

Etiology of Chest Pain in Children and Adolescents Referred to Cardiology Clinic

Carleen L. Hanson, MD; John S. Hokanson, MD

ABSTRACT

Objective: To determine the proportion of children referred to pediatric cardiology clinic for chest pain diagnosed with a cardiac cause for the pain.

Design: Medical records of patients evaluated for chest pain at the University of Wisconsin Children's Hospital from 2004 to 2006 were reviewed, including the studies performed and final diagnosis.

Results: A total of 135 patients, including 78 boys, ranging from 4 to 17 years were evaluated. Eighty-four (62%) patients had pain for at least 1 month. All patients had an electrocardiogram (ECG), and most had an echocardiogram performed. Only 1 patient (0.7%) was found to have a cardiac cause for the pain. In 6 patients (4.3%), there was possible supraventricular tachycardia based on history, but no evidence of abnormality on subsequent testing. Ninety-five percent of the patients were diagnosed with noncardiac chest pain.

Conclusion: The incidence of cardiac chest pain in our study population is less than previously reported. Many patients were referred to cardiology clinic despite having had normal testing by the referring physician. Primary care physicians should be reassured when patients have a normal history, physical examination, and testing. Referral to pediatric cardiology usually is not necessary under these circumstances.

INTRODUCTION

Although a cardiac cause for chest pain is uncommon in children, concern for this possibility by family and primary care physicians prompts referral to the pediatric cardiologist. It has been reported that the complaint of chest pain accounts for 5.2% of all pediatric cardiology consults in an inpatient and emergency room setting.¹

Multiple retrospective²⁻⁴ and prospective⁵⁻¹¹ studies have been performed in the past to evaluate the etiology of chest pain in children; a cardiac etiology is reported in 0% to 15% of

• • •

Author Affiliations: Division of General Pediatric and Adolescent Medicine, Department of Pediatrics University of Wisconsin – Madison, Madison, Wis (Hanson); Division of Cardiology, Department of Pediatrics, University of Wisconsin – Madison, Madison, Wis (Hokanson).

Corresponding Author: Carleen Hanson, MD; 5249 East Terrace Dr, Madison, WI 53718; phone 608.265.1656; fax 608.265.0935; e-mail clhanson@pediatrics.wisc.edu.

patients. However, few studies^{2,9,10} have reported on patients referred to a cardiology clinic. In addition, most studies were completed in the 1970s and 1980s.²⁻⁸ Subsequent to these earlier reports, there have been substantial advances in the ability to assess the cardiovascular system with noninvasive techniques. Children evaluated in a pediatric cardiology clinic in recent years would be the most likely to have the presence of cardiac abnormalities detected. The objective of this study was to determine the proportion of patients referred to a pediatric cardiology clinic for the complaint of chest pain who were diagnosed with a cardiac etiology for their pain.

METHODS

We performed a retrospective medical record review of patients evaluated for chest pain from January 1, 2004, through December 31, 2006, at the University of Wisconsin Children's Hospital Pediatric Cardiology Clinic. Patients up to but not exceeding 18 years were included if they were evaluated for the chief complaint of chest pain during the study period.

Patients were identified using 2 modalities: billing codes and echocardiogram records. In addition to the diagnosis of "chest pain," our billing code search also included other diagnoses that may be related to or might cause chest pain, including precordial pain, hypertrophic obstructive cardiomyopathy, dilated cardiomyopathy, coronary artery anomalies, myocarditis, pericarditis, arrhythmia, long-QT syndrome, Wolff-Parkinson White (WPW) syndrome, palpitations, asthma, gastroesophageal reflux disease (GERD), vocal cord dysfunction, and anxiety. We searched echocardiogram records for a study indication of chest pain.

This study was approved by the Institutional Review Board of the University of Wisconsin School of Medicine and Public Health.

RESULTS

Two hundred thirty patient encounters were identified by echocardiogram indication and 1180 patient encounters were found by the billing code search, for a total of 1410 encounters. One hundred thirty-five patient visits met the inclusion criteria; 1275 patient visits were excluded.

The study population included 78 boys and 57 girls, with ages ranging from 4 to 17 years (average 11.5 years). Seventy-five percent of children were at least 9 years of age. Between 40 and 50 children with the complaint of chest pain were evaluated in each year of the study. Sixty-nine percent of children were greater than the 50th percentile for body mass index (BMI).

Chest pain characteristics are shown in Table 1. Eighty-four (62%) patients had pain for at least 1 month. The frequency and duration of the pain were variable. Forty-three (32%) patients described their pain as sharp, which was the most common descriptor. The most common locations of the pain were the left chest (52 patients, 39%) and sternum (43 patients, 32%).

The most common event precipitating chest pain was exercise, reported in a total of 76 patients (56%). Forty patients (30%) reported having pain only with exercise, and 36 patients (27%) had pain both with exercise and at rest. Twenty-six patients (19%) reported taking a deep breath as preceding the pain. Less-reported triggers were movement (4 patients); after exercise concluded (3 patients); illness, palpitations, and anxiety (2 patients each); and eating (1 patient). Some patients reported multiple precipitating events. In 25 patients, no precipitating event was identified; in 11 patients, no precipitating event was documented.

Palpitations, the most common symptom associated with chest pain, were reported in 57 (42%) patients. Dyspnea and dizziness were the other commonly associated symptoms, with reports by 44 (33%) patients and 35 (26%) patients, respectively. Syncope was reported in 4 (3%) patients. No associated symptoms were reported in 40 (30%) children.

On physical exam, 5 (4%) patients had elevated blood pressure (above the 95th percentile for age, sex, and height). Eight patients had reproducible chest pain on palpation of their chest. Fifty-one patients had murmurs or clicks heard on physical exam in the cardiology clinic. Eight (16%) of them had findings on echocardiogram consistent with the exam findings. Four of the patients had mitral valve abnormalities, and 1 each had pulmonary valve stenosis, subaortic membrane, ventricular septal defect, and bicuspid aortic valve. The remaining patients were felt to have innocent murmurs.

Patients underwent various testing modalities in the course of their work-up for chest pain. Some of the testing was performed by the referring physician and interpreted at his or her clinic; some of these interpretations were completed by the

Table 1. Pain Characteristics

	Number (N = 135)	Percent (totals may not equal 100% due to rounding)
Duration of symptoms		
Single episode	10	7
< 1 week	1	1
1 week to 1 month	17	13
> 1 month to 6 months	50	37
> 6 months	37	27
Not documented	20	15
Frequency of pain		
Single episode	10	7
< 1 per month	11	8
1/month to < 1 per week	22	16
1/week to < 1 per day	19	14
Once or more per day	22	16
Not documented	51	38
Length of episodes		
< 1 minute	12	9
1 to 5 minutes	31	23
6 – 15 minutes	19	14
16 minutes – 1 hour	18	13
2 hours – 1 day	10	7
> 1 day	4	3
Not documented	41	30
Quality of pain^a		
Sharp	43	32
Pressure	17	13
Tightness	8	6
Squeezing	7	5
Burning	6	4
Dull	4	3
Other	29	21
Not documented	37	27
Location of pain^a		
Left	52	39
Sternal	43	32
Right	14	10
Diffuse	11	8
Epigastric	5	4
Other	4	3
Not documented	34	25

^a Totals do not add up as some patients had multiple descriptors of their pain.

referring physician and some were by specialists. These tests are useful in identifying children and adolescents with clearly normal or abnormal studies. However, obtaining and interpreting electrocardiograms (ECGs) and echocardiograms on pediatric patients can be challenging, and at times, studies that were initially interpreted as abnormal or possibly abnormal were repeated and interpreted as normal by the pediatric cardiologist.

All of the patients had an ECG performed at least once during their evaluation. Of the 74 ECGs performed by the referring physician, 48 (65%) were normal, and 26 (35%) were thought to be abnormal. The most common abnormality

Table 2. Abnormalities Found on Electrocardiograms (ECGs) in Children with Chest Pain from Referring Physicians and in Cardiology Clinic

	Number	Percent (of 135)
Abnormal ECGs from referring physician	26/74	19
Chamber hypertrophy	8 (31%)	
Axis deviation	4 (15%)	
Premature atrial contractions	3 (12%)	
Pre-excitation/Wolff-Parkinson-White syndrome	3 (12%)	
First degree atrioventricular (AV) block	2 (8%)	
Right ventricular (RV) conduction delay	2 (8%)	
Possible faulty lead placement	2 (8%)	
J-point elevation	1 (4%)	
Low atrial rhythm	1 (4%)	
Nonspecific T wave changes	1 (4%)	
Abnormal ECGs from cardiology evaluation	40/89	30
Chamber hypertrophy	15 (38%)	
Axis deviation	6 (15%)	
Pre-excitation/Wolff-Parkinson-White syndrome	5 (13%)	
Low atrial rhythm	3 (8%)	
Incomplete right bundle branch block (RBBB)	2 (5%)	
Borderline first degree block and RV conduction delay	2 (5%)	
Chamber hypertrophy with premature ventricular contraction (PVC)	1 (3%)	
Borderline first degree block	1 (3%)	
Possible Brugada with chamber hypertrophy	1 (3%)	
Axis deviation with intraventricular conduction delay	1 (3%)	
Bradycardia with early repolarization	1 (3%)	
T-wave abnormality	1 (3%)	
Borderline prolonged QTc	1 (3%)	
Possible Brugada vs early repolarization	1 (3%)	
Intraventricular conduction delay	1 (3%)	

Some patients had more than 1 type of abnormality detected.

detected was possible chamber enlargement. Eighty-nine ECGs were obtained in the cardiology clinic. Of these, 49 (55%) were normal, and 40 (45%) were thought to be abnormal. Again, the most commonly detected abnormality was possible chamber enlargement. One patient with Wolff-Parkinson-White syndrome had this diagnosis before evaluation for chest pain in the cardiology clinic. Table 2 details the abnormalities noted on the ECGs.

Thirty (22%) patients had echocardiograms ordered by the referring physicians prior to the cardiology appointment; 12 were thought to be abnormal. The most common abnormal finding was a possible coronary abnormality (either possible coronary artery fistula or abnormality of a coronary artery origin). Coronary arteries in children can be difficult to clearly delineate and, if they are not well visualized or if there is artifact, this may be interpreted as a possible coronary artery abnormality. Ninety-three (69%) patients had echocardiograms performed during the cardiology visit; 21 were abnormal. The most common finding was an abnormality of the mitral valve. In total, 108 patients (80%) had an echocardiogram performed as part of their evaluations; none was found to have echocardiographic

findings related to the chest pain. Five patients with previously known echocardiographic abnormalities had the abnormality again demonstrated on echocardiogram during their work-up (1 each of mitral valve abnormality, pulmonary valve stenosis, ventricular septal defect, atrial septal defect, and bicuspid aortic valve). Table 3 provides further details on the echocardiogram results.

A follow-up cardiology evaluation was recommended in 19 patients based on their incidental cardiac findings (either by ECG or echocardiogram). Twelve patients received a recommendation for bacterial endocarditis prophylaxis based on their incidental cardiac findings, as all patients were seen prior to the 2007 revision of the American Heart Association guidelines. However, following the 2007 AHA guidelines, this recommendation would no longer be necessary in any of these patients.¹²

Seventeen percent (5/30) of patients with abnormalities suspected on the initial echocardiogram later were found to have normal echocardiograms. These included 1 patient with possible coronary artery fistula, 1 patient with possibly elevated right-sided pressures, 1 patient with possible sub-aortic membrane, 1 patient with enlarged aortic root, and 1 patient with possible mitral valve abnormality.

The diagnoses of the patients with chest pain are shown in Table 4. Only 1 patient (0.7%) was determined to have a cardiac cause for his chest pain (pericarditis). Eighteen patients (13%) were diagnosed initially as having a possible cardiac cause for their chest pain, but on further testing, only 6 were still thought to have a possible cardiac cause. (In these 6 patients, a tachyarrhythmia was suspected based on history, but was not demonstrated on either a Holter and/or event monitor). One-hundred sixteen patients (86%) were diagnosed with noncardiac chest pain after the initial visit. At the conclusion of their cardiac evaluation, 128 patients (94.8%) were diagnosed with noncardiac chest pain.

The single patient deemed to have a cardiac cause for his chest pain was a 16-year-old boy who presented after a 2- to 3-day history of chest pressure starting in his upper-chest bilaterally and then moving more centrally. The discomfort was preceded by less than 1 day of a vomiting illness that had also affected other members of his family. There were no complaints

of fever, dizziness, or shortness of breath, although he did have 1 episode of a brief sensation of skipped heartbeats. An ECG was obtained that demonstrated ST segment changes in the inferior leads. Chest radiograph was normal. A troponin I level was elevated at 5.07 (normal 0-0.05). He was diagnosed with pericarditis, but no significant pericardial effusion was seen on his echocardiogram. He was treated with ibuprofen, and within 3 days his troponin I level was normal.

Twenty-nine patients (21%) were determined to have cardiac findings that were not thought to explain their chest pain by the consulting pediatric cardiologist. Mitral valve abnormalities were the most common incidental finding, in 8 patients (6%). Hypertension was documented in 5 patients, and Wolff-Parkinson-White syndrome in 4 patients. There were 3 patients each with borderline prolonged PR-interval and atrial septal defect, and 2 patients were found to have a small ventricular septal defect. Finally, there was 1 patient each with mild aortic dilation, possible coronary artery fistula, pulmonary valve stenosis, bicuspid aortic valve, and mildly elevated right-sided pressures. One patient had 2 incidental findings.

DISCUSSION

This is the largest study to evaluate chest pain in a pediatric cardiology clinic. Previous studies have reported between 50 and 100 patients.^{2,9,10} In this study, all of the patients had at least 1 ECG performed, and 80% of the patients had an echocardiogram performed as part of their evaluation. The high percentage of patients with this comprehensive testing should increase the likelihood of documenting the presence of cardiac pathology, if it is present. Additionally, we did not exclude patients who had known cardiac abnormalities if they were referred for evaluation of chest pain. This also would be expected to increase the likelihood of finding patients with a cardiac cause for their chest pain.

There is an obvious selection bias present in our subjects. The frequency of a cardiac cause for chest pain would be expected to be lower in the primary care physician's office than in the cardiologist's office. Presumably, children with a clinical history suggesting a noncardiac etiology, including a reassur-

Table 3. Abnormal Echocardiograms in Children with Chest Pain from Referring Physicians and in Cardiology Clinic

	Number	Percent (of 135)
Abnormal echocardiograms from referring physician	12	9
	Number (n = 12)	Percent (of abnormal referring echocardiograms) ^a
Possible coronary artery abnormality	7	58
Elevated right-sided pressure	2	17
Atrial level shunt	2	17
Mildly dilated right ventricle	1	8
Increased left ventricular wall thickness	1	8
Decreased function	1	8
Mitral valve prolapse	1	8
Pulmonary insufficiency with increased wall thickness	1	8
	Number	Percent (of 135)
Abnormal initial echocardiograms from cardiology evaluation	21	16
	Number (n = 21)	Percent (of abnormal cardiology clinic echocardiograms) ^a
Mitral valve abnormality	7	33
Small ventricular septal defect	2	10
Small secundum atrial septal defect	2	10
Possible coronary artery fistula	2	10
Right coronary origin slightly high (potential normal variant)	2	10
Possible subaortic membrane	1	5
Mild pulmonary valve stenosis	1	5
Bicuspid aortic valve	1	5
Mild-moderate tricuspid regurgitation	1	5
Mild aortic dilation	1	5
Right-sided pressures upper limits normal/mildly elevated	1	5

^aTotal does not add up to 100% as some studies had more than 1 abnormal finding.

Table 4. Diagnosis in Children with Chest Pain at Time of Initial Cardiology Clinic Visit

	Number of patients (N = 135)	Percent
Cardiac	1	0.7
Possibly cardiac	18	13
Diagnosis after follow-up		
Non-cardiac	12 (67%)	
Possibly cardiac	6 (33%)	
Noncardiac	116^a	86
Musculoskeletal	25 (22%)	
Respiratory	16 (14%)	
Gastrointestinal/Gastroesophageal reflux disease	13 (11%)	
Anxiety	3 (3%)	
Precordial catch	2 (2%)	
Not specified/idiopathic	63 (54%)	

^aTotal of subcategories is greater than 100% due to multiple diagnoses in some patients.

ing personal and family history and a normal physical examination, would not have been referred to pediatric cardiology. Therefore, this study population excludes those children for whom a cardiac cause was already excluded by their primary provider. Accordingly, referral to cardiology would be more likely if an abnormality were detected on the initial evaluation by the primary care provider, even if that finding did not suggest an etiology likely to cause chest pain. Therefore, we expected the incidence of cardiac abnormalities to be higher in this study population than in the general population.

Of interest, the incidence of a cardiac cause for chest pain of 1/135 (0.7%) in this study is lower than that reported by most previous studies. Even if the 6 patients with a possible, but non-documented arrhythmia are included, the overall incidence of cardiac-induced chest pain is 7/135 (5.2%).

One possible explanation for the low incidence of cardiac-induced chest pain in our population is a decreasing threshold for referral to the pediatric cardiology clinic from the primary care physician. In recent years, news and media coverage of sudden deaths in athletes has created heightened concern among both families and physicians. Primary care physicians may be fearful of missing cardiac pathology and assuming responsibility for clearing athletes to participate in sports. This hypothesis is supported by the fact that there were 50 (37%) patients referred who had no abnormalities on the cardiac tests ordered by the primary care physician (1 or more of ECG, echocardiogram, chest radiograph, Holter monitor, or event monitor). Additionally, 11 (8%) of those patients had both a normal ECG and echocardiogram before referral to pediatric cardiology.

Another potential reason that more children with chest pain are being referred to pediatric cardiology is the increased number of overweight and obese pediatric patients. It is possible that with increasing concern for premature coronary disease in overweight children, primary care physicians have fears of early atherosclerotic heart disease as a possible cause of chest pain. Our study population included a higher number of patients with an increased body mass index (BMI) than might have been expected (69% of patients had a BMI greater than the 50th percentile, 24% had a BMI greater than the 85th percentile, and 10% had a BMI greater than the 95th percentile) although these numbers may be reflective of the referral population in general.

The sensitivity and specificity of ECG evaluation of the child with chest pain have not been studied previously. The pretest probability of ischemia or other cardiac causes of chest pain in this population is low, and our data suggests that the specificity of ECG testing is poor. Of the 163 ECGs per-

formed, 24 suggested ventricular hypertrophy or enlargement. All patients with these findings on ECG had an echocardiogram, none of which demonstrated cardiac chamber enlargement or hypertrophy. Of the 163 ECGs performed, 42 demonstrated some other form of electrical abnormality, but only 1 of these abnormalities was thought to be related to the presenting complaint of chest pain. Similarly, incidental findings on echocardiography unrelated to the presenting complaint of chest pain were common. In our population, the only change in clinical care was the now outdated recommendation for bacterial endocarditis prophylaxis in 12 patients.

CONCLUSION

Chest pain is a common complaint in children. Although a pediatric cardiology referral may provide reassurance to the family and primary care physician, this study suggests that the outpatient evaluation of chest pain in children only rarely identifies a cardiac origin for the chest pain. Primary care physicians should be reassured that when patients have a normal history, physical examination, and testing, referral to pediatric cardiology is usually not necessary.

Acknowledgment: The authors would like to thank Ellen Wald, MD, for her guidance and assistance in the preparation of this manuscript.

Funding/Support: None.

Financial Disclosure: None.

REFERENCES

1. Geggel RL. Conditions leading to pediatric cardiology consultation in a tertiary academic hospital. *Pediatrics*. 2004;114:409-417.
2. Fyfe DA, Moodie DS. Chest pain in pediatric patients presenting to a cardiac clinic. *Clin Pediatr*. 1984;23:321-324.
3. Selbst SM. Chest pain in children. *Pediatrics*. 1985;75:1068-1070.
4. Zavaras-Angelidou KA, Weinhouse E, Nelson DB. Review of 180 episodes of chest pain in 134 children. *Pediatr Emerg Care*. 1992;8:189-193.
5. Driscoll DJ, Glicklich LB, Gallen WJ. Chest pain in children: a prospective study. *Pediatrics*. 1976;57:648-651.
6. Pantell RH, Goodman BW. Adolescent chest pain: a prospective study. *Pediatrics*. 1983;71:881-887.
7. Selbst SM, Ruddy RM, Clark BJ, et al. Pediatric chest pain: a prospective study. *Pediatrics*. 1988;82:319-323.
8. Rowe BH, Dulberg CS, Peterson RG, et al. Characteristics of children presenting with chest pain to a pediatric emergency department. *Can Med Assoc J*. 1990;143:388-394.
9. Tunaoglu FS, Olguntürk R, Akcaby S, et al. Chest pain in children referred to a cardiology clinic. *Pediatr Cardiol*. 1995;16:69-72.
10. Evangelista JK, Parsons M, Renneburg AK. Chest pain in children: diagnosis through history and physical examination. *J Pediatr Health Care*. 2000;14:3-8.
11. Massin MM, Bourguignon A, Coremans C, et al. Chest pain in pediatric patients presenting to an emergency department or to a cardiac clinic. *Clin Pediatr*. 2004;43:231-238.
12. Wilson W, Taubert KA, Gewitz M, et al. Prevention of infective endocarditis: guidelines from the American Heart Association. *Circulation*. 2007;116:1736-1754.

advancing the art & science of medicine in the midwest

WMJ

WMJ (ISSN 1098-1861) is published through a collaboration between The Medical College of Wisconsin and The University of Wisconsin School of Medicine and Public Health. The mission of *WMJ* is to provide an opportunity to publish original research, case reports, review articles, and essays about current medical and public health issues.

© 2011 Board of Regents of the University of Wisconsin System and The Medical College of Wisconsin, Inc.

Visit www.wmjonline.org to learn more.