Small Steps in Impacting Clinical Auscultation of Medical Students

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Abstract

The objective of this study was to determine if a training module improves the auscultation skills of medical students at the University of Maryland School of Medicine. Second-year medical students completed pretests on 12 heart sounds followed by a 45-minute training module on clinical auscultation, with retesting immediately after the intervention and during their third-year pediatrics clerkship. The control group consisted of third-year medical students who did not have the intervention. There was a 23% improvement in the identification of heart sounds postintervention ($P < .001$). Diastolic and valvular murmurs were poorly identified pre- and post intervention. There was a 6% decline in accuracy of the intervention group in the following academic year. The intervention group was superior to the control group at identifying the tested heart sounds (49% vs 43%, $P = .04$). The accuracy of second-year medical students in identifying heart sounds improved after a brief training module.

Keywords

cardiac auscultation, heart murmurs, medical students, intervention, diastolic murmurs

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Introduction

The majority of children have a murmur detected on physical examination at some point in their lives.[1] Studies have estimated that cardiac murmurs may be present in more than 50% of children.[1,2] Most of these murmurs are functional; less than 1% of children have congenital cardiac defects.[2,3] General pediatricians have to decide whether or not the murmurs they identify in their patients require further evaluation by a pediatric cardiologist, as pathologic murmurs can be an indication of life-threatening heart disease. Having solid clinical auscultation skills is important to avoid unnecessary referrals that can lead to expensive specialist visits and testing for nonpathologic murmurs. In general, it has been found that the cardiac auscultation skills of physicians are poor and are even worse among medical students.[4-6] It is expected that as medical students continue their training their auscultation skills should improve, and it is logical to assume that a strong foundation in cardiac auscultation will lead to improved skills later in a physician's career. However, it is unclear whether there is an intervention that can be made early in medical training that can lead to improved cardiac auscultation skills. Moreover, there is a paucity of studies on the ability of medical students to retain cardiac auscultation skills after they are learned.

There are studies that show some improvement in cardiac auscultation skills among medical students and family medicine physicians following the use of multimedia CD-ROM, mobile electronic device based, or web-based cardiac auscultation programs.[7-9] Others have suggested small group sessions as a method of improvement in cardiac auscultation skills.[10] However, other interventions including the use of electronic sensor-based stethoscopes have been less successful.[11] The purpose of this study was to investigate (1) whether an educational module delivered via infrared stethoscope would lead to an improvement in clinical auscultation skills in second-year medical students; (2) whether any demonstrated improvement would remain 1 year later; and (3) whether trained students differed, 1 year after the intervention, from untrained third-year students.

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Methods

This study was conducted at the University of Maryland Medical Center and was determined to be exempt by the Human Research Protection office at the University of Maryland School of Medicine.

The intervention group consisted of second-year students in the class of 2016. The intervention was conducted in October 2013 as part of the Pediatric Physical Diagnosis program. Second-year students completed a pretest assessment of their ability to identify 12 heart sounds via an infrared stethoscope (Cardionics, Webster, TX). In addition, a high-fidelity overlay of the same heart sounds was delivered through the auditorium speakers. The participants were tested on 12 distinct heart sounds, chosen from "The Big 12 of Essential Cardiac Auscultation" (Umedic, Miami, FL): continuous murmur, systolic click, aortic stenosis, pericardial rub, mitral stenosis, fourth heart sound, innocent murmur, aortic regurgitation, mitral regurgitation, third heart sound, tricuspid regurgitation, and physiologic S2 split with inspiration.

Prior to the pretest, each participant was randomly assigned a numbered answer sheet packet with one sheet for the pretest and the other for the posttest. The pretest answer sheets were collected prior to the training module. The training consisted of a 45-minute session in which auscultation sounds were presented to participants through the stethoscopes and repeated at least 6 times. The heart sounds were all delivered at heart rates between 60 and 75 beats per minute. Following the intervention, the posttests were completed on answer sheets with the same numbers so that pre- and posttest performance could be compared. No participant information was collected, and individual participant performance was anonymous. Students then completed their usual second-year curriculum and began their third-year clerkships in July 2014 as expected. Students in the intervention group were retested on the same 12 heart sounds with the same setup in the fifth week of their 6-week required third-year Pediatrics clerkship blocks, and responses were collected anonymously.

The control group consisted of third-year students in the class of 2015 who had not received the training module during their second-year Pediatric Physical Diagnosis course. Students were tested with the same equipment and heart sounds in the fifth week of their 6-week required Pediatrics clerkship. Answer sheets were anonymous, and no identifying information was collected.

Analysis included (1) comparison of the mean pre- and posttest scores for each of the 12 heart sounds in the intervention group during their second-year experience using McNemar's test; (2) comparison of the mean posttest scores of the intervention group right after the training module and at the end of their third-year clerkships with χ^2 test of independence; and (3) comparison of the mean scores of the intervention group at the end of their clerkships with those of the control group and the end of their third-year Pediatrics clerkships using the χ^2 test of independence. $P < .05$ was considered significant.

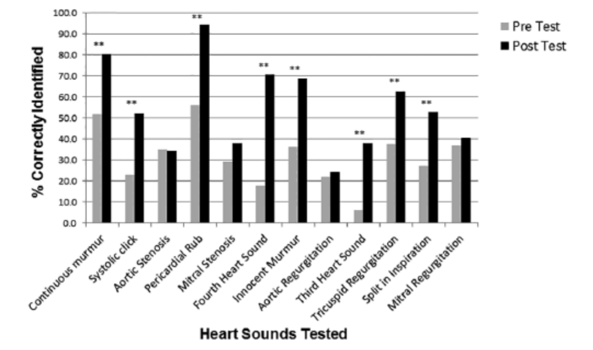

Figure 1. Percentage of heart sounds identified by the intervention group before and after the intervention. $^{**}P < .001$.

Results

One hundred and fifty-seven second-year medical students participated in the intervention. Of those 157, 108 were retested during their third-year Pediatrics clerkship. The remaining 48 students were not tested due to the investigators' and students' inability to be present at scheduled student lecture sessions. Fifty-two medical students who were naïve to this auscultation training formed the control group.

Intervention Group: Pretest Findings

Prior to training, the intervention group most often correctly identified the pericardial rub (56%) and continuous murmur (52%). These were the only 2 heart sounds that were correctly identified by 50% or more of the group; the least correctly identified sounds were the third (6%) and fourth (18%) heart sounds (Figure 1).

Intervention Group: Posttest

There was significant improvement in the correct identification of the continuous murmur, systolic click, pericardial rub, innocent murmur, third and fourth heart sounds, tricuspid regurgitation, and split S2 in inspiration by the intervention group after training (Figure 1). Of these heart sounds, 7 were correctly identified by 50% or more of the group. There was no

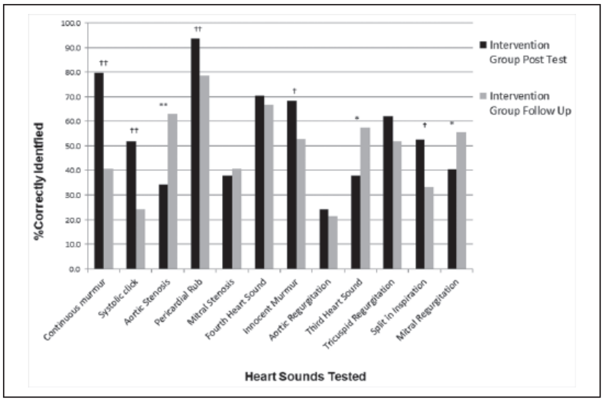

Figure 2. Percentage of heart sounds identified by the intervention group immediately after the intervention and on follow-up. For improving skills: **P* < .05, ***P* < .001; for worsening skills: †*P* < .05, ††*P* < .001.

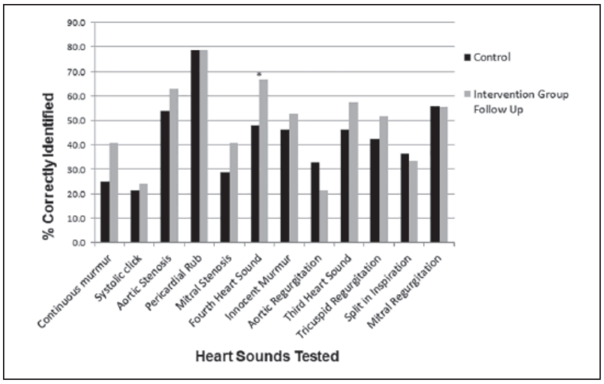

Figure 3. Percentage of heart sounds identified by the intervention group on follow-up compared with the control group. **P* < .05.

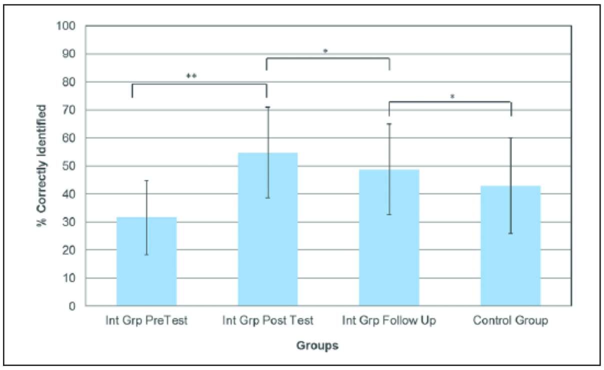

Figure 4. Comparison of percentage of heart sounds identified between the groups. **P* < .05, ***P* < .001.

significant worsening in the identification of any murmurs noted. The pericardial rub (94%) and continuous murmurs (80%) were again the most accurately identified heart sounds on the posttest. Aortic regurgitation and aortic stenosis were the least accurately identified heart sounds in this group at 24% and 34% accuracy, respectively.

Intervention Group: Retesting in the Third Year

When retested in the third year, the pericardial rub and fourth heart sound were the most correctly identified heart sounds, with 79% and 67% correct answers by the intervention group, respectively. The least correctly identified heart sounds were the aortic regurgitation murmur and systolic click, at 21% and 24%, respectively. Comparisons are shown in Figure 2. There was significant improvement in the group's ability to identify aortic stenosis, the third heart sound, and mitral regurgitation. However, there was significant worsening in the identification of the continuous murmur, systolic click, pericardial rub, innocent murmur, and S2 split in inspiration (Figure 2).

Control Group: Testing in the Third Year

In the control group, the pericardial rub and mitral regurgitation murmur were the most correctly identified heart sounds, with 79% and 56% correct, respectively. The least correctly identified heart sounds were the systolic click and continuous murmur at 21% and 25% correct, respectively. Only 3 heart sounds (pericardial rub, mitral regurgitation, and aortic stenosis) were correctly identified by 50% or more of the control group.

Control Versus Intervention

Figure 3 shows the comparison between the control group and the intervention group at the end of the third-year clerkship on each specific heart sound. Only the fourth heart sound was significantly better identified by the intervention group compared to the control group.

The overall diagnostic accuracy of the intervention group at baseline was 32% (SD 13%) and significantly increased to 55% (SD 16%) postintervention ($P < .001$; Figure 4). At the 1-year follow-up, the diagnostic accuracy of the intervention group fell to 49% (SD 16%; Figure 4), suggesting that there was a 6% decay in skills ($P = .004$). However, the control group accurately identified 43% (SD 17%) of the cardiac murmurs, significantly worse than the intervention group at a similar level of training ($P = .04$; Figure 4).

Discussion

Our results clearly show that the teaching module led to immediate improvement of the cardiac auscultation skills of the intervention group by 23% after a single session. Though there was a statistically significant improvement in the diagnostic accuracy of the intervention group, a diagnostic accuracy of 55% is not satisfactory. It is unclear why out of the 12 heart sounds tested, the continuous murmur, systolic click, pericardial rub, third and fourth heart sounds, innocent murmur, split second sound, and murmur of tricuspid regurgitation were the only heart sounds found to have significantly improved following the intervention. The pericardial friction rub was the most accurately identified heart sound after the training module, and even with later decline, a high percentage of the intervention group, 80%, were still able to successfully identify this murmur at follow-up testing. This is not surprising as the pericardial friction rub is one of the most distinctive heart murmurs, is multicomponent, and heard in both diastole and systole.

Sixty-nine percent of the intervention group was able to correctly identify an innocent heart murmur after the training intervention. However, at follow-up, there was a 14% decline in ability to recognize this murmur. The control group did not fare better as only 46% of the group identified this murmur accurately as compared to the intervention group ($P = .51$). This is a concerning finding, as clinicians frequently encounter innocent murmurs and should be able to differentiate them from those that are pathologic. Improving a clinician's ability to identify innocent murmurs should lead to a reduction in the number of additional and potential unnecessary studies, pediatric cardiology referrals, and subsequently health care costs and parental anxiety. Medical students have been noted in the past to misidentify innocent murmurs as pathologic, potentially due to a lack of confidence.[3] We believe that frequent and repeated training and exposure to heart sounds will improve clinician confidence and competence and decrease unnecessary referrals. This was highlighted in a study by Høyte et al, where medical students needed an average of 500 repetitions of heart sounds to show proficiency in identifying heart sounds.[12]

Even with clinical exposure in the third year of medical school, the intervention group demonstrated a 6% decline in their clinical auscultation skills at 1-year follow-up. They were, however, superior to the control group who did not have exposure to the teaching intervention. Specifically, the control group was 11% better than the intervention group at the 1-year follow-up at identifying aortic regurgitation but this was not statistically significant ($P = .19$). Conversely, the intervention group, at the 1-year follow-up, was better than the control group at identifying 8 of the tested heart sounds. Only one of these differences met statistical significance, the fourth heart sound ($P = .02$). It is unclear why these differences exist, however; this may be related to the differences in clinical experiences each medical student has even within the same year of training.

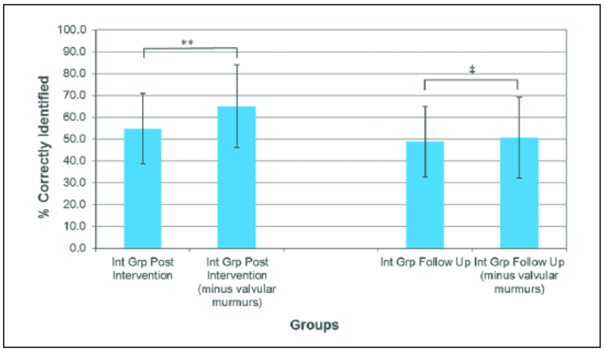

Figure 5. Comparison of percentage of heart sounds identified by the intervention group, with and without diastolic and valve-related murmurs. **$P < .001$, ‡$P > .05$.

Murmurs of aortic and mitral origin were poorly identified by the intervention group before and after the intervention. When these murmurs are excluded from the analysis, there is a significant improvement in the diagnostic accuracy of the intervention group who now identified 65 of the heart sounds tested ($P < .001$) but no significant difference at the 1-year follow-up ($P = .43$; Figure 5).

Diastolic murmurs such as aortic regurgitation (AR) and mitral stenosis (MS) tend to present a challenge for most physicians in training. In this study, both the intervention and control groups were poor at identifying these murmurs. There was no significant improvement in the diagnostic accuracy of these murmurs even after the intervention. There was regression in the diagnostic accuracy of AR by the intervention group at 1-year follow-up but a minimal improvement in identifying MS. In both cases there was no statistically significant difference. These findings are disappointing but not unexpected, as diastolic heart murmurs are much less frequently encountered in general clinical practice than systolic murmurs and even less common in pediatrics. Diastolic murmurs are softer, lower frequency, and more difficult to hear. There may therefore be a need for specific attention to be given to diastolic and valve-related murmurs in the medical school curriculum.

Limitations

The study was limited by the small number of medical students in the control group. We were hampered by the loss of some members of the intervention group at the 1-year follow-up due to the difficulty in coordinating the research study sessions with the third-year medical student lectures. One further limitation was the assumption that the clinical exposure of medical students is overall standardized and this may be a false assumption as exposure within clinical rotations differs. Also, the exposure to heart sounds in a classroom setting is quite different from real-life scenarios in clinical medicine, and skills acquired in the classroom may be hard to extrapolate to clinical situations.

Conclusions

The diagnostic accuracy of second-year medical students in identifying cardiac murmurs is improved by a training module. However, there was a decline in the diagnostic accuracy with 6% decay in these skills 1 year after the intervention. Their skills were superior to those of third-year medical students, at the same level of medical school education, who did not receive the intervention. This type of intervention may have a place in the medical student curriculum to improve the cardiac auscultation skills of medical students who may go on to become primary care physicians who will serve as the first line in detecting pathologic murmurs in children.

Future Directions

Future studies should be aimed at improving the accuracy of diagnosing diastolic murmurs as these murmurs were the most poorly identified murmurs regardless of level of medical school education or if group received the intervention. Using heart sounds from actual patients would also be an improvement for future studies. The adventitial sounds from respirations and other noises that are encountered during clinical interactions can be distracting. However, it is important for testing in this type of scenario as well rather than just serene/sterile simulated sounds. Providing medical students with self-directed modules, whether in class or online, may be necessary to allow students to have enough repetitions of hearing these heart sounds.

Author Contributions

EKB: contributed to conception and design; contributed to acquisition, analysis, and interpretation; drafted manuscript; critically revised manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy.

LOL: contributed to conception and design; contributed to analysis and interpretation; critically revised manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy.

PRG: contributed to conception and design; contributed to acquisition, analysis, and interpretation; drafted manuscript; critically revised manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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