Cardiac auscultation skills among medical trainees

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ABSTRACT

Background Many experts suspect there has been a gradual decline in cardiac auscultation skills among physicians, though no studies have examined this hypothesis over time. We sought to better evaluate the long-term change in medical trainees' cardiac auscultation skills.

Methods We performed a repeated cross-sectional study to analyze medical trainee performance on a cardiac auscultation simulation test over an 11-year period. The simulation tests involved identifying pre-recorded heart sounds and murmurs. Test results were analyzed with linear regression to evaluate temporal trends in scores. Performance on individual heart sounds and murmurs was also analyzed.

Results We included results from 411 simulation tests representing 348 medical students (84.7%), 37 residents (9.0%), and 26 cardiology fellows (6.3%). The overall average test score was 7.7 points (SD 2.5). Test scores declined over time for all trainees by 0.15 points per year (P=0.003). Fellows performed better than medical students by an average of 2.1 points ($P < 0.001$), while residents performed better than medical students by an average of 1.1 points ($P = 0.008$). Overall performance on individual heart sounds and murmurs was variable with no significant change in performance over time.

Conclusion Medical student trainees at an academic medical center had declining cardiac auscultation skills over time, with a possible similar decline noted among internal medicine residents and cardiology fellows. This study underscores the importance of broad investment in strategies for teaching cardiac auscultation to preserve and improve this essential skill.(Am Heart J 2025;286:14–17.)

Background

The practice of cardiac auscultation, a key component of the physical examination, has come into question in the modern era. At the same time, the use of advanced diagnostic imaging, such as echocardiography, has massively proliferated.[1] In this setting, many experts suspect there has been a gradual decline in cardiac auscultation skills among physicians, though no studies have examined this hypothesis over time.[2,3] In this repeated cross-sectional study, we sought to better evaluate the change in cardiac auscultation skills among medical trainees by analyzing performance on a cardiac auscultation simulation test.

Methods

Data sources

From July 2008 to October 2018, medical trainees (medical students, internal medicine residents, and cardiology fellows) rotating on the cardiology service at an academic teaching hospital were administered anonymous auscultation simulation tests (Supplementary). Trainees were asked to identify 16 heart sounds and murmurs, which were transmitted from a wireless infrared transmitter to stethoscope receivers. These included heart sounds (S3, S4, systolic ejection click, fixed S2, paradoxically split S2, and increased P2 sound), systolic murmurs (aortic stenosis, aortic stenosis with premature ventricular contraction, mitral valve prolapse, acute and chronic mitral regurgitation, and hypertrophic obstructive cardiomyopathy), and other murmurs (mitral stenosis, aortic regurgita-

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tion, patent ductus arteriosus, and pericardial friction rub).

Statistical analyses

All available simulation test results were analyzed for this study. Trainees were separated into 3 groups: medical students, internal medicine residents, and cardiology fellows. Simulations were scored based on the number of heart sounds and murmurs correctly identified, from 0 to 16. To evaluate both the trend in simulation scores over time and difference between groups, linear regression was performed. This linear model incorporated an effect for each student group. A higher order model with interaction terms between trainee group and time was created, but there were not enough data for such a model to be considered more explanatory than the lower order model. To evaluate overall performance in identifying each heart sound and murmur, the following were analyzed: (1) the overall probability that each sound would be recognized correctly, (2) the difficulty of each sound (baseline random effect) using a mixed effects model, (3) the probability of correctness for each sound over time, and (4) the change in performance on each sound over time (random effect for time) using a mixed effects model. Given the absence of data from the years 2009 and 2010, we utilized both residuals and leverage analysis to ensure that data from 2008 did not have undue influence over the model fits. Statistical analysis was performed in R v4.2.3. Analysis and manuscript preparation followed STROBE guidelines. This study was approved by the Cedars-Sinai Medical Center Institutional Review Board.

Results

We analyzed the results from 411 cardiac auscultation simulation tests from 2008 to 2018. These tests were completed by 348 medical students (84.7%), 37 internal medicine residents (9.0%), and 26 cardiology fellows (6.3%). The overall average simulation test score for all trainees was 7.7 points (SD 2.5). Cardiology fellows performed better than medical students by 2.1 points ($P < .001$), while internal medicine residents performed better than medical students by 1.1 points ($P = .008$). Simulation test scores declined over time for cardiology fellows, internal medicine residents, and medical students by 0.15 points per year ($P = .003$, Figure 1). Both the residuals and leverage analysis did not show that data from 2008 had an undue influence over the model fits. Overall performance on each simulation question was highly variable. The highest performance was on identifying patent ductus arteriosus, followed by acute mitral regurgitation, and then hypertrophic cardiomyopathy. The lowest performance was on identifying systolic ejection click, then mitral stenosis, and then mitral valve prolapse. There was no significant change in performance on individual heart sounds or murmurs over time (Figure 2).

Discussion

This study demonstrates that medical students at an academic medical center had declining cardiac auscultation skills over time. Our results also suggest that internal medicine residents and cardiology fellows had a similar decline. Trainees more readily identified certain heart sounds and murmurs over others, including patent ductus arteriosis and acute mitral regurgitation over systolic ejection click and mitral stenosis. There was no significant change in performance on individual questions over time, and thus it does not appear that any individual question(s) drove the overall decline in simulation test scores.

Over the 11-year time period of the study, several improvements to the physical examination curriculum for medical students were implemented at our institution. These changes mirrored or in some cases created best practices and nationwide trends to improve clinical skills training. A new competency-based curriculum for teaching clinical skills was introduced, including integrated and progressive instruction, simulation with standardized patients, systematic evaluations, and individualized feedback and learning plans.[4] A dedicated clinical skills education center for trainees opened in 2008, which was renovated into a state-of-the-art simulation and clinical skills education center in 2011. Despite this institutional investment into physical examination education, medical students continued to demonstrate declining cardiac auscultation skills.

There are several possible explanations for the decline in cardiac auscultation skills among medical trainees. The increasing volume of medical knowledge taught in medical school curricula as well as the increasing use of echocardiography may deemphasize the cardiac examination. Trainees also now face a higher burden of documentation and electronic health record use, which decreases the amount of time they can engage in direct patient care such as performing and practicing the physical examination.[5] With lower overall cardiac auscultation skills, trainees may find themselves in a negative cycle where they find the cardiac examination less useful and thus become less inclined to utilize the examination to make clinical decisions. Further, as groups of trainees advance to become attending physicians responsible for instructing new trainees, their declining auscultation skills may result in declining auscultation teaching skills, perpetuating a negative generational cycle.

Limitations

Several limitations merit consideration. Conclusions about internal medicine resident and cardiology fellow cardiac auscultation skills trends were limited by sam-

Figure 1. Auscultation simulation performance by trainee group over time. Figure 1 source file uploaded separately. Auscultation simulation scores for each trainee are represented by individual points. The maximum score was 16. Trend lines for each trainee group are overlaid.

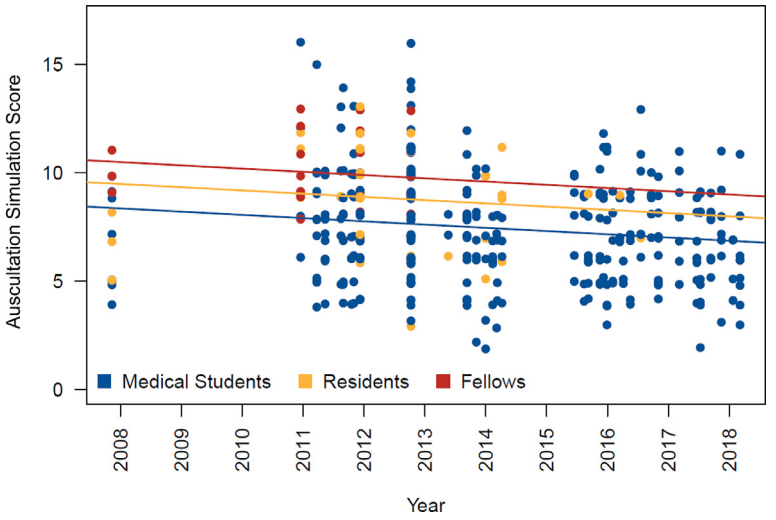
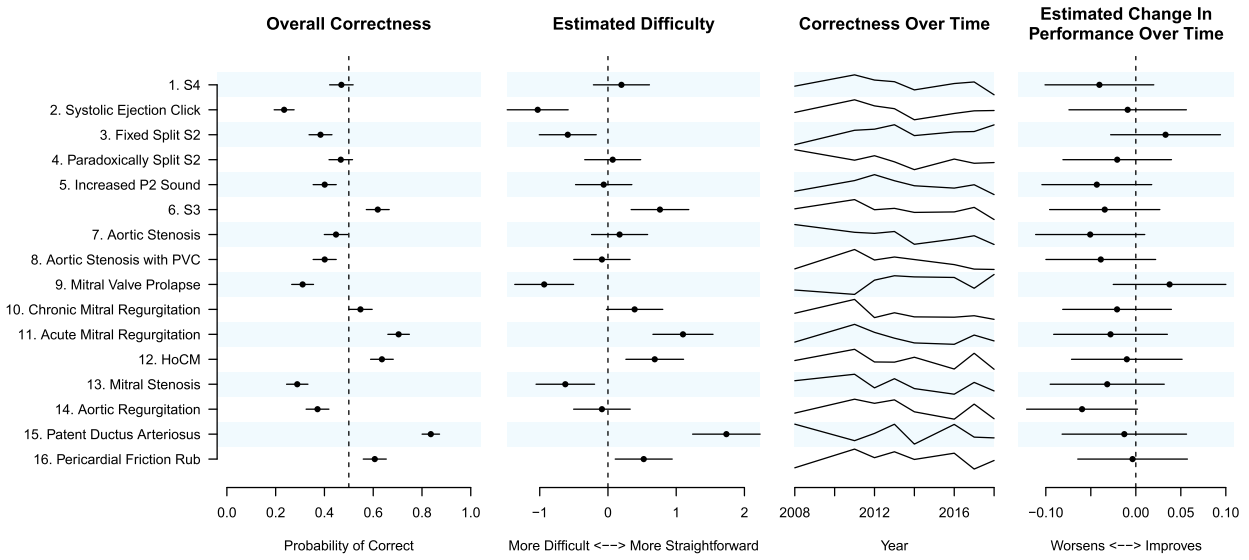


Figure 2. Performance on individual heart sounds and murmurs. Figure 2 source file uploaded separately. Overall correctness is the probability of recognizing each sound correctly. Estimated difficulty is an odds ratio indicating the inherent difficulty of each sound. Correctness over time is a graphical illustration of variation in correctness rates over time. Estimated change in performance over time is an odds ratio change per year, demonstrating change in performance on each sound over time. Abbreviations: HoCM, hypertrophic obstructive cardiomyopathy; PVC, premature ventricular contraction.



ple size. Trainee-level factors such as clinical evaluations were not available for analysis. The use of an auscultation simulation test with multiple choice response as a proxy for cardiac auscultation skills was a potential limitation, though similar tests have previously been found to represent valid assessment methods for auscultation.[6] Our dataset, spanning from 2008 to 2018, may not reflect the most recent cardiac auscultation training techniques. However, given the long duration of our study and others' findings that contemporary trainees have significant deficiencies in their cardiac auscultation skills, our findings continue to hold salience today.[7]

Cardiac auscultation, and more broadly the physical examination, both remain essential to clinical practice.

Proper physical examination skills can not only identify innocent findings and obviate the need for expensive studies, but also pinpoint critical findings that may otherwise have been missed. The physical examination is also a critical component in creating the patient-physician relationship, an entity formed during history-taking and careful physical examination.[8,9]

There are many validated strategies for teaching the physical examination to trainees, such as web-based modules, multimedia classroom lectures, supervised examinations, small group sessions, simulators, and mobile applications leveraging spaced learning and retrieval practice techniques.[10,11] We recommend that medical schools, training programs, and professional societies continue to increase investment in evidence-based strategies for teaching cardiac auscultation to their trainees and practicing physicians. Ultimately, increased emphasis of cardiac auscultation and the physical examination by experts at all levels of medical training, including undergraduate, graduate, and continuing medical education, is essential to preserving and improving this valuable skill.

Conclusion

Medical student trainees at an academic medical center had declining cardiac auscultation skills over time, with a possible similar decline noted among internal medicine residents and cardiology fellows. This decline may be due to the increasing volume of medical knowledge taught in medical schools, increasing use of advanced imaging, higher burden of documentation which decreases direct patient care, or declining auscultation teaching skills of clinical skills instructors. This study underscores the importance of broad investment in strategies for teaching cardiac auscultation to preserve and improve this essential skill.

Declaration of competing interest

We declare no competing interests or relationships with industry.

CRediT authorship contribution statement

Neil S. Zhang: Writing – original draft, Methodology, Data curation, Conceptualization. **Joy Y. Yang:** Visualization, Methodology, Formal analysis. **Joshua I. Goldhaber:** Writing – review & editing. **Binh An P. Phan:** Writing – review & editing, Conceptualization. **Melvin D. Cheitlin:** Writing – review & editing, Data curation, Conceptualization.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ahj.2025.03.006.

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