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ORIGINAL ARTICLE

Association of left ventricular dysfunction with pediatric sepsis.

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ABSTRACT… Objective: To explore the relationship between left ventricular dysfunction (LVD) and clinical outcomes in children with severe sepsis or septic shock. **Study Design:** Cross-sectional study. **Setting:** Department of Pediatrics and Pediatric Intensive Care Unit (PICU), Ziauddin Hospital, Karachi, Pakistan. **Period:** December 2024 to June 2025. **Methods:** A total of 122 children aged 1 month to 18 years with severe sepsis or septic shock were analyzed. Outcomes assessed were need for mechanical ventilation, PICU stay, and mortality. Data were analyzed using SPSS v26, with frequencies for categorical variables, means for continuous data. Chi-square/Fisher's exact or t-tests were used, with significance at $p<0.05$. **Results:** Among 122 children, the mean age was 4.8±2.5 years, while 68 (55.7%) children were female. There were 63 (51.6%) children who had severe sepsis, and 59 (48.4%) with septic shock. Septic shock cases had lower systolic (90.5±25.7 vs 112.8±33.3 mmHg, $p=0.001$) and diastolic blood pressure (55.9±16.5 vs 70.2±24.7 mmHg, $p<0.001$), higher heart rate (151.9±27.9 vs 134.2±37.1 bpm, $p=0.004$) and respiratory rate (47.1±10.6 vs 39.9±15.9, $p=0.006$). LVDD was present in 77 (63.1%) and RVDD in 67 (54.9%), without any significant differences. There was no statistically significant differences with respect to mortality ($p=0.110$). **Conclusion:** Left ventricular diastolic dysfunction was highly prevalent among children with pediatric sepsis. Children with septic shock demonstrated significantly greater hemodynamic compromise.

Key word: Children, Left Ventricular Dysfunction, Mortality, PICU, Septic Shock.

INTRODUCTION

Pediatric sepsis is a significant cause of morbidity and mortality, with global estimates indicating a 7.7% prevalence and a 14% mortality rate in PICUs.[1,2] A crucial factor influencing patient outcomes is sepsis-associated organ dysfunction.[3] Children with sepsis may experience left ventricular dysfunction (LVD).[4,5] Intubated septic patients with LV diastolic dysfunction (LVDD) face higher rates of failed spontaneous breathing trials and ventilator weaning[6,7] Some researchers have also shown that LVD is related with higher death rates in septic populations.[8,9]

Existing pediatric research on LVD in sepsis is limited by small sample sizes, inconsistent LVD definitions, and varying outcome measures.[10,11] A study from the USA showed that LVDD was present in 53% of children with sepsis. Still, they found no significant association of LVDD with the need for invasive mechanical ventilation (MV).[12] Raj and colleagues reported that 37% of children with septic shock had systolic dysfunction and 33% had diastolic dysfunction, whereas 17% of children had both systolic and diastolic dysfunction.[13] Another study documented the prevalence of LVD in 72% of children with sepsis.[14]

In Pakistan, while there is some research on cardiac issues in pediatric populations, specific data focusing on LVD in septic children remain scarce.[12-14] Given the scarcity of targeted research on LVD in septic children within Pakistan, there is a pressing need for comprehensive studies. This study was planned aiming at exploring the relationship between LVD and clinical outcomes in children with severe sepsis or septic shock. The findings of this study, along with furnishing the local data, can help health providers in identifying children at higher risk, guiding treatment strategies, and improving overall prognosis, specifically leading to better risk stratification, personalized treatment plans, and potentially reduced mortality and morbidity.

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METHODS

This cross-sectional study was carried out at the Department of Pediatrics and Pediatric Intensive Care Unit (PICU), Ziauddin Hospital, Karachi, Pakistan, from November 2024 to May 2025 after getting it approved from the institutional ethical review board (Letter number: 10060425AMPED). The inclusion criteria were children of any gender aged 1 month to 18 years, and diagnosed with severe sepsis or septic shock. The exclusion criteria were pre-existing congenital heart disease, known cardiomyopathy, or inability to complete echocardiographic imaging due to any reason. Severe sepsis was labeled based on clinical suspicion of infection and signs of organ dysfunction with hypoperfusion with or without hypotension. Septic shock was labeled on the basis of clinical suspicion of the infection along with signs of organ dysfunction with hypoperfusion or hypotension despite adequate fluid resuscitation. Informed and written consent was obtained from parents/guardians. A sample size of 122 was calculated using the OpenEpi sample size calculator, considering the expected proportion of LVD in pediatric sepsis as 72.0%[14], with a 95% confidence level and an 8% margin of error.

Baseline demographics and clinical information of the eligible patients, including age, gender, weight, height, and underlying medical conditions (chronic illnesses), were recorded. Relevant laboratory investigations were performed. Echocardiography and Doppler imaging was carried out by a pediatric cardiologist with over three years of post-fellowship experience within 24 hours of the admission to assess LVSD and RVDD. LVSD was defined as an ejection fraction (EF) <55%, and an RVDD as an E ratio ≥ 15. All patients received treatment according to institutional protocols. The final outcome was noted as improved/deceased/referred. Data were systematically recorded on a specially predesigned proforma for accuracy and consistency.

The statistical analysis was performed using "IBM-SPSS Statistics" version 26.0. The qualitative variables were presented in the form of frequency with percentage. For the numeric variables, means with standard deviations were computed. Chi-square test / Fisher's exact test or independent sample t-test (as appropriate) were employed, taking $p<0.05$ as significant.

RESULTS

In a total of 122 children, 68 (55.7%) were females, and the mean age was 4.8±2.5 years. There were 63 (51.6%) children who were diagnosed with severe sepsis, and 59 (48.4%) with septic shock. The mean age of children with severe sepsis was 5.1±2.2 years, compared to 4.5±2.7 years in those with septic shock ($p=0.180$). The proportion of males and females was comparable with respect to sepsis type ($p=0.492$). Children with severe sepsis had a significantly higher mean weight than those with septic shock ((15.4±5.9 kg vs. 12.8±4.3 kg, $p=0.011$), whereas mean height did not differ significantly (94.4±16.2 cm vs. 90.5±25.8 cm, $p=0.461$). Children with septic shock exhibited higher mean heart rates (151.9±27.9 vs 134.2±37.1 beats/min, $p=0.004$) and respiratory rates (47.1±10.6 vs 39.9±15.9 breaths/min, $p=0.006$) compared to those with severe sepsis. The mean systolic ($p=0.001$), and diastolic blood pressures ($p<0.001$) were significantly lower in the septic shock group. The mean temperature and Glasgow coma scale scores were similar among children (Table-I).

Children with severe sepsis demonstrated significantly higher mean serum creatinine ($p=0.016$). The mean base deficit was significantly higher in the septic shock children ($p=0.005$), while the mean HCO_3 was significantly lower among children with septic shock ($p<0.001$). The mean pCO_2 was significantly lower in the septic shock children (38.3±10.9 vs 44.6±16.2 mmHg, $p=0.029$), and details shown in Table-II.

The LVDD was observed in 43 (68.3%) children with severe sepsis and 34 (57.6%) with septic shock ($p=0.224$). The RVDD was seen in 31 (49.2%) of severe sepsis cases, and 36 (61.0%) septic shock cases ($p=0.190$). The mean EF was relatively lower in the severe sepsis group (28.0±11.9% vs 31.9±11.2%, $p=0.104$). The requirement for MV was similar in both groups (41.3% in severe

sepsis and 39.0% in septic shock). The mean duration of MV was significantly longer in the septic shock children (p=0.019). Overall, 90 (73.7%) children improved, while mortality was reported in 24 (19.7%) children. There was no statistically significant differences with respect to mortality (p=0.110), and the details are given in Table-III

DISCUSSION

This study found a high prevalence of LVDD, which was present in 68.3% of children with severe sepsis, and 57.6% of those with septic shock. This high rate of LVDD aligns with Ginsburg et al.[12], who reported LVDD in 53% in severe sepsis or septic shock.

Characteristics		Severe Sepsis (n=63)	Septic Shock (n=59)	P-Value
Gender	Male	26 (41.3%)	28 (47.5%)	0.492
	Female	37 (58.7%)	31 (52.5%)	
Age		5.1±2.2	4.5±2.7	0.180
Weight (kg)		15.4±5.9	12.8±4.3	0.011
Height (cm		94.4±16.2	90.5±25.8	0.461
Heart rate (beats/min)		134.2±37.1	151.9±27.9	0.004
Respiratory rate (respirations / min)		39.9±15.9	47.1±10.6	0.006
Temperature (^{0}F)		99.8±8.0	100.3±1.4	0.622
Systolic blood pressure		112.8±33.3	90.5±25.7	0.001
Diastolic blood pressure		70.2±24.7	55.9±16.5	<0.001
Glasgow coma scale score		13.9±2.1	14.1±1.5	0.641

Table-I. Comparison of demographic characteristics and vital signs (N=122)

Parameters	Severe Sepsis (n=63)	Septic Shock (n=59)	P-Value
ScvO2 (%)	90.3±7.5	93.6±4.0	0.105
Serum lactate (mmol/L)	4.5±5.3	6.0±6.1	0.385
Leukocytes count ($10^3/\mu L$)	18.4±37.8	11.6±8.8	0.197
Platelets ($10^3/\mu L$)	261.3±162.7	253.7±136.1	0.786
Procalcitonin (ng/mL)	1.8±3.1	3.0±2.7	0.162
Creatinine (mg/dL)	0.9±0.3	0.7±0.3	0.016
Alanine Aminotransferase (U/L)	42.6±16.4	49.1±15.8	0.157
Aspartate Aminotransferase (U/L)	48.5±11.1	48.9±11.9	0.867
Prothrombin time (sec)	19.6±10.4	19.0±8.6	0.803
Activated Partial Thromboplastin Time (sec)	28.4±17.5	35.5±21.8	0.163
B-type Natriuretic Peptide (pg/mL)	8681.7±10641.7	12037.7±29156.8	0.557
Hemoglobin (g/dL)	8.9±2.1	9.6±1.8	0.051
C-reactive protein (mg/L)	44.4±47.7	53.9±49.6	0.300
Urea (mg/dL)	32.2±14.5	29.7±16.9	0.565
Bilirubin (mg/dL)	2.0±6.6	0.4±0.2	0.386
pH	7.1±1.7	7.2±0.3	0.682
pO2 (mmHg)	116.4±45.8	127.8±42.5	0.210
Base deficit (mEq/L)	-1.2±2.6	-3.4±3.7	0.005
pCO2 (mmHg)	44.6±16.2	38.3±10.9	0.029
HCO3 (mEq/L)	17.9±4.5	13.9±4.6	<0.001

Table-II. Association of laboratory parameters with severe sepsis or septic shock (N=122)

Characteristics		Severe Sepsis (n=63)	Septic Shock (n=59)	P-Value
Left ventricular diastolic dysfunction		43 (68.3%)	34 (57.6%)	0.224
Right ventricular diastolic dysfunction		31 (49.2%)	36 (61.0%)	0.190
Ejection fraction (%)		28.0±11.9	31.9±11.2	0.104
Need for mechanical ventilation		26 (41.3%)	23 (39.0%)	
Duration of mechanical ventilation (days)		2.9±1.3	4.1±1.6	0.019
Duration of pediatric intensive care unit stay (days)		4.7±3.0	5.9±3.6	0.068
Pediatric intensive care unit outcome	Improved	44 (69.9%)	46 (77.9%)	0.110
	Deceased	12 (19.0%)	12 (20.3%)	
	Referred	7 (11.1%)	1 (1.7%)	

Table-III. Comparison of outcome variables among children (N=122)

The current prevalence, slightly higher than that in Ginsburg et al., may be attributed to differences in population demographics, the timing of echocardiographic assessment, or more inclusive criteria for organ dysfunction in a pediatric setting in South Asia.[12] This study noted the presence of RVDD in 49.2% of severe sepsis, and 61.0% of septic shock cases. Furian et al.[15], documented RV systolic dysfunction in nearly a third of adults with severe sepsis or septic shock, with RV dysfunction being independently associated with poor outcomes.

Echocardiographically determined EF was found to be relatively lower in the severe sepsis group compared to those with septic shock, although this difference was not statistically significant (28.0±11.9% vs. 31.9±11.2%, p=0.104). Berrios et al.[16], through meta-analysis, identified a pooled sensitivity of depressed LVEF for mortality at 52% and specificity at 63%, suggesting that a low EF alone is neither highly sensitive nor specific as a predictor of mortality in sepsis. The moderate diagnostic value is echoed in this study, where despite high rates of dysfunction, EF did not show a statistically significant difference across groups or correlate robustly with mortality or ventilator requirement. This study also documented that children with septic shock exhibited more pronounced cardiovascular compromise, with significantly higher mean heart and respiratory rates, and lower BP compared to those with severe sepsis. These findings depict that children with septic shock often present with greater hemodynamic instability and require more aggressive supportive therapy.

Duration of MV was significantly prolonged among children with septic shock (p=0.019). Ginsburg et al.[12], showed that the median duration of ventilation was also longer among those with LVDD, although the association was not statistically significant when broader definitions of diastolic dysfunction were used. This finding draws attention to the complex interplay between myocardial relaxation, ventilatory weaning, and systemic inflammation in septic children. Prolonged MV may increase the risk of secondary infections, barotrauma, and further prolong ICU stay, all of which contribute to morbidity in the critically ill. Vallabhojosyula and colleagues.[18], in a prospective cohort also noted that LV systolic and diastolic dysfunction were not independently associated with duration of ventilation or ICU stay, suggesting that myocardial dysfunction in sepsis is only one component in a multifactorial process influencing critical care outcomes. Serum creatinine was significantly higher among children with severe sepsis. This finding contrasts with Guangwei et al.[12], which linked baseline LVD in septic shock with increased risk for subsequent acute kidney injury and higher mortality. These findings are indicative of more severe metabolic acidosis in septic shock, which is consistent with the clinical progression of sepsis toward cardiovascular collapse and global tissue hypoperfusion. Kim et al.[19], and Furian et al.[15], confirm the relevance of metabolic acidosis as both a marker and mediator of adverse outcomes in sepsis.

Regarding overall outcomes, mortality rates in both severe sepsis and septic shock groups were

statistically similar (19.0% vs. 20.3%, p=0.110). These findings are in agreement with studies such as those by Vallabhojosyula et al.[18], and Ginsburg et al.[12], which found no significant association between either LV systolic or diastolic dysfunction and in-hospital mortality in the context of sepsis, especially after adjusting for confounding factors. Conversely, study in adult populations by Kim et al., demonstrate that severe LVD, particularly EF <30%, remains an independent predictor of mortality, especially among those without preexisting cardiovascular disease or with bacteremia.[19] The apparent divergence between pediatric and adult populations may be due to differences in the etiology of myocardial dysfunction, the greater plasticity and recovery potential of the pediatric myocardium, and variation in critical care interventions and thresholds for escalation.[20]

Regarding limitations, echocardiographic assessment was performed within 24 hours of PICU admission but was not routinely repeated during the course of illness or at recovery. The study did not assess all potential confounding variables such as fluid balance, specific inotropic therapies, or genetic predisposition to cardiac dysfunction, which may influence both myocardial function and clinical outcomes. The use of echocardiographic cut-offs for defining systolic and diastolic dysfunction may vary between studies and may not fully capture the spectrum of myocardial impairment, particularly in children with underlying comorbidities or complex congenital anomalies.[21,22]

CONCLUSION

Left ventricular diastolic dysfunction was highly prevalent among children with pediatric sepsis. Children with septic shock demonstrated significantly greater hemodynamic compromise, including higher heart and respiratory rates and lower BP, as well as more pronounced metabolic acidosis and longer duration of MV. This study underscore the burden of myocardial dysfunction in pediatric sepsis and highlight the importance of early cardiac evaluation and tailored supportive care. Further research is warranted to determine whether targeted cardiac interventions can improve clinical outcomes in this high-risk population.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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2	**Heena Rais:** Conception, data collection, methodology.
3	**Tayyaba Anwer:** Data collection, critical revisions, proof reading.
4	**Saba Safdar:** Methodology, critical revisions.
5	**Fatima Ghayas Siddiqi:** Data entry, drafting, proof reading.
6	**Payal Bai:** Data analysis, study design.