ORIGINAL RESEARCH

Echocardiographic Evaluation of Cardiac Changes in Dengue Patients: A Prospective Study at a Tertiary Care Center

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ABSTRACT
Background: Dengue fever has been increasingly recognized for its potential cardiac complications beyond the traditional hematological manifestations. This study aimed to evaluate the spectrum of echocardiographic changes in patients with dengue fever and assess their clinical significance. **Material and Methods:** We conducted a prospective observational study on 100 confirmed dengue patients admitted to our tertiary care hospital. All patients underwent comprehensive echocardiographic evaluation on admission and follow-up assessments as clinically indicated. Correlation with clinical severity, biomarkers, and outcomes was analyzed. **Results:** Echocardiographic abnormalities were detected in 28% of patients (95% CI: 19.5-37.9%). The most common findings were left ventricular systolic dysfunction (10%), diastolic dysfunction (8%), pericardial effusion (7%), and regional wall motion abnormalities (3%). Patients with severe dengue had significantly higher incidence of echocardiographic abnormalities compared to non-severe cases (45.8% vs. 21.1%, p=0.009). Left ventricular ejection fraction was significantly lower in the severe dengue group ($54.2\pm8.7\%$ vs. $61.3\pm5.2\%$, p<0.001). Most echocardiographic abnormalities resolved by follow-up at 4 weeks, although 3% of patients had persistent changes. **Conclusion:** Echocardiographic abnormalities are common in dengue fever, with higher prevalence in severe cases. Routine echocardiography may be beneficial for early detection of cardiac involvement, especially in severe dengue, to guide appropriate management strategies and improve outcomes.
Keywords: Dengue, Echocardiography, Myocarditis, Pericardial effusion, Left ventricular dysfunction

INTRODUCTION

Dengue fever is one of the most rapidly spreading mosquito-borne viral diseases globally, with an estimated 390 million infections occurring annually according to the World Health Organization (WHO).[1,2] While traditionally recognized for its hematological manifestations, growing evidence suggests significant cardiac involvement in patients with dengue infection.[3,4]

The spectrum of cardiac manifestations in dengue ranges from asymptomatic electrocardiographic changes to severe myocarditis and heart failure.[5,6] The pathogenesis of cardiac involvement is multifactorial, including direct viral invasion of cardiomyocytes, cytokine-mediated injury, immune-mediated mechanisms, and metabolic derangements.[7,8]

Previous studies have reported varying prevalence rates of cardiac involvement in dengue, ranging from 15% to 50%.[9-11] This wide range may be attributed to differences in study populations, severity of dengue cases, and diagnostic methodologies. While electrocardiographic changes have been widely documented, echocardiographic evaluation provides more detailed information about structural and functional cardiac abnormalities.[12,13]

Despite the growing recognition of cardiac involvement in dengue, the specific patterns of echocardiographic changes, their temporal evolution, and clinical significance remain inadequately characterized.[14] Early detection of cardiac involvement through echocardiography may facilitate timely intervention and potentially improve outcomes.[15]

This study aimed to comprehensively evaluate the spectrum of echocardiographic changes in patients with dengue fever, correlate these findings with clinical severity and biomarkers, and assess their impact on short-term outcomes.

MATERIAL AND METHODS
Study Design and Setting
We conducted this prospective observational study at our tertiary care hospital. The study was approved by Institutional Ethics Committee and written informed consent was obtained from all participants or their legal representatives.

Study Population
A total of 100 consecutive patients aged ≥18 years with laboratory-confirmed dengue infection were enrolled. Dengue diagnosis was confirmed by positive NS1 antigen and/or positive IgM antibody test. Patients with pre-existing cardiac conditions (coronary artery disease, valvular heart disease, cardiomyopathy), chronic kidney disease, or chronic liver disease were excluded to avoid confounding the assessment of dengue-related cardiac manifestations.

Clinical and Laboratory Evaluation
All patients underwent detailed clinical examination at admission and daily thereafter. Patients were classified according to the 2009 WHO dengue classification as non-severe dengue (with or without warning signs) or severe dengue.[16] Laboratory investigations included complete blood count (daily), liver function tests, renal function tests, serum electrolytes, and coagulation profile at admission and as clinically indicated. Cardiac biomarkers (Troponin I and NT-proBNP) were measured in all patients at admission and subsequently if clinically indicated. Electrocardiography (ECG) was performed daily during hospitalization.

Echocardiographic Evaluation
All patients underwent comprehensive transthoracic echocardiography within 24 hours of admission. Standard views were obtained in accordance with the American Society of Echocardiography guidelines. Follow-up echocardiography was performed in patients with abnormal baseline findings, at discharge, and at 4 weeks post-discharge.
The following parameters were assessed:
1. Left ventricular dimensions and wall thickness
2. Left ventricular systolic function (ejection fraction by modified Simpson's method)
3. Left ventricular diastolic function (E/A ratio, deceleration time, E/e' ratio)
4. Regional wall motion abnormalities
5. Right ventricular function (TAPSE, S' velocity)
6. Valvular function
7. Presence and severity of pericardial effusion

Left ventricular systolic dysfunction was defined as ejection fraction <50%. Diastolic dysfunction was graded according to standard criteria. Pericardial effusion was classified as minimal (<5 mm), small (5-10 mm), moderate (10-20 mm), or large (>20 mm).

Statistical Analysis
Data were analyzed using SPSS version 25.0. Categorical variables were expressed as frequencies and percentages, while continuous variables were expressed as mean ± standard deviation or median with interquartile range (IQR) depending on the distribution of data. Patients were stratified into two groups based on the presence or absence of echocardiographic abnormalities. Chi-square test or Fisher's exact test was used to compare categorical variables between groups. Student's t-test or Mann-Whitney U test was used for continuous variables, as appropriate. Correlation between echocardiographic parameters and laboratory markers was assessed using Pearson's or Spearman's correlation coefficient. Multivariate logistic regression analysis was performed to identify independent predictors of echocardiographic abnormalities. Variables with a p-value <0.1 in univariate analysis were included in the multivariate model. A p-value <0.05 was considered statistically significant.

RESULTS
Demographic and Clinical Characteristics
Of the 100 patients enrolled, 56 (56%) were male, and the mean age was 35.8 ± 13.7 years. According to the WHO classification, 76 (76%) patients had non-severe dengue, and 24 (24%) had severe dengue. The median duration of fever at presentation was 4 days (IQR: 3-6 days). The baseline characteristics of the study population are summarized in Table 1.

Prevalence and Patterns of Echocardiographic Abnormalities
Echocardiographic abnormalities were detected in 28 patients (28%, 95% CI: 19.5-37.9%). The prevalence was significantly higher in patients with severe dengue compared to non-severe dengue (45.8% vs. 21.1%, p=0.009). The patterns of echocardiographic abnormalities are detailed in Table 2. Some patients had multiple abnormalities. Among patients with left ventricular systolic dysfunction, the mean ejection fraction was 43.5 ± 4.2%. Most cases (8/10) had mild dysfunction (EF 40-49%), while 2 patients had moderate dysfunction (EF 30-39%). Regional wall motion abnormalities were predominantly observed in the septal and inferior walls. Pericardial effusion was minimal to small in most cases (5/7), with only 2 patients having moderate effusion. No cases of large pericardial effusion or cardiac tamponade were observed.

Comparison of Echocardiographic Parameters Between Severe and Non-severe Dengue
Detailed echocardiographic parameters in severe versus non-severe dengue groups are presented in Table 3.

Correlation with Biomarkers

Significant negative correlations were observed between LVEF and both cardiac biomarkers: Troponin I ($r = -0.42$, $p<0.001$) and NT-proBNP ($r = -0.48$, $p<0.001$). Positive correlations were found between E/e' ratio and NT-proBNP ($r = 0.38$, $p<0.001$). Patients with elevated cardiac biomarkers had a significantly higher prevalence of echocardiographic abnormalities (83.3% vs. 17.0%, $p<0.001$ for Troponin I; 77.8% vs. 16.3%, $p<0.001$ for NT-proBNP). (Figure 1 and 2)

Temporal Evolution of Echocardiographic Changes

Follow-up echocardiography at discharge showed improvement in 16/28 (57.1%) patients with initial abnormalities. By 4 weeks post-discharge, 25/28 (89.3%) patients had complete resolution of echocardiographic abnormalities. Persistent changes at 4 weeks were observed in 3 patients (3% of the total cohort), all of whom had severe dengue with myocarditis. (Figure 3)

Clinical Outcomes

Patients with echocardiographic abnormalities had a longer hospital stay compared to those without (median 7 days vs. 5 days, $p<0.001$). Two patients (2%) developed cardiogenic shock requiring inotropic support, both of whom had severe left ventricular dysfunction. One patient (1%) died due to refractory shock and multi-organ failure.

Predictors of Echocardiographic Abnormalities

In multivariate analysis, several factors were independently associated with the presence of echocardiographic abnormalities (Table 4).

Table 1: Baseline characteristics of the study population

Characteristic	All patients (n=100)	No Echo abnormalities (n=72)	Echo abnormalities (n=28)	p-value
Age (years)	35.8 ± 13.7	33.2 ± 12.5	42.6 ± 14.6	0.002
Male gender	56 (56%)	40 (55.6%)	16 (57.1%)	0.88
Duration of fever (days)	4 (3-6)	4 (3-5)	5 (4-6)	0.03
Severe dengue	24 (24%)	13 (18.1%)	11 (39.3%)	0.009
Warning signs present	42 (42%)	26 (36.1%)	16 (57.1%)	0.04
Platelet count (<50,000/μL)	38 (38%)	23 (31.9%)	15 (53.6%)	0.03
Elevated Troponin I	12 (12%)	2 (2.8%)	10 (35.7%)	<0.001
Elevated NT-proBNP	18 (18%)	4 (5.6%)	14 (50%)	<0.001

Table 2: Patterns of Echocardiographic abnormalities

Echocardiographic finding	Frequency
Left ventricular systolic dysfunction	10%
Diastolic dysfunction	8%
Pericardial effusion	7%
Regional wall motion abnormalities	3%
Right ventricular dysfunction	2%
Valvular regurgitation (mild)	6%

Table 3: Comparison of Echocardiographic parameters between severe and non-severe dengue

| Parameter	Non-severe dengue (n=76)	Severe dengue (n=24)	p-value
LVEF (%)	61.3 ± 5.2	54.2 ± 8.7	<0.001
E/A ratio	1.32 ± 0.28	1.18 ± 0.36	0.04
E/e' ratio	7.8 ± 2.1	10.2 ± 3.4	<0.001
LVEDD (mm)	47.2 ± 3.8	48.6 ± 4.5	0.12
LA volume index (ml/m²)	24.3 ± 5.1	28.6 ± 6.3	0.001
TAPSE (mm)	22.6 ± 2.7	20.8 ± 3.4	0.007
Pericardial effusion	3 (3.9%)	4 (16.7%)	0.03

LVEF: Left ventricular ejection fraction; LVEDD: Left ventricular end-diastolic diameter; LA: Left atrium; TAPSE: Tricuspid annular plane systolic excursion

Table 4: Independent predictors of Echocardiographic abnormalities

| Factor	Adjusted Odds Ratio	95% CI	p-value
Age >40 years	2.4	1.2-4.8	0.01
Severe dengue	2.8	1.4-5.6	0.003
Elevated Troponin I	4.6	1.9-11.2	<0.001
Platelet count <50,000/μL	1.9	1.1-3.4	0.03

CI: Confidence Interval

Figure 1: Clinical Characteristics by Echocardiographic Findings (%)
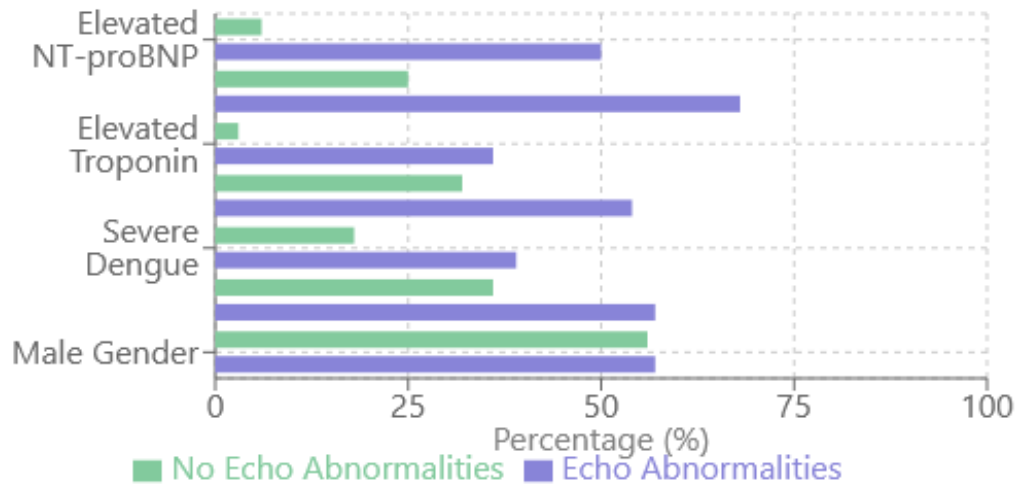
This horizontal bar chart compares the clinical characteristics between patients with and without echocardiographic abnormalities, highlighting the significant differences particularly in biomarker levels and disease severity.
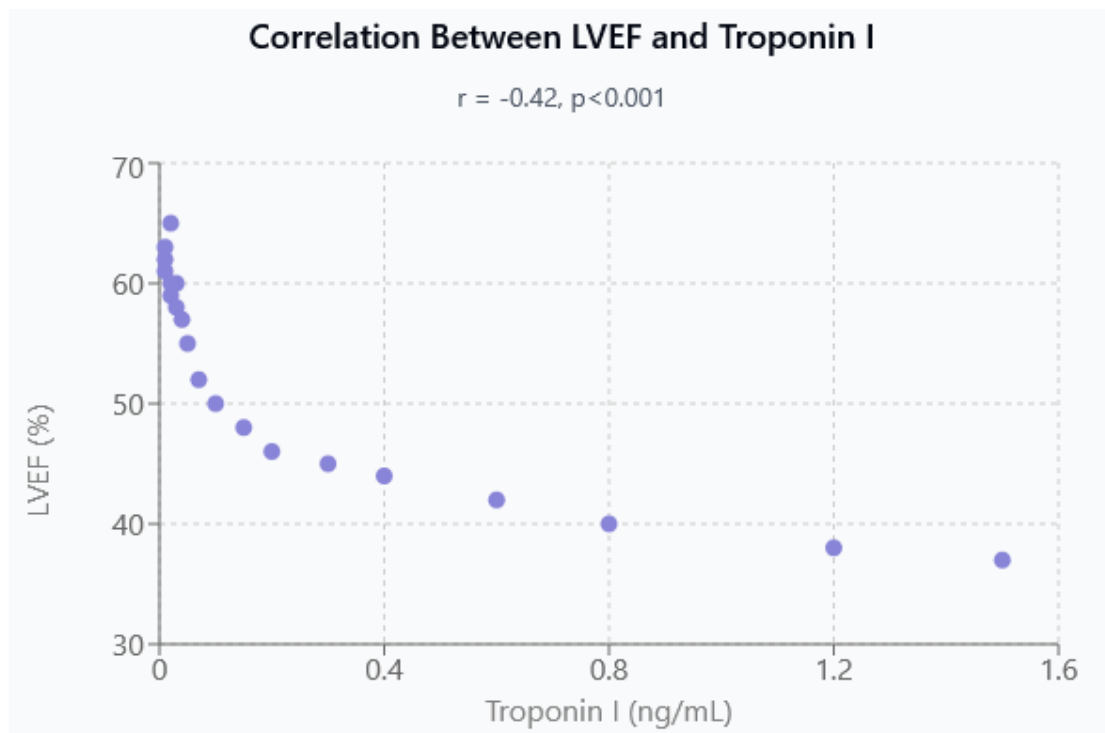
Figure 2: Correlation Between LVEF and Troponin I

Scatter plot Showing the negative correlation between LVEF (Left Ventricular Ejection Fraction) and Troponin I levels (r = -0.42, p<0.001). The downward trend illustrates how higher Troponin I levels are associated with lower LVEF values, which supports your finding that cardiac biomarkers correlate with echocardiographic abnormalities.
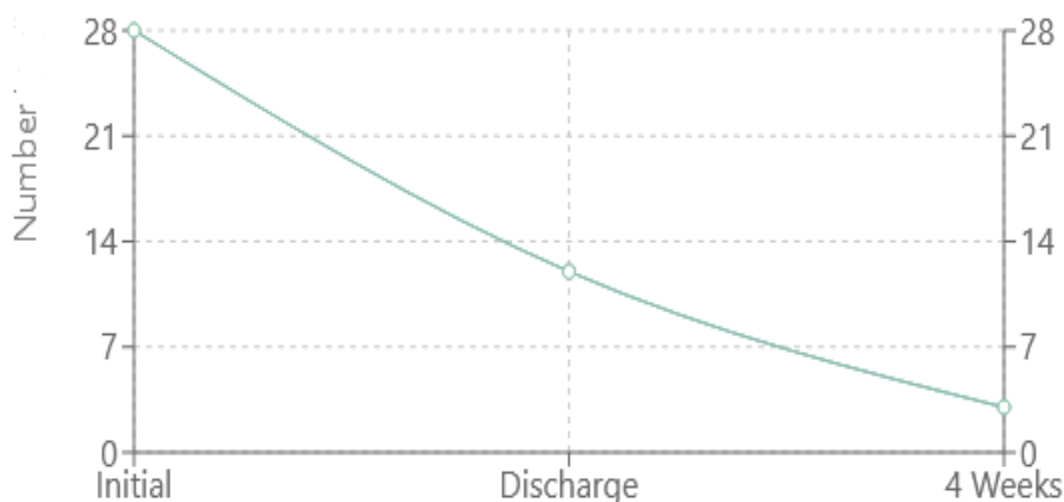
Figure 3: Temporal Evolution of Echocardiographic Abnormalities

This line chart shows the resolution pattern of echocardiographic abnormalities over time, demonstrating that while 28% of patients initially had abnormalities, only 3% had persistent changes at 4 weeks follow-up.(89.3% resolution rate)

DISCUSSION

This prospective study provides comprehensive insights into the spectrum of echocardiographic abnormalities in patients with dengue fever. We found that echocardiographic abnormalities were present in 28% of dengue patients, with significantly higher prevalence in severe dengue cases.

Left ventricular systolic dysfunction was the most common echocardiographic finding, observed in 10% of patients. This is consistent with previous studies that have reported rates of 6-15%.[11,17,18] The dysfunction was predominantly mild to moderate and transient, supporting the concept that dengue-associated myocardial involvement is usually reversible. The pathogenesis likely involves a combination of direct viral invasion, cytokine-mediated injury, and autonomic dysfunction.[19]

Pericardial effusion was observed in 7% of patients, similar to the rate reported by Yacoub et al. (8%)[20] and slightly higher than the 4% reported by Garg et al.[11] The effusions were predominantly minimal to small and did not cause hemodynamic compromise, suggesting that they represent a manifestation of the generalized capillary leak syndrome characteristic of dengue rather than a primary pericardial process.[3]

Diastolic dysfunction, found in 8% of our patients, has been less frequently reported in previous studies,[11] possibly due to variations in assessment methods or study populations. Kaagaard et al. highlighted the importance of assessing diastolic parameters in dengue patients, as diastolic abnormalities may precede systolic dysfunction and could represent early markers of myocardial involvement.[21]

The significantly higher prevalence of echocardiographic abnormalities in severe dengue (45.8% vs. 21.1%) underscores the importance of cardiac evaluation in these patients. This finding is consistent with other studies that have reported more frequent and severe cardiac involvement in dengue

hemorrhagic fever and dengue shock syndrome.[22,23] The increased cardiac involvement in severe dengue may be related to the more pronounced inflammatory response and endothelial dysfunction seen in these cases.[19]

The temporal pattern of echocardiographic changes observed in our study provides valuable insights into the natural history of cardiac involvement in dengue. Most abnormalities (89.3%) resolved by 4 weeks post-discharge, suggesting that dengue-associated cardiac involvement is largely reversible. However, the persistence of abnormalities in 3% of patients indicates the potential for long-term cardiac sequelae in a small subset of cases, particularly those with severe dengue and myocarditis. This finding is consistent with the observations of Satarasinghe et al., who reported persistent abnormalities in 2.5% of cases at 3-month follow-up.[24]

The correlation between echocardiographic abnormalities and cardiac biomarkers in our study supports their complementary role in the evaluation of dengue-associated cardiac involvement. Elevated Troponin I was a strong independent predictor of echocardiographic abnormalities (OR 4.6, 95% CI 1.9-11.2), suggesting that biomarker screening could help identify patients who would benefit from echocardiographic evaluation.

Age >40 years emerged as an independent predictor of echocardiographic abnormalities in our study, consistent with previous reports that have identified older age as a risk factor for cardiac involvement in dengue.[11,25,26] This may be related to age-associated changes in cardiovascular reserve and immune response.

Our study has several strengths, including its prospective design, comprehensive echocardiographic evaluation using standardized protocols, and follow-up assessment to determine the evolution of cardiac abnormalities. However, there are also limitations to

consider. First, the sample size was relatively small, which may limit the generalizability of our findings. Second, we did not perform cardiac magnetic resonance imaging (CMR), which could have provided more detailed information on myocardial involvement and tissue characterization. CMR has been shown to be more sensitive than echocardiography in detecting subtle myocardial changes in viral myocarditis.[27] Additionally, longer follow-up would have been valuable to assess for potential late cardiac sequelae.

CONCLUSION

Echocardiographic abnormalities are common in dengue fever, affecting approximately one-fourth of patients, with higher prevalence in severe cases. Left ventricular systolic dysfunction, diastolic dysfunction, and pericardial effusion are the most frequent findings. While most abnormalities resolve with clinical recovery, a small subset of patients may have persistent changes, highlighting the importance of follow-up evaluation. Our findings suggest that routine echocardiographic evaluation should be considered in dengue patients, particularly those with severe disease, older age, thrombocytopenia, or elevated cardiac biomarkers. Early detection of cardiac involvement through echocardiography may facilitate appropriate management strategies and potentially improve outcomes. Future studies with larger sample sizes, advanced imaging modalities such as CMR, and longer follow-up periods are needed to further characterize the spectrum, mechanisms, and long-term implications of cardiac involvement in dengue fever.

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