

## Original Article

# Prevalence and diagnostic accuracy of heart disease in children with asymptomatic murmurs

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**Abstract** This study was performed to determine the prevalence of CHD among children referred with asymptomatic murmurs and to determine the diagnostic accuracy of the assessment of asymptomatic heart murmurs by general paediatricians. We reviewed the records of children who had been referred by general paediatricians to a cardiology clinic for further evaluation of a heart murmur. The referring paediatricians' clinical assessment of the murmur was compared with the cardiologist's echocardiographic diagnosis. A total of 150 children were referred by paediatricians to a paediatric cardiologist for further assessment of a heart murmur. Out of 150 children, 72 had a paediatrician's diagnosis of innocent murmur; of these 72 patients, two (3%) had heart disease on echocardiography. In all, after echocardiography, a range of congenital heart lesions was found in 28 (19%) of the 150 children. CHD is not rare among children with asymptomatic heart murmurs. In this series of children with asymptomatic murmurs, 19% had heart lesions on echocardiography. Most, but not all, of the children with heart lesions were identified on clinical examination by general paediatricians.

**Keywords:** Paediatricians; asymptomatic heart murmur; echocardiography

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**H**EART MURMURS ARE A COMMON PROBLEM encountered in general paediatric practice. The ultimate goal in the assessment of cardiac murmurs is to determine whether heart disease is present, and if so, to refer the patient to a paediatric cardiologist for further management; or if heart disease is excluded, to reassure the family and patient. However, it can be quite challenging to clinically exclude heart disease even for paediatric cardiologists, let alone general practitioners and paediatricians.<sup>1</sup> Unfortunately, in the past, when there was diagnostic uncertainty, children have been followed-up for years as outpatients, resulting in prolonged anxiety for families and pressure on outpatient services. Paediatric cardiology outreach

clinics have been set up in many district general hospitals in England to facilitate local access to expert cardiology services.<sup>2</sup> Echocardiography is widely available from various sources for providing diagnostic certainty and reducing anxiety.<sup>2</sup> A useful guide for management of heart murmurs by non-cardiologists has been provided by Gladman; however, there are insufficient data to guide clinicians and managers in allocation of resources.<sup>3</sup>

By determining the prevalence of heart disease among children with asymptomatic murmurs and paediatricians' ability to identify these children clinically, we hope to help address the question as to whether all children with asymptomatic murmurs should be offered an echocardiogram.

## Method and setting

The setting was Leighton Hospital, a district general hospital in Crewe, England, with a catchment

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population of about 250,000. Patients were referred by local general practitioners or the hospital's emergency department to the children's wards or to the outpatients department. The paediatric department's policy, at the time of the study, was to refer any child with an asymptomatic heart murmur to a visiting paediatric cardiologist.

This referral policy was not a standard practice in the United Kingdom and enabled us perform the study. Referrals to the paediatric cardiologist were made using a form designed for the purpose. The form requested information on the heart murmur and the paediatrician's assessment regarding whether it was innocent or pathological. Referrals to the cardiology clinic were made by postgraduate trainees with at least 2 years paediatric experience or by general paediatric consultants.

The referred children had either been previously evaluated in the general paediatric outpatient clinic or had been discharged from the paediatric wards. At the cardiology clinic, patient data including detailed description of any murmur and echocardiography findings were recorded on a form designed for the purpose. The cardiologist's clinical diagnosis was not recorded. All patients who attended the cardiology clinic had an echocardiogram.

Data were reviewed for children who were referred to the cardiology clinic for evaluation of an asymptomatic heart murmur over a 2-year period. The general paediatricians' clinical assessment of the murmur was compared with the cardiologist's echocardiographic diagnosis. Patients were classified as "CHD" when there was an echo diagnosis of a CHD. Basic statistical analysis was used for the determination of any significant differences. Data from ancillary testing such as chest radiographs and electrocardiograms were not reviewed or included in the analysis.

## Results

Over the 2-year study period, 230 children were referred to the paediatric cardiology clinic at Leighton Hospital. 24 children did not attend for various reasons; 206 children attended, with the following age distribution: 0–1 month, 13 (6%); 1–12 months, 69 (33%); 1–5 years, 75 (37%); 5–10 years, 25 (12%); 10–15 years, 17 (8%); and 16 years, 7 (3%). The modal interval between referral and attendance at the cardiology clinic was 15 weeks.

Out of the 206 children, 161 were referred primarily for the assessment of a heart murmur. The remaining 45 were referred for the following indications: post cardiac surgery follow-up, symptoms thought to be related to heart disease, screening for heart disease due to family history or syndrome, possible arrhythmia, and for follow-up of antenatal diagnoses.

Table 1. General paediatricians' diagnoses compared with cardiologist's diagnoses.

Paediatricians' diagnoses of murmurs	Cardiologist's diagnoses of murmur		
	Innocent	No murmur	CHD
Innocent	72	70	0
CHD	74	44	4
Not stated	4	1	3
Total	150	11	7
	100%	(76%)	(5%)
			(19%)

Table 2. Cardiologist's diagnoses in the 28 children with CHD.

Ventricular septal defect	11 (Large 1, moderate 4, small 6)
Atrial septal defect	5
Pulmonary stenosis	4
Aortic stenosis	2
Patent ductus arteriosus	2
Tetralogy of Fallot	2
Mitral regurgitation	1
Aortic regurgitation	1

Of the 161 referred primarily for the assessment of a heart murmur, 11 had had a previous echocardiogram.

There were 150 children referred primarily for the assessment of a heart murmur who had not had a previous echocardiogram. Out of the 150 patients, 72 had a paediatrician's diagnosis of innocent murmur; of these 72 patients, two of them (3%) had a heart defect on echocardiography. In all, 74 had a clinically pathological murmur, and of these 74 patients 26 (35%) had a heart defect on echocardiography. In four cases, the referrer did not record whether the murmur was considered innocent or pathological. In all, after echocardiography, a range of congenital heart lesions was found in 28 (19%) of the 150 children (see Table 1).

The general paediatricians' clinical assessment had a sensitivity of 93% (95% confidence interval 75–99%), specificity of 59% (95% confidence interval 50–68%), positive predictive value of 35% (95% confidence interval 25–47%), and negative predictive value of 97% (95% confidence interval 89–99%) for detection of CHD. When a pathological murmur was present, the positive likelihood ratio was 2.3, and when the murmur was not pathologic the negative likelihood ratio was 0.1.

Table 2 shows details of the cardiologist's diagnoses in the 28 children with CHD. Their age range was from 1 month to 8 years. There were two patients referred with provisional diagnoses of innocent murmur who turned out to have CHD.

Patient 1 – an asymptomatic murmur, grade 3/6, was heard during admission with tonsillitis at the age

Table 3. Occurrence of CHD at different ages.

Age	Number of patients		
	Total	CHD (%)	95% confidence intervals
0–1 month	6	5 (83%)	42–96%
1–12 months	49	13 (27%)	16–40%
1–5 years	65	9 (14%)	7–24%
5–10 years	19	1 (5%)	1–24%
10–15 years	10	0	0–28%
16 years	1	0	0–84%
Total	150	28 (19%)	

Table 4. Likelihood of CHD with different grades of murmur.

Grading of murmur by referring doctor	Cardiologist's diagnosis		
	Total	Innocent/no murmur	CHD
1/6	19	18 (95%)	1 (5%)
2/6	53	48 (90%)	5 (10%)
3/6	32	20 (63%)	12 (37%)
Not recorded	46	36 (78%)	10 (22%)
	150		

of 14 months. The grade 3/6 murmur was still present when the child was reviewed in the general paediatric clinic a month later.

Echocardiography at the age of 18 months showed a moderate-to-large patent ductus arteriosus, which was later occluded with an Amplatzer device.

Patient 2 – A murmur, heard on routine examination at birth, was still present during review at 2 months of age. It was recorded as 3/6 intensity and no other abnormalities were detected.

Echocardiogram at 3 months of age, repeated at 29 months, showed mild aortic valve dysplasia with mild stenosis and trivial regurgitation.

Table 3 shows that CHD was significantly more common with murmurs in the first month of life, compared with children between 1 month and 15 years of age. There were insufficient numbers of 16-year-old patients for comparison.

When murmurs were classified by intensity, there was a clear association with echocardiographic diagnosis of heart disease (see Table 4).

## Discussion

Heart murmurs are common in children, and they are often referred to a specialist for further assessment. Of all new murmur referrals to our outreach cardiology clinic with no previous echocardiogram, 19% (95% confidence interval: 13–27%) were diagnosed with cardiac lesions of varying significance. Khushu et al reported a similar figure of 20% in their UK study of

children with asymptomatic heart murmurs referred from primary care to a general paediatrician with expertise in echocardiography.<sup>4</sup> They had a similar policy of arranging echocardiography for all children with heart murmurs. In a study from Denmark, Hansen and Birkebaek found a CHD rate of 23% in children referred for their first evaluation of asymptomatic heart murmurs.<sup>5</sup> Pushparajah et al reported a lower prevalence of 8.5% among children referred with asymptomatic murmurs by general practitioners and paediatricians.<sup>6</sup> Smythe et al,<sup>7</sup> in a study of children with asymptomatic murmurs who were referred by community-based general practitioners and general paediatricians to a tertiary service, found that 45 out of 158 (28%) children had a congenital heart lesion. Other studies, quoting prevalence rates of 20–51%, are not comparable because of differences in patient characteristics.<sup>8–11</sup> Our data are in line with other studies, suggesting that between 8 and 28% of children with asymptomatic heart murmurs would be diagnosed with congenital heart abnormalities, of varying levels of significance, if they were offered echocardiography. Most, if not all, of these children will need follow-up and a few will require catheterisation and surgery.

In the present study, seven patients (5% of the study population) had no murmur when the cardiologist reviewed them. It is possible, although very unlikely, that they never had a murmur to start with. A more likely explanation is that the murmur had become inaudible with time, as the modal waiting time to attend the cardiology clinic was 15 weeks.<sup>12</sup>

In our study, two patients with heart disease would have been missed, out of 72 patients (3%), if all those with clinically innocent murmurs were discharged without echocardiography; one of these patients had a large patent ductus arteriosus requiring device closure, and the other had aortic valve dysplasia associated with mild stenosis and regurgitation. Having been graded as 3/6 intensity, these murmurs should not have been classified as innocent. Given that clinicians are going to make errors in classification of murmurs, it may be prudent to deploy additional criteria to help identify children with CHD. In this study, the two “missed” cases both had murmurs that persisted over time, and this feature could be used to classify the murmurs as potentially pathological.

Similar to other studies,<sup>13</sup> we found the incidence of heart disease to be significantly higher in neonates, and all the children with heart disease were 8 years old or younger. Our findings confirm the previously published observation that louder murmurs (grades 3/4 or 4/4) are more likely than softer murmurs to be pathological.<sup>9</sup>

To avoid a delayed diagnosis of CHD in children with asymptomatic murmurs, a possible approach

would be to provide echocardiography, by technicians or paediatricians with the necessary expertise, for all patients with persistent or loud murmurs.<sup>6,14</sup> When such patients are less than 1 month old, echocardiography should be arranged with some urgency. Patients with definite or possible abnormalities on echocardiography would then be referred to paediatric cardiologists, either conventionally or by telecardiology.<sup>15</sup> This two-tier approach would provide greater diagnostic certainty for those with normal hearts, enable paediatric cardiologists to concentrate on children with heart disease, and reduce the otherwise high financial costs associated with identifying all patients with CHD among the children with asymptomatic murmurs.

#### *Limitations and strengths of this study*

It is not certain whether some children with clinical diagnosis of innocent murmur were not referred to the paediatricians and subsequently to the cardiology clinic. Although unlikely, if such screening occurred, the true prevalence of CHD in children with asymptomatic murmurs would be lower than reported. A further potential limitation is inter-observer variation in the grading of murmurs due to level of training, experience, and basic auscultatory skill, as well as degree of patient co-operation, especially in the younger children.

By the use of proformas during normal clinical work, detailed clinical information was recorded in a high proportion of cases, and the observed clinical performance is more likely to be similar to usual standards of practice. A single paediatric cardiologist performed all echocardiograms. The study did not set out to determine the diagnostic accuracy of the cardiologist's clinical assessment and therefore did not record the cardiologist's clinical diagnosis before the echocardiogram.

A detailed discussion of the financial implications of detecting heart disease in children with murmurs is beyond the scope of this article. Yi et al, in addressing this issue, found that the cost-effectiveness of the various strategies is dependent not only on the actual costs of the echo and consultations but also on the prevalence of heart disease.<sup>16</sup> When the prevalence is high, as reported in this study, the more intensive strategies became less financially unfavourable.

#### **Conclusions**

CHD is not rare among children with asymptomatic heart murmurs.

In this series of children with asymptomatic heart murmurs in a district hospital in England, 19% had heart lesions on echocardiography. Most, but not all, of these children with heart lesions, of varying levels

of significance, were identified on clinical examination by general paediatricians. These results suggest that without greater reliance on echocardiography, there may be a delay in the diagnosis of CHD in a small proportion of children presenting to non-cardiologists with asymptomatic heart murmurs.

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#### **Conflicts of Interest**

None.

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