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Point of Care Functional Echocardiography to Assess Preload Markers of Haemodynamic Status in Term Neonates with Shock

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Abstract

Background: Neonatal shock is associated with impaired tissue perfusion and altered cardiovascular physiology, but conventional clinical parameters may not adequately characterize the underlying hemodynamic state. Point-of-care functional echocardiography may provide additional information regarding preload and cardiac function.

Objective: To evaluate preload-related functional echo cardio graphic parameters in term neonates with shock and compare them with haemodynamically stable term neonates, and to assess their ability to differentiate septic from non-septic shock.

Methods: This hospital-based prospective observational case-control study was conducted in the Neonatal Intensive Care Unit of Karnataka Institute of Medical Sciences, Hubli, from July 2022 to December 2023. Twenty-five term neonates with clinically diagnosed shock were compared with 25 gestational age-, age- and weight-matched haemodynamically stable controls. Clinical parameters and functional echo cardio graphic measurements, including maximum and minimum inferior vena cava (IVC) diameter, IVC collapsibility

index (cIVC) and left ventricular end-diastolic area (LVEDA), were assessed. Statistical analysis was performed using SPSS version 22.0.

Results: Neonates with shock had significantly higher heart rates and lower systolic, diastolic and mean arterial blood pressures compared with controls ($p < 0.001$). Median capillary refill time was also significantly prolonged in cases (4 vs. 2 seconds; $p < 0.001$). Maximum IVC diameter was higher in cases than controls (0.84 ± 0.13 vs. 0.68 ± 0.20 cm; $p=0.002$), whereas minimum IVC diameter was lower (0.35 ± 0.10 vs. 0.45 ± 0.13 cm; $p=0.004$). Mean cIVC was significantly higher in cases (57.92 ± 10.9% vs. 33.12 ± 8.1%; $p<0.001$). LVEDA was also significantly higher among cases (239.8 ± 36.5 vs. 219.9 ± 11.1 mm^2; $p=0.010$). Sepsis was the commonest cause of shock (52%). For identifying septic shock, cIVC had an AUC of 0.66, while LVEDA had an AUC of 0.36. At a cIVC cut-off >50%, sensitivity was 69.2% and specificity was 33.3%.

Conclusion: Functional echocardiography demonstrated significant differences in preload-related parameters between term neonates with shock and stable controls. Although cIVC showed modest discriminatory ability for septic shock, its limited specificity indicates that it should not be used as an isolated diagnostic marker. Functional echocardiography may serve as a useful adjunct to clinical assessment of neonatal hemodynamic status.

Keywords: Neonatal Shock, Functional Echo Cardio Graphy, Point-Of-Care Ultrasound, Inferior Vena Cava, Collapsibility Index, Preload, LVEDA, Septic Shock.

Introduction

Neonatal shock is a state of circulatory dysfunction characterized by inadequate tissue perfusion and oxygen delivery relative to metabolic requirements. It remains an important cause of morbidity and mortality in neonatal intensive care units. The recognition of shock in neonates is particularly challenging because clinical manifestations may be subtle and conventional parameters such as blood pressure may remain preserved despite significant alterations in systemic blood flow. Furthermore, neonatal shock is a heterogeneous condition that may result from hypo volemia, sepsis, myocardial dysfunction, hypoxic - ischemic injury, pulmonary hypertension or other disturbances of cardiovascular physiology. Therefore, assessment based solely on heart rate, capillary refill time and blood pressure may not provide a complete picture of the underlying hemodynamic state.[1,2]

Functional echocardiography has emerged as an important bedside tool for evaluating cardiovascular physiology in critically ill neonates. Unlike conventional clinical assessment, echocardiography provides real-time information regarding cardiac function, preload, after load and systemic blood flow.

Neonatologist - performed echocardiography can therefore help identify the predominant Patho physiological component of shock and facilitate a more individualized approach to hemodynamic assessment.[1–3] Current consensus recommendations support the use of targeted neonatal echocardiography and cardiac point-of-care ultrasound as adjuncts to clinical assessment in neonates with cardiovascular instability.[3,4]

Assessment of preload is particularly relevant in neonatal shock because administration of intravenous fluid does not necessarily result in an improvement in cardiac output in every neonate. Excessive fluid administration may also be harmful, particularly in neonates with myocardial dysfunction or altered

pulmonary vascular resistance. Consequently, objective markers of preload and ventricular filling may assist in identifying the underlying cardiovascular physiology.[5] However, reliable clinical markers of preload adequacy and fluid responsiveness in neonates remain limited.[5]

The inferior vena cava (IVC) is one of the echo cardio graphic structures that can be assessed at the bedside as a potential marker of intravascular filling. Respiratory variation in IVC diameter can be expressed as the IVC collapsibility index (cIVC), calculated from the maximum and minimum IVC diameters during respiration. Previous neonatal studies have demonstrated an association between IVC collapsibility and hemodynamic variables, including central venous pressure, although the relationship between IVC-derived measurements and actual fluid responsiveness remains incompletely established.[6],[7] Importantly, IVC diameter itself may vary with gestational age and body size, making interpretation of absolute measurements challenging.[6]

Left ventricular end-diastolic dimensions provide another potential estimate of ventricular filling and preload. Functional echo cardio graphic studies in neonates with shock have demonstrated alterations in ventricular filling and other cardiac functional parameters compared with haemodynamically stable neonates. [8],[9] However, neonatal shock represents a complex physiological state, and no single echo cardio graphic measurement is likely to adequately characterize the entire hemodynamic profile.

Evidence specifically addressing functional echo cardio graphic preload markers in term neonates with shock remains relatively limited. A study of term neonates with shock demonstrated significant differences in several functional echo cardio graphic parameters compared with stable controls, highlighting the potential role of bedside echocardiography in the assessment of neonatal shock.[8] Similarly, studies evaluating septic shock have reported alterations in IVC-derived preload parameters and ventricular filling measurements.[5],[9] Nevertheless, available studies have shown variable results, and recent systematic evidence indicates considerable heterogeneity among neonatal functional echo cardio graphic studies, particularly regarding the diagnostic and predictive performance of IVC collapsibility.[10]

In view of these limitations, bedside functional echo cardio graphy may provide valuable additional information regarding preload and cardiovascular physiology in neonates presenting with shock. The present study was therefore undertaken to evaluate point-of-care functional echo cardio graphic preload markers, particularly IVC maximum and minimum diameters, IVC collapsibility index and left ventricular end-diastolic area, in term neonates with clinically diagnosed shock, and to compare these parameters with those of haemodynamically stable term neonates. A secondary objective was to explore the ability of these echo cardio graphic parameters to differentiate septic shock from shock due to other causes.

Materials and Methods

Study Design and Setting

The present study was designed as a hospital-based prospective observational case-control study conducted in the Neonatal Intensive Care Unit (NICU) of Karnataka Institute of Medical Sciences (KIMS) Hospital, Hubli, Karnataka, India. The study was conducted over a period of 18 months, from July 2022 to December 2023.

Study Population

All term neonates admitted to the NICU during the study period were screened for eligibility. Neonates with gestational age ≥37 completed weeks who developed clinical features of shock during hospitalisation were enrolled as cases. A comparable group of haemodynamically stable term neonates, matched for gestational age, age and weight, was enrolled as controls.

Eligibility Criteria

Inclusion criteria for cases

- Term neonates with gestational age ≥37 completed weeks.
- Neonates admitted to the NICU who developed clinical shock during the study period.
- Written informed consent obtained from the parent or legal guardian.

Shock was clinically defined by the presence of tachycardia (heart rate >160 beats/min), prolonged capillary refill time (≥3 seconds), and/or hypotension, defined as systolic and/or diastolic blood pressure below the 5th percentile for gestational age, weight and postnatal age.

Exclusion criteria

1. Neonates with known congenital heart disease.
2. Neonates requiring mechanical ventilation.
3. Neonates already receiving inotropic support at the time of assessment.
4. Neonates with major congenital anomalies.

Sample Size

The sample size was estimated using previously reported inferior vena cava (IVC) collapsibility index (CI) data comparing term neonates with septic shock and normal neonates. Assuming a pooled standard deviation of 20 units, a mean difference of 17.33 units, a two-sided significance level of 5% and 80% statistical power, the calculated sample size was 21 neonates in each group. Considering a possible 10% attrition rate, the required recruitment was increased to approximately 25 neonates per group. During the study period, 30 neonates were enrolled as cases, while 25 haemodynamically stable term neonates were included as controls.

Data Collection

After obtaining written informed consent, demographic and clinical information was recorded using a structured data collection proforma. Maternal and perinatal variables included booking status of pregnancy, onset and course of labour, mode of delivery, birth weight, gestational age, date of birth and intrauterine growth status. Details of neonatal resuscitation, Apgar scores at 1 and 5 minutes, and postnatal age at admission and at development of shock were also documented.

Clinical parameters recorded included heart rate, capillary refill time, systolic blood pressure, diastolic blood pressure, mean arterial blood pressure and oxygen saturation. The requirement for supplemental oxygen, clinical diagnosis, course of hospitalization and other relevant treatment details were also recorded.

All neonates were managed according to the existing NICU treatment protocols based on their clinical condition. Importantly, the findings obtained during functional echo cardio graphic assessment were not used to guide or alter the clinical management of shock.

Functional Echo cardio graphic Assessment

Functional echo cardio graphy was performed immediately after clinical diagnosis of shock in all cases by a single trained neonatal resident. The examination was performed with the neonate in the supine position using standard echo cardio graphic views as

recommended by the American Society of Echo cardio graphy.

Any fluid therapy being administered at the time of assessment was documented. Functional echo cardio graphic measurements were obtained before completion of the first fluid bolus, wherever applicable.

The left ventricular end-diastolic area (LVEDA) was estimated in the apical view. The inferior vena cava (IVC) was visualized in the sub costal long-axis view. The maximum IVC diameter (D max) and minimum IVC diameter (D min) were measured using M-mode imaging approximately 1.5–2 cm proximal to its confluence with the right atrium. Measurements were obtained perpendicular to the long axis of the IVC during end-expiration and end-inspiration over a single respiratory cycle in spontaneously breathing neonates.

Each IVC diameter measurement was obtained in triplicate, and the mean of the three measurements was used for analysis.

Inferior Vena Cava Collapsibility Index

The IVC collapsibility index (cIVC) was calculated using the following formula:

$$cIVC\ (\%) = [(D\ max - D\ min) / D\ max] \times 100$$

where D max represents the maximum IVC diameter and D min represents the minimum IVC diameter during the respiratory cycle.

Control Group

Gestational age-, weight - and age - matched haemodynamically stable term neonates admitted for routine postnatal care during the study period were selected as controls. Controls did not have clinical evidence of shock and underwent assessment using the same relevant clinical and echo cardio graphic parameters as the cases.

Ethical Considerations

Written informed consent was obtained from the parents or legal guardians of all participating neonates before enrolment. Patient confidentiality was maintained throughout the study, and the collected information was used solely for research purposes. The study was conducted after obtaining approval from the appropriate Institutional Ethics Committee.

Statistical Analysis

Data were entered into Microsoft Excel and subsequently analysed using IBM SPSS Statistics version 22.0. Categorical variables were expressed as frequencies and percentages. Continuous variables were expressed as mean ± standard deviation, depending on the distribution of the data.

Categorical variables, including sex, clinical diagnosis, liquor characteristics and resuscitation performed, were compared between cases and controls using the Chi-square test. Continuous variables such as Apgar scores, blood pressure, heart rate and IVC measurements were compared between the two groups using the independent-samples Student's t-test for normally distributed data. Appropriate statistical tests were selected based on the distribution of variables. A p-value <0.05 was considered statistically significant.

Results and Observations

During the study period from July 2022 to December 2023, a total of 2520 term neonates were admitted to the Neonatal Intensive Care Unit of KIMS Hospital, Hubli. Among these, 302 neonates developed shock. After application of the eligibility criteria and exclusion of neonates with mechanical ventilation, congenital heart disease, major congenital anomalies, pre - existing inotropic support and inadequate cardiac echo cardio graphic windows, 25 neonates with shock were included

in the final analysis as cases. A total of 25 age-, sex-, gestational age- and weight-matched haemodynamically stable term neonates were included as controls.

Table 1: Comparison of Baseline Demographic Characteristics Between Cases and Controls

Parameter	Cases n (%)	Controls n (%)	p-value
Weight for gestational age			0.08
SGA	14 (56.0)	7 (28.0)	
AGA	11 (44.0)	17 (68.0)	
LGA	0 (0)	1 (4.0)	
Sex			1.00
Female	11 (44.0)	11 (44.0)	
Male	14 (56.0)	14 (56.0)	
Age at assessment, days, mean ± SD	4.3 ± 3.2	3.3 ± 1.3	—
Mode of delivery			0.17
NVD	12 (48.0)	15 (60.0)	
AVD	2 (8.0)	1 (4.0)	
LSCS	11 (44.0)	9 (36.0)	

The cases and controls were comparable with respect to sex and mode of delivery. Male neonates constituted 56% of both groups. The mean age at assessment was 4.3 ± 3.2 days among cases and 3.3 ± 1.3 days among controls. SGA neonates were more frequent among cases (56%) than controls (28%), although this difference was not statistically significant (p=0.08).

Table 2: Comparison of Clinical Parameters Between Cases and Controls

Clinical parameter	Cases, Mean ± SD	Controls, Mean ± SD	p-value
Heart rate (beats/min)	168.56 ± 6.9	134.6 ± 9.8	<0.001
Systolic BP (mmHg)	55.4 ± 5.8	67.4 ± 6.2	<0.001
Diastolic BP (mmHg)	35.4 ± 4.0	44.6 ± 5.1	<0.001
Mean arterial pressure (mmHg)	42.1 ± 4.1	52.2 ± 4.9	<0.001
Capillary refill time (seconds), median (IQR)	4 (4–5)	2 (2–3)	<0.001

Neonates with shock demonstrated significantly higher heart rates and significantly lower systolic, diastolic and mean arterial blood pressures compared with controls. The mean heart rate was 168.56 ± 6.9 beats/min in cases compared with 134.6 ± 9.8 beats/min in controls (p<0.001). The mean systolic blood pressure was 55.4 ± 5.8 mmHg in cases versus 67.4 ± 6.2 mmHg in controls. Similarly, mean diastolic blood pressure and mean arterial pressure were significantly lower among cases. Median capillary refill time was prolonged in cases [4 (4–5) seconds] compared with controls [2 (2–3) seconds], with a statistically significant difference (p<0.001).

Table 3: Etiological Diagnosis Among Neonates With Shock

Diagnosis	Cases, n	Percentage
Sepsis	13	52.0
Hypoxic-ischaemic encephalopathy	6	24.0
Metabolic causes	4	16.0
Me conium aspiration syndrome	2	8.0
Total	25	100.0

Sepsis was the most common underlying diagnosis among neonates with shock, accounting for 52% of cases. Hypoxic-ischaemic encephalopathy was the second most common cause (24%), followed by metabolic causes (16%) and me conium aspiration syndrome (8%). The metabolic causes included hypoglycemia and severe dehydration.

Table 4: Comparison of Maximum Inferior Vena Cava Diameter Between Cases and Controls

Group	Number	Mean (cm)	SD	p-value
Cases	25	0.84	0.13	0.002
Controls	25	0.68	0.20	
Total	50			

The mean maximum IVC diameter was significantly higher among cases (0.84 ± 0.13 cm) than controls (0.68 ± 0.20 cm). The difference was statistically significant (p=0.002).

Table 5: Comparison of Minimum Inferior Vena Cava Diameter Between Cases and Controls

Group	Number	Mean (cm)	SD	p-value
Cases	25	0.35	0.10	0.004
Controls	25	0.45	0.13	
Total	50			

The mean minimum IVC diameter was 0.35 ± 0.10 cm among cases compared with 0.45 ± 0.13 cm among controls. The difference was statistically significant (p=0.004).

Table 6: Comparison of Inferior Vena Cava Collapsibility Index Between Cases and Controls

Group	Number	Mean (%)	SD	p-value
Cases	25	57.92	10.9	<0.001
Controls	25	33.12	8.1	
Total	50			

The mean IVC collapsibility index was markedly higher among neonates with shock (57.92 ± 10.9%) compared with controls (33.12 ± 8.1%). This difference was highly statistically significant (p<0.001), indicating greater respiratory variation and collapsibility of the IVC among neonates with shock.

Table 7: Comparison of Left Ventricular End-Diastolic Area Between Cases and Controls

Group	Number	Mean (mm^2)	SD	p-value
Cases	25	239.8	36.5	0.010
Controls	25	219.9	11.1	
Total	50			

The mean left ventricular end-diastolic area (LVEDA) was 239.8-± 36.5 mm^2 in cases and 219.9 ± 11.1 mm^2 in controls. The difference between the groups was statistically significant (p=0.010), with higher LVEDA values observed among neonates with shock.

Table 8: ROC Analysis of IVC Collapsibility Index and LVEDA for Identification of Septic Shock

Parameter	AUC	95% CI	p-value
IVC collapsibility index	0.66	0.43–0.87	0.19
LVEDA	0.36	0.11–0.61	0.27

The ROC analysis demonstrated an area under the curve (AUC) of 0.66 (95% CI: 0.43–0.87) for IVC collapsibility index, suggesting modest discriminatory ability for septic shock. The AUC for LVEDA was 0.36 (95% CI: 0.11–0.61), indicating poor discriminatory performance. Neither parameter demonstrated statistically significant discrimination at the conventional 5% level.

Table 9: Diagnostic Performance of IVC Collapsibility Index at a Cut-off of >50% for Septic Shock

Diagnostic parameter	Estimate (%)	95% CI (%)
Sensitivity	69.2	38.6–90.0
Specificity	33.3	9.9–65.1
Positive predictive value	52.9	27.8–77.0
Negative predictive value	50.0	15.7–84.3

At an IVC collapsibility index cut-off of >50%, the sensitivity for identifying septic shock was 69.2%, while specificity was 33.3%. The positive predictive value was 52.9% and the negative predictive value was 50.0%. Thus, an IVC collapsibility index >50% demonstrated relatively good sensitivity but limited specificity for identifying septic shock in this study population.

Discussion

The present prospective case-control study evaluated point-of-care functional echo cardio graphic preload markers in term neonates with clinically diagnosed shock and compared them with haemodynamically stable term neonates. The principal findings were that neonates with shock had significantly higher heart rates, lower systolic, diastolic and mean arterial blood pressures, and prolonged capillary refill times compared with controls. On functional echocardiography, maximum IVC diameter, minimum IVC diameter, IVC collapsibility index and left ventricular end-diastolic area differed significantly between the two groups. The IVC collapsibility index was substantially higher in neonates with shock. However, its ability to distinguish septic shock from shock due to other causes was only modest, with an AUC of 0.66.

In the present study, clinical markers clearly differentiated neonates with shock from stable controls. The mean heart rate was significantly higher in cases, whereas systolic, diastolic and mean arterial pressures were significantly lower. Capillary refill time was also markedly prolonged. These findings are consistent with the physiological changes expected during circulatory compromise. However, clinical assessment alone may not identify the underlying mechanism of shock or reliably distinguish abnormalities in preload, contractility and systemic blood flow. Previous studies have similarly emphasized that neonatal shock is difficult to define using a single clinical parameter and that clinical and echo cardio graphic definitions of shock may not always correspond.[2,11]

The predominance of sepsis as the underlying cause of shock in our study is noteworthy. Sepsis accounted for 52% of cases, followed by hypoxic-ischaemic encephalopathy, metabolic causes and me conium aspiration syndrome. Neonatal sepsis is an important cause of cardiovascular dysfunction, and septic shock may be associated with changes in myocardial performance, vascular tone and preload.

A systematic review of echo cardio graphic studies in septic neonates demonstrated heterogeneous cardio vascular abnormalities, including alterations in ventricular function and pulmonary vascular physiology, emphasizing that neonatal septic shock cannot be considered a uniform hemodynamic condition.[12]

A major finding of the present study was the significant difference in IVC dimensions between cases and controls. The maximum IVC diameter was greater in neonates with shock, whereas the minimum diameter was smaller. Consequently, the respiratory variation in IVC diameter was greater in the shock group, resulting in a significantly higher cIVC. The mean cIVC was 57.92% among cases compared with 33.12% among controls ($p<0.001$).

Our findings are broadly consistent with previous work evaluating echo cardio graphic preload markers in neonatal shock. A study specifically evaluating functional echo cardio graphic preload markers in neonatal septic shock included IVC collapsibility index among several measures of preload and demonstrated the feasibility of assessing these parameters before and after fluid administration.[5] Another study involving term neonates with shock reported significant differences in cIVC and other functional echo cardio graphic variables between neonates with shock and haemodynamically stable controls.[8] These observations support the potential usefulness of IVC assessment as an additional bedside measure of cardiovascular physiology.

The physiological interpretation of IVC collapsibility in neonates, however, requires caution. An increased cIVC may reflect reduced venous filling or altered right-sided loading conditions, but it should not automatically be interpreted as proof of hypovolemia or fluid responsiveness.

Neonatal respiratory mechanics, spontaneous breathing pattern, intra thoracic pressure, right ventricular function and vascular tone may all influence IVC dimensions. Furthermore, IVC diameter is affected by gestational age and body size. A study comparing echo cardio graphic IVC measurements with central venous pressure in neonates found a strong relationship between IVC collapsibility index and central venous pressure, while absolute IVC dimensions were related to gestational age and body weight.[6]

The higher cIVC observed in our shock group therefore suggests altered preload physiology, but it cannot by

itself establish that these neonates would respond to fluid administration. This distinction is important because fluid responsiveness and preload status are not synonymous. A neonate may have a low preload but fail to increase cardiac output after fluid administration because of myocardial dysfunction or other cardiovascular limitations. Consequently, functional echo cardio graphy should be interpreted as a comprehensive physiological assessment rather than relying on a single parameter.

The present study also demonstrated a statistically significant difference in LVEDA between the groups. LVEDA was higher among neonates with shock than controls. This finding differs from the intuitive expectation that reduced preload should necessarily result in a smaller ventricular end-diastolic area.

However, neonatal shock is physiologically heterogeneous, and LVEDA is influenced by ventricular compliance, after load, myocardial performance and loading conditions. Therefore, a larger LVEDA should not be interpreted in isolation as evidence of increased preload. Previous neonatal studies have demonstrated complex and sometimes overlapping changes in ventricular filling and cardiac performance during shock.[9],[11]

The relationship between clinical shock and echo cardio graphic parameters is further complicated by the diverse etiologies represented in our study. Sepsis, hypoxic-ischaemic injury, metabolic disturbances and respiratory disease may produce different combinations of altered preload, contractility and vascular resistance. Functional echocardiography is therefore particularly valuable because it can potentially identify the predominant cardiovascular phenotype rather than simply confirming the presence or absence of shock. This is consistent with recommendations emphasizing the use of neonatal echocardiography to characterize cardiovascular physiology in critically ill neonates.[3],[4]

An important secondary analysis in our study was the comparison of neonates with septic shock and those with shock due to other causes. The IVC collapsibility index showed an AUC of 0.66 (95% CI: 0.43–0.87), indicating modest discriminatory ability. At a cIVC cut-off of >50%, sensitivity was 69.2%, while specificity was only 33.3%. The positive and negative predictive values were 52.9% and 50.0%, respectively. These findings suggest that although a higher cIVC was associated with shock in the overall cohort, it had limited ability to specifically identify septic shock.

The limited specificity observed in our study is clinically relevant. Increased IVC respiratory variation may occur in different forms of neonatal circulatory compromise and is therefore unlikely to be specific for sepsis. Moreover, the small number of neonates in the septic and non-septic subgroups resulted in wide confidence intervals around the ROC estimates. Thus, the present findings should be interpreted as exploratory rather than as evidence for using a cIVC >50% as a definitive diagnostic threshold for septic shock.

The LVEDA demonstrated even poorer discriminatory ability for septic shock, with an AUC of 0.36. This suggests that LVEDA alone is not a useful discriminator between septic and non-septic causes of shock in the present population. The findings reinforce the concept that no single echo cardio graphic parameter can adequately characterize the complex hemodynamic of neonatal shock. Recent systematic review evidence similarly found substantial heterogeneity in studies of functional echocardiography in neonatal shock and did not demonstrate a consistent significant difference in

IVC collapsibility index between shock and control groups across pooled studies.[10]

The discrepancy between our significant case-control difference in cIVC and the limited diagnostic performance for septic shock is understandable. The first comparison addressed shock versus hemodynamic stability, whereas the ROC analysis addressed septic shock versus other causes of shock. Thus, cIVC may reflect altered cardiovascular loading associated with shock without being sufficiently specific to identify the etiology of shock. This distinction is important when interpreting bedside echo cardio graphic measurements.

The findings of the present study support the role of point-of-care functional echocardiography as an adjunct to conventional clinical assessment.

Current recommendations emphasize that neonatal echocardiography should complement rather than replace clinical examination and other hemodynamic assessments.[3],[4] Functional echocardiography can provide real-time information about loading conditions and cardiac function and may help clinicians develop a more complete physiological understanding of a neonate with circulatory compromise.[2],[13]

The study has several strengths. It prospectively evaluated term neonates with clinically diagnosed shock and used a matched stable control group. Echo cardio graphic measurements were obtained immediately after diagnosis of shock and before completion of the first fluid bolus, reducing the possibility that subsequent fluid administration would alter the baseline measurements. Measurements of IVC diameter were performed in triplicate, with the mean value used for analysis, thereby improving measurement reliability. The echo cardio graphic assessment was also performed by a single trained neonatal resident, which may have reduced inter-observer variability.

However, several limitations should be considered. First, the study was conducted at a single tertiary-care centre and included a relatively small number of neonates. Second, the sample size for the etiological subgroup analysis was particularly small, with only 13 neonates with septic shock and 12 with other causes of shock. This limits the precision of the ROC estimates and may explain the wide confidence intervals. Third, the study assessed echo cardio graphic parameters at a single time point and did not evaluate serial changes following fluid administration or resolution of shock. Fourth, cIVC was assessed in spontaneously breathing neonates and may be influenced by respiratory pattern and other physiological factors. Fifth, the study did not establish whether these preload markers predicted actual fluid responsiveness, as changes in cardiac output or stroke volume following a standardized fluid challenge were not used as the reference outcome.

Despite these limitations, the study adds to the growing body of evidence supporting functional echo cardio graphy in neonatal hemodynamic assessment. The significant differences observed in IVC measurements and cIVC between neonates with shock and stable controls suggest that these parameters may provide useful information about altered loading conditions. However, the modest ROC performance for septic shock indicates that cIVC should not be used as an isolated diagnostic marker of septic shock.

Conclusion

Point-of-care functional echocardiography demonstrated significant differences in preload-related parameters between term neonates with shock and hemodynamically stable neonates. Neonates with shock had higher IVC

collapsibility and significant alterations in IVC diameters and LVEDA. However, IVC collapsibility showed only modest ability to differentiate septic from non-septic shock. Thus, functional echocardiography may serve as a useful adjunct to clinical assessment of neonatal shock, but individual parameters should not be used in isolation to guide diagnosis or management.

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