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Original article

Variation in effectiveness of a cardiac auscultation training class with a cardiology patient simulator among heart sounds and murmurs

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ABSTRACT

Background: Effectiveness of simulation-based education in cardiac auscultation training is controversial, and may vary among a variety of heart sounds and murmurs. We investigated whether a single auscultation training class using a cardiology patient simulator for medical students provides competence required for clinical clerkship, and whether students' proficiency after the training differs among heart sounds and murmurs.

Methods: A total of 324 fourth-year medical students (93–117/year for 3 years) were divided into groups of 6–8 students; each group participated in a three-hour training session using a cardiology patient simulator. After a mini-lecture and facilitated training, each student took two different tests. In the first test, they tried to identify three sounds of Category A (non-split, respiratory split, and abnormally wide split S2s) in random order, after being informed that they were from Category A. They then did the same with sounds of Category B (S3, S4, and S3 + S4) and Category C (four heart murmurs). In the second test, they tried to identify only one from each of the three categories in random order without any category information.

Results: The overall accuracy rate declined from 80.4% in the first test to 62.0% in the second test ($p < 0.0001$). The accuracy rate of all the heart murmurs was similar in the first (81.3%) and second tests (77.5%). That of all the heart sounds (S2/S3/S4) decreased from 79.9% to 54.3% in the second test ($p < 0.0001$). The individual accuracy rate decreased in the second test as compared with the first test in all three S2s, S3, and S3 + S4 ($p < 0.0001$).

Conclusions: Medical students may be less likely to correctly identify S2/S3/S4 as compared with heart murmurs in a situation close to clinical setting even immediately after training. We may have to consider such a characteristic of students when we provide them with cardiac auscultation training.

Introduction

Cardiac auscultation is one of the most important physical examination skills, providing useful information to diagnose patients with a variety of heart diseases [1]. Not only does the identification of a typical heart murmur strongly suggest the existence of a certain valvular heart disease or congenital heart disease [2], but the presence of heart murmurs has also been shown to predict new-onset heart failure in primary care outpatients [3]. An abnormality in the second heart sound is also a helpful clue in the diagnostic process of patients with overloaded right ventricle or electrical conduction disturbances that affect right ventricular performance [1]. The third sound is one of the most important manifestations in patients with congestive heart failure and has been shown to be independently associated with adverse outcomes in patients with chronic heart failure [4]. Detection of the fourth sound at the left ventricular apex area suggests increased diastolic stiffness in the left ventricle, which is most likely to be found in older patients with hypertension [5]. However, Mangione et al. have shown that cardiac auscultatory skills are lacking not only in medical students but also in internal medicine and family medicine trainees [6,7]. Furthermore, Vukanovic-Criley et al. [8] reported that cardiac examination skills do not improve after the third year of medical school, and may decline after years

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in clinical practice. It is crucial for medical students, therefore, to acquire competence to identify these abnormal heart sounds and murmurs preceding the participation in clinical clerkship.

Medical students in Japan have to pass the objective structured clinical examination (OSCE) run by the Common Achievement Tests Organization, a public interest incorporated association in Japan, before they initiate clinical clerkship, usually in their fifth year of six-year undergraduate medical education [9,10]. The clinical skills and attitude that medical students have to acquire before participation in clinical clerkship are defined by the Common Achievement Tests Organization in Japan. With regard to cardiac auscultation, students should be able to identify split second sound (S2) and the existence of third (S3) and fourth (S4) sounds as well as systolic and diastolic heart murmurs.

Although technology-enhanced medical simulation is a useful tool for health professional learners to acquire a variety of knowledge and skills as well as desirable behaviors [11], its effectiveness in cardiac auscultation training is still controversial [12–20]. Furthermore, it is not known whether the effectiveness of auscultation training using a cardiology patient simulator differs among a variety of heart sounds and murmurs. We investigated whether a single three-hour cardiac auscultation training class using a cardiology patient simulator in a rotational clinical-skills training course preceding clinical clerkship provides our fourth-year medical students with sufficient competence for participation in clinical clerkship. We also tried to determine whether students' proficiency in cardiac auscultation at the end of the training class varies among heart sounds and murmurs.

Methods

Participants and simulators

A total of 324 fourth-year medical students (93–117 students/year for 3 years, 272 male and 52 female students) at Tohoku University School of Medicine participated in a three-hour cardiac auscultation training class using a cardiology patient simulator ("K", Kyoto-Kagaku, Kyoto, Japan) [21] during a rotational clinical-skills training course in preparation for clinical clerkship that starts in the fifth year of a six-year undergraduate medical education. This rotational clinical-skills training course consisted of 14 independent single three-hour classes for medical interview, a variety of physical examinations, and several basic clinical procedures including standard precautions, venous blood sampling, surgical gown technique, etc. Medical students were divided into groups consisting of 6–8 students. Numbers of students assigned to the groups, which had 6, 7, and 8 students, were 72 (22.2%), 140 (43.2%), and 112 (34.6%), respectively. Each group visited the Clinical Skills Laboratory at Tohoku University School of Medicine for cardiac auscultation training in turn on Wednesday afternoon from the end of August to the middle of December. Since this rotational clinical-skills training class was part of a mandatory course, all of the fourth-year medical students participated in not only our cardiac auscultation training class but also all of the other training classes of the course. Ethical approval was obtained from the Ethical Committee of Tohoku University Graduate School of Medicine.

Two teachers (YK and MT) were engaged in this three-hour auscultation training class. After a short introduction to the class, the teachers gave a mini-lecture regarding cardiac auscultation skills, heart sounds including both respiratory split and abnormally wide split S2s, S3, S4, and four heart murmurs (aortic stenosis, aortic regurgitation, mitral regurgitation, and mitral stenosis) (Table 1). The abnormally wide split S2 represents such a sound as heard in patients with right ventricular overload or complete right bundle branch block. After the mini-lecture, we assigned one or two students to each of four Simulator "K"® units, and the students practiced cardiac auscultation using the simulators while the two teachers facilitated it. Cardiac sounds and murmurs learned by the students in this class are shown in Table 2.

Table 1
Schedule of the three-hour cardiac auscultation training class using a cardiology patient simulator.

Time	Contents
1:00–2:30 p.m.	Mini-lecture and auscultation training using a cardiology patient simulator
2:30–3:00 p.m.	Self-training with a cardiology patient simulator
3:00–3:30 p.m.	First test followed by feedback
3:30–3:50 p.m.	Mini-lecture and cardiac palpation using a simulator (thrills, apex beat, etc.)
3:50–4:00 p.m.	Second test followed by feedback

Table 2
Heart sounds and murmurs learned in the cardiac auscultation training class using a cardiology patient simulator.

Category A	Category B	Category C
Non-split S2	S3	Aortic stenosis
Respiratory split S2	S4	Aortic regurgitation
Abnormally wide split S2	S3 + S4	Mitral regurgitation
		Mitral stenosis

S2, second sound; S3, third sound; S4, fourth sound.

Simulator "K"® is a human-sized mannequin with four small built-in speakers at the aortic, pulmonic, tricuspid, and mitral valve areas. It provides 88 variations of cardiac sounds and murmurs, including arrhythmias that were prerecorded from real patients [21]. Therefore, in contrast to Harvey® (Laerdal Medical, Stavanger, Norway) [22–24], learners use an ordinary type of stethoscope for Simulator "K"®. A computer controls the simulator so that respiratory split S2 is synchronized to both breath sounds and respiratory abdominal wall motion. Furthermore, the simulator has pulsations of the carotid arteries in addition to those of the brachial, radial, and femoral arteries, which help learners to distinguish systolic and diastolic murmurs.

Two different auscultation tests

After a mini-lecture and facilitated practice of distinguishing heart sounds and murmurs using Simulator "K"®, each student took two different auscultation tests using the simulator (Fig. 1).

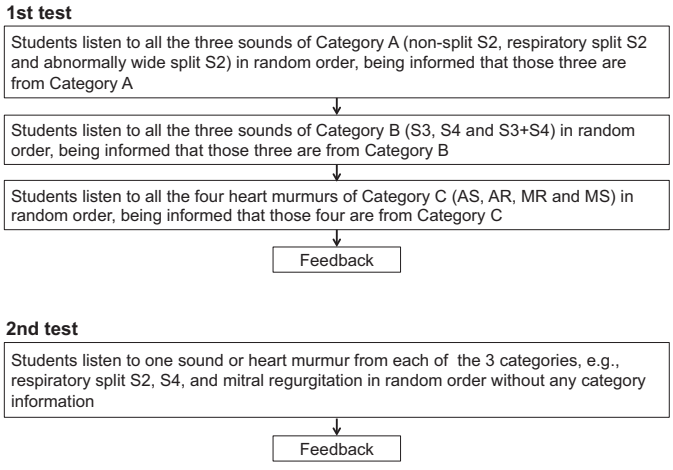

Fig. 1. Protocols of the first and second tests. S2, second sound; S3, third sound; S4, fourth sound; AS, aortic stenosis; AR, aortic regurgitation; MR, mitral regurgitation; MS, mitral stenosis.

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