

A comparison of clinical paediatric murmur assessment with echocardiography

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Abstract

Objective: To compare the clinical acumen of paediatric cardiovascular examination between various hospital paediatrician grades.

Design: Prospective data collection of clinical and echocardiography findings on paediatric echocardiography referrals.

Setting and patients: All paediatric patients (birth - 14 years) referred for echocardiography, in a regional hospital catering for the island population of Malta. Echocardiography was carried out by three paediatricians with tertiary training in this technique.

Main outcome measures: Pre-echocardiography clinical diagnoses were compared with echocardiography results according to grade of referring hospital doctor (ranging from houseman to consultant). Both normal and abnormal hearts at echocardiography were included.

Results: Echocardiographers had the highest clinical accuracy and the highest attempts at reaching a clinical diagnosis. Accuracy and attempts at diagnosis decreased as doctor's hospital grade decreased, from consultant to houseman. Ventricular septal defect was the most easily diagnosed lesion. Atrial septal defect was often misdiagnosed as pulmonary stenosis.

Key words

Echocardiography, congenital heart disease

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Introduction

Abnormalities in paediatric cardiovascular examination are not uncommon, and not necessarily pathological.^{1,2} Indeed, up to 50% of school aged children have physiological murmurs^{3,4} and it has been estimated that the ratio of innocent murmurs to pathological murmurs is 10:1.¹ Abnormal cardiovascular physical findings in childhood, most commonly a murmur, may prompt referral for further assessment to a regional/tertiary centers.^{5,6} After specialist review, echocardiography may then be used to confirm or exclude the presence of cardiac anomalies. Echocardiography is an accurate, objective and non-invasive cardiac imaging technique.⁷ However, echocardiography is not an inexpensive investigation, and in addition, may entail sedation.⁸

The accuracy of clinical examination in deciding whether findings are pathological or not, and hence the need for echocardiography, depends on the clinical experience of the examiner.^{9,10}

Malta has one regional hospital (St. Luke's) which caters for all paediatric cardiology needs for the entire country, including echocardiography. Hospital grades are similar to those in the United Kingdom, and increase in seniority from houseman, through to senior house officer, registrar, senior registrar and consultant. Children are referred to St. Luke's with suspected pathological murmurs from general practitioners, private paediatricians, school medical officers and from state sponsored child health and development screening services. Such children are then seen in an outpatient clinic by a doctor, with grades ranging from a supervised houseman/senior house officer, to a consultant. In this clinic, there is free access to radiology (for CXR) and to electrocardiography, if desired. If deemed necessary, children are then referred on for an echocardiogram. Echocardiograms in St. Luke's Hospital are performed by one of three paediatricians who have trained in this technique in tertiary centres in the United Kingdom (MB, VM, VG).¹¹

In this study we compared pre-echocardiography clinical assessment of murmurs in children referred to St. Luke's hospital, with subsequent echocardiography results. Clinicians were subdivided by hospital grade, which was taken as a proxy for experience. Urgent referrals (e.g. for cyanosis) were not included in this study as they went straight to echocardiography.

Methods

This study, with the approval of the Ethics Committee, was conducted between January 1995 and December 1996. The ages of children included in this study ranged from the first day of life to fourteen years. An echocardiography request form was

Table 1: Accuracy of clinical diagnosis by lesion

Hospital Doctor	Normal	VSD	ASD	PS	PDA	TOF	AS	MVP	Total
No attempt at diagnosis	27	1	2	3	0	0	0	1	34
Correct diagnosis	147	21	1	2	0	1	0	0	172
Incorrect diagnosis	55	5	13	7	3	2	1	2	88
Total	229	27	16	12	3	3	1	3	294
Percentage of above	Normal	VSD	ASD	PS	PDA	TOF	AS	MVP	Abnormal total
No attempt at diagnosis	12	4	13	25	0	0	0	33	12
Correct diagnosis	64	78	6	17	0	33	0	0	59
Incorrect diagnosis	24	19	81	58	100	67	100	67	30

VSD=Ventricular septal defect; ASD=Atrial septal defect; PS=Pulmonary stenosis; PDA=Patent ductus arteriosus; TOF=Tetralogy of Fallot; AS=Aortic stenosis; MVP=Mitral valve prolapse

specially designed for this study. It was left at the discretion of the examining doctor as to whether children seen with murmurs were referred for an echocardiogram or not, and therefore normal clinical practice was undisturbed.

Each referral was categorised by the hospital doctor after clinical examination as having a 'normal' or 'pathological' heart, and abnormalities suspected to be present were noted on the request form. Children seen in the outpatient setting are not selected to be seen by any specific grade of doctor.

Just before the echocardiogram, the referred child was re-examined by the echocardiographer who attempted an independent, pre-echocardiography, clinical diagnosis. The echocardiogram was then performed and the result was also noted. If multiple lesions were present, then the most haemodynamically significant lesion and therefore the lesion producing the most clinical signs, was taken as the primary diagnosis.

The echocardiography machine used was the same throughout (Hewlett Packard Sonos 5500) with two-dimensional, M-mode, and colour, pulse wave and continuous wave Doppler. The data was entered and analysed in Excel.

Results

294 patients had correctly filled forms and an echocardiogram performed. 229 had normal hearts and 65 had structural cardiac abnormalities. The abnormalities were ventricular (n=27) and atrial septal defects (n=16), pulmonary stenosis (n=12), patent ductus arteriosus (n=3), tetralogy of Fallot (n=3), aortic stenosis (n=1) and mitral valve prolapse (n=3) (Table 1).

Table 1 shows the accuracy of hospital diagnosis by nature of lesion (if any). Hospital doctors attempted a diagnosis in almost 90% of cases, whether an abnormality was actually present or not (Table 1). The lesion most easily clinically diagnosed was ventricular septal defect. There were 25 false negative referrals in that these children were referred for echocardiography in the belief in that they had innocent murmurs with normal hearts but echocardiography actually showed some form of structural abnormality.

Echocardiographers attempted an equivalent number of clinical diagnoses (92%), in both normal and abnormal hearts (Table 2). Accuracy was much higher for normal hearts, and was also slightly higher for abnormal hearts (Table 2) when

Table 2: Accuracy of clinical diagnosis by lesion for echocardiographers only

Echocardiographer	Normal	VSD	ASD	PS	PDA	TOF	AS	MVP	Total
No attempt at diagnosis	2	0	2	1	0	0	0	0	5
Correct diagnosis	225	23	2	11	1	3	0	3	268
Incorrect diagnosis	2	4	12	0	2	0	1	0	21
Total	229	27	16	12	3	3	1	3	294
Percentage of above	Normal	VSD	ASD	PS	PDA	TOF	AS	MVP	Abnormal Total
No attempt at diagnosis	1	0	13	8	0	0	0	0	2
Correct diagnosis	98	85	13	92	33	100	0	100	92
Incorrect diagnosis	1	15	75	0	67	0	100	0	7

VSD=Ventricular septal defect; ASD=Atrial septal defect; PS=Pulmonary stenosis; PDA=Patent ductus arteriosus; TOF=Tetralogy of Fallot; AS=Aortic stenosis; MVP=Mitral valve prolapse

Table 3: Accuracy of clinical diagnosis by hospital grade excluding echocardiographers

Hospital diagnosis	Consultant	Senior Registrar	Registrar	Senior House Officer	Houseman	Total
No attempt at diagnosis	6	3	3	9	8	29
Correct diagnosis	38	32	27	38	11	146
Incorrect diagnosis	14	20	24	16	8	82
Total	58	55	54	63	27	257

Percentage of above	Consultant	Senior Registrar	Registrar	Senior House Officer	Houseman	Total
No attempt at diagnosis	10	6	6	14	30	11
Correct diagnosis	66	58	50	60	41	57
Incorrect diagnosis	24	36	44	25	30	32

compared with other hospital doctors.

Overall, attempts at diagnosis increased with increasing hospital grade (Table 3), with consultant grade physicians attempting to reach a diagnosis more frequently than other grades, and with house officers making the least attempt at reaching a diagnosis prior to echocardiography. The same trend is also seen in diagnostic accuracy, with consultants reaching a correct diagnosis with the highest frequency, and house officers being the least likely to reach a correct diagnosis. Formal diagnostic test analysis as outlined in Table 4 confirmed this trend, with sensitivity also varying according to clinical grade, increasing from 64% to 73%.

Discussion

Cardiovascular examination in children often detects murmurs. Murmurs are produced by turbulence arising from the heart and vascular system that results in sound waves in the range of 20 to 2000 Hz.

Murmurs represent one of the most common reasons for

referral for paediatric specialist review. Nearly all paediatric murmurs are heard in normal hearts and are not due to cardiac pathology. Innocent murmurs are comprised of five systolic murmurs and two continuous types of murmurs. Innocent murmurs include Still's murmur (the commonest innocent murmur) and this is typically audible between the ages of two to six years as a high pitched systolic murmur heard at the left lower left sternal edge extending to the apex. This murmur is louder in the supine position. A pulmonary flow murmur can be heard in older children and adolescents as an ejection systolic murmur confined to the second and third intercostal spaces at the left sternal border. Neonatal pulmonary branch systolic murmurs are soft ejection murmurs heard in neonates and infants up to one year of age. The most common type of continuous murmur heard in children is the venous hum of late infancy and early childhood and this is audible at the upper right sternal edge, is louder in the upright position, accentuated in diastole and can be eliminated by turning the head to the left side, lying down the child or exerting firm pressure at the right

Table 4: Diagnostic test characteristics

	Hospital Doctor *	Echocardiographer	Consultant	Senior Registrar
Sensitivity	73%	99%	73%	64%
Specificity	57%	31%	29%	42%
Pos. pred. Value	85%	84%	87%	78%
Neg. pred. Value	38%	90%	14%	26%
Accuracy	69%	84%	67%	59%

	Registrar	Senior House Officer	Houseman
Sensitivity	64%	74%	69%
Specificity	67%	45%	100%
Pos. pred. Value	78%	84%	100%
Neg. pred. Value	50%	31%	38%
Accuracy	65%	69%	74%

LCI=Lower confidence interval; UCI=Upper confidence interval

*Hospital doctor includes all grades but excludes echocardiographers

Table 5: *Listening areas for common pediatric heart murmurs*

Area	Murmur
Upper right sternal border	Aortic stenosis, venous hum
Upper left sternal border	Pulmonary stenosis, pulmonary flow murmurs, atrial septal defect, patent ductus arteriosus
Lower left sternal border	Still's murmur, ventricular septal defect, tricuspid valve regurgitation, hypertrophic cardiomyopathy, subaortic stenosis
Apex	Mitral valve regurgitation

side of the base of the neck. Other innocent murmurs may be caused by septal hypertrophy due to myocardial fat deposition, physiologic pulmonary stenosis and supraclavicular murmurs.¹² Virtually all of these murmurs are accentuated by fever, anaemia and other conditions that increase cardiac output. No follow-up for innocent murmurs is required.¹³

A proper history and physical examination can usually identify children who are likely to have cardiac anomalies. Characteristics of pathologic murmurs include a murmur with intensity of grade 3/6 or louder, a diastolic murmur or an increase in intensity when the patient is standing. Symptoms such as chest pain, family history of Marfan syndrome or sudden death in young family members and malformation syndromes (e.g., Down syndrome) are also important factors to consider as these conditions are associated with an increased likelihood of cardiac pathology.¹⁴ Community doctors should refer for evaluation all those patients who fulfill these criteria or in whom there are other, potentially worrying features. Children with specific cardiac pathology may require antibiotic prophylaxis for dental/surgical procedures and it is therefore important that even minor lesions are diagnosed.¹⁵

Initial screening before referral for echocardiogram should be carried out in an outpatient setting. Indeed, if all children with a murmur were to have an echocardiogram performed routinely, this practice would generate huge waiting lists and costs.^{7,16,17} However clinical assessment alone may not provide

complete reassurance to all families, and tests, such as echocardiograms, may be necessary in order to alleviate the anxiety and misperceptions generated about heart murmurs, especially after an internet search.¹⁸ A one month follow-up questionnaire obtained from parents of children without heart disease at assessment showed that 10% continued to believe that their child had a heart problem.¹⁹

Previous studies have shown that if a heart murmur is determined to be innocent on clinical examination by a cardiologist, there is no need for further investigation.^{1,5,20} We have explored this issue further by comparing the diagnostic skills of different grades of paediatricians when evaluating a child with a heart murmur.

In this study, the echocardiographers were the most accurate in the clinical detection of cardiac pathology, or its absence. This is attributed to the fact that echocardiographers have the greatest experience since they examine all children prior to performing an echocardiogram.

Doctors with less paediatric cardiology exposure naturally experience more difficulty. Indeed housemen and senior house officers attempted the least diagnoses. In contrast, these two grades had accuracy approaching that of the consultant/senior registrar grade. This is attributed to the fact that in the outpatient setting, these grades would discuss the case with the firm's consultant/senior registrar. It is likely that housemen and senior house officers attempted a diagnosis after actual physical review by a more experienced paediatrician, and no attempt made at a diagnosis if the case was only discussed verbally. Above these two grades, diagnostic accuracy increased almost linearly, as did efforts to reach a clinical diagnosis.

The type of lesion also affected the diagnostic accuracy. The most common type of lesion detected was a ventricular septal defect, which usually also has florid signs. As found in this study, 77% of hospital doctors correctly identified this lesion. Hospital doctors also felt confident in making this diagnosis and only 4% did not attempt such a diagnosis. This is in contrast to atrial septal defect, which has much softer signs. In our study, 81% of hospital doctors misdiagnosed atrial septal defect, and most diagnosed this lesion as PS, a common error.²¹

The auscultatory characteristics of innocent and common pathological murmurs are shown in Figure 1. In the normal heart, the splitting of the second sound varies with respiration but remains split throughout the cardiac cycle in an atrial septal defect. The site where a murmur is heard loudest can also be useful (Table 5). The features that distinguish an innocent murmur from an atrial septal defect are shown in Table 6.²²

Physicians can only acquire confidence and accuracy by

Functional Murmur

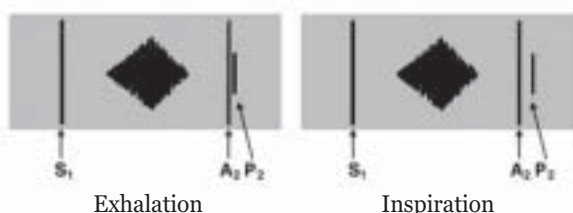


Figure 1: *The auscultatory characteristics of innocent and common pathological murmurs*

Table 6: *Physical findings in functional (innocent) heart murmur and atrial septal defect*

Physical finding	Innocent murmur	Atrial septal defect
Precordial activity	Normal	Increased
First heart sound (S1)	Normal	Normal
Second heart sound (S2)	Splits and moves with respiration	Widely split and fixed (ie, does not move with inspiration)
Systolic murmur (supine)	Crescendo/decrescendo Possibly vibratory at lower left sternal border	Crescendo/decrescendo “Flow” at upper left sternal border
Systolic murmur (standing)	Decreases in intensity	Does not change
Diastolic murmur	Venous hum	Inflow “rumble” across tricuspid valve area

repeated and supervised training including examination and auscultation of innocent and pathological murmurs. This can only be achieved in the setting of a postgraduate training program that would cater not only for paediatricians-to-be, but also for family doctors. Such a program would involve a paediatric rotation during housemanship or shortly thereafter, and may also include refresher periods of retraining that may be part of a continuing medical education program.

Conclusion

Experienced doctors are more likely to differentiate between normal and abnormal hearts. The commoner lesions are also more easily diagnosed. Echocardiographers represent the doctors with most experience, whilst housemen had less experience.

References

- McCrindle BW, Shaffer KM, Kan JS, Zahka KG, Rowe SA, Kidd L. Cardinal clinical signs in the differentiation of heart murmurs in children. *Arch Pediatr Adolesc Med* 1996;150:169-174.
- Pelech AN. Evaluation of the pediatric patient with a cardiac murmur. *Pediatr Clin North Am* 1999;46:167-188.
- Gibson S. Clinical significance of heart murmurs in children. *Med Clin North Am*. 1946;30:35-36.
- Caceres CA, Perry LW. The innocent murmur: A problem in clinical practice. Boston, MA: Little Brown and Co; 1967.
- Geva T, Hegesh J, Frand M. Reappraisal of the approach to the child with heart murmurs: is echocardiography mandatory? *Int J Cardiol* 1988;19:107-13.
- Thompson WR, Hayek CS, Tuchinda C, Telford JK, Lombardo JS. Automated cardiac auscultation for detection of pathologic heart murmurs. *Pediatr Cardiol* 2001;22:373-379.
- Grech V. The evolution of diagnostic trends in congenital heart disease: A population-based study. *J Paediatr Child Health* 1999;35:387-391.
- Danford DA, Nasir A, Gumbiner C. Cost assessment of the evaluation of heart murmurs in children. *Pediatrics* 1993; 91:365-368.
- Rushforth JA, Wilson N. Should general practitioners have access to paediatric cardiologists? *BMJ* 1992;305:1264-1265.
- Van Oort A, Le Blanc-Botden M, De Boo T, Van Der Werf T, Rohmer J, Daniels O. The vibratory innocent heart murmur in schoolchildren: difference in auscultatory findings between school medical officers and a pediatric cardiologist. *Pediatr Cardiol* 1994;15:282-287.
- Grech V. Trends in presentation of congenital heart disease in a population-based study in Malta. *Eur J Epidemiol* 1999;15:881-887.
- Pelech AN. The cardiac murmur. When to refer? *Pediatr Clin North Am* 1998;45:107-122.
- Smith KM. The innocent heart murmur in children. *J Pediatr Health Care* 1997;11:207-214.
- Wiles H, Saul JP. Paediatric cardiac auscultation. *J South Carolina Med Ass.* 1999;95:375-379.
- Dajani AS, Taubert KA, Wilson W, Bolger et al. Prevention of bacterial endocarditis. Recommendations by the American Heart Association. *JAMA* 1997;277:1794-1801.
- Smythe JF, Teixeira OH, Vlad P, Demers PP, Feldman W. Initial evaluation of heart murmurs: are laboratory tests necessary? *Pediatrics* 1990;86:497-500.
- Swenson JM, Fischer DR, Miller SA, Boyle GJ, Ettedgui JA, Beerman LB. Are chest radiographs and electrocardiograms still valuable in evaluating new pediatric patients with heart murmurs or chest pain? *Pediatrics* 1997;99:1-3.
- Weale S. Surfer, heal thyself. *Guardian* 1995 Sept 20:13.
- McCrindle BW, Shaffer KM, Kan JS, Zahka KG, Rowe SA, Kidd L. An evaluation of parental concerns and misperceptions about heart murmurs. *Clin Pediatr (Phila)* 1995;34:25-31.
- Newburger JW, Rosenthal A, Williams RG, Fellows K, Miettinen OS. Non-invasive tests in the initial evaluation of heart murmurs in children. *N Engl J Med* 1983;13:61-64.
- Rajakumar K, Weisse M, Rosas A, Gunel E et al. Comparative study of clinical evaluation of heart murmurs by general pediatricians and pediatric cardiologists. *Clin Pediatr (Phila)* 1999;38:511-518.
- McConnell ME, Adkins SB 3rd, Hannon DW. Heart murmurs in pediatric patients: when do you refer? *Am Fam Physician.* 1999;60:558-565.