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Cardiac Physical Exam Skills and Auscultation Session for Pediatric Interns

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Abstract

Introduction: Physicians need adequate physical exam skills. Unfortunately, interns have variable physical exam skills, and teaching is often limited to rounds, an inconsistent setting. Physical exam skills, particularly those involving auscultation, require practice. Our goal was to create a cardiac physical exam workshop for pediatric interns that would improve their performance on an interactive assessment of their ability and understanding in physical exam and murmur interpretation. **Methods:** We completed a targeted needs assessment and then developed a 2-hour workshop on the pediatric cardiac physical exam targeted to pediatrics residents. The workshop included didactics, group discussion, and practice interpreting common pediatric murmurs. Pediatrics residents completed the assessment as a pretest and then participated in the workshop. At the end of the workshop, the assessment was administered as a posttest, followed by a reassessment 3 months later. Nonparametric statistical analysis was conducted. Pre- and posttest scores were compared using the Wilcoxon signed rank test. **Results:** Twenty-five residents completed the workshop, including 22 pediatrics residents, one pediatrics/anesthesia combined resident, one pediatric neurology resident, and one resident completing a preliminary year in pediatrics prior to dermatology residency. There was a significant increase in the mean score on the assessment from pre- to posttest (pretest $M = 54\%$, posttest $M = 71\%$, $p < .001$). This increase was sustained at the 3-month reassessment ($M = 67\%$). **Discussion:** This cardiac physical exam workshop demonstrated improvement in physical exam knowledge and interpretation ability as measured by an online pre-/posttest.

Keywords

Auscultation, Cardiac Examination, Murmurs, Cardiovascular Medicine, Clinical Teaching/Bedside Teaching, Pediatric Cardiology, Pediatrics, Physical Examination

Educational Objectives

By the end of the workshop, learners will be able to:

1. Describe how to accurately measure heart rate.
2. Describe how to accurately measure respiratory rate.
3. Describe how to select the proper blood pressure cuff for a patient.
4. Describe how to accurately measure a manual blood pressure in an upper extremity.
5. Describe how to accurately measure a manual blood pressure in a lower extremity.
6. Identify the major listening posts on the chest wall.
7. Identify and describe S1 and S2 heart sounds with auscultation.
8. Identify and describe normal versus abnormal splitting of S2 with auscultation.
9. Accurately describe murmurs in regard to timing, grade, quality, location, and radiation pattern.
10. Name at least two locations in the upper extremity for palpating pulses.
11. Name at least two locations in the lower extremity for palpating pulses.
12. Accurately describe what the different grades of pulses correspond to.
13. Describe how to accurately measurement and document liver edge.

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Introduction

The physical exam is a safe, inexpensive, and accurate means of diagnosis valued by both faculty and resident physicians.[1] However, in the current climate of medicine, an increase in reliance on diagnostic imaging technology[2,3] has decreased the emphasis on the physical exam and, subsequently, physical exam teaching.[2-5] This has led to a wide variance in the quality of

physical exam teaching and an erosion in physical exam skills.[2,5-9] One of the most prominent areas of this erosion in physical exam skills is the cardiac physical exam, particularly cardiac auscultation.[10]

Effective physical exam teaching, specifically cardiac physical exam, is difficult.[6,7] Being able to adequately teach this process requires substantial time and energy,[11] and both residents and faculty feel that a lack of teaching is a major barrier to improving physical exam skills.[1,3] This difficulty is amplified when teaching methods are limited to didactics, as teaching the physical exam must pass along not only knowledge but also skills, which can be difficult in a lecture setting. Trainees must learn to elicit and interpret a finding, understand the underlying physiology, and develop an assessment by interpreting the physical exam finding within the context of the patient.[2] This is best done through teaching methods that include demonstration of the findings and discussion of their interpretations.[3] Demonstrating and teaching of the physical exam, however, are often at the mercy of patient population, potentially leading to gaps in learning.[3,5,7]

To combat this limitation, much of the recent literature on physical exam teaching focuses on the use of high-fidelity simulation.[12,13] While there is promise in these techniques, there are also significant barriers. High-fidelity simulation requires faculty with the knowledge and experience to run the simulations, use of expensive equipment, and, often, space for a simulation lab. We set out to develop a physical exam workshop with a lower space requirement, less need for technology expertise from faculty, and a lower burden of expensive equipment.

There is also a gap in the literature on effective programs for teaching the cardiac physical exam in pediatric patients. Programs for cardiology teaching and murmur databases exist,[13-15] but a pediatric physical exam is a unique context that often induces apprehension in trainees.[16] Pediatric physical exam workshops also exist.[16] However, there are few with an emphasis on the cardiac exam, and many involve the use of complex patient simulations and/or standardized patients,[14,16] limiting their application in diverse settings with resource limitations.

Our goal was to develop an intervention that would allow for efficient teaching of the theory of cardiac physical examination as well as interpretation of findings in the context of the pediatric cardiac exam without reliance on resources such as standardized patients and simulation labs. This intervention utilized didactic teaching as well as small-group and case discussion, with a particular focus on the discussion of cardiac murmurs and their interpretation. We evaluated the effectiveness of the intervention with an online pre-/posttest that assessed the participants' knowledge of physical exam theory, as well as their ability to interpret physical exam findings and develop appropriate assessments and plans based on those findings.

Methods

Curriculum development began with a targeted needs assessment. Key stakeholders were identified as cardiology faculty, graduate medical education leadership, and pediatrics residents. We asked key stakeholders which curricular domains related to cardiac physical exam had the greatest need for further teaching and development for pediatric interns. There was significant overlap on identified areas. Cardiology faculty consistently identified heart murmur evaluation, understanding of the underlying physiologic basis of physical exam findings, and description/communication of exam findings. Medical education leadership consistently identified the areas of heart murmur evaluation and description. Similarly, pediatric residents identified evaluation and interpretation of heart murmurs. With these results, we developed educational objectives.

Having identified specific educational objectives, we developed the workshop format and content. The workshop was designed as a 2-hour, small-group activity for one to three residents that would take place at the beginning of a required 2-week rotation through cardiology clinic. Educational strategies utilized included didactic teaching, group discussion, and case scenarios. Didactics focused on the underlying physiologic basis of physical exam findings. The practice of heart murmur interpretation and description was primarily done through small-group discussion of heart murmur audio files. This was followed by practice interpreting mystery murmurs accompanied by a brief description of a case scenario. To guide and structure the workshop, we developed a presentation utilizing PowerPoint (Appendix A).

The session began with administration of a pretest (Appendix B) approximately 15 minutes in duration. The workshop proceeded to the didactic discussion of the structure of physical examinations and obtaining vital signs, as well as general observation and inspection. We discussed the basic science of sound waves and auscultation, including demonstration of stethoscope use and methods of auscultation. The workshop then transitioned to an interactive group discussion with the presentation of audio files of normal and abnormal heart sounds (Appendix A). These discussions were structured with the initial presentation of the audio file. We also referred to the physiology of the cardiac cycle and connected the auscultatory findings to the physiology and pathophysiology in an attempt to make connections between the findings and underlying physiology.

We moved on to discussion of heart murmurs. This included the characteristics that should be documented and the rationale for their documentation. Audio files were played, and learners were asked if the murmur was diastolic or systolic, as well as about the duration and shape (holosystolic, systolic ejection, early diastolic, etc.). Learners were next asked to characterize the murmur and to discuss their impressions with the other learners. We frequently returned to previously discussed murmurs and offered comparisons (e.g., holosystolic vs. systolic ejection, vibratory vs. harsh). After discussion of heart murmurs, we proceeded to mystery murmur presentations. Learners were presented with a murmur and brief clinical history and were required to think through the murmur out loud and to characterize it. We asked the learners to give a possible diagnosis. Finally, the diagnosis was revealed and key points discussed before moving on to the next mystery murmur. In total, discussion of auscultation and heart murmurs represented the majority of the workshop duration, requiring approximately an hour. After discussion of the murmurs, we proceeded to lung examination, abdominal examination, and extremity examination. These discussions were done in a didactic format. This completed the presentation of the material, and the workshop concluded with the posttest administration.

We developed a novel, interactive, online assessment for the pretest/posttest/3-month assessment that included multiple-choice questions and short answers. The assessment examined medical knowledge, physical exam finding interpretation, and medical decision-making. This assessment was developed within the Moodle educational website[17] and was built utilizing the branching logic of the lesson format within Moodle. This allowed us to construct an assessment that was responsive to the choices the intern made within the case scenarios. Appendix B contains this assessment in a PowerPoint format, with embedded audio files and hyperlinks to guide trainees through the assessment and allow them to record their responses for grading. Appendix C features the assessment as a Word document that can be utilized as a written exam with a proctor playing the audio files for the trainees. Appendix C also has the scoring and correct answers noted within the document.

The assessment gave learners options on which physical exam findings they wished to elicit. Findings were presented, and learners were allowed to select another finding or move on. Different findings were presented based on the choices made. For example, audio files with faster heart rates and more difficult interpretation were presented if the participant chose to perform an abdominal examination prior to auscultation. Learners were also presented with different audio files based on the location selected for auscultation. After the learners finished eliciting the physical exam findings, they were asked to describe the murmurs and select the most probable diagnosis and, finally, the best plan. In addition to the case scenarios, the assessment included both short-answer and multiple-choice questions on knowledge of physical exam theory and physiology. Experienced cardiology and cardiac critical care faculty evaluated the assessment for content validity. Third-year pediatrics residents piloted the assessment and provided feedback on its clarity and length.

After each session, the lead author graded the assessments based on a scoring rubric developed by consensus between authors. Participants were awarded 1 point for each correct answer. For questions that required description of heart murmurs, participants were awarded 1 point for each accurate descriptor. For example, with the ventricular septal defect murmur, participants were awarded 1 point for stating that the murmur was systolic, 1 point for harsh, and an additional point for holosystolic. For questions that required listing, 1 point was given for each correct answer; for example, when asked what vital signs remained to be obtained, 1 point was given each for blood pressure, temperature, and oxygen saturation.

For data analysis, nonparametric statistical analysis was conducted. We compared pre- and posttest scores using the Wilcoxon signed rank test. All analyses were generated using SPSS software (IBM SPSS Statistics v24.0).

Results

A total of 25 residents participated. There were 22 categorical pediatrics residents, one combined pediatrics and neurology resident, one combined pediatrics and anesthesia resident, and one resident completing a preliminary intern year in pediatrics with plans to go on to a dermatology residency. The combined pediatrics/neurology resident was in the control group. Both the combined pediatrics/anesthesia resident and the resident completing their preliminary year were in the intervention group. All participants were in their first year of postgraduate training, with the exception of the pediatrics/anesthesia resident, who was in the third year of postgraduate training. There were eight male and 17 female participants. This ratio was similar to the residency program as a whole, with 18 males and 50 females. The residency program was a medium-sized program (approximately 20-25 residents per year) affiliated with a large freestanding children's hospital and tertiary care center in the upper Midwest.

The mean score on the pretest was 54%, with an interquartile range of 53%-58%. The mean score on the posttest was 71%, with an interquartile range of 68%-75%. The 3-month reassessment mean was 67%, with an interquartile range of 60%-73% (Figure). The most commonly missed question was interpretation/diagnosis of a peripheral pulmonary stenosis murmur, with only five trainees answering it correctly on the pretest. This was also the question learners most improved on, with all 25 students answering it correctly on the posttest and 20 answering it correctly on the 3-month assessment. The question that the trainees performed the best on was calculation of respiratory rate, with 23 correct answers on the pretest and 24 correct answers on the posttest and 3-month assessment.

Given the sample size of 25 participants, we decided to use nonparametric testing in our statistical analysis. Comparing the pretest and posttest scores using the Wilcoxon signed rank test, we found that there was a statistically significant difference between the pretest scores and posttest scores ($p = .001$). There was no statistically significant difference between the posttest and the 3-month reassessment ($p = .06$). There was a statistically significant difference between the 3-month reassessment and the pretest ($p = .001$).

Discussion

There have been consistent reports on the decline in physical exam skills amongst trainees and medical practitioners in recent decades. Despite these reports, effective methods for teaching physical exams in a hectic clinical setting are still inadequate.[3,10] This publication describes the successful implementation of a workshop to increase pediatric interns' knowledge of the cardiac physical exam and ability to interpret cardiac physical exam findings. Our project aimed to report a method of physical exam teaching that would provide an efficient and effective means of furthering trainees' physical exam skills and ability to interpret physical exam findings. Specifically, we looked at the impact of an interactive physical exam workshop with a focus on heart murmurs on the ability of pediatric interns to perform on a computer-based, interactive assessment of their physical exam knowledge and findings-interpretation skills.

The workshop has relatively low time requirement for facilitators and participants. The technologic requirements are minimal, only a computer and speakers, and no requirement for a simulation lab or expertise in running simulation software or cases. The use of audio files has been demonstrated to be helpful in the interpretation of murmurs in the past,[10] and USMLE board exams

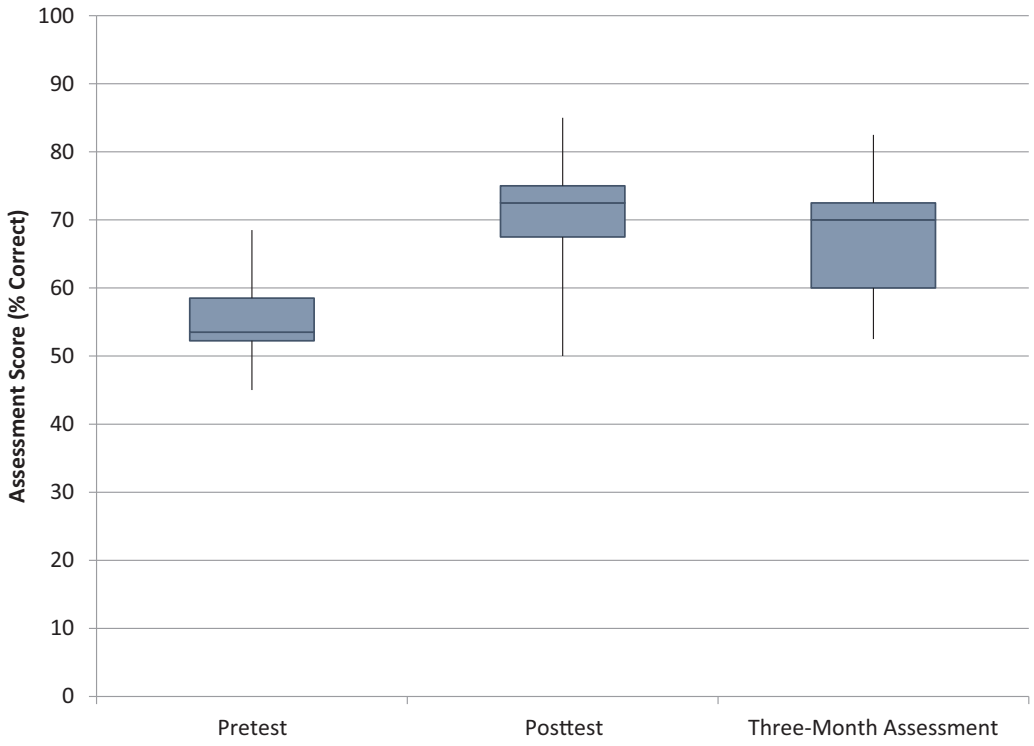

Figure. Assessment scores. In each box, the bottom of the vertical line is the minimum score, the bottom of the box is the 25th percentile, the horizontal line is the median, the top of the box is the 75th percentile, and the top of the vertical line is the maximum value.

include audio files in question stems.[18] The utilization of audio files in this workshop therefore has the advantage of providing familiarity with this application of technology. Furthermore, audio files give us the ability to expose interns to auscultatory findings that they may not otherwise encounter due to the fluctuating nature of patient populations. The small-group workshop format of the intervention promotes free discussion, allowing participants and facilitators to remark on their interpretation and description of findings, particularly heart murmurs.

The assessment in this intervention is an online test built to be as interactive as possible, demonstrate knowledge of the physiologic basis of physical exam findings, provide interpretation of physical exam findings, and develop an appropriate plan. The development of this assessment was an exercise in balancing a robust assessment of physical exam skills with practical restraints on time, space, and available technology. The assessment utilizes multiple-choice questions to test medical knowledge and short-answer segments to allow for description/interpretation of findings. Furthermore, the participants are required to indicate what elements of the physical exam they want to perform and in what sequence. This format allows different findings to be demonstrated in different scenarios within the same case presentation. Examples of this include different murmur audio files being presented depending on where the participant chose to listen and demonstrating a faster heart rate if the child was agitated by previous elements of the exam. This allows for assessment not only of medical knowledge but also of interpretation of findings and decision-making.

A crucial element that contributed to the success of this project was the targeted needs assessment and early engagement of its key stakeholders (pediatric medical education leadership, cardiology faculty, and pediatrics residents). Early inclusion allowed us to obtain buy-in from these groups. This support helped us to secure the time and space required to implement the workshop, not always easily done in a busy clinic and with many groups vying for resident time and cognitive load. The information obtained in the targeted needs assessment also allowed us to develop the goals and objectives of the workshop early on and ensure that all major topics desired by the key stakeholders were included in the final product while avoiding time-consuming curricular rewrites.

Limitations include the need for in-person facilitators and a physical space to conduct the workshop. One of the biggest advantages of the workshop is the interactive nature that allows for discussion and rumination on the heart murmurs. To achieve this, however, the workshop needs to have a facilitator as well as the time and space for the facilitator and learners to gather and discuss. A further limitation is the use of the same assessment as a posttest and 3-month assessment, allowing for the possibility of specific item retention. To help limit this, the follow-up assessment has been spaced 3 months after the workshop. Ideally, as our murmur audio file library grows, we can utilize more files and develop a 3-month assessment with unique items.

Limits to the evaluation and data analysis include the small sample size. The number of pediatric interns on the rotation limited the number of participants. That being said, results were very encouraging, with a statistically significant increase in mean score from pretest to posttest. It should also be noted that due to logistical restraints, it was not possible for us to develop an OSCE-style assessment, which would have allowed for direct observation of physical exam performance. We did attempt to create an assessment that allowed for the evaluation of the participants' ability to interpret physical exam findings as well as their decision-making ability.

The key next step in the development of this workshop is to secure faculty and participant time to introduce a standardized evaluation of the performance of a physical exam. This would permit a more robust assessment of resident abilities that could then be utilized not only to demonstrate improvement but also to refine the goals, objectives, and teaching methods of the workshop. Furthermore, we aim to continually expand our audio file library and improve the sound quality, allowing for a more accurate reproduction of the auscultatory findings and an expansion of assessment items.

In summary, we have been able to address a key need in physical exam teaching and interpretation with the development of a workshop aimed at improving pediatric interns' knowledge of physical exam findings and interpretation of those findings. The workshop is unique in its focus on pediatric cardiac exams and has proven feasible to introduce into a busy clinical rotation and effective in improving physical exam knowledge and interpretation ability in participants.

Appendices

A. Workshop Slides.pptx

B. Assessment - Interactive Version.pptx

C. Assessment - Questions With Answers.docx

All appendices are peer reviewed as integral parts of the Original Publication.

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