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Original Article

Utility of physical examination and comparison to echocardiography for cardiac diagnosis

Ashish Patel, Nitin Singh Tomar, Anil Bharani *

Department of Medicine, M.G.M. Medical College, Indore, M.P., India

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ABSTRACT

Objective: To find out the accuracy of cardiac auscultation using non-digital stethoscope in physical diagnosis of cardiac diseases.

Methods: We enrolled 104 consecutive patients with abnormal cardiac auscultatory findings attending cardiology clinic and not previously evaluated by echocardiography. One time detailed cardiac physical examination followed by echocardiography within 1 month was undertaken. Agreement between two methods was calculated using mean pair percentage agreement, kappa statistics (κ) and calculation of 95% confidence interval (CI) for kappa statistics.

Results: Using kappa statistics, there was almost perfect agreement between cardiac auscultation and echocardiography for the detection of mitral stenosis ($\kappa = 0.865$; CI 0.76–0.97) and ventricular septal defect ($\kappa = 0.872$; CI = 0.73–1.01). Substantial agreement was noted for aortic stenosis ($\kappa = 0.752$; CI = 0.56–0.94), pulmonary stenosis ($\kappa = 0.647$; CI = 0.33–0.97) and atrial septal defect ($\kappa = 0.646$; CI = 0.32–0.97), while moderate agreement was found for mitral regurgitation ($\kappa = 0.470$; CI = 0.30–0.64), aortic regurgitation ($\kappa = 0.456$; CI = 0.25–0.66) and tricuspid regurgitation ($\kappa = 0.575$; CI = 0.38–0.77).

For combined mitral stenosis and mitral regurgitation lesions, almost perfect agreement was found for mitral stenosis ($\kappa = 0.842$; CI = 0.691–0.993) while fair agreement noted for mitral regurgitation ($\kappa = 0.255$; CI = −0.008 to 0.518).

Conclusion: Careful clinical auscultation using a stethoscope remains a valuable tool for cardiac diagnosis. Decision on initial diagnosis and management of valvular and congenital heart diseases should be based on clinical examination and integrating such information with echocardiography as required.

What is already known?

Physical examination is a sensitive tool for diagnosis of cardiac diseases.
Echocardiography is rapidly supplanting and often used as an alternative to physical examination diagnoses at first patient encounter.

What this study adds:

Physical examination is still a valid tool for diagnosis of cardiac diseases. Structured training in physical methods including cardiac auscultation should be part of undergraduate and postgraduate teaching curriculum in India.

1. Introduction

Despite the glorious past of cardiac auscultation and thrill of making bedside diagnoses, proficiency in this clinical skill has been deteriorating over past many decades.[1–5] Further, some North American medical schools are providing medical students with hand held pocket ultrasound equipments to make a cardiac diagnosis with the ultrasound equipment on first patient encounter rather than using stethoscope.[6,7] Should stethoscope be discarded as a cardiac diagnostic tool on the pretext of its limited diagnostic yield? In the resource poor settings, cardiac auscultation should continue to serve as a useful tool to

* Corresponding author at: 119, Ravindra Nagar, Indore, M.P. 452 018, India.
E-mail address: anilbharani@gmail.com (A. Bharani).

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physicians for taking immediate clinical decisions on encountering patients.

There are many situations, in which clinical examination provide important insight into disease condition, which may not be provided by echocardiography in a given context. Recent editorial in the Journal of the American College of Cardiology has clearly identified few of such situations.[8]

We planned this study to find out the accuracy of cardiac auscultation using non-digital stethoscope in physical diagnosis of cardiac diseases compared to gold standard echocardiography to know its utility in current times to avoid over utilization of echocardiography resources in initial cardiac diagnosis.

2. Methods

2.1. Selection of patients

We enrolled all consecutive patients with cardiovascular diseases attending cardiology clinic at M.Y. Hospital, Indore with abnormal cardiac auscultatory findings from February 2015 to September 2015. Patients who had echocardiography evaluation earlier at any time were not included. The study protocol was approved by institutional Ethics and Scientific review board and a valid informed consent was obtained from all patients prior to inclusion in the study. Additionally children above 7 years gave assent for participation.

2.2. Study design

This is a cross-sectional, observational study with one time clinical examination and echocardiography of patients enrolled in the study.

First, the patients were selected on outpatient basis, based on having some abnormal cardiac auscultatory findings. They were physically examined by senior most cardiologist using non-digital Littmann Master Cardiology stethoscope and detailed findings on inspection, palpation, percussion and auscultation were recorded. The examining cardiologist had an experience of 30 years in cardiology practice. It was assumed that physical examination by a senior faculty would provide best possible accuracy in physical examination. Murmurs were characterized in terms of location, grading and timings in cardiac cycle. Characteristics of heart sounds, extra sounds and abnormal sounds were also noted. The examining cardiologist was allowed to have sufficient time for performing clinical examination but not allowed to have access to history and other investigations of the patients before committing and recording physical examination in a standardized format. The intra-observer variability for assessment of lesion severity was less than 5%.

Most of the patients underwent echocardiographic evaluation on the day of examination but some within 1 month of auscultation. This included M-Mode, 2-D, Colour Flow Mapping, pulse wave and continuous wave Doppler using adult and pediatric transducers (GE Logic-3 Expert Machine, GE medical system, Phoenix, AZ, USA). The echocardiographer had no knowledge of clinical findings and was allowed to have sufficient time as may be required for performing echocardiography.

2.3. Outcome measures and statistical analysis

Echocardiography was considered as a gold standard diagnostic test. Agreements between echocardiographic diagnoses were compared with auscultatory diagnoses using kappa statistics.[9–11] Since kappa statistics requires number of categories of observation to be same between the two observers, lesions diagnosed as trivial on the echocardiographic basis were recorded as equivalent to no lesion for the purpose of calculation of kappa statistics. Kappa statistics was calculated both for agreement on presence or absence of disease as well as for agreement on the severity of disease in question. Table 1 shows interpretation of calculated kappa statistics.[10] Mean pair agreement index (observed percentage agreement) for each diagnosis was also calculated.[12] Calculation of 95% confidence interval (CI) was done to further characterize agreement based on the kappa statistics.

Table 1
Interpretation of kappa.[9,10]

Kappa	Agreement
<0	Less than chance agreement
0.01–0.20	Slight agreement
0.21–0.40	Fair agreement
0.41–0.60	Moderate agreement
0.61–0.80	Substantial agreement
0.81–0.99	Almost perfect agreement

SPSS version 20.0 was used for analyzing the data. In situations, where it did not provide direct output like 95% confidence interval for kappa statistics, manual calculations were performed.

3. Results

A total of 104 patients were included in the study with age ranging from 2 to 85 years. Most of the patients were of 21–50 years age group (56%).

A total of 210 diagnoses were sorted out based on echocardiographic findings. Majority of cases had valvular disease of rheumatic etiology with many of them having multivalvular involvement, others had congenital heart diseases. Most common diagnoses in decreasing order of frequency were mitral regurgitation (MR, 37.5%), mitral stenosis (MS, 31.7%), aortic regurgitation (AR, 24%), tricuspid regurgitation (TR, 23.1%), aortic stenosis (AS, 30.5%), ventricular septal defect (VSD, 12.5%), pulmonary stenosis (PS, 6.7%) and atrial septal defect (ASD, 5.8%) (Table 3). Single cases of patent ductus arteriosus (PDA), cor triatriatum, ruptured sinus of valsalva into right ventricle (RSOV) and aortic valve prolapse (AVP) were also noted.

Among patient with rheumatic heart diseases, mitral valve was most often involved, both clinically and by echocardiography. Mixed lesions were frequent, with combined MS + MR being most common (16.34%), followed by combined MR + AR (11.53%), MS + AR (6.73%), MR + AS (3.84%), MS + AS (1.92%) and MS + MR + AS + AR (1.92%). Five patients were found to have occult MS. Atrial fibrillation was found in 16 patients, of which 9 were having underlying mitral stenosis.

3.1. Valvular heart diseases

In general, agreement between clinical auscultation and echocardiography was better for detection of stenotic lesions as compared to regurgitant lesions (Table 2). Almost perfect agreement was noted for detection of MS ($\kappa = 0.865$; CI 0.76–0.97) while substantial agreement was found for AS ($\kappa = 0.752$; CI = 0.56–0.94).

Moderate agreement was noted for TR ($\kappa = 0.575$; CI = 0.38–0.77); MR ($\kappa = 0.470$; CI = 0.30–0.64) and AR ($\kappa = 0.456$; CI = 0.25–0.66).

In general, agreement on disease severity was inferior to that of disease detection only (Tables 3 and 4). Taken isolated and mixed lesions together, there was substantial agreement for assessment of severity of disease for MS ($\kappa = 0.704$; CI = 0.58–0.83) and moderate agreement for AS ($\kappa = 0.569$; CI = 0.38–0.76), and TR ($\kappa = 0.454$; CI = 0.29–0.62). Fair agreement was noted for severity assessment of MR ($\kappa = 0.326$; CI = 0.18–0.47). Only slight agreement was found for severity assessment of AR ($\kappa = 0.018$; CI = −0.01 to 0.04).

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Table 2
Disease detection by cardiac auscultation versus echocardiography.

Diagnosis	Number (%) (total no. = 104)	Missed on clinical examination	Over diagnosed on clinical examination	Mean pair agreement index	Kappa	SE	95% CI, lower limit	95% CI, upper limit
MS	33 (31.7)	4	2	94.23	0.865	0.05	0.76	0.97
MR	39 (37.5)	19	6	76.92	0.470	0.09	0.30	0.64
AS	14 (13.5)	3	3	94.23	0.752	0.10	0.56	0.94
AR	25 (24)	15	2	83.65	0.456	0.11	0.25	0.66
TR	24 (23.1)	9	6	85.58	0.575	0.10	0.38	0.77
PS	7 (6.7)	3	1	96.15	0.647	0.16	0.33	0.97
ASD	6 (5.8)	2	2	96.15	0.646	0.16	0.32	0.97
VSD	13 (12.5)	1	2	97.12	0.872	0.07	0.73	1.01
PAH	26 (25)	8	13	79.81	0.494	0.09	0.31	0.68

SE – standard error, CI – confidence interval, AR – aortic regurgitation, AS – aortic stenosis, ASD – atrial septal defect, MR –mitral regurgitation, MS – mitral stenosis, PAH – pulmonary arterial hypertension, PS – pulmonary stenosis, TR – tricuspid regurgitation, VSD – ventricular septal defect.

Table 3
Comparison of lesion severity assessment by cardiac auscultation compared to echocardiography.

	Echocardiography	Auscultatory diagnosis number (%)
MS		
Mild	6	4 (66.7%)
Moderate	4	4 (100%)
Severe	23	20 (87%)
MR		
Mild	21	8 (38.1%)
Moderate	9	5 (55.6%)
Severe	9	9 (100%)
AS		
Mild	9	2 (22.2%)
Moderate	1	1 (100%)
Severe	4	4 (100%)
AR		
Mild	15	3 (20%)
Moderate	3	0 (0%)
Severe	7	4 (57.1%)
TS		
Moderate	1	0 (0)
Severe	1	1 (100%)
TR		
Mild	8	3 (37.5%)
Moderate	7	4 (57.1%)
Severe	9	7 (77.8%)
PS		
Mild	4	1 (25%)
Moderate	0	0 (0)
Severe	3	3 (100%)
PR		
Mild	2	1 (50%)
Severe	1	1 (100%)

AR – aortic regurgitation, AS – aortic stenosis, MR – mitral regurgitation, MS – mitral stenosis, PR – pulmonary regurgitation, PS – pulmonary stenosis, TS – tricuspid stenosis, TR – tricuspid regurgitation.

Additional kappa analysis was also performed for detecting agreement between physical examination and echocardiography for multi-valvular involvement by excluding cases of single valve involvement from the analysis.

For combined MS and MR lesions, almost perfect agreement was found for MS ($\kappa = 0.842$; CI = 0.691–0.993) while that for MR dropped to fair agreement level ($\kappa = 0.255$; CI = −0.008 to 0.518).

For combined MS, MR and TR lesions, there was almost perfect agreement for MS ($\kappa = 0.826$; CI = 0.636–1.016) and TR ($\kappa = 0.811$; CI = 0.609–1.017) but MR was clinically missed in many patient with combined lesion of MS, MR and TR ($\kappa = 0.182$; CI = −0.124 to 0.488).

When considering patient with co-existing MS and AR, agreement for MS detection was substantial ($\kappa = 0.741$; CI = 0.463–1.019) while only slight agreement was found for detection of AR ($\kappa = 0.140$; CI = −0.199 to 0.479; $P = 0.23$).

For patient with combined TR and MR, there was substantial agreement for detection of TR ($\kappa = 0.657$; CI = 0.453–0.861) and fair agreement for detection of MR ($\kappa = 0.247$; CI = 0.002–0.492).

For patient with combined AS and AR, there was substantial agreement for detection of both AS ($\kappa = 0.626$; CI = 0.352–0.9) and AR ($\kappa = 0.781$; CI = 0.544–1.018).

Stenotic and regurgitant valvular lesions, when sorted according to disease severity on echocardiography and audibility of respective associated murmur on clinical examination, it became apparent that diagnosis is much more likely to be missed on physical examination in mild valvular lesions compared to moderate to severe valvular lesions (Table 3).[13]

3.2. Congenital heart diseases

Almost perfect agreement was found between clinical and echocardiographic detection for VSD ($\kappa = 0.872$; CI = 0.73–1.01)

Table 4
Kappa analysis of lesion severity assessment by cardiac auscultation compared to echocardiography.[a]

Diagnosis	Mean pair agreement index	Kappa	SE	95% CI, lower limit	95% CI, upper limit
MS	87.5	0.704	0.06	0.58	0.83
MR	66.34	0.326	0.07	0.18	0.47
AS	89.42	0.569	0.10	0.38	0.76
AR	80.76	0.018	0.01	−0.01	0.04
TR	79.8	0.454	0.09	0.29	0.62
PS	95.19	0.009	0.01	−0.01	0.03
ASD	95.19	0.564	0.16	0.25	0.88
VSD	96.15	0.835	0.08	0.68	0.99
PAH	75	0.438	0.08	0.28	0.60

SE – standard error, CI – confidence interval, AR – aortic regurgitation, AS – aortic stenosis, ASD – atrial septal defect, MR – mitral regurgitation, MS – mitral stenosis, PAH – pulmonary arterial hypertension, PS – pulmonary stenosis, TR – tricuspid regurgitation, VSD – ventricular septal defect.
[a] Severity assessment combining mild, moderate and severe categories.

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while substantial agreement noted for detection of PS ($\kappa = 0.647$; CI = 0.33–0.97) and ASD ($\kappa = 0.646$; CI = 0.32–0.97) (Table 2).

There was almost perfect agreement for detection of shunt size in VSD patients ($\kappa = 0.835$; CI = 0.68–0.99). However, there was only moderate agreement for detection of shunt size in ASD patients ($\kappa = 0.564$; CI = 0.25–0.88). For assessment of severity of PS, there was only slight agreement ($\kappa = 0.008$; CI = −0.01 to 0.03).

3.3. Other conditions

Moderate agreement was noted for detection of PAH ($\kappa = 0.494$; CI = 0.31–0.68) between clinical diagnosis and Echo Doppler assessed pulmonary artery systolic pressures.

4. Discussion

Among all disease conditions studied in this study, there was almost perfect agreement between cardiac auscultation and echocardiography for the detection of MS. It seems to be due to familiarity of physicians with the auscultatory findings of MS in India. A high degree of accuracy in detection of mid diastolic murmur of MS by a cardiologist is reported previously.[14,15]

Similarly, there was almost perfect agreement for detection of VSD which is most common congenital cardiac anomaly with distinctive physical findings.

There was moderate agreement between both methods for detection of TR, MR and AR.

This study found an inferior agreement for detection of regurgitant valvular lesions as compared to stenotic valvular lesions by method of physical examination. It is a well-known fact that even severe MR can be clinically silent, particularly in patients with ring dilatation and papillary muscle dysfunction.[16,17] Echocardiography is the most sensitive method for detection of valvular regurgitation. However reporting of trace physiological regurgitation by echocardiography causes undue anxiety in the patients.[18,19] Detection of trace or trivial regurgitant lesion, most of the time does not contribute to or alter the patient management. Further, clinically silent valvular regurgitation in an asymptomatic person with normal examination is of dubious significance. Such information may lead to unnecessary referrals for further testing or frequent echocardiographic monitoring of disease progression, aiding frequently to increased health care cost.[18] However, echo detection of silent mitral regurgitation in patients of acute rheumatic fever is valuable, helping in diagnosing presence of carditis in a given case.

Agreement between clinical auscultation and echocardiography for moderate to severe valvular lesion was much better, suggesting that mild valvular heart disease may be missed on ascultation. Raldon et al. have reported similar findings with <20% of mild regurgitant lesion being audible by cardiac auscultation. They also found that cardiac auscultation was accurate for separation of flow murmurs from organic murmur.[13] Thus, the need for unnecessary echocardiography can be curtailed if careful cardiac auscultation is utilized.

Overall a lower agreement was found for assessment of disease severity, as compared to detection of presence of disease which is an expected finding. Diagnosis of disease is a dichotomous variable with sharp difference between two, either present or absent. People are more likely to agree on such variables. Disease severity on the other hand is a continuous variable with blurred distinction between the mild, moderate and severe disease. People are less likely to agree on compartmentalization/categorization of a continuous variable. Thus kappa statistics in such circumstances, like ours, generate inferior agreement.

The ability of cardiac examination to assess the exact cause of the murmur is limited if more than one lesion is present. Thus the echocardiography should be performed in patients with murmurs of unknown cause who are suspected of having significant heart disease.

A grade I/II intensity ejection systolic murmur of short duration at the left sternal border, with no increase in intensity with valsalva maneuver, associated with normal S2, no other abnormal sound and no evidence of ventricular hypertrophy or dilatation are considered innocent murmur and usually of no functional significance. When finding from cardiac examination are considered together with history, electrocardiogram and chest X-ray, the correct diagnosis can usually be made. Thus "screening" echocardiography should not be used as an alternative to clinical examination.[20,21] Though safe and sensitive diagnostic tool, extreme sensitivity of echocardiography often lead to detection of physiological valvular regurgitation with potential to label it as a disease. Such "echocardiographic disease", which does not alter management plan, has potential to provoke anxiety in asymptomatic persons affecting quality of life. In addition, similar to physical examination skills, echocardiographic acquisition and interpretation also requires expertise and experience, which may not be available everywhere.

In a perspective article on point-of-care ultrasound in medical education, authors cautioned about the risk of misdiagnosis when diagnostic ultrasound is used by inexperienced practitioners.[22] Although medical students may be able to make relatively crude assessment of ventricular function, more sophisticated anatomical assessment will require substantially more training. In addition, false positive findings may lead to additional and often unnecessary testing, and false negatives may provide untruthful reassurance.[22]

With the introduction of digital stethoscope, cardiac auscultation is likely to become more objective and can provide impetus in mastering art of physical diagnosis which will provide more confidence in establishing clinico-technological correlation which in turn increases quality of care as well as reduction of healthcare cost.

Echocardiography however remains a very versatile tool for diagnosis of conditions that cannot be diagnosed by auscultation such as cortriatriatum, left ventricular aneurysm, intracardiac clot, for assessment of ventricular functions, detection of vegetations and complications of infective endocarditis.

This study demonstrates that physical examination remains valuable even in the present era of highly sensitive imaging modalities but requires experience. Cardiology teaching should continue to lay emphasis on rigorous clinical skills training rather than discarding it in favor of diagnostic investigations.

4.1. Limitation of the study

The sample size was small not allowing application of kappa statistics for some of the lesions. A senior cardiologist had performed the physical examination and naïve cardiologists may not achieve that level of accuracy to make accurate diagnosis based on physical examination alone.

5. Conclusion

Careful clinical auscultation using a stethoscope remains a valuable tool for cardiac diagnosis. Decision on initial diagnosis and management of valvular and congenital heart diseases should be based on clinical examination and integrating such information with echocardiography as required.

Conflicts of interest

The authors have none to declare.

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