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Brief Report

Outcomes of Using Heart Sound Simulator in Teaching Cardiac Auscultation

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Abstract

Background: Despite continued curriculum reform, the clinical skills competencies of medical graduates at all levels are steadily declining within a training system, where bedside opportunities become a luxury and the laboratory tests prevail over the clinical skills. While high-fidelity expensive simulators are being embraced by high-procedure volume specialties, low-fidelity and relatively inexpensive simulators, such as the heart sounds simulators remain under-utilized in medical training.

Method: We used a commercially available heart sound synthesizer in 2-hour training sessions with students and residents. Pre-post testing was completed at the beginning of the training session and three weeks after the session; participant responses were recorded by audience interactive response system.

Results: We utilized paired t-tests to show a significant increase in knowledge and skills 3 weeks after completion of the simulation training ($t = 17.7$; $p < 0.001$) with a large effect size (Cohen's $d = 3.67$).

Conclusions: Based on our findings and the review of literature, we recommend that heart sound simulation should be introduced at the medical student level as the standard for teaching cardiologic auscultation findings and as preparation for auscultation of live patients. We also suggest that training with digitally simulated heart sounds is similarly beneficial in resident training.

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Introduction

The use of clinical simulation in medical professional training is growing continuously. Anesthesiology and Emergency Medicine use clinical simulation on a regular basis. Among the Emergency Medicine Residency programs, for example, 91% use some form of clinical simulation, 85% use manikin-supported simulation, and 43% own simulation equipments. The average simulation use in EM residency programs is 10 hours per year.[1]

Other training programs reach out to clinical simulation as well. A study assessed outcomes of the participation of 18 pediatric residents in a manikin-based simulation in emergency pediatrics, and found improvement in task-specific technical skills (64% to 93%) and in resident practice behaviors (65% to 85%).[2] A randomized trial in Advanced Cardiac Life Support (ACLS) simulation with 38 second-year internal medicine residents demonstrated that resident performance improved significantly using clinical simulation and such gains were not observed as a function of clinical experience alone.[3]

Despite easy access to on line and multimedia resources for learning physical examination, literature and feedback from faculty have continued demonstrating deficiencies of clinical skills in residents and medical students (MS3-4), particularly cardiac auscultation. We present our experience of using heart sounds simulator (Cardionics, Houston) in teaching cardiac auscultation to medical students (MS3-4) and residents (Internal Medicine and Pediatrics) during the period 2004-2008.

Methods

We report the results from the participation of medical students in the third and fourth year of their program, and residents in internal medicine and pediatrics, in a 2-hour training session in cardiac auscultation. The elective training utilized electronic heart sound simulation coupled with didactic teaching and discussion about the origin of heart sounds. The study was approved by the institutional review board (IRB #E00112/2009; Texas Tech University HSC, El Paso, TX).

We used a commercially available heart sound synthesizer/simulator (CardioSim digital heart sound system, versions V-VII; Cardionics, Inc.). Each training session started with a multimedia 10-scenario pre-test (Table 1). Each auscultatory scenario consisted of a brief description of the patient's physical status, site of auscultation, the audio clip and five response options. Answers were recorded with an audience interactive response system (AIRS, Turning Point, Version 4.0) for measuring the baseline heart sounds recognition level of the participants.

Table 1. Pre and post test scenarios: Participants were asked to listen to the auscultation clip and select the best answer from a MCQ menu.

Auscultation Details	Simulated Sounds
1. Cardiac auscultation along LSB of a 35 y-o patient	1. Normal cardiac auscultation
2. Cardiac auscultation at 2nd ICS, LSB of a 40 y-o patient	2. Mid-systolic murmur of valvular aortic stenosis
3. Cardiac auscultation at 5th ICS, LSB of a 30 y-o college student	3. Normal S1, S2 and S4
4. Cardiac auscultation at apex of a 25 y-o patient with progressive shortness of breath	4. Mid-systolic click of mitral valve prolapsed
5. Cardiac auscultation along the left sternal border of a 30 y-o patient	5. Both systolic and diastolic murmurs of aortic stenosis and regurgitation
6. Cardiac auscultation at apex of a 36 y-o woman	6. Systolic murmur and mid-systolic click of a severe mitral valve prolapsed
7. Cardiac auscultation at 2nd ICS, LSB of a 22 y-o patient	7. Systolic murmur and wide fixed splitted S2 of atrial septal defect
8. Cardiac auscultation at 2nd ICS, LSB of a 21 y-o patient.	8. Continuous murmur of patent ductus arteriosus
9. Cardiac auscultation at apex of a 28 y-o patient	9. Splitted S2 and diastolic murmur of mitral stenosis
10. Cardiac auscultation at apex of a 46 y-o patient	10. Systolic murmur and diastolic murmur of mitral stenosis and regurgitation

The faculty presenter used a highly interactive teaching approach to ensure the learners' comprehension and practice opportunities. During the first session, the participants were trained in basic cardiac auscultation such as timing the cardiac cycle, differentiating heart sounds and heart murmurs, pitch, location of maximum heart sound/murmur intensity and other clinical characteristics. The simulated heart sounds or murmurs were played multiple times for the participants to practice, besides the discussion of pathophysiology of the auscultatory findings. Of note, the participants were not given the same heart sounds used in the testing mode; rather, they were taught the principles of recognizing the sounds and the related under-laying pathology. Re-testing was done 3 weeks after the completion of the first session by using the heart sound simulator and the same 10 questions of the pre-test. Participants' responses were recorded with AIRS.

A paired *t*-test was used for analysis of participants' pre and post-test data. The data collected during the pre- and post-tests for each group were analyzed utilizing statistical software SPSS 17.0.

Results

Sixty three (63) participants took the 2-hour training session in cardiac auscultation (2004-2008). Table 2 presents the group mean scores at the pre- and post-test. For the overall mean for the ten groups, the mean pre-test score was 31.4 (SD = 11.96), and the mean post-test score was 73.6 (SD = 11.04). The paired t-test showed a statistically significant difference ($t = 17.7$; $p < 0.001$) for the pre- and post-test results. Cohen's d – a measure of the magnitude of the differences between pre and post-test – was 3.67. A close inspection of Table 2 reveals that there is considerable variability between groups (e.g., year of assessment and students versus residents). This is probably due to the small numbers in the groups and variability of prior learning. Nonetheless, the short term (3 weeks) improvement of knowledge and skills in cardiac auscultation was large (Cohen's d is large).

Discussion

The 2008 Academic Emergency Medicine Consensus Conference outlined six areas for research about the role of simulation in clinical training: (1) measurement of procedural skills; (2) development of performance standards; (3) assessment and validation of training methods, simulator models and assessment tools; (4) optimization of training methods; (5) transfer of skills learned in simulation to patient care; and (6) prevention of skill decay over time.[4]

Deliberate practice with problem-solving, feedback and opportunities for multiple repetitions of performed tasks and/or responses to a given situation help refine

Table 2. Pre-and post-test results for heart simulation exercise participants, tested with audience response system, 2004-2008.

Date	Participants	Pre-test	Post-test
April 2004	MS IV students	32.00	68.00
August 2004	MS IV students	24.00	62.00
August 2005	MS IV students	38.00	87.00
February 2006	MS IV students	62.00	94.00
August 2006	MS IV students	28.00	66.00
August 2007	MS IV students	22.00	78.00
August 2007	IM residents	34.00	81.00
August 2008	MS IV students	26.00	72.00
December 2008	MS III students	22.00	67.00
December 2008	Pediatric Residents	26.00	61.00

student behaviors.[5] A qualitative study explored student experiences with a 2-hour simulation-based exercise involving management of acutely ill patients; 94% of the students rated their experiences with simulation as "excellent" and 91% suggested that simulation should be a "mandatory" part of student clerkships.[6]

Despite continued curriculum reform, clinical skills competencies in medical graduates at all levels have steadily declined, particularly their physical examination skills.[7] The causes of this deficiency appear to be multi-factorial: (1) inadequate teaching/training in clinical skills, (2) inadequate exposure or contact with teacher-trainer, (3) inadequate opportunities for self-assessment of clinical skills competency, (4) inadequate learners' motivation in correcting the deficiency, and (5) inadequate training of physical examination skills for the trainers.[8] In the current training system and the practice of medicine, bedside teaching opportunities become a luxury; and the laboratory tests prevail over the clinical skills. Not too often learners' competencies in physical examination are properly tested and validated by standardized tests such as National Board of Medical Examiners or specialty boards.

Studies have supported the educational effectiveness of teaching cardiac physical examination with Harvey simulator in improving learners' cardiac auscultation skills.[9-10] In a study including 64 individuals (practicing clinicians, residents and students), a 2-hour workshop on cardiac auscultation using Harvey simulator was sufficient to show significant improvement (37% to 81%) in participant recognition of auscultatory findings.[10] Utilizing a digital heart sound simulator (Cardionics Inc., Houston) for a total of 2hr 15 min for teaching cardiac auscultation, another study involving 15 family practice residents showed improved learners' heart sound recognition from 36% on pre-test to 62% on post-test.[11]

Although high-fidelity and expensive clinical simulators are becoming more popular among the high-volume and procedure-related specialties such as anesthesiology, emergency medicine or surgery, low-fidelity and relatively inexpensive simulators such as heart sound simulators are still under-utilized in medical training. In addition, the majority of faculty trainers are unfamiliar with these teaching tools.

Study Limitations

Our study has some important limitations, which we would like to acknowledge and discuss:

1. In our pre-post test study design, the participants may have sought additional information in the area of heart sounds between the initial training and the post-testing completed 3 weeks thereafter. The authors did not ask the study participants to provide such additional information at the time of the post-test.
2. As with any study that utilizes a before/after design, some of the effect may be due to some other factor that changed over time, to which the participants were exposed to outside of the study.

Conclusion

Our experience in using cardiac simulation for testing and training clinical skills confirmed the deficiency in cardiac auscultation skills of not only medical students but also residents. Our findings highlight the learners' lack of self-motivation in learning basic clinical skills such as cardiac auscultation, despite available access to multitude of learning and training resources. More importantly, it appears that the current teaching-training system didn't provide adequate opportunities for learners to self-assess their clinical skills competency. With the use of a heart sound simulator and interactive teaching, we were able to demonstrate a significant improvement in cardiac auscultation skills in our participants, even at three weeks after the intervention.

In light of our findings and building upon the findings and recommendations of previous studies, we would like to recommend that heart sound simulation should be introduced at medical student level as the standard for teaching cardiologic auscultatory findings and as a preparation for cardiac auscultation of live patients. In addition, we suggest that training with digitally simulated heart sounds is beneficial at higher professional training levels, such as residency training.

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