International Journal of Contemporary Pediatrics
Nahrel R et al. Int J Contemp Pediatr. 2026 Jul;13(7):1147-1153
https://www.ijpediatrics.com
pISSN 2349-3283 | eISSN 2349-3291
DOI: https://dx.doi.org/10.18203/2349-3291.ijcp20261905

Original Research Article

The utility of umbilical cord blood culture in the diagnosis of early onset sepsis in neonates at a tertiary care hospital

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Received: 29 April 2026
Accepted: 08 June 2026

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ABSTRACT

Background: Umbilical cord offers an alternative site for blood culture collection. Umbilical cord blood culture (UCBC), obtained aseptically immediately after delivery, is painless, technically simpler method that allows collection of an adequate blood volume before antibiotic exposure. Objective was to study utility of UCBC in the diagnosis of early onset sepsis in neonates

Methods: Hospital based prospective study was carried out among 100 neonates delivered by normal vaginal delivery (NVD) and lower segment caesarean section (LSCS), who were at risk of developing EOS. Information was collected from structured proforma for each patient. Details of newborn and mother/Risk factors including maternal and neonatal risk factor was taken/clinical feature of newborn risk for early onset sepsis was taken. Qualifying patient underwent detailed history, clinical examination and sepsis screening was sent in NICU. Umbilical cord blood sample was processed for five days and growth and antibiotic sensitivity was reported.

Results: Majority mothers were <20 years (47%). Mostly they belonged to gestational age of 28-34 week. Majority had birth weight between 1-1.5 kg (37%). Most common risk factor was pre-mature rupture of membranes (72%). Tachypnea was most common clinical feature (35%). 33% were culture positive by UCBC compared to 17% by peripheral venous blood culture (PVBC). Most common organism isolated by UCBC was *Acinetobacter* (11%). Sensitivity, specificity, PPV, NPV sepsis screening compared to UCBC was 90.9%, 53.7%, 49.2%, 92.3% respectively. Sensitivity, specificity, PPV, NPV of sepsis screening compared to PVBC was 82.4%, 43.4%, 22.9%, 92.3% respectively. Sensitivity, specificity, PPV, NPV of UCBC compared to PVBC was 77.8%, 76.8%, 42.4%, 94.03% respectively.

Conclusions: Early-onset neonatal sepsis was more common among preterm, low-birth-weight neonates and those exposed to maternal risk factors, particularly PROM.

Keywords: Blood culture, Diagnosis, Sepsis, Neonates

INTRODUCTION

Neonatal sepsis is a clinical syndrome of systemic infection occurring in the first 28 days of life, characterized by signs and symptoms of infection with or without bacteraemia. Despite advances in neonatal care, it remains a major cause of neonatal morbidity and mortality worldwide, particularly in low- and middle-income countries (LMICs). The disease is often associated with rapid clinical deterioration, and delays in diagnosis or initiation of appropriate therapy significantly increase fatality rates. According to the World Health Organization (WHO), neonatal infections including sepsis, pneumonia, and meningitis account for a substantial proportion of the 2.3-2.5 million neonatal deaths globally each year.[1]

The estimated global incidence of neonatal sepsis ranges from 2,200 to 3,900 per 100,000 live births, with the highest burden in South-East Asia and sub-Saharan

Africa. Survivors of neonatal sepsis face a significantly increased risk of long-term neurodevelopmental impairments, thereby contributing to lifelong disability and economic burden. India bears the highest global burden of neonatal sepsis. Data from the National Neonatal Perinatal Database (NNPD) report an incidence of approximately 30 per 1,000 live births. Neonatal infections contribute to nearly 30-50% of neonatal deaths in developing countries, with sepsis being a leading cause. Factors such as high prevalence of prematurity, low birth weight (LBW), inadequate antenatal care, poor intrapartum infection control practices, and limited access to advanced neonatal care significantly increase the risk of neonatal sepsis in India.[2,3]

Chhattisgarh, a predominantly tribal and socioeconomically disadvantaged state in central India, has a disproportionately high burden of neonatal morbidity and mortality. Hospital-based studies from Sick Newborn Care Units (SNCUs) and tertiary care centres consistently identify neonatal sepsis as a leading cause of NICU admissions and neonatal deaths. Studies from Bilaspur and Raipur, report that 12-20% of hospitalized neonates are diagnosed with clinical or culture-positive sepsis. Tertiary care NICU studies from Raipur have shown that early-onset sepsis accounts for nearly 70-71% of severe sepsis cases, indicating predominant vertical transmission. Mortality rates exceeding 50%, particularly among preterm and very-low-birth-weight (VLBW) neonates, highlight the aggressive nature of EOS in this population.[4,5]

Overall, available regional data indicate that neonatal sepsis affects approximately 12-20% of admitted neonates in Chhattisgarh, with mortality ranging from 18% to over 50%, depending on gestational age, birth weight, and disease severity.[4]

The umbilical cord (placental end) offers an alternative site for blood culture collection. UCBC, obtained aseptically immediately after delivery, is a painless, technically simpler method that allows collection of an adequate blood volume before antibiotic exposure. Several Indian studies have demonstrated higher culture positivity rates with UCBC, particularly in cases of early-onset sepsis, compared to PVBCs. These findings support UCBC as a valuable diagnostic tool for early pathogen detection and timely initiation of appropriate antimicrobial therapy.[6,7]

Umbilical cord blood represents the fetal intravascular environment at birth and therefore reflects in-utero infection and inflammation When vertical transmission occurs, bacteria present in the foetal bloodstream can be isolated from cord blood. Since this blood is obtained before postnatal environmental exposure, it accurately reflects intrauterine infection and helps in early detection of EOS. Adequate volume and reduced skin contamination further enhance its diagnostic yield.[8]

Early-onset neonatal sepsis remains a major contributor to neonatal morbidity and mortality, particularly in developing countries, and its early diagnosis is challenging due to non-specific clinical features. Although PVBC is the diagnostic gold standard, it is limited by sampling difficulties, small blood volumes, and delayed results. UCBC, obtained at birth, may overcome these limitations; however, concerns regarding contamination and diagnostic reliability persist. This study aims to evaluate the utility of UCBC as an alternative or adjunct to peripheral blood culture in the diagnosis of early-onset neonatal sepsis.

METHODS

Hospital based prospective study was carried out at neonatal intensive care unit and labor room and Emergency Operation theatre of a tertiary care hospital over a period of one year from December 2024 to November 2025 among 100 neonates delivered by NVD and LSCS, who were at risk of developing EOS.

From the previous study, the prevalence of early onset sepsis in neonates was 20.9%.[9] Based on this, with 95% confidence level and 10% precision, the sample size came out to be 64. We included 100 neonates in this study. They were included consecutively.

All neonates who were delivered in the study hospital and were at risk of developing early onset sepsis, having maternal risk factors like premature or prolong rupture of membrane (>18 hours), prolonged labour (>24 hours both stages) and difficult delivery with instrumentation, Foul smelling liquor, febrile illness in the mother during or within two weeks of delivery, single unclean or more than three vaginal examinations during labour were included. Those with neonatal risk factors like prematurity and LBW, birth asphyxia [Apgar score less than 4 at 1 minutes] were also included. Those who were out born neonates, neonates born without risk factors for sepsis were excluded.

Institution ethics committee permission was obtained. Child assent was obtained from the parents or guardians of the study participants. Information was collected from structured proforma for each patient. Details of newborn and mother/risk factors including maternal and neonatal risk factor was taken/clinical feature of newborn risk for early onset sepsis was taken. Qualifying patient underwent detailed history, clinical examination and sepsis screening was sent in NICU.

Umbilical cord was clamped at the placental side and the fetal side. Thereafter the cord was cut. The cord was wiped three times with 70% isopropyl alcohol using sterile technique. Using a sterile 22-gauge needle and syringe, approximately 2 mL of blood was drawn into the syringe from the umbilical vein from placental end. Syringe was replaced with a new sterile needle and the top of culture bottle was wiped with alcohol. Then 2 mL

of blood was injected in an aerobic blood culture bottle containing media brain heart infusion broth supplemented with 0.05% SPS and was sent to the microbiology laboratory. Sample was processed for five days and growth and antibiotic sensitivity was reported.[10]

The data was expressed as percentage. Sensitivity, specificity, positive predictive value and the negative predictive value was calculated. Youden's index was also calculated to specify the diagnostic performance of the screening test like sepsis screening.

RESULTS

Majority of the mothers were below the age of 20 years (47%) followed by 26-30 years (30%). Most commonly they belonged to the gestational age of 28-34 weeks followed by 34-37 weeks. Females were more than males. Majority had birth weight between 1-1.5 kg (37%) followed by normal birth weight (31%). The 59% had APGAR score of seven or more.

Most common risk factor was pre-mature rupture of membranes seen in 72% of the cases followed by prematurity and LBW in 56% of the cases. Tachypnea was the most common clinical feature seen in 35% of the cases followed by tachycardia in 26%.

The 33% were culture positive by UCBC compared to 17% by PVBC (Table 3).

Most common organism isolated by UCBC was *Acinetobacter* in 11% of cases followed by *E. coli* in 7% cases. Similarly, most common organism isolated by PVBC was *Acinetobacter* in 7% followed by *E. coli* in 4% and *Enterobacter* in 4%.

The sensitivity, specificity, positive predictive value, negative predictive value of sepsis screening compared to UCBC was 90.9%, 53.7%, 49.2% and 92.3% respectively. The Youden's index value was 0.4464 meaning moderate diagnostic effectiveness of sepsis screening when compared to UCBC.

The sensitivity, specificity, positive predictive value, negative predictive value of sepsis screening compared to UCBC was 82.4%, 43.4%, 22.9% and 92.3% respectively. The Youden's index value was 0.2572 meaning very low diagnostic effectiveness of sepsis screening when compared to PVBC.

Table 1: Distribution of participants as per baseline characteristics.

Characteristics		N	Percentage (%)
Age of mothers (in years)	<20	47	47.0
	21-25	17	17.0
	26-30	30	30.0
	31-35	05	05.0
	>35	01	01.0
Gestational age (weeks)	<28	06	6.0
	28-34	38	38
	34-37	20	20
	>37	36	36
Gender of neonates	Male	39	39.0
	Female	61	61.0
Birth weight (kg)	<1	5	5
	1-1.5	37	37
	1.5-2.5	27	27
	> 2.5	31	31
APGAR score at 5 min	<7	41	41.0
	≥7	59	59.0

Table 2: Distribution based on clinical characteristics.

Clinical characteristics		N	Percentages (%)
Risk factors	Prolonged labor	30	30.0
	PROM	72	72.0
	Maternal fever	19	19.0
	PV examination	11	11.0
	Foul smelling liquor	00	00
	Chorioamnionitis	02	2.0
	IUGR	15	15.0
	Prematurity and LBW	56	56.0
	Birth asphyxia	35	35.0

Continued.

Clinical characteristics		N	Percent (%)
Clinical features	Seizure	22	22
	Tachycardia	26	26
	Bradycardia	11	11
	Tachypnea	35	35
	Hypothermia	08	18
	Pronged CRT	18	18
	Hypoglycemia	10	10
	Feed intolerance	15	15
	Bleeding	04	4
	Skin mottling	01	1
	Abdominal distension	08	8
Investigations	TLC <5000	31	31
	TLC >20000	4	4
	ANC	30	30
	I/T ratio	18	18
	CRP	45	45
	Micro ESR	25	25

Table 3: Results of UCBC and PVBC among newborn.

Culture	UCBC	Percentage	PVBC	Percentage (%)
Positive	33	33.0	17	17.0
Negative	67	67.0	83	83.0
Total	100	100	100	100

Table 4: Organisms growth in UCBC and PVBC among newborn.

Organisms	UCBC	Percentage	PVBC	Percentage (%)
Acinetobacter	11	11.0	07	7.0
Enterobacter	07	07.0	04	4.0
Nilfermentor	04	04.0	01	1.0
Klebsiella	03	03.0	00	00
Pseudomonas	01	01.0	00	00
E. Coli	07	07.0	04	4.0
S. aureus	00	00	00	00
GB *Streptococci*	00	00	00	00

Table 5: Diagnostic utility of sepsis screening compared to UCBC.

Sepsis screening	UCBC		Total	P value
	Positive	Negative		
Positive	30	31	61	0.003
Negative	3	36	39	
Total	33	67	100	

Table 6: Diagnostic utility of sepsis screening compared to PVBC.

Sepsis screening	PVBC		Total	P value
	Positive	Negative		
Positive	14	47	61	0.004
Negative	3	36	39	
Total	17	83	100	

The sensitivity, specificity, positive predictive value, negative predictive value of UCBC compared to PVBC was 77.8%, 76.8%, 42.4% and 94.03% respectively. The Youden's index value was 0.5467 meaning better diagnostic effectiveness of UCBC when compared to PVBC.

Table 7: Diagnostic utility of UCBC compared to PVBC.

UCBC	PVBC		Total	P value
	Positive	Negative		
Positive	14	19	33	<0.0001
Negative	4	63	67	
Total	18	82	100	

DISCUSSION

In this study, the majority of mothers were less than 20 years (47%), followed by 26-30 years (30%), 21-25 years (17%), 31-35 years (5%), and >35 years (1%), with a mean age of 23.26±2.326 years. These findings indicate

that most participants were young adults. Similar trends were reported by Meena et al who found that 68% of mothers were aged 20-30 years, and by Mulay et al where 60% of mothers were between 21-25 years.[11,12]

In the present study, NVD accounted for 74% of births, while 26% underwent LSCS. Previous studies support these findings like study by Meena et al found 70% NVD and 30% LSCS among neonates with EOS.[11] Mulay et al reported 72% NVD and 28% LSCS.[12] These findings indicate that although LSCS can reduce risk in some scenarios, neonates delivered vaginally with high-risk maternal factors remain susceptible to EOS.

In this study, 38% of neonates were preterm (28-34 weeks), 36% were term (>37 weeks), 20% were between 34-37 weeks, and 6% were <28 weeks. Preterm neonates are particularly vulnerable due to immature immune systems, underdeveloped skin and mucosal barriers, and limited maternal antibody transfer. Stoll et al reported that 40% of EOS cases involved preterm neonates, while Meena et al found 35% late preterm and 40% term neonates in their study.[2,11] Mulay et al reported 38% of EOS cases in 28-34 weeks gestation and 34% in term neonates.[12] Collectively, these studies demonstrate that preterm and late-preterm neonates constitute a significant proportion of EOS cases and require close monitoring.

In this study, females comprised 61% of neonates, while males accounted for 39%. Although gender is not a primary risk factor for EOS, several studies have reported similar trends. Meena et al found that 55% of neonates were female, Mulay et al reported 58%.[11,12] Stoll et al found no significant global gender difference but noted slight female predominance in hospital-based studies.[4] These findings suggest that female predominance may reflect regional demographic patterns rather than an inherent susceptibility.

In present study, 37% of neonates weighed 1-1.5 kg, 27% weighed 1.5-2.5 kg, 31% weighed >2.5 kg, and 5% weighed <1 kg. LBW was present in 56% of neonates. LBW is a well-recognized risk factor for EOS. Meena et al where 50% of neonates were LBW.[11] Mulay et al reported 55% LBW.[12] These consistent findings highlight the association between LBW and susceptibility to early infections due to compromised immunity and physiological reserves.

In the present study, 59% of neonates had APGAR scores ≥7 at birth, while 41% had scores <7. Low APGAR scores are indicative of perinatal distress and correlate with increased EOS risk. Liu et al reported that 40–45% of neonates with low APGAR scores were at heightened risk for EOS, and Meena et al observed 42% of neonates with APGAR <7.[11,13] Mulay et al reported 39% low APGAR.[12] These findings consistently support that compromised perinatal status is a significant risk factor for EOS.

The predominant risk factors in this study were PROM (72%), prematurity and LBW (56%), and followed by birth asphyxia (35%), IUGR (15%), prolonged labour (30%), maternal fever (19%), PV examination (11%), and chorioamnionitis (2%). Meena et al reported PROM in 65%, prematurity 50%, and LBW 55%, while Mulay et al observed PROM in 70%, LBW 57%, and prematurity 48%.[11] These studies confirm that PROM, prematurity, and LBW are consistently identified as major predictors of EOS.

Clinically, tachypnoea (35%) and tachycardia (26%) were the most common presenting features. These nonspecific signs reiterate the diagnostic challenge of EOS and the importance of laboratory support for early confirmation. Similar observations have been reported in previous studies. Meena et al documented that signs such as respiratory distress, lethargy, temperature instability, and poor feeding were common but lacked specificity, emphasizing that clinical features alone are insufficient to reliably diagnose EOS.[11] Thus, the clinical profile observed in the present study is consistent with findings reported in previous studies, reaffirming that early-onset neonatal sepsis often presents with subtle, nonspecific, and overlapping clinical manifestations.

Among sepsis screening tests, CRP was positive in 45%, TLC abnormalities in 31%, ANC derangement in 30%, and I/T ratio elevation in 18%. These parameters, though helpful, lack sufficient sensitivity and specificity when used individually, as supported by prior literature. Hence, reliance solely on sepsis screen without microbiological confirmation may lead to over-or under-treatment. Comparable findings were reported by Islam et al where 61% of neonates were sepsis-screen positive, but only 17.3% had positive UCBCs and 9.09% had positive PVBSs.[14] Despite sepsis screening showing high sensitivity, its low specificity resulted in a significant number of false-positive cases. Similarly, Meena et al found that sepsis screen had 100% sensitivity, its positive predictive value was low (9%), indicating limited diagnostic accuracy when used alone.[11]

UCBC was positive in 33% of neonates, whereas PVBC was positive in 17%. Meena et al reported UCBC positivity of 32% versus 20% for PVBC, while Mulay et al found UCBC 30% and PVBC 18%.[11,12] These studies consistently demonstrate that UCBC detects a higher proportion of infections compared to conventional peripheral blood culture.

In this study, *Acinetobacter* (11%) was the most frequently isolated organism in UCBC, followed by Enterobacter and *E. coli* (7% each), *Nilfermentor* (4%), *Klebsiella* (3%), and *Pseudomonas* (1%). PVBC isolates were similar but less frequent. Meena et al reported *Acinetobacter* (12%), *E. coli* (8%), and *Klebsiella* (5%), Mulay et al reported *Acinetobacter* (10%), *Enterobacter* (7%), and *E. coli* (6%).[11,12] These studies indicate a predominance of Gram-negative organisms in Indian

EOS cases, in contrast to high-income countries where group B *Streptococcus* is more prevalent.

UCBC showed a sensitivity of 90.91%, specificity 53.73%, PPV 49.18%, NPV 92.31%, and accuracy 66%. Meena et al reported sensitivity 88% and specificity 55%, Mulay et al observed sensitivity 91% and specificity 50%, Meena et al found sensitivity 89% and specificity 52%.[11,12] These studies confirm that UCBC consistently demonstrates high sensitivity and negative predictive value, making it a reliable tool to rule out EOS.

PVBC demonstrated sensitivity 82.35%, specificity 43.37%, PPV 22.95%, NPV 92.31%, and accuracy 50%. Meena et al reported sensitivity 80% and specificity 45%, Mulay et al observed sensitivity 81% and specificity 42%.[11,12] These findings indicate moderate ability to detect septic neonates but highlight UCBC's superiority.

In this study, 42.4% of UCBC-positive neonates were also PVBC positive, while 57.6% were PVBC negative. The association was highly significant ($p<0.00001$). Mulay et al reported 43% concordance, Meena et al observed 40%.[11,12] These findings support UCBC as an early, non-invasive diagnostic adjunct to PVBC.

Statistical analysis demonstrated that UCBC had a higher detection rate and good concordance with PVBC. Although PVBC remains the gold standard, UCBC exhibited strong diagnostic performance, particularly a high negative predictive value, as supported by studies by Meena et al.[11] The increased yield without additional invasive procedures adds to its clinical utility. Overall, UCBC proved to be a reliable, painless, and technically easier method for early detection of EOS, especially in high-risk neonates.

UCBC demonstrates high sensitivity and negative predictive value for detecting EOS and identifies more infections than PVBC. Gram-negative organisms, particularly *Acinetobacter*, *Enterobacter*, and *E. coli*, were most frequently isolated. UCBC is a valuable early diagnostic tool, especially for high-risk neonates, complementing PVBC and enabling rational antibiotic use. These findings align with multiple Indian and international studies, reinforcing its role in early detection and management of EOS.

UCBC positivity is higher than PVBC positivity because umbilical cord blood is collected immediately at birth when foetal bacteraemia and bacterial load are highest, allows a larger blood volume to be sampled, and is obtained before antibiotic exposure or immune-mediated bacterial clearance, whereas PVBC is usually collected later with smaller volumes when bacteraemia may already be reduced or intermittent.

UCBC shows higher positivity than PVBC because it reduces false-negative results by detecting early, low-grade, or intermittent bacteraemia, identifies infection even in mild or early EOS cases where PVBC may be negative, and when collected with proper sterile techniques represents true bacteraemia rather than contamination.

Limitations

The limitation of this study was small sample size, single-center study, lack of advanced septic screening tests. This was a hospital-based time bound study. Multicentric studies should be conducted to improve knowledge in UCBC and thereby reduce the mortality among these high-risk group babies. There is a possibility of contamination during umbilical cord blood sampling, which may influence the specificity and false-positive rate of UCBC. UCBC may detect transient bacteraemia or colonization rather than true systemic infection, leading to potential overdiagnosis of EOS. Difficulty in differentiating true pathogens from contaminants, especially with isolation of skin flora such as coagulase-negative *Staphylococci*. In resource-limited settings, logistical constraints, delayed processing, and laboratory infrastructure limitations may affect the accuracy and reliability of UCBC results.

CONCLUSION

Early-onset neonatal sepsis was more common among preterm, low-birth-weight neonates and those exposed to maternal risk factors, particularly PROM. UCBC identified sepsis in a higher proportion of neonates compared to PVBC. UCBC demonstrated high sensitivity (90.91%) and a high negative predictive value (92.31%), making it a reliable test to rule out EOS. UCBC is a simple, painless, and effective diagnostic modality that complements PVBC. Incorporation of UCBC in the evaluation of high-risk neonates can facilitate early diagnosis, support rational antibiotic use, and potentially reduce neonatal morbidity and mortality.

Recommendations

Larger multicentric studies are recommended to validate these findings. UCBC should be considered as a routine adjunct to PVBC in EOS evaluation. Integration of UCBC into neonatal sepsis protocols may improve early diagnosis and antibiotic stewardship.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Nahrel R, Xalxo S, Shrey M. The utility of umbilical cord blood culture in the diagnosis of early onset sepsis in neonates at a tertiary care hospital. Int J Contemp Pediatr 2026;13:1147-53.