



## Original Research

# Etiological Evaluation in Children Referred to the Pediatric Cardiology Outpatient Clinic with Chest Pain

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### ABSTRACT

**Objectives:** One of the most common reasons for pediatric cardiology referrals is chest pain in childhood. Although it is mostly innocent in character, it is rarely associated with life-threatening pathologies. In this study, it was aimed to evaluate the etiological causes in children with chest pain.

**Methods:** Our study included 1000 children who were referred to the pediatric cardiology clinic with the complaint of chest pain between January 2019 and June 2022. Demographic characteristics, accompanying complaints, echocardiographies, electrocardiographies, 24-h rhythm holters, treadmill exercise test, computed tomography angiography, and non-cardiac findings related to etiology were analyzed retrospectively from the file archives of the patients.

**Results:** Five hundred and nine (50.9%) of the patients were female and 491 (49.1%) were male. The mean age of the patients was 11.3 y (range: 3–18 years). Cardiological pathology associated with chest pain was detected in only 6.8% of the patients. Among the etiologies of chest pain, mitral valve prolapse (MVP) was the most common cardiological pathology with a rate of 2.1%. In the non-cardiac etiological evaluation of chest pain, idiopathic causes with a frequency of 48%, musculoskeletal pathologies with a frequency of 22.6%, respiratory pathologies with a frequency of 7.9%, psychiatric pathologies with a frequency of 7.3%, gastrointestinal pathologies with a frequency of 4.1%, and familial Mediterranean fever with a frequency of 2.4%, miscellaneous with a frequency of 1.1% were found, respectively.

**Conclusion:** In the study, it was determined that non-cardiac causes were more common among the etiological causes of chest pain in the pediatric age group. In addition, MVP was the most common cause of cardiac chest pain.

**Keywords:** Chest pain, children, etiology

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Although chest pain is often a major concern for families, it is rarely associated with cardiac events. Chest pain constitutes 0.2–0.6% of the applications to pediatric clinics and emergency services.<sup>[1]</sup> It is mostly idiopathic and often no pathology can be detected in the etiology. Lab-

oratory tests are rarely helpful in diagnosis.<sup>[2]</sup> It peaks between the ages of 10–14, especially in the adolescent age group.<sup>[3]</sup> While traumatic events are common in boys, psychogenic and costochondritis-related pains are more common in girls.<sup>[1]</sup> Age is also important in chest pain. While

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psychogenic pathologies are more common in the adolescent age group, heart and respiratory tract pathologies are more common in younger age groups.<sup>[2]</sup> Cardiac chest pain is rare in the etiology of chest pain. In various studies, its frequency among the etiologies of chest pain has been shown to be 0.5–5%.<sup>[3,4]</sup> Although controversial among cardiac pathologies, mitral valve prolapsus (MVP) is the most common etiologic cause.<sup>[5]</sup> A good anamnesis and physical examination are the most valuable method in the etiological evaluation of chest pain, despite all the technological possibilities. In this study, it was aimed to show the cardiac and non-cardiac etiological causes in children who were referred to the pediatric cardiology outpatient clinic with the complaint of chest pain.

## Methods

One thousand children aged 3–18 years, who were referred to the pediatric cardiology clinic of Hamidiye Etfal Training and Research Hospital between January 2019 and January 2023, were included in the study. Data of all patients were obtained retrospectively from patient file archives. Age, gender distribution, examination findings, family histories, chest pain characteristics, relationship with effort, other accompanying system complaints and findings, number of recurrent admissions, electrocardiography (ECG) and transthoracic echocardiography findings, troponin results, 24-h rhythm holter monitoring findings, treadmill exercise test results, coronary, and aortic angiography results were evaluated. Additional disease diagnoses obtained from the file archives of the patients during follow-up were noted. The study was performed in accordance with the Helsinki Declaration. The study was approved by the Hamidiye Etfal Training and Research Hospital Ethics Committee (2387/4.7.2023).

## Statistical Methods

Statistical analyses were performed using the SPSS 21 software (SPSS Inc., Chicago, IL, USA). Visual (histograms) and analytical (Kolmogorov-Smirnov) methods were used to determine whether the variables were normally distributed. The Chi-square test or Fisher's exact test was used for categorical comparisons of nominal values in different groups.  $p < 0.05$  was considered statistically significant.

## Results

The children included in the study were 509 (50.9%) girls and 491 (49.1%) boys. The mean age of the patients was 11.38 ( $\pm 3.55$ ). Thirty-three (3.3%) of the children included in the study had a family history of sudden death and/or ischemic heart disease under the age of 40 years. At the

time of admission, 17% of the children had pain duration  $< 1$  month, 57.4% between 1 and 6 months, and 25.6% longer than 6 months (Table 1). In the last 3 years, 70 (7%) female and 45 (4.5%) male patients applied to our clinic with similar complaints more than once. The frequency of repeated admissions was higher for girls than for boys ( $p = 0.02$ ). The pain characteristics of patients with chest pain were stabbing in 277 (27.7%) and compressing in 723 (72.3%). There was no significant difference between boys and girls in terms of pain characteristics ( $p = 0.89$ ). Chest pain developed in 100 (10%) of the patients during exertion, in 822 (82.2%) at rest, and in 78 (7.8%) both conditions. Chest pain was more common in girls at rest and at exertion in boys ( $p = 0.001$ ). Chest pain was accompanied by shortness of breath in 130 (13%) of the patients, palpitation in 95 (9.5%), syncope in 17 (1.7%), and fatigue in 21 (2.1%). Shortness of breath and palpitations accompanying chest pain were more common in girls and fatigue was more common in boys ( $p < 0.001$ ,  $p = 0.01$ ,  $p = 0.04$ , respectively) (Table 2).

Echocardiography and ECG sampling were performed on all patients. According to the history, physical examination, and clinical findings, exercise test was performed in 292 patients, rhythm holter test was performed in 162 patients, and CT angiography was performed in 15 patients. Various degrees of structural and functional disorders were detected in cardiological examinations. As structural and arrhythmic pathologies that can be considered as factors in the etiology of chest pain; MVP was determined in 21 (2.1%) patients, myocarditis in 4 (0.4%) patients, pericarditis in 3 (0.3%) patients, aortic stenosis in 2 (0.2%) patients, hypertrophic cardiomyopathy in 2 (0.2%) patients, moderate-severe aortic insufficiency in 3 (0.3%) patients, coronary anomalies (two coronary bridg-

**Table 1.** Demographic and clinical characteristics of children presenting with chest pain

	n (%)
Age, mean $\pm$ SD	11.38 ( $\pm 3.55$ )
Gender	
Female	509 (50.9)
Male	491 (49.1)
Positive family history*	33 (3.3)
Onset of chest pain, time (months)	
$< 1$	170 (17)
1–6	574 (57.4)
$> 6$	256 (25.6)

\*:  $< 40$  years of age with a history of ischemic heart disease and/or sudden death.

**Table 2.** Chest pain characteristic and comparison of distribution as gender

	Total n (%)	Female n (%)	Male n (%)	p
Repeated admission	115 (11.5)	70 (7)	45 (4.5)	<b>0.02</b>
Pain character				
Stabbing pain	277 (27.7)	142 (14.2)	135 (13.5)	0.89
Compressive pain	723 (72.3)	367 (36.7)	356 (35.6)	
Exertion-rest relationship				
On exertion	100 (10)	32 (3.2)	68 (6.8)	<b>&lt;0.001</b>
At rest	822 (82.2)	448 (44.8)	374 (37.4)	
In both	78 (7.8)	29 (2.9)	49 (4.9)	
Accompanying complaints				
Shortness of breath	130 (13)	86 (8.6)	44 (4.4)	<b>&lt;0.001</b>
Palpitation	95 (9.5)	60 (6)	35 (3.5)	<b>0.01</b>
Syncope	17 (1.7)	12 (1.2)	5 (0.5)	0.10
Fatigue	21 (2.1)	6 (0.6)	15 (1.5)	<b>0.04</b>

**Table 3.** Cardiac chest pain pathologies in the pediatric age group and comparison of distribution as gender

	Total n (%)	Female n (%)	Male n (%)	p
MVP	21 (2.1)	18 (1.8)	3 (0.3)	<b>&lt;0.001</b>
Aortic stenosis	2 (0.2)	1 (0.1)	1 (0.1)	
Aortic regurgitation (moderate to severe)	3 (0.3)	0	3 (0.3)	
Aortic aneurysm	1 (0.1)	1 (0.1)	0	
Cardiomyopathy	2 (0.2)	0	2 (0.2)	
Myocarditis	4 (0.3)	0	4 (0.3)	
Pericarditis	3 (0.3)	3 (0.3)	0	
Coronary artery anomalies	5 (0.5)	2 (0.2)	3 (0.3)	
Arrhythmias	27 (2.7)	10 (1)	17 (1.7)	0.14
Supraventricular arrhythmias	14 (1.4)	3 (0.3)	11 (1.1)	
Ventricular arrhythmias	13 (1.3)	7 (0.7)	6 (0.6)	

MVP: Mitral valve prolapse.

ing, one coronary ectasia, one coronary ectasia with fistulized to the right ventricle, and one coronary with a single root origin) in 5 (0.5%) patients, and aortic aneurysm in 1 (0.1%) patient. MVP was more common in girls with chest pain than boys ( $p < 0.001$ ). Supraventricular arrhythmias (supraventricular extrasystoles, supraventricular tachycardia, and atrial tachycardia) were detected in 14 (1.4%) patients, and ventricular arrhythmias (ventricular early beats and ventricular tachycardia) were detected in 13 (1.3%) patients (Table 3).

In the follow-ups of the patients, musculoskeletal pathologies (costal and rib pathologies, costochondritis, pectus chest deformities, chest trauma, etc.) were found in 226

(22.6%) patients, respiratory pathologies (reactive airway pathologies, pulmonary embolism in one patient through CT pulmonary angiography) in 79 (7.9%), psychogenic pathologies (panic attack, anxiety, mood disorders, depression, etc.) in 7.3 (7.3%), gastrointestinal pathologies (gastritis, esophagitis, reflux, etc.) in 41 (4.1%), familial Mediterranean fever in 24 (2.4%) patients, and miscellaneous pathologies (hereditary spherocytosis, malignancy, thelarche, nephrolithiasis) in 11 (1.1%) patients. The frequency of psychiatric disorders was higher in girls with chest pain than boys ( $p = 0.04$ ). No etiology could be detected in 480 (48%) of the patients and they were classified as idiopathic (Table 4).

**Table 4.** Etiological causes of chest pain in the pediatric age group and comparison of distribution as gender

	Total n (%)	Female n (%)	Male n (%)	p
Idiopathic	480 (48)	240 (24.8)	240 (23.2)	0.58
Musculoskeletal pathologies	226 (22.6)	112 (11.2)	114 (11.4)	0.65
Respiratory system pathologies	79 (7.9)	38 (3.8)	41 (4.1)	0.61
Psychiatric Pathologies	73 (7.3)	46 (4.6)	27 (2.7)	<b>0.04</b>
Cardiological pathologies	68 (6.8)	35 (3.5)	33 (3.3)	0.92
Gastrointestinal system pathologies	41 (4.1)	22 (2.2)	19 (1.9)	0.72
Familial Mediterranean Fever	24 (2.4)	12 (1.2)	12 (1.2)	0.93
Miscellaneous (two lymphoma, one osteosarcoma, six thelarche, one nephrolithiasis, and one hereditary spherocytosis)	11 (1.1)	6 (0.6)	5 (0.5)	

## Discussion

Chest pain is the second most common complaint among pediatric cardiology outpatient clinic admissions after murmurs, and it is the most common reason for admission especially in the adolescent age group.<sup>[6]</sup> In adult patients, more than 50% of emergency admissions with chest pain are of cardiac origin. These patients are accompanied by varying frequencies of mortality.<sup>[7]</sup> Therefore, chest pain in children is a major concern for parents. Although it is often an unnecessary concern, the etiological distinction of chest pain should be made. Evaluation of patients should begin with a good history and physical examination. In the pediatric age group, no cause can often be found in the etiology of chest pain. Therefore, the most common group is idiopathic (12–45%). In studies, musculoskeletal system pathologies and chest wall anomalies (35%), psychogenic causes (9–20%), respiratory tract pathologies (15–21%), digestive system pathologies (4–7%), and less frequently cardiac (5%) pathologies can cause chest pain in the etiology.<sup>[8]</sup> In the etiological evaluation, disease history, family history, pain character, accompanying symptoms, and examination findings and laboratory findings should be evaluated in detail. While shortness of breath, cough, and fever indicate respiratory problems; depression, headache, and anxiety; major stressful events, such as hyperventilation, palpitations, family history of divorce, or trouble adjusting to school, indicate more psychogenic events. If there is a recent history of trauma, traumatic pain should be considered in the foreground. If chest pains are accompanied by vomiting, hematemesis, and reflux, gastrointestinal problems are the main factor, while chest pains with symptoms such as shortness of breath and palpitations may indicate heart diseases.<sup>[8,9]</sup> Some conditions, such as pulmonary embolisms, may exhibit features of cardiac and respiratory tract pathologies together.<sup>[10]</sup> The important thing in the evaluation of chest pain is to detect life-threatening pathologies among often innocent chest pains. Although rare, serious patholo-

gies related to heart diseases may present with chest pain. Similar to the study of Çiçek et al.,<sup>[11]</sup> in our study, cardiological pathologies were found as the etiology of chest pain in 6.8% of the patients. Cardiological chest pains may develop due to structural disorders or may occur due to rhythmic pathologies. Ischemia is the cause of chest pain in structural cardiac pathologies such as MVP, aortic stenosis, pulmonary stenosis, cardiomyopathies, aortic dissection, and aneurysm. In conditions such as myocarditis, pericarditis, and kawasaki, chest pain is thought to develop secondary to inflammation.<sup>[4]</sup> MVP is the most common structural pathology in patients presenting with chest pain, as demonstrated in our study. The frequency of MVP in children presenting with chest pain was found to be 2–3% in various studies.<sup>[4,12]</sup> MVP is the most common structural heart disease in the normal population. In studies conducted in the pediatric population, its frequency has been shown to be 0–5%, although it varies according to age groups.<sup>[13,14]</sup> Although it was the most common pathology among cardiac-induced chest pain pathologies in our study, its place in the etiology is controversial considering its prevalence in the community. In a study, it was shown that the increase in the frequency of reflux in MVP patients is associated with chest pain.<sup>[15]</sup> Coronary anomalies are perhaps the most important pathology among structural cardiac anomalies. It is often difficult to diagnose. Most of the time, it does not show any symptoms at rest and its first symptom may be sudden death.<sup>[16]</sup> The most important diagnostic criterion is clinical suspicion. They usually do not show any findings on echocardiography and resting ECG. In the study conducted by Davis et al.<sup>[17]</sup> in 2388 healthy children, they found coronary artery outflow anomaly in 0.17% of the participants. In our study, coronary ectasia, coronary outflow and course anomaly, and coronary bridging were found in 0.5% of them. Chest pains caused by exertion should be evaluated in detail. All our patients with coronary anomaly had chest pain triggered by exertion and elevated troponin. Therefore, if there is strong clinical suspicion with supportive lab-

oratory findings, patients should undergo coronary artery imaging. Only 9 (0.9%) patients who were referred to the cardiology outpatient clinic were hospitalized and treated at the time of first admission. Other patients were referred to the relevant centers for elective treatment according to the findings in their follow-up. Patients with bridging and outlet anomalies were referred to the advanced cardiology center. While one of the patients with coronary bridging was followed up clinically, the follow-up records of the other patients could not be accessed. Valve replacement was planned for a patient with bicuspid aorta accompanied by aortic insufficiency and stenosis. Patients with aortic aneurysm and right ventricular fistulized coronary ectasia were operated during their follow-up. Ablation therapy was applied to a patient with SVT. Patients with perimyocarditis recovered with medical supportive treatment. Other patients with non-cardiac complaints and findings were referred to the relevant clinical centers.

In our study, findings such as recurrent presentation, shortness of breath, and palpitation were statistically more frequent in female patients than in male patients. Shortness of breath and palpitations are frequently seen among the somatic findings of psychiatric disorders such as panic attack in children.<sup>[18]</sup> Studies have shown that psychiatric disorders are more common in girls who present with chest pain than in boys.<sup>[19]</sup> Similarly, in our study, the number of psychiatric pathologies in female patients was higher than in males.

Exertional chest pain and fatigue symptoms were higher in male patients than in females. This possible difference may be related to the higher incidence of respiratory pathologies such as asthma in boys in the childhood age group.<sup>[20]</sup> Similarly, in our study, the number of respiratory tract pathologies in male patients was higher than in females. Although the number of respiratory pathologies in male was higher than in female in our study, it was not statistically significant. This may possibly be related to the number of undiagnosed patients with respiratory tract pathologies in the idiopathic group. The incidence of exercise-induced asthma in healthy children with chest pain appears to be higher than previously reported. Obstructive symptoms developed in 72.7% of the children in response to the exercise test performed by Wiens et al.<sup>[21]</sup> in 88 children with chest pain. Among the gastrointestinal pathologies, reflux is one of the important pathologies frequently encountered in childhood. Chest pain may show extraesophageal symptoms such as cough, asthma, and laryngitis.<sup>[22]</sup> Its incidence varies with age. Reflux incidence increases in the adolescent age group.<sup>[23]</sup> This may be associated with an increased incidence of chest pain in the adolescent group. In studies conducted with children with chest pain, the frequency of gastrointestinal pathology including reflux was

found to be 3.1 and 8.9.<sup>[11,19]</sup> In our study, the frequency of gastrointestinal pathology was found to be 4.1% in children with chest pain.

FMF is one of the pathologies frequently encountered in clinical practice in our study. Its frequency in the general population in our country has been shown to be approximately 0.1%.<sup>[24]</sup> Cardiology clinics are one of the clinics where they are first diagnosed because of their frequent recurrent episodes of chest pain. The most important finding in diagnosis is usually recurrent attacks. In some cases, they may present with the etiology of pericarditis as the first attack.<sup>[25]</sup> In our study, FMF was found in the etiology of 24 (2.4%) of the patients who presented with chest pain. In the etiological examination of 134 patients admitted with chest pain by Çiçek et al.,<sup>[11]</sup> FMF was found in 2 (1.4%) of the patients. FMF was also detected in one of our patients who presented with chest pain and in whom we found pericarditis.

Although non-cardiac causes are more common in the etiology of chest pain in the pediatric age group, serious cardiac pathologies that are much rarer and may be life-threatening should be excluded with a detailed clinical evaluation with laboratory support. The primary goal in chest pain should be to relieve the family and patient's concerns. Etiological evaluation should be initiated with a detailed history and physical examination. Especially, patients who describe compressive pain with exertion and/or patients with pathology in cardiac rhythm and cardiac auscultation findings should be evaluated for further cardiological evaluation. ECG is a well-screening tool in the preliminary evaluation of rhythmic pathologies. Echocardiographic examination is often required for the detection of structural cardiac pathologies. In the presence of clinical suspicion, patients should undergo further tests such as exercise test, 24-h rhythm holter, and coronary angiography.

### Limitation

Our study was a retrospective study. Prospective studies are needed, especially to determine the non-cardiac etiological causes exactly.

### Conclusion

In the study, it was determined that non-cardiac causes were more common among the etiological causes of chest pain in the pediatric age group. In addition, MVP was the most common cause of cardiac chest pain.

### Disclosures

**Ethics Committee Approval:** The study was approved by the Ethics Committee of University of Health Sciences Türkiye, Sisli Hamidiye Etfal Training and Research Hospital (No: 2387, dated 04.07.2023).

**Peer-review:** Externally peer-reviewed.

**Conflict of Interest:** None declared.

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