

Clinical and Echocardiographic Criteria for the Diagnosis of Dilated Cardiomyopathy in Children

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ABSTRACT

Dilated cardiomyopathy (DCM) and non-rheumatic carditis in children share an overlapping clinical presentation and are frequently indistinguishable at the bedside, yet they differ fundamentally in treatment strategy and prognosis. The aim of the study was to identify the clinical, laboratory and echocardiographic parameters that reliably discriminate between these two conditions. A retrospective comparative study included 40 children: 31 with DCM (main group) and 9 with non-rheumatic carditis (comparison group). Seventy-four parameters were analysed, covering anthropometry, clinical findings, vital signs, electrocardiography, echocardiography, chest radiography and laboratory data. Body mass index-for-age Z-scores were calculated using the WHO LMS method. Non-parametric statistics were applied (Mann-Whitney U test, Fisher exact test, Spearman rank correlation). The groups were comparable in age, body weight, height, body mass index and Z-score (all $p > 0.05$). Significant between-group differences were found for cyanosis (90.3 % vs 33.3 %, $p = 0.001$), oxygen saturation (95.84 $\pm$ 1.66 % vs 97.33 $\pm$ 0.87 %, $p = 0.003$), left ventricular ejection fraction (35.52 $\pm$ 14.06 % vs 55.17 $\pm$ 7.14 %, $p = 0.007$), heart rate ($p = 0.025$), tricuspid regurgitation (40.7 % vs 0 %, $p = 0.037$) and total serum protein ($p = 0.037$). An ejection fraction below 45 % was recorded in 74.2 % of children with DCM and in none of the comparison group. Conventional clinical signs of myocardial involvement and inflammatory laboratory markers showed no discriminative value. Correlation analysis revealed a consistent association between anemia and haemodynamic burden in DCM.

Introduction

Dilated cardiomyopathy is the most common form of cardiomyopathy in the pediatric population and the leading cardiac indication for heart transplantation in children. Population-based registries report an annual incidence of pediatric cardiomyopathy of approximately 1.1-1.2 cases per 100 000 children, with the dilated phenotype accounting for roughly half of all cases [1, 2]. Outcomes remain unfavourable: within five years of diagnosis, a substantial proportion of affected children either die or undergo transplantation [3]. The disease is defined by left ventricular dilatation accompanied by impaired systolic function that cannot be explained by abnormal loading conditions or coronary artery disease [4].

Non-rheumatic carditis, which in children most often represents viral myocarditis, is one of the principal conditions in the differential diagnosis of DCM. The two entities may present with an almost identical clinical picture: cardiomegaly, systolic murmur, muffled heart sounds, hepatomegaly, tachycardia, dyspnoea and other manifestations of circulatory failure [5, 6]. At the same time, acute myocarditis is potentially reversible and may require specific anti-inflammatory or immunomodulatory treatment, whereas DCM in most cases demands long-term heart failure therapy and early assessment for transplantation [7]. Consequently, the accuracy of the initial differentiation directly determines the therapeutic pathway.

Relevance.

In routine pediatric practice, particularly at the primary and secondary levels of care, the initial diagnostic decision continues to rely largely on physical examination findings. Endomyocardial biopsy

and cardiac magnetic resonance imaging, which constitute the reference standards for the verification of myocarditis, are not universally available and are rarely performed in children in resource-limited settings. It is therefore of practical importance to determine which of the routinely obtainable parameters actually possess discriminative power and which, despite their traditional diagnostic authority, do not.

The question is rarely addressed directly. Most published series compare children with cardiomyopathy against healthy controls, a design that inevitably demonstrates differences in nearly every parameter and consequently yields little differential-diagnostic information. A comparison against a clinically similar nosological entity is methodologically more demanding but provides answers to the question actually faced by the clinician at the bedside. Data of this type obtained in the population of Uzbekistan have not been published previously.

Materials and Methods

Study design and population. A retrospective, cross-sectional, single-centre comparative study was performed. The study sample comprised 40 children admitted to a specialised cardiology department. The main group consisted of 31 children with dilated cardiomyopathy and the comparison group of 9 children with non-rheumatic carditis. The age of the participants ranged from 1 to 200 months. The diagnosis in each case was established by the attending cardiologist on the basis of the clinical picture, echocardiography and chest radiography in accordance with accepted diagnostic criteria [4, 6].

Non-rheumatic carditis rather than healthy children was deliberately selected as the comparison condition. This choice allows the identification of features specific to DCM rather than features of cardiac disease in general, and corresponds to the clinically meaningful question of differential diagnosis.

Parameters studied. Seventy-four parameters were recorded for each patient: demographic and anthropometric data; history; clinical signs (cough, dyspnoea, cyanosis, tachycardia, weakness, oedema, reduced appetite, hepatomegaly, splenomegaly, cardiac border enlargement, systolic murmur, muffled heart sounds); vital signs (heart rate, systolic and diastolic blood pressure, respiratory rate, oxygen saturation); electrocardiographic findings (conduction block, arrhythmia); echocardiographic measurements (end-diastolic and end-systolic dimensions, end-diastolic volume, ejection fraction, valvular regurgitation, pulmonary hypertension); the cardiothoracic ratio on chest radiography; complete blood count; and biochemical parameters including total protein, transaminases, lactate dehydrogenase, creatine kinase and serum electrolytes.

Anthropometric assessment. Body mass index was calculated as weight in kilograms divided by the square of height in metres. The body mass index-for-age Z-score was computed by the LMS method, $Z = ((\text{BMI}/M)^L - 1)/(S \times L)$, where L, M and S are the age- and sex-specific reference parameters. The WHO Child Growth Standards (2006) were applied for children aged up to 60 months and the WHO Growth Reference (2007) for older children [8, 9]. The adjustment procedure described in Chapter 7 of the WHO methodological guidance was applied to values exceeding three standard deviations. The implementation was validated against 24 previously calculated Z-scores, with a discrepancy of 0.00 for all cases.

Statistical analysis. The distribution of quantitative variables was assessed by skewness and kurtosis. Pronounced departures from normality were observed for most biochemical parameters (skewness up to 5.53; kurtosis up to 29.99). Given this finding, the small size of the comparison group and the presence of ordinal scales, non-parametric methods were used throughout. Quantitative variables are presented as mean $\pm$ standard deviation with the number of observations, and between-group comparisons were performed using the Mann-Whitney U test with normal approximation and correction for tied ranks. Qualitative variables are presented as absolute frequencies and percentages of the number of observations with known values, and were compared using the two-sided Fisher exact test, which, unlike the chi-square test, imposes no requirement on minimum expected cell frequencies. Associations were assessed by the Spearman rank correlation coefficient with significance evaluated through the t-transformation. Missing values were handled by pairwise deletion; imputation was not performed. Comparisons in which fewer than five observations were available in either group were designated statistically unsupported and no p-value was calculated. The critical significance level was set at 0.05; all tests were two-sided.

Results

Comparability of the groups. No statistically significant differences between the groups were found with respect to age, body weight, height, body mass index or Z-score (Table 1). The groups are therefore comparable, and the differences identified subsequently cannot be attributed to differences in age or physical development.

Table 1. Comparability of the study groups (Mann-Whitney U test).

Parameter	DCM (n = 31)	Carditis (n = 9)	p
Age, months	67.87 +/- 61.64	94.89 +/- 50.25	0.128
Body weight, kg	20.52 +/- 17.32	20.00 +/- 5.41	0.109
Height, cm	103.06 +/- 31.93	106.00 +/- 16.22	0.456
Body mass index, kg/m ²	16.75 +/- 3.47	17.64 +/- 1.93	0.250
BMI-for-age Z-score	-0.17 +/- 2.01	0.68 +/- 1.53	0.231

A high standard deviation of the Z-score in the main group (+/- 2.01) accompanied by a mean close to zero reflects the bidirectional nature of the deviations: both marked undernutrition and excess body mass are present within the DCM group, and these deviations offset one another in the mean value.

Clinical findings. Of the seventeen clinical signs examined, only cyanosis differed significantly between the groups (Table 2). The classical triad on which clinical diagnosis of myocardial involvement traditionally relies, namely systolic murmur, muffled heart sounds and enlargement of the cardiac borders, occurred with comparable frequency in both conditions and therefore does not permit their differentiation.

Table 2. Frequency of clinical signs (Fisher exact test).

Clinical sign	DCM, n (%)	Carditis, n (%)	p
Systolic murmur	31/31 (100 %)	8/9 (88.9 %)	0.225
Weakness	29/31 (93.5 %)	7/9 (77.8 %)	0.213
Muffled heart sounds	29/31 (93.5 %)	7/9 (77.8 %)	0.213
Enlargement of cardiac borders	28/31 (90.3 %)	6/9 (66.7 %)	0.115
Cyanosis	28/31 (90.3 %)	3/9 (33.3 %)	0.001
Reduced appetite	27/31 (87.1 %)	6/9 (66.7 %)	0.316
Dyspnoea	25/31 (80.6 %)	6/9 (66.7 %)	0.394
Oedema	24/31 (77.4 %)	5/9 (55.6 %)	0.227
Cough	24/31 (77.4 %)	4/9 (44.4 %)	0.097
Hepatomegaly	23/31 (74.2 %)	6/9 (66.7 %)	0.686
Tachycardia	19/30 (63.3 %)	6/9 (66.7 %)	1.000
Anemia	13/31 (41.9 %)	5/9 (55.6 %)	0.705
Rickets	11/31 (35.5 %)	4/9 (44.4 %)	0.705
Splenomegaly	5/24 (20.8 %)	1/9 (11.1 %)	1.000

Vital signs, echocardiography and chest radiography. Significant differences were established for heart rate and oxygen saturation; diastolic blood pressure approached the threshold of significance (Table 3). Although the absolute difference in oxygen saturation is small and both mean values lie within the normal range, the difference is highly significant owing to the low dispersion of this parameter, and it is consistent with the high frequency of cyanosis in the main group.

Table 3. Vital signs, echocardiographic and selected laboratory parameters (Mann-Whitney U test).

Parameter	DCM	Carditis	p
Heart rate, bpm	116.00 +/- 21.93	97.00 +/- 17.79	0.025
Systolic blood pressure, mm Hg	92.10 +/- 22.05	93.89 +/- 14.09	0.160
Diastolic blood pressure, mm Hg	57.10 +/- 12.70	62.78 +/- 10.93	0.051
Respiratory rate, per min	33.68 +/- 9.22	30.44 +/- 12.90	0.085
Oxygen saturation, %	95.84 +/- 1.66	97.33 +/- 0.87	0.003
Ejection fraction, %	35.52 +/- 14.06 (n = 31)	55.17 +/- 7.14 (n = 6)	0.007
End-diastolic volume, mL	97.71 +/- 59.66 (n = 31)	57.80 +/- 21.92 (n = 5)	0.131
Cardiothoracic ratio, %	64.12 +/- 7.48 (n = 16)	48.00 (n = 1)	not assessable
Total serum protein, g/L	66.79 +/- 6.72 (n = 29)	72.88 +/- 5.38 (n = 8)	0.037
Serum calcium, mmol/L	2.02 +/- 0.13 (n = 26)	1.92 +/- 0.04 (n = 8)	0.050

The ejection fraction proved to be the most informative quantitative discriminator, the difference between group means amounting to 19.65 percentage points. The cardiothoracic ratio in the main group was 64.12 +/- 7.48 %, which exceeds the upper limit of normal for all pediatric age groups and documents radiographic cardiomegaly in every child examined; a between-group comparison was not possible because only one measurement was available in the comparison group.

The distribution of patients by the degree of systolic dysfunction (Table 4) represents the most clinically convincing result of the study. An ejection fraction below 45 % was recorded in 23 of 31 children with DCM (74.2 %) and in none of the children in the comparison group, whereas a preserved ejection fraction was observed in two thirds of children with carditis.

Table 4. Distribution of patients by the degree of left ventricular systolic dysfunction.

Ejection fraction category	DCM, n (%)	Carditis, n (%)
Below 30 % (severe dysfunction)	11/31 (35.5 %)	0/6 (0 %)
30-44 % (moderate)	12/31 (38.7 %)	0/6 (0 %)
45-54 % (mild)	3/31 (9.7 %)	2/6 (33.3 %)
55 % and above (preserved)	5/31 (16.1 %)	4/6 (66.7 %)

Valvular regurgitation. Tricuspid regurgitation was detected exclusively in the main group (11/27, 40.7 %, versus 0/8, 0 %; p = 0.037). This is pathophysiologically consistent, since involvement of the right-sided chambers reflects a later and more advanced stage of myocardial remodelling. Mitral regurgitation was frequent in both groups (89.7 % versus 66.7 %; p = 0.131) and had no discriminative value. Aortic regurgitation (9.5 % versus 0 %) and pulmonary hypertension (20.0 % versus 0 %) did not reach statistical significance.

Electrocardiographic and inflammatory parameters. No significant differences were found for conduction block (4.5 % versus 28.6 %; p = 0.136) or arrhythmia (26.9 % versus 0 %; p = 0.299). Equally, none of the inflammatory markers differed between groups: leukocytes (p = 0.617), erythrocyte sedimentation rate (p = 0.503) and eosinophils (p = 0.197). The widely held assumption that carditis is accompanied by a more pronounced inflammatory response was not confirmed in this sample. These negative findings must be interpreted with caution, since the statistical power available with nine comparison subjects is insufficient; the results indicate that a difference was not demonstrated rather than that no difference exists.

Correlation analysis. Within the main group, several statistically significant associations formed coherent clusters (Table 5). The first cluster links haemoglobin with haemodynamic burden: haemoglobin correlated inversely with respiratory rate and heart rate and directly with oxygen saturation and end-diastolic volume. These four concordant associations describe a single mechanism whereby anemia compels compensation for reduced oxygen-carrying capacity through increased cardiac and respiratory rates, imposing an additional burden on an already compromised myocardium [10]. The second cluster relates total protein to disease severity: total protein correlated directly with ejection fraction and inversely with the cardiothoracic ratio, which permits its consideration as an accessible laboratory marker of severity. The third cluster comprises inverse associations of platelet count with all

three chamber dimensions. Finally, the strongest single association in the study was the direct correlation between age and haemoglobin, indicating that the younger the child, the more profound the anemia.

Table 5. Statistically significant correlations within the DCM group (Spearman rank correlation).

Parameter 1	Parameter 2	n	rho	p
Age (months)	Haemoglobin	30	0.668	< 0.001
Ejection fraction	Total protein	29	0.549	0.002
Respiratory rate	Haemoglobin	30	-0.502	0.005
Heart rate	Haemoglobin	30	-0.474	0.008
End-diastolic volume	Platelets	29	-0.480	0.009
End-diastolic dimension	Platelets	28	-0.426	0.024
Oxygen saturation	Haemoglobin	30	0.402	0.028
Cardiothoracic ratio	Total protein	16	-0.524	0.038

Limitations.

The principal limitation of the study is the size of the comparison group, which restricts the statistical power available for detecting moderate differences and precludes comparison of parameters incompletely recorded in that group. The retrospective single-centre design entails a possible selection bias towards more severe cases. More than fifty comparisons were performed without formal correction for multiplicity, which is appropriate for an exploratory study but means that results with p-values close to 0.05 require confirmation in a larger sample; the findings with p below 0.01, namely cyanosis, oxygen saturation and ejection fraction, are robust to such correction.

Conclusion

1. In children, dilated cardiomyopathy and non-rheumatic carditis cannot be reliably differentiated on the basis of clinical findings or routine inflammatory laboratory markers. Systolic murmur, muffled heart sounds, enlargement of the cardiac borders, hepatomegaly, dyspnoea and oedema occur with comparable frequency in both conditions.

2. The left ventricular ejection fraction is the principal discriminating parameter. A value below 45 % was recorded in 74.2 % of children with dilated cardiomyopathy and in none of the children with non-rheumatic carditis, whereas a preserved ejection fraction was present in 66.7 % of the comparison group as against 16.1 % of the main group.

3. Cyanosis (p = 0.001), oxygen saturation (p = 0.003), heart rate (p = 0.025), tricuspid regurgitation (p = 0.037) and total serum protein (p = 0.037) possess additional discriminative value and may serve as supporting criteria where echocardiography is not immediately available.

4. Radiographic cardiomegaly is a constant feature of dilated cardiomyopathy in children: the cardiothoracic ratio in the main group was 64.12 +/- 7.48 %, exceeding the upper limit of normal in every case examined.

5. Anemia in children with dilated cardiomyopathy is consistently associated with increased haemodynamic burden, as evidenced by concordant correlations of haemoglobin with respiratory rate, heart rate and oxygen saturation. Correction of anemia should therefore be regarded as a component of heart failure management in this population, and younger children, in whom anemia is most profound, constitute a group of elevated risk.

6. Reduction of total serum protein is associated with poorer contractile function and greater cardiac dimensions, which allows this inexpensive and widely available parameter to be used as a marker of disease severity.

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