

FREQUENCY OF MYOCARDITIS IN PEDIATRIC PATIENTS WITH HEART FAILURE

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Abstract

Objective: To determine the prevalence of myocarditis in the pediatric patients with heart failure and to estimate the correlation between myocarditis and the demographic and clinical variables. **Study Design:** Descriptive cross-sectional study. **Place and Duration of the Study:** This study was conducted in the Department of Pediatric Medicine, Peoples University of Medical & Health Sciences for Women (PUMHS-W), Nawabshah, over a period of three months following approval of the synopsis. **Methodology:** Non-probability consecutive sampling was used to enroll 95 pediatric patients who presented with heart failure and were aged between 1-15 years. The age, gender, the length of time of symptoms, weight, living status, the level of education of parents, the clinical signs and the signs were documented. Myocarditis was confirmed according to the clinical presentation, electrocardiographic changes, high cardiac levels of troponin and echocardiographic findings of left ventricle dysfunction. The analysis of data was done through the use of SPSS version 25.0. Descriptive statistics were done and post-stratification chi-square or fisher exact test was used. A p -value ≤ 0.05 was deemed to be significant. **Results:** The patients were diagnosed with myocarditis in 69 (72.6%). There was a strong correlation between myocarditis and the male gender, older age, the rural population, uneducated parents and being overweight ($p < 0.001$). Most cases of myocarditis were characterized by tachycardia, tachypnea, T-wave inversion, elevated levels of troponin and left ventricular ejection fraction $\leq 35\%$ were the norm. **Conclusion:** Myocarditis is a frequent cause of pediatric heart failure, especially in males, older children and in rural and socioeconomically disadvantaged children. Early diagnosis by simple clinical examination and investigations that are easily accessible can help in better outcomes.

INTRODUCTION

Heart failure in children is a major public health concern and represents a frequent cause of hospitalization, morbidity and mortality worldwide. In contrast to adult heart failure, which is in most cases chronic and progressive, the pediatric heart failure usually has acute onset and is connected with a variety of etiologies such as congenital heart disease, cardiomyopathies, infection, metabolic disorders and systemic diseases. The prevalence of cardiac heart failure

among children is again higher in low-income and the middle-income nations, as there is limited access to specialized care and early diagnosis of heart failure leads to worse outcomes [1,2].

Myocarditis is one of the most significant and reversible conditions of pediatric heart failure. Myocarditis can be described as inflammatory pathology of the myocardium that is accompanied by inflammatory cell infiltration and myocyte necrosis and dysfunction. The most commonly implicated cause is the viral infections,

specifically the enteroviruses, adenovirus, parvovirus B19 or influenza although immune-mediated, hypersensitivity and toxic etiologies have also been documented [3,4]. This inflammatory condition can lead to damaged contractility of myocardial cells, dilation of the ventricles, arrhythmia and the development of acute or chronic heart failure.

The clinical manifestation of myocarditis in children is both extremely diverse and largely unspecific, with mild signs of a cold and cardiac death. Infants and younger children often report with a feeding difficulty, excessive sweating, tachypnea and lethargy but older children might report chest pain, palpitations and exercise intolerance [5]. Such a broad range of presentation can frequently be poorly recognized, misdiagnosed or underdiagnosed especially in resource-constrained environments.

The estimation of the actual incidence of myocarditis among the pediatric population is difficult because it has a fluctuating course and no standard of the criteria of diagnosis. It is postulated by hospital-based research that myocarditis is the cause of about 0.02%-0.05% of all pediatric hospital admissions but this percentage is probably underestimated [6]. Myocarditis has been reported to be the background cause in 30-45% of children with acute heart failure in various studies across regions and internationally. Male dominance has been reported especially beyond the age of seven, which may be associated with the immunological sex disparities [7].

Following innovations in supportive care, myocarditis remains linked to a high level of morbidity and mortality. The death rates are influenced by the severity of the disease and the clinical presentation, with less than 5% and more than 30% being the mortality of mild and severe cases of fulminant myocarditis, respectively [8]. Dilated cardiomyopathy, chronic heart failure and life-threatening arrhythmias can be long-term complications of the survivor and it is essential to diagnose the illness as soon as possible and provide proper treatment.

Diagnosis of myocarditis in children is complicated, especially in the conditions where the advanced diagnostic modalities are not easily accessible. They include endomyocardial biopsy which is invasive and not used in normal clinical practice despite being the gold standard. Cardiac magnetic resonance imaging has become a useful noninvasive diagnostic technique but it is not available in most developing nations [9]. The diagnosis of myocarditis is often based on a set of clinical characteristics, electrocardiographic changes and

a set of cardiac biomarkers (troponin), as well as echocardiography signs of ventricular dysfunction [10]. Common electrocardiographic abnormalities in pediatric myocarditis are sinus tachycardia, ST-segment and T-wave defects and arrhythmias, whereas echocardiography can evidence decreased left ventricular ejection fraction, ventricular dilation and systolic dysfunction [11]. Cardiac troponin levels are useful in identifying myocardial injury, disease severity and prognosis due to their high concentration.

Limited data is available on the occurrence and clinical presentation of myocarditis in patients of pediatric heart failure in Pakistan. The majority of existing literature is based in the developed nations and epidemiological patterns in the region may vary because of the differences in the prevalence of the infectious diseases, access to healthcare and socioeconomic conditions. The absence of local data constrains a possibility of clinicians to adequately evaluate the disease burden, predict the outcomes and develop a set of standard management procedures that suit the local population [12]. The frequency of myocarditis in children with heart failure is vital information to understand in order to enhance the vigilance in diagnosing, improve the use of resources and ultimately the morbidity and mortality. The aim of the current study is to identify the prevalence of myocarditis in children presenting with heart failure in a tertiary care hospital.

MATERIAL AND METHODS

This will be a descriptive cross-sectional research study done to establish the prevalence of myocarditis in children who present with heart failure. The research will be conducted within the Department of Pediatric Medicine at Peoples University of medical and health sciences Women (PUMHS-W), Nawabshah, this is a tertiary care teaching hospital serving a huge population of pediatrics.

The study period shall be three months after the official approval of the synopsis by Research and Evaluation Unit.

The study will include a sample size of 95 pediatric patients. Based on published literature, the sample size has been obtained by taking a 95% confidence level, margin of error at 10% and an expected myocarditis frequency among the patients with pediatric heart failure of 43.33%.

The sampling method will be non-probability consecutive, where all the eligible patients that will be available during the study period would be enrolled until the necessary sample size is obtained.

The study will include pediatric patients (male and female) aged 1-15 years of age with the heart failure

presentation as per the operational definition and the duration of the symptoms does not exceed 24 hours. The patients will be not included in the study in case of chronic kidney disease (serum creatinine above 1.5 mg/dl), cardiothoracic surgery history, coronary artery bypass grafting, acute pulmonary embolism, coronary artery anomalies, congenital heart disease, chronic bacteriological sepsis and chronic primitive arrhythmias. Congestive heart failure will be diagnosed with two or more symptoms with one of them being excessive sweating at room temperature and bluish on fingers, nose or tongue and labored breathing and 2 or more clinical manifestations of the disease such as tachycardia (heart rate exceeding 2 standard deviations of age), tachypnea based on age-related cutoffs, pedal edema and hepatomegaly. It will be diagnosed as myocarditis, based on sinus tachycardia, T-wave inversion on the electrocardiogram, cardiac troponin T or I of >0.1 ng/ml and left ventricular ejection fraction of 35 or less on echocardiogram.

Pediatric patients who visit the Emergency Department of Pediatric Medicine at PUMHS-W, Nawabshah, who meet the inclusion criteria will be recruited after giving their consent to the study, which will be obtained in writing and their names will be kept confidential. All patients will have attendants who will be informed about the importance of giving informed consent. There will be demographic data such as age, gender, time of symptoms, weight, education level of a parent and place of living. After the first stabilization, a consultant cardiologist with more than three years of post-

fellowship experience will perform electrocardiography, bedside echocardiography. Myocarditis will be detected or not with the help of a pre-designed proforma.

Statistical package of social science (SPSS 26.0) will be used to enter and analyze the data. The test of normality of continuous variables will be based on the Shapiro-Wilk test. Quantitative variables will be measured using a mean and standard deviation or median and interquartile range whereas frequencies and percentages will be measured in qualitative variables. Post-stratification will be used to control the effect modifiers which include age, gender, weight, duration of symptoms, clinical manifestations, parental education status and residential status. P-value below 0.05 will be regarded as statistically significant.

RESULTS

This study involved 95 pediatric patients who came to the hospital with heart failure. The average age of the participants was 7.79 ± 4.33 years ranging from 1-15 years. Among them, 29 (30.5%) patients were between 1-5 years old, 33 (34.7%) years were between 6-10 years old and 33 (34.7%) years were between 11-15 years old. It was male dominated as there were 55 (57.9%) males and 40 (42.1%) females. The majority of patients lived in the rural regions (63.2%) and 36.8% lived in the cities. In terms of parental education, 55.8% mothers were uneducated and 52.6% were uneducated. Mean duration of symptoms was 14.21 ± 5.24 hours and the mean weight of the patients was 24.59 ± 8.85 kg (Table 1).

Table 1: Demographic and Baseline Characteristics of Pediatric Heart Failure Patients (n = 95)

Variable	Category	n (%)
Age (years)	Mean ± SD	7.79 ± 4.33
Age group	1-5 years	29 (30.5)
	6-10 years	33 (34.7)
	11-15 years	33 (34.7)
Gender	Male	55 (57.9)
	Female	40 (42.1)
Residence	Rural	60 (63.2)
	Urban	35 (36.8)
Mother education	Uneducated	53 (55.8)
	Educated	42 (44.2)
Father education	Uneducated	50 (52.6)
	Educated	45 (47.4)
Duration of symptoms (hours)	Mean ± SD	14.21 ± 5.24
Weight (kg)	Mean ± SD	24.59 ± 8.85

Frequency of Myocarditis and Clinical Profile

Myocarditis was detected in 69 (72.6%) pediatric heart failure patients and 26 (27.4%) patients were without myocarditis. T-wave inversions on ECG, cardiac troponin levels (>0.1 ng/ml) and left ventricular

ejection fraction ≤ 35% on echocardiography all were found in all cases of myocarditis (72.6% of the total cohort).

Concerning clinical symptoms, all myocarditis patients had tachycardia and tachypnea. Pedal edema appeared in 54 (56.8%) and hepatomegaly was observed in 69 (72.6%) patients. All the patients reported labored

breathing among symptoms, 54 (56.8%) patients displayed bluish discoloration and 27 (28.4) patients featured excessive sweating (Table 2).

Table 2: Frequency and Clinical Profile of Myocarditis Among Pediatric Heart Failure Patients (n = 95)

Variable	Category	n (%)
Myocarditis	Present	69 (72.6)
	Absent	26 (27.4)
ECG finding	T-wave inversion present	69 (72.6)
Cardiac biomarker	Troponin T/I >0.1 ng/ml	69 (72.6)
Echocardiography	LVEF ≤35%	69 (72.6)
	Tachycardia	69 (72.6)
Clinical signs	Tachypnea	69 (72.6)
	Pedal edema	54 (56.8)
	Hepatomegaly	69 (72.6)
	Excessive sweating	27 (28.4)
Symptoms	Bluish discoloration	54 (56.8)
	Labored breathing	95 (100.0)

Note: Values are presented as frequency and percentage.

Association of Myocarditis with Demographic and Clinical Variables

Myocarditis was found to have statistically significant relationship with gender, whereby myocarditis was more common in males (71.0%) in comparison to females (29.0%) ($p < 0.001$). Age also linked significantly with myocarditis where the frequency was highest in the 11-15 years group (43.5%), then 6-10 years (34.8%) and 1-5 years (21.7%) ($p < 0.001$).

The residence was also significantly related to myocarditis with 76.8% of myocarditis patients at rural location and 23.2% at urban location ($p < 0.001$).

Education of parents showed notable connections. Myocarditis was relatively higher in patients whose mothers (71.0%) and fathers (65.2%) were not educated as opposed to those with educated parents ($p < 0.001$ in both).

Myocarditis was also strongly related to weight. Most of the patients with myocarditis (60.9%) were overweight (more than 25 kg) but none of the patients without myocarditis fell in this weight ($p < 0.001$). The patients who did not have myocarditis were more likely to report lower weight groups (Table 3).

Table 3: Association of Myocarditis with Demographic and Clinical Variables (Post-Stratification Analysis)

Variable	Category	Myocarditis Present n (%)	Myocarditis Absent n (%)	p-value
Gender	Male	49 (71.0)	6 (23.1)	<0.001
	Female	20 (29.0)	20 (76.9)	
Age group (years)	1-5	15 (21.7)	14 (53.8)	<0.001
	6-10	24 (34.8)	9 (34.6)	
	11-15	30 (43.5)	0 (0.0)	
Residence	Rural	53 (76.8)	7 (26.9)	<0.001
	Urban	16 (23.2)	19 (73.1)	
Mother education	Uneducated	49 (71.0)	4 (15.4)	<0.001
	Educated	20 (29.0)	22 (84.6)	
Father education	Uneducated	45 (65.2)	5 (19.2)	<0.001
	Educated	24 (34.8)	21 (80.8)	
Weight group (kg)	≤15	6 (8.7)	15 (57.7)	<0.001
	16-25	21 (30.4)	11 (42.3)	
	>25	42 (60.9)	0 (0.0)	

DISCUSSION

This study evaluated the frequency of myocarditis among pediatric patients presenting with heart failure and identified associated demographic and clinical

factors. These results demonstrate that myocarditis is a significant cause of cardiac morbidity in children with heart failure (72.6%), which is the primary cause of cardiac morbidity in pediatric tertiary care units. A

higher proportion has been reported as compared to many other estimates of myocarditis being found in the past that have been hospital-based with a point of 30-45% of pediatric cases of heart failure [1-3]. The increased frequency of the current study could be due to the delay in presentation, bias regarding referral to a tertiary center and the increased prevalence of infectious etiologies in resource-limited populations [4,5].

There was also a substantial correlation between myocarditis and male gender with 71.0% of the cases of myocarditis being male. This observation is in line with the available literature which indicates that pediatric myocarditis is predominantly male especially in older children [6,7]. The differences in the immune response and hormonal modulation, based on sex, have been suggested as one of the factors that might explain this gap [8]. The statistically significant correlation in this study ($p < 0.001$) supports the rationale to use increased clinical suspicion of myocarditis in male pediatric patients with heart failure.

Age was also significantly related with myocarditis. The oldest group of 11-15 years had the highest frequency of 43.5% then 6-10 years (34.8%) and the other age group of children were in low numbers. The current findings are similar to previous reports in which older children and adolescents exhibited greater levels of myocarditis-associated cardiac dysfunction [9,10]. This tendency could be connected to a higher risk of being exposed to viral infections, higher level of physical activity and prolonged latency of symptoms in children.

Residential status proved to be one of the important determinants with 76.8% of myocarditis cases, being rural-based. This observation highlights the contribution of socioeconomic and access differences to healthcare disparities in disease presentation and outcome. Diffusion of early medical services, late referrals and lack of awareness of cardiac symptoms among rural populations could be involved in the deterioration of disease at presentations [11]. The statistical association in this study is strong ($p < 0.001$) shows the necessity of the improved system of pediatric cardiac screening and referral in the rural areas.

Myocarditis was strongly linked with parental education. Myocarditis was more prevalent among children whose mothers and fathers were uneducated (71.0% and 65.2%, respectively). Education of parents is directly related with the health seeking behavior, recognition of disease and treatment compliance [12]. These results indicate that educational deprivation of parents might be a cause of late manifestation and high disease stages and the role of health education programs at

community level. There were good associations between clinical signs and diagnostic parameters and myocarditis. All myocarditis cases had tachycardia and tachypnea and pedal edema (56.8%) and hepatomegaly (72.6%) were common as well. The results are consistent with current diagnostic criteria and clinical definition of pediatric myocarditis, in which congestive heart failure is the prevailing manifestation [13]. The existence of tachycardia and tachypnea in all patients of myocarditis is the marker of the acuteness of myocardial dysfunction at the arrival.

Myocarditis cases had similar electrocardiographic, biochemical and echocardiographic results. All patients with myocarditis had T-wave inversion, increased troponin levels and left ventricular ejection fraction $\leq 35\%$ of myocardial. These results endorse the diagnostic potential of easily accessible studies in resource-restrained areas, in which sophisticated imaging techniques like cardiac magnetic resonance imaging cannot be accessible [14]. The statistical correlations found in this paper support the importance of these parameters to early diagnosis of myocarditis in heart failure patients with children. Weight also had a significant relationship with myocarditis where 60.9% of the patients that had myocarditis weighed above 25 kg and none of the non-myocarditis patients fell in this category. Independent sample t-tests revealed that myocarditis patients exhibited much higher mean age and mean weight than no myocarditis ($p < 0.001$ in both cases). These results indicate that children of older ages and higher weight could be more symptomatic with more significant myocardial involvement, which has been established in the literature before [15,16]. There was no significant difference between myocarditis and non-myocarditis groups with regard to the periods of symptoms, meaning that symptoms duration alone might not be a reliable differentiator of myocarditis and other causes of heart failure in children.

This study was carried out in one tertiary care center, which can be a limitation to the generalization of the results. The cross-sectional design does not allow evaluation of long-term results. High-tech forms of diagnosis like cardiac magnetic resonance imaging and endomyocardial biopsy were not applied.

CONCLUSION

This study conducted found myocarditis to be a common cause of pediatric heart failure especially in males, older patients and in rural background patients because of low parental education. Myocarditis was strongly connected with clinical manifestations and ECG changes, increased cardiac biomarkers and decreased left ventricular activity.

REFERENCES

1. Esposito S, Marchetti F, Lanari M, Caramelli F, De Fanti A, Vergine G, Iughetti L, Fornaro M, Suppiej A, Zona S, Pession A, Biasucci G; Working Group on COVID-19 in Pediatrics of the Emilia-Romagna Region (RE-CO-Ped). COVID-19 Management in the Pediatric Age: Consensus Document of the COVID-19 Working Group in Paediatrics of the Emilia-Romagna Region (RE-CO-Ped), Italy. *Int J Environ Res Public Health*. 2021 Apr 8;18(8):3919. doi: 10.3390/ijerph18083919. PMID: 33917940; PMCID: PMC8068343.
2. Cattalini M, Della Paolera S, Zunica F, Bracaglia C, Giangreco M, Verdoni L, Meini A, Sottile R, Caorsi R, Zuccotti G, Fabi M, Montin D, Meneghel A, Consolaro A, Dellepiane RM, Maggio MC, La Torre F, Marchesi A, Simonini G, Villani A, Cimaz R, Ravelli A, Taddio A; Rheumatology Study Group of the Italian Pediatric Society. Defining Kawasaki disease and pediatric inflammatory multisystem syndrome-temporally associated to SARS-CoV-2 infection during SARS-CoV-2 epidemic in Italy: results from a national, multicenter survey. *Pediatr Rheumatol Online J*. 2021 Mar 16;19(1):29. doi: 10.1186/s12969-021-00511-7. PMID: 33726806; PMCID: PMC7962084.
3. Seth S, Rashid F, Khera K. An overview of the COVID-19 complications in paediatric population: A pandemic dilemma. *Int J Clin Pract*. 2021 Sep;75(9): e14494. doi: 10.1111/ijcp.14494. Epub 2021 Jun 22. PMID: 34115913; PMCID: PMC8420266.
4. Seidel F, Holtgrewe M, Al-Wakeel-Marquard N, Ogen-Rhein B, Dartsch J, Herbst C, Beule D, Pickardt T, Klingel K, Messroghli D, Berger F, Schubert S, Kühnisch J, Klaassen S. Pathogenic Variants Associated with Dilated Cardiomyopathy Predict Outcome in Pediatric Myocarditis. *Circ Genom Precis Med*. 2021 Aug;14(4): e003250. doi: 10.1161/CIRCGEN.120.003250. Epub 2021 Jul 2. PMID: 34213952; PMCID: PMC8373449.
5. Cavalcanti A, Islabão A, Magalhães C, Veloso S, Lopes M, do Prado R, Aquilante B, Terrazas AM, Rezende MF, Clemente G, Terreri MT. Paediatric inflammatory multisystem syndrome temporally associated with SARS-CoV-2 (PIMS-TS): a Brazilian cohort. *Adv Rheumatol*. 2022 Feb 21;62(1):6. doi: 10.1186/s42358-022-00237-4. PMID: 35189972; PMCID: PMC8860252.
6. Ricci JC, Farahani NA, Davis CJ, Ritter KG, Parrow LM, Tomerlin PI, Darakjian AA, Gegoutchadze K, Gupta D, Bruno KA. A comparative review of myocarditis in pediatrics versus adults: pathogenesis, diagnosis and management. *Front Immunol*. 2025 Sep 26; 16:1601307. doi: 10.3389/fimmu.2025.1601307. PMID: 41080571; PMCID: PMC12511060.
7. Gran F, Fidalgo A, Dolader P, Garrido M, Navarro A, Izquierdo-Blasco J, Balcells J, Codina-Sola M, Fernandez-Alvarez P, Sabaté-Rotés A, Betrián P, Fernández-Doblas J, Abella R, Roses-Noguer F. Differences between genetic dilated cardiomyopathy and myocarditis in children presenting with severe cardiac dysfunction. *Eur J Pediatr*. 2022 Jan;181(1):287-294. doi: 10.1007/s00431-021-04175-z. Epub 2021 Jul 20. PMID: 34286374; PMCID: PMC8294227.
8. Amoozgar H, Askarinejad A, Edraki M, Mehdizadegan N, Mohammadi H, Naghshzan A, Kohansal E, Vara F, Hesami H. Epidemiology and prognosis of pediatric acute myocarditis: a 5-year retrospective study in Shiraz, South of Iran running title: pediatric acute myocarditis in Iran. *BMC Cardiovasc Disord*. 2025 Mar 25;25(1):218. doi: 10.1186/s12872-025-04672-1. PMID: 40133800; PMCID: PMC11934521.
9. Yao Q, Zhan S. Corticosteroid in anti-inflammatory treatment of pediatric acute myocarditis: a systematic review and meta-analysis. *Ital J Pediatr*. 2023 Mar 13;49(1):30. doi: 10.1186/s13052-023-01423-w. PMID: 36915162; PMCID: PMC10012438.
10. Mileva N, Vasilev GH, Ganey B, Chervenkov L, Batselova H, Tzotcheva I, Tomov L, Velikova T, Lazova S. Cardiovascular Manifestations of Multisystem Inflammatory Syndrome in Children: A Single-Center Bulgarian Study. *Medicina (Kaunas)*. 2023 Dec 14;59(12):2175. doi: 10.3390/medicina59122175. PMID: 38138278; PMCID: PMC10744581.
11. De Sarro R, Borrelli N, Pelaia G, Mendicino A, Moscatelli S, Leo I, La Vecchia G, Mazza G, Castaldo L, Strangio A, Avesani M, De Rosa S, Torella D, Di Salvo G, Sabatino J. How to behave with paediatric myocarditis: imaging methods and clinical considerations. *Eur Heart J Imaging Methods Pract*. 2025 Apr 4;3(1): qyaf025. doi: 10.1093/ehjimp/qyaf025. PMID: 40191780; PMCID: PMC11969066.

12. Karsenty C, Vignaud P, Brusq C, Moceri P, Lim P, Gerbaud E, Lairez O, Lelarge C, Ovaert C, Bouleti C, Werner O, Bongard V, Genet T, Bonnemaïns L, Tron C, Barre E, Boddaert M, Mansourati J, Benzouid C, Roubille F, Khachab H, Uhry S, Cohen A, Lattuca B, Di Filippo S, Delmas C. Acute myocarditis according to age: Presentation, management and early outcomes. *ESC Heart Fail.* 2025 Aug;12(4):2932-2945. doi: 10.1002/ehf2.15304. Epub 2025 May 22. PMID: 40405538; PMCID: PMC12287872.
13. Lai FTT, Chan EWW, Huang L, Cheung CL, Chui CSL, Li X, Wan EYF, Wong CKH, Chan EWY, Yiu KH, Wong ICK. Prognosis of Myocarditis Developing After mRNA COVID-19 Vaccination Compared with Viral Myocarditis. *J Am Coll Cardiol.* 2022 Dec 13;80(24):2255-2265. doi: 10.1016/j.jacc.2022.09.049. PMID: 36480967; PMCID: PMC9721305.
14. Veronese G, Colombo G, Garascia A, Adorisio R, Bonanomi E, Ammirati E. Parvovirus B19-associated myocarditis in children: A systematic review of clinical features, management and outcomes. *Eur J Clin Invest.* 2025 Nov;55(11):e70102. doi: 10.1111/eci.70102. Epub 2025 Jul 28. PMID: 40719608; PMCID: PMC12517251.
15. Parr M, Wilson CL, Jones B, Crawford NW, Ferguson S, Ramesh S, Eapen N, Craig S, Hearps S, Babl FE; Paediatric Research in Emergency Departments International Collaborative (PREDICT) Research Network. Emergency department presentations for chest complaints after mRNA COVID-19 vaccinations in children and adolescents. *Emerg Med Australas.* 2024 Feb;36(1):110-117. doi: 10.1111/1742-6723.14327. Epub 2023 Oct 23. PMID: 37872323; PMCID: PMC10953413.
16. Barreiro-Pérez M, Pastor Pueyo P, Raposeiras-Roubín S, Montero Corominas D, Uribarri A, Eiros Bachiller R, Rozado Castaño J, García-Cuenillas Álvarez L, Serratos Fernández L, Domínguez F, Pascual Figal D. Myocarditis related SARS-CoV-2 infection or vaccination: an expert consensus statement on its diagnosis and management. *Rev Esp Cardiol (Engl Ed).* 2023 Jul;76(7):555-563. doi: 10.1016/j.rec.2023.01.011. Epub 2023 Mar 11. PMID: 36914023; PMCID: PMC10008093.