A novel approach to teaching cardiac auscultation

Graham Peigh[2], Joseph Majdan[3]

**Abstract**

**Purpose:** Despite standard instruction, medical students cannot reliably identify common heart sounds and murmurs. The authors developed a novel approach to teach cardiac auscultation that uses process-based techniques to increase the diagnostic ability and confidence of physicians in training.

**Methods:** 64 medical students were initially presented with a random selection of 10 heart sounds from Harvey, The Cardiopulmonary Patient Simulator, and graded on how many they could successfully recognize on a scale from 1-10. All students were then taught the novel approach to cardiac auscultation (the lesson). One day following the lesson, students were presented with another random selection of 10 heart sounds from Harvey, and graded on how many sounds they could correctly identify. Students then completed a survey regarding their confidence levels.

**Results:** Students correctly identified more heart sounds after undergoing the lesson (prior to lesson: 4.1 (1.05); after lesson: 6.7 (1.00); p<0.001). Following the lesson, students also reported increased confidence in their ability to listen to heart sounds (prior: 1.70 (0.46); after: 3.13 (0.33); p<0.001).

**Conclusion:** The novel approach to teaching cardiac auscultation is an effective means of instruction that increases diagnostic ability and confidence among medical students.

**Keywords:** Cardiac Auscultation, Physical Exam, Medical Education, Process Based Learning.

**Introduction**

The stethoscope has been an instrumental part of a physician’s diagnostic toolkit since its invention by Rene Theophile Hyacinthe Laënnec in 1816 (Roguin, 2006). This is for a very good reason as cardiac auscultation is a high fidelity and cost effective way of diagnosing patients with cardiac pathology (Chizenr, 2008). Especially in
today’s healthcare landscape where more physician encounters take place in the outpatient setting with limited accessibility to immediate cardiac imaging, it is clinically relevant and essential for physicians to accurately diagnose patients using cardiac auscultation (Chizner, 2008). As such, cardiac auscultation is a skill that physicians in training must master.

Unfortunately, with the advent of higher technology to diagnose cardiac pathology, the resources allotted for teaching cardiac auscultation are disappointingly low (Chizner, 2008). It is commonly understood that the only way trainees can master cardiac auscultation is through dedicated instruction and repetition (Mangione, Nieman, Gracely & Kaye, 1993; Vukanovic-Criley, 2006; Spatz, LeFrancois & Ostfeld, 2011; Barrett, Lacey, Sekara, Linden & Gracely, 2004). Previous studies have found that only 25-48% of Internal Medicine Residency programs provide their trainees with instruction in cardiac auscultation (Mangione et al., 1993; Mangione & Duffy, 2003). This lack of instruction is reflected in the inability of trainees to use cardiac auscultation to diagnose patients. When presented with 12 common cardiac heart sounds, Internal Medicine Residents were only able to correctly diagnose at a rate of 19%-20% (Mangione et al., 1993; Mangione & Nieman, 1997). Cardiology fellows did not perform much better, as they were only able to diagnose 22% of cardiac heart sounds by auscultation (Mangione et al., 1993). Due to the low level of accuracy in diagnosing common pathological cardiac sounds among physicians in training, there is a pressing need for more dedicated instruction in cardiac physical exam, and higher fidelity teaching methods (Mangione & Nieman, 1997). Equally important is the development of a clinically simple and logical approach to listening to heart murmurs and sounds that will take the mystery and doubt out of auscultation for medical students.

Generations of medical students have been taught auscultation by being instructed to listen to specific areas on a patient’s chest where particular valves are best heard. If a murmur or abnormal sound is not heard at a specific location, a trainee is taught that the corresponding valve does not have any pathology (Chizner, 2008). This rigid approach often causes the medical student to be confused and have self-doubt.

A number of studies suggest methods of increasing cardiac auscultation competence among medical trainees. Medical students who were presented with prerecorded heart sounds from computers and patient simulators demonstrated better diagnostic abilities than their counterparts who did not receive this educational intervention (Butter, McGaghie, Cohen, Kaye & Wayne, 2010). Other studies have shown that trainees who listened to a particular murmur or heart sound over 300 times demonstrated an increased ability to recognize that sound on a real patient (Barnett et al., 2004; March, Bedynek & Chizner, 2005).

These methods of instruction largely rely on memorization and pattern recognition rather than application of the principles of cardiac physiology and pathophysiology. They do not encourage the higher level thinking that is necessary for making complex diagnoses that occur in clinical settings (Chizner, 2008). Instead, trainees are encouraged to rush through this portion of the physical exam and quickly determine if what they hear matches a recording they memorized (Chizner, 2008). This can lead to a high rate of misdiagnosis.

Cardiac auscultation is a thought exercise, and should be taught as such (Chizner, 2008). Students do not learn the processes behind cardiac physiology and pathophysiology by simply memorizing heart sounds from a specific location on the chest. Furthermore, by merely listening to and memorizing sounds through headphones, trainees lose the opportunity to learn specifically where to place a stethoscope, how much pressure to use, and how to handle it on a patient’s chest (Chizner, 2008). Because the standard method of teaching cardiac auscultation has the above shortcomings, the entire patient’s condition is not taken into account resulting in limited generalizability (Chizner, 2008; Hanifin, 2010). Thus, the standard methods of teaching cardiac auscultation do not increase confidence among students, as students do not trust their diagnostic findings (Tiffen, Corbridge, Shen & Robinson, 2011).

In order to create the strongest learning experience for a student, learning theory states that instructors must
incorporate and teach why certain events occur. Learning the process by which to address a problem is a more fruitful learning exercise than pure memorization (Fischer, 2011; Johnson, Charchanti & Troupis, 2012). To accomplish this goal, the authors created a novel method of teaching cardiac auscultation that emphasizes process-based learning over memorization. The authors’ method of instruction simultaneously teaches students to recognize the most common cardiac murmurs and reinforces the physiology and pathophysiology of the heart. The present study seeks to determine if this novel method of instruction enhances diagnostic ability among learners. Importantly, as this is a process-based method, the authors predict that learners will believe that their skills are generalizable to a large patient population. As such, this study also assesses whether this novel method of instruction impacts a trainee’s confidence when performing cardiac auscultation.

Method

64 medical students beginning their third year of medical school at Sidney Kimmel Medical College at Thomas Jefferson University (Philadelphia, PA) were included in this IRB approved study. Prior to any intervention, students were assessed on their ability to identify 10 heart sounds recorded from real patients, transmitted through Harvey, The Cardiopulmonary Patient Simulator (Harvey). The only instruction students had received on cardiac murmurs to this point in medical school was from a lecture-based series on cardiac auscultation, cardiac physiology, and cardiac pathophysiology in preparation for United States Medical Licensing Exams. The 10 heart sounds included in this study were a random selection of the following 12 common sounds: aortic stenosis, aortic sclerosis, pulmonary stenosis, atrial septal defect, aortic regurgitation, mitral stenosis, mitral regurgitation, ventricular septal defect, tricuspid regurgitation, mitral valve prolapse, S4 gallop, and S3 gallop. On a blank sheet of paper, students were asked to identify the ten murmurs or heart sounds that they heard. Students were then taught how to perform cardiac auscultation using the novel method of instruction as detailed below. The same faculty member taught all students.

The following day, students returned and were asked to identify another random selection of 10 heart sounds transmitted through Harvey on a blank sheet of paper. Clinical faculty graded the pre and post-tests and results were recorded for analysis.

Following the post-test, students took a survey on their confidence levels regarding listening to heart sounds and successfully identifying cardiac murmurs. Students indicated how much they agreed with five statements from "not at all" to "very high degree." For statistical analysis, these phrases were converted into a Likert scale (1: "not at all"; 2: "small degree"; 3: "moderate degree"; 4: "high degree"; 5: "very high degree"). Scores for each student were entered into a database. The results are expressed as mean (standard deviation). Student’s t-tests for continuous variables were performed as appropriate.

The Novel Approach to Teaching Cardiac Auscultation

The novel approach to teaching cardiac auscultation is as follows. Students are first instructed to visually divide a patient’s sternum in half with an imaginary line. Then, they are told to listen above and below that mid-sternal line. If a murmur or abnormal heart sound is heard, a student determines whether the murmur is loudest above or below the line. Taking relevant cardiac anatomy into account, students are instructed that murmurs best heard above the line must have their origin in the aortic valve, pulmonic valve, or in an atrial septal defect. If the murmur is loudest below the mid sternal line, it must have its origin in the mitral valve, tricuspid valve, or in a ventricular septal defect. By having medical students first listen to two broad sections of the chest rather than in four very specific locations students are not constrained to a traditional format. Importantly, students also develop a process to more realistically
deal with the variable clinical presentations of heart sounds.

After determining where the murmur is heard loudest, students are instructed to determine if the murmur is best heard in systole or diastole. Students can easily do this by feeling the radial pulse. Students learn that S1 occurs directly before the pulse is felt, and S2 directly after. Thus, systolic murmurs are often heard in coordination with the radial pulse.

If the murmur is best heard in systole above the line, students learn that it must be a systolic ejection murmur and due to stenosis. If the murmur is best heard in systole below the line, the murmur must be holosystolic and due to leaking. Thus students are taught to use "guilt by location" when diagnosing systolic murmurs. This is in contrast to a student attempting to determine systolic ejection versus holosystolic murmurs purely by character, which can be extremely confusing. For systolic ejection murmurs, students employ the principles of cardiac physiology to determine if the murmur is a murmur of aortic stenosis which radiates across the chest (Gallavardin's phenomenon), a murmur of pulmonary stenosis which, like all right sided murmurs, varies with respirations (Carvallo's sign) or the functional stenosis of an atrial septal defect which has a fixed second heart sound. Holosystolic murmurs must be a leaking murmurs of either mitral regurgitation if heard loudest towards or past the apex; tricuspid regurgitation if the murmur varies with respirations (Carvallo's sign), or a ventricular septal defect, if the murmur is localized to the lower sternal border.

If the murmur is best heard in diastole above the line, students learn that it must be a regurgitation murmur of either aortic regurgitation or pulmonic regurgitation (Carvallo's sign). If the murmur is loudest below the line in diastole, it must be a stenotic murmur of either mitral stenosis or tricuspid stenosis (Carvallo's sign).

Finally, students are instructed to listen for and differentiate S3 and S4 gallops, mid-systolic clicks, and splitting of the second heart sounds. All of these heart sounds produce extra sounds on auscultation. Because the S3 and S4 gallops have their origins in the ventricles (volume and pressure overload), they are best heard below the mid-sternal line. Likewise a mid-systolic click has its origins in either the mitral or tricuspid valves and is also best heard below the mid-sternal line. Any splitting of the second heart sound is best heard above the line since it represents movements of the aortic and pulmonic valves. As such, extra sounds best heard above the mid-sternal line must be splitting of the second heart sound. A summary of this novel approach is provided in Figure 1.

As students undergo this method of instruction, they are encouraged to visualize the heart sounds both physically and within the cardiac cycle. Students also have an opportunity to listen to real patients with various murmurs and develop this process of identifying heart sounds. All students are given feedback and guidance from clinician educators. The entire learning experience takes roughly one hour.

**Results**

64 students were instructed with the novel approach to teaching cardiac auscultation. All of the students were in their third year of medical school at Sidney Kimmel Medical College at Thomas Jefferson University (Philadelphia, PA), and had successfully passed their preclinical coursework and Step 1 of the United States Medical Licensing Examination.

All students were graded on a scale from 0-10 based on how many heart sounds they successfully identified. Prior to undergoing the novel approach to teaching cardiac auscultation, students correctly identified 4.13 (1.05) heart sounds. After learning cardiac auscultation through the novel approach, students correctly identified 6.7 (1.00) heart sounds.
sounds (p<0.001).

On a survey assessing confidence in listening to heart sounds, students recorded that their confidence increased significantly after learning cardiac auscultation through the novel method of instruction (Confidence prior to instruction: 1.70 (0.46); Confidence following instruction: 3.13 (0.33) (p<0.001)). Additionally, students reported that they had a "high degree" of intent to use novel method of cardiac auscultation when assessing heart sounds in the future (4.00 (0.47)). Finally, students indicated that learning this new method of cardiac auscultation increased their interest in improving physical diagnosis skills to a small degree (2.06 (0.92)) and that there is a high degree of likelihood that they would teach their colleagues how to listen to heart sounds using this novel technique (3.89 (0.54)).

Discussion

Despite cardiac auscultation being a high fidelity and low cost method of diagnosing cardiac pathology, dedicated instruction of this physical exam technique is lacking in undergraduate and graduate medical education (Chizner, 2008; Mangione et al., 1993; Mangione & Duffy, 2003). This low rate of instruction is reflected in the inability of students and trainees to accurately diagnose the majority of cardiac heart sounds in the clinical setting (Mangione et al., 1993; Mangione & Nieman, 1997). The methods for teaching cardiac auscultation traditionally rely upon inefficient learning methods that stress memorization and pattern recognition, rather than more robust process based learning techniques (Chizner, 2008). Because of this, the authors developed this novel approach to teach cardiac auscultation that emphasizes the learning process rather than pure memorization. By learning through this novel approach to cardiac auscultation, students reinforce their knowledge of cardiac physiology, envision where pathologic heart sounds occur both physically and within the cardiac cycle, and do not rely on simply memorizing heart sounds from an electronic device. This novel approach also takes into account the variable locations where murmurs can occur in the clinical setting and gives medical students greater proficiency and confidence in performing a logical and robust auscultation of the heart.

Results from our study show that this novel approach to teaching cardiac auscultation significantly increases the ability of third year medical students to recognize common heart sounds and murmurs, and also increases their confidence in performing the cardiac exam. Of significant note, no prior study has shown an increase in both diagnostic ability and confidence after being presented with an educational intervention teaching cardiac auscultation. Based on these results, the novel method of teaching cardiac auscultation is an effective way to teach students the art of cardiac auscultation.

The traditional method of teaching cardiac auscultation, by which a student places his or her stethoscope on four predetermined locations and listens for specific sounds, does not allow students to have a high level of diagnostic accuracy or confidence in performing cardiac auscultation when they encounter sounds that are not immediately familiar to them. Medical education is shifting away from a memorization-based model towards a process-based model. It is more important for a student to know how to apply a concept in various clinical settings rather than it is for that student to merely recognize a medical phenomenon in isolation (Johnson et al., 2012). Teaching students by process rather than memorization enhances scientific knowledge and allows concepts to be more memorable and generalizable (Fischer, 2011). By teaching students a logical and clinically relevant process to go through, as our novel method emphasizes, students identify cardiac heart sounds at a significantly higher rate, and display more confidence when doing so.

The diagnostic ability of our sample of students prior to being taught cardiac auscultation through this novel
The approach was stronger than the diagnostic ability of students in previous studies (Mangione et al., 1993; Mangione & Nieman, 1997). However, after learning through this novel approach to teaching cardiac auscultation, students identified cardiac heart sounds at a significantly higher rate than they had prior to the educational intervention. A reason our students performed better than students in previous studies may be the result of the specific heart sounds used. We presented students with a selection of the 12 most basic heart sounds—sounds that every physician should be able to interpret. Our philosophy, supported by literature, is that it is imperative for students to master the fundamentals of cardiac auscultation prior to advancing to more rare and complex sounds (Chizner, 2008). We are fully aware that, as is true of all of medicine, variables to these rules will exist. Yet we firmly believe that this novel approach will provide a sound foundation and level of confidence to medical students so that they will master those variables as they mature as clinicians. Future research could assess the use of this novel approach to teach students more advanced heart sounds. Another line of research could test the long-term retention of diagnostic abilities after being taught with the novel approach to cardiac auscultation.

**Conclusion**

The majority of medical trainees do not undergo instruction on cardiac auscultation. Of those who do receive instruction, the traditional methods of teaching emphasize memorization and do not lead to diagnostic excellence or high levels of confidence among trainees. The authors developed a novel approach to teach cardiac auscultation that significantly increases diagnostic ability, and allows medical students to approach the cardiac physical exam with enhanced confidence. This novel method of teaching cardiac auscultation is an effective way to teach students how to perform cardiac auscultation.

**Take Home Messages**

1. The Novel Approach to Teaching Cardiac Auscultation described in this article increases the diagnostic ability and confidence of medical students with regard to cardiac auscultation.
2. This new approach to teaching cardiac auscultation allows for medical students to learn from process-based techniques, so they can understand common heart sounds.
3. Rather than listening in four static locations, by using the Novel Approach to Teaching Cardiac Auscultation, students learn to listen in numerous areas over the precordium.
4. The Novel Approach to Teaching Cardiac Auscultation prepares medical students for a dynamic practice environment.

**Notes On Contributors**

Graham Peigh, MD is an Internal Medicine Resident at McGaw Medical Center at Northwestern Memorial Hospital (Chicago, IL). Graham has particular interests in cardiology and medical education.

Joseph F. Majdan, MD is an Associate Professor of Medicine at Sidney Kimmel Medical College. He is also a cardiologist and has taught medical students for 36 years. Dr. Majdan stresses developing a template and process to perform the history and physical, and always emphasizes seeing the humanity in patients.
Acknowledgements

Bibliography/References


https://doi.org/10.1378/chest.126.2.470


https://doi.org/10.1007/s11606-010-1309-x


https://doi.org/10.1016/j.cpcardiol.2008.03.003


https://doi.org/10.1097/016/paa.0b013e3181bb9a51


https://doi.org/10.1002/ase.1296


https://doi.org/10.1016/S0012-3692(16)48689-7


https://doi.org/10.1001/jama.1997.03550090041030


https://doi.org/10.7326/0003-4819-119-1-199307010-00009


Appendices

Declarations

The author has declared that there are no conflicts of interest.

This has been published under Creative Commons "CC BY 4.0" (https://creativecommons.org/licenses/by-sa/4.0/)

AMEE MedEdPublish: rapid, post-publication, peer-reviewed papers on healthcare professions’ education. For more information please visit www.mededpublish.org or contact mededpublish@dundee.ac.uk.