better assess the effects of the active experimental stage of Kolb's ELT on medical students. It would provide more opportunities for students to work through the learning theory many times. The implications from a research perspective may allow for further investigations regarding the proper timing between simulation activities, helping create a best practices model for simulation in undergraduate medical school education. There is also an opportunity to create a secondary data set from all the medical simulation pre- and posttest assessments to compare the current data set to prior or future academic years. This data comparison would be useful to evaluate the quality or consistency of the delivery of simulation activities over time and offer insight into the future development of simulation activities.

When considering the development of future simulation activities, there is an opportunity to study different simulation or debriefing delivery methods (virtual reality vs. live in-person simulation) and compare the results. There is also an opportunity to evaluate the timing of the simulation activities in relation to the curriculum. After initial exposure to a particular medical simulation, students could repeat the simulation in subsequent years. A comparison of the results may yield new information in terms of a more appropriate place for the simulation in the curriculum. A change in the debriefing session postsimulation may also be necessary if a comparison of in-person vs virtual remote debriefing sessions suggests that one mode is more effective than the other.

Conclusions

The cardiac rhythm identification and the pharmacologic management of a stable patient with cardiac arrhythmia simulation activity utilized in this study was rooted in Kolb's ELT. Future investigation is warranted to maximize learner experiences in the curriculum, with special investigation into whether subsequent experiences should be the same or different to meet the fourth stage of Kolb's ELT, active experimentation [6]. The provision of such guided learning

experiences may require dedicated educators and curriculum developers to ensure strategic placement of cardiac-related simulation activities in the curriculum throughout all 4 years of medical school, allowing for reinforcement of the clinical reasoning abilities that students develop as they enter and progress through residency.

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Competing interests: None reported.

Ethical approval: This was reviewed by the A.T. Still University Institutional Review Board and found to be in the exempt category according to 45CFR46.104 (d)(2)(i).

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