Section: Pathology

Original Research Article

CORRELATION OF HEMATOLOGICAL PARAMETERS AND BLOOD CULTURE FINDINGS IN THE DIAGNOSIS OF NEONATAL SEPSIS: A RETROSPECTIVE STUDY

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ABSTRACT

Background: Neonatal sepsis remains a major cause of neonatal morbidity and mortality, particularly in resource-limited settings. Although blood culture is the gold standard for diagnosis, delayed results and suboptimal sensitivity necessitate the use of rapid adjunctive diagnostic markers. Hematological parameters derived from routine complete blood count are inexpensive and readily available and may facilitate early diagnosis. **Aim:** To evaluate the correlation between hematological parameters and blood culture findings in neonates with suspected sepsis and assess their diagnostic utility in predicting culture-proven neonatal sepsis. **Materials and Methods:** This retrospective observational study included 100 neonates with clinically suspected sepsis admitted to a tertiary care teaching hospital. Demographic details, hematological parameters, and blood culture findings were retrieved from hospital records. Hematological abnormalities, including thrombocytopenia, leukopenia, and elevated immature-to-total neutrophil (I/T) ratio, were compared between culture-positive and culture-negative neonates. Statistical analysis was performed using the Chi-square test, and odds ratios (ORs) were calculated to determine the strength of association. **Results:** Blood culture was positive in 38% of neonates. *Klebsiella pneumoniae* (42.1%) was the predominant pathogen, followed by *Escherichia coli* (23.7%), *Staphylococcus aureus* (18.4%), and coagulase-negative *Staphylococci* (15.8%). Thrombocytopenia was the most common hematological abnormality (45%), followed by elevated I/T ratio (40%) and leukopenia (21%). Compared with culture-negative neonates, culture-positive cases showed significantly higher frequencies of thrombocytopenia (71.1% vs. 29.0%; OR=6.00; $p<0.001$), elevated I/T ratio (68.4% vs. 22.6%; OR=7.43; $p<0.001$), and leukopenia (34.2% vs. 12.9%; OR=3.51; $p=0.022$). Elevated I/T ratio emerged as the strongest predictor of culture-positive neonatal sepsis. **Conclusion:** Routine hematological parameters, particularly elevated I/T ratio and thrombocytopenia, are valuable adjunctive markers for the early diagnosis of neonatal sepsis. Their use alongside clinical assessment can facilitate timely therapeutic intervention while awaiting definitive blood culture results, especially in resource-constrained settings.

INTRODUCTION

Neonatal sepsis remains a major contributor to neonatal morbidity and mortality worldwide, particularly in low- and middle-income countries where the burden of infection, limited laboratory access, delayed referral, and antimicrobial resistance continue to affect neonatal outcomes.[1-4] It is defined as a systemic infection occurring within the first 28 days of life and is commonly classified as early-onset or late-onset sepsis according to the timing of presentation.[5,6] Globally, neonatal sepsis is estimated to affect millions of newborns each year, with reported mortality remaining substantial despite advances in neonatal intensive care and antimicrobial therapy.[1,2] Early recognition and prompt initiation of appropriate treatment are therefore essential to reduce mortality, prevent complications, and improve long-term outcomes.[5-7]

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The diagnosis of neonatal sepsis is challenging because clinical manifestations are often subtle, nonspecific, and may overlap with non-infectious neonatal conditions. Features such as poor feeding, lethargy, respiratory distress, apnea, temperature instability, irritability, and circulatory compromise may occur in both septic and non-septic neonates.[5,8] As a result, clinicians frequently initiate empirical antibiotics while awaiting confirmatory investigations. However, unnecessary antibiotic exposure may promote antimicrobial resistance, disturb the developing neonatal microbiome, prolong hospitalization, and increase healthcare costs.[7,9,10] Hence, there is a continued need for rapid, inexpensive, and reliable diagnostic markers that can assist early clinical decision-making.

Blood culture remains the gold standard for confirmation of neonatal sepsis because it identifies the causative organism and enables targeted antimicrobial therapy.[5,6,11] Nevertheless, its clinical utility is limited by the time required for bacterial growth, usually 48–72 hours, and by false-negative results caused by prior antibiotic exposure, low-level bacteremia, inadequate blood volume, or intermittent organism circulation.[5,11,12] These limitations are especially important in resource-limited settings, where advanced biomarkers and automated culture systems may not be consistently available.[3,4,13]

Hematological parameters obtained from a routine complete blood count are widely used as adjunctive tools in the evaluation of suspected neonatal sepsis because they are inexpensive, rapidly available, and easily repeatable. Total leukocyte count, absolute neutrophil count, immature-to-total neutrophil ratio, platelet count, and peripheral smear changes reflect the host inflammatory response to infection.[14,15] An elevated I/T ratio is considered an early marker of bacterial infection due to increased release of immature neutrophils from the bone marrow, whereas thrombocytopenia may result from platelet consumption, immune-mediated destruction, endothelial injury, or bone marrow suppression during systemic infection. Leukopenia and neutropenia may also indicate severe or overwhelming infection, although isolated leukocyte indices have variable diagnostic accuracy.[14,15]

Several studies have evaluated individual hematological indices and hematological scoring systems for early diagnosis of neonatal sepsis, with encouraging but variable results across different populations.[14,15] Such variation may be related to differences in gestational age, birth weight, timing of sepsis, pathogen distribution, prior antibiotic exposure, and laboratory methodology. Therefore, institution-specific evaluation of hematological parameters against blood culture findings remains important. The present retrospective study was undertaken to correlate hematological parameters with blood culture findings among neonates with clinically suspected sepsis and to assess their utility as early adjunctive diagnostic indicators.

MATERIALS AND METHODS

This retrospective observational study was conducted in the Department of Pathology in collaboration with the Neonatal Intensive Care Unit (NICU) of a tertiary care teaching hospital. Medical records of neonates evaluated for suspected neonatal sepsis during the study period were reviewed. Neonates aged 0–28 days with clinical features suggestive of sepsis who had undergone both hematological investigations and blood culture examination were included in the study. Cases with incomplete medical records, congenital hematological disorders, or unavailable blood culture reports were excluded. Demographic details, including age at presentation, sex, birth weight, gestational age, hematological parameters, and blood culture findings, were retrieved from hospital records, laboratory registers, and electronic databases.

Venous blood samples collected as part of routine clinical management were analyzed for complete blood count using an automated hematology analyzer. Hematological parameters evaluated included hemoglobin concentration, total leukocyte count (TLC), absolute neutrophil count (ANC), immature-to-total neutrophil (I/T) ratio, platelet count, and peripheral smear findings. Blood cultures were processed according to standard microbiological protocols. Isolated organisms were identified using conventional biochemical methods and/or automated identification systems available in the microbiology laboratory. Hematological abnormalities, including thrombocytopenia (<150,000/µL), leukopenia, and elevated I/T ratio (>0.2), were assessed and correlated with blood culture findings to determine their diagnostic utility in neonatal sepsis.

Data were entered into Microsoft Excel and analyzed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were summarized as frequencies and percentages. Associations between blood culture positivity and hematological parameters were assessed using the Chi-square test or Fisher's exact test, as appropriate. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated to estimate the strength of association between hematological abnormalities and culture-proven neonatal sepsis. A two-tailed p value of <0.05 was considered statistically significant.

RESULTS

A total of 100 neonates with clinically suspected neonatal sepsis were included in the study. Blood culture was positive in 38 (38%) cases and negative

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in 62 (62%) cases. Hematological parameters were evaluated in all neonates and correlated with blood culture findings to determine their diagnostic utility.

Table 1: Baseline characteristics of the study population and blood culture status

Variable	Frequency (n=100)	Percentage (%)
Male	58	58.0
Female	42	42.0
Blood culture positive	38	38.0
Blood culture negative	62	62.0

The study included 100 neonates with suspected sepsis, comprising 58 (58%) males and 42 (42%) females. Blood culture confirmed neonatal sepsis in 38 (38%) neonates, while 62 (62%) had negative culture results. The observed culture positivity indicates that over one-third of clinically suspected cases had microbiologically proven sepsis.

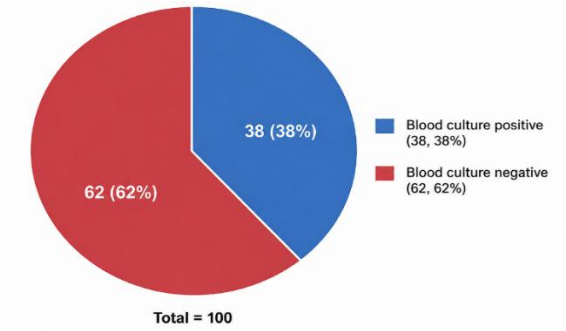

Figure 1: Distribution of blood culture-positive and blood culture-negative neonates with suspected neonatal sepsis

Table 2: Distribution of bacterial isolates among blood culture-positive neonates (n = 38)

Organism isolated	Number	Percentage (%)
Klebsiella pneumoniae	16	42.1
Escherichia coli	9	23.7
Staphylococcus aureus	7	18.4
Coagulase-negative Staphylococci	6	15.8

Among the 38 culture-positive neonates, Klebsiella pneumoniae was the predominant pathogen, accounting for 42.1% of isolates. Escherichia coli was the second most frequently isolated organism (23.7%), followed by Staphylococcus aureus (18.4%) and coagulase-negative Staphylococci (15.8%). Gram-negative organisms collectively constituted the majority of bloodstream isolates in neonatal sepsis.

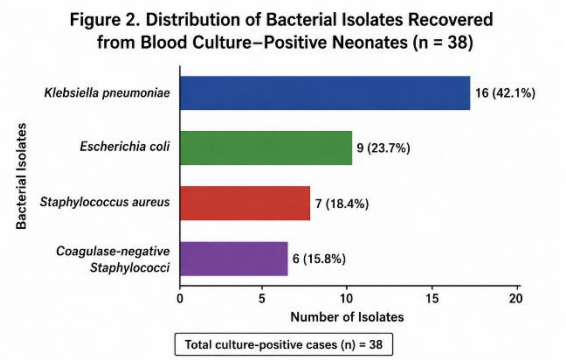

Figure 2: Distribution of bacterial isolates recovered from blood culture-positive neonates

Table 3: Overall frequency of hematological abnormalities among neonates with suspected sepsis (N = 100)

Hematological abnormality	Number	Percentage (%)
Thrombocytopenia (<150,000/µL)	45	45.0
Elevated I/T ratio (>0.2)	40	40.0
Leukopenia	21	21.0

Table 3 summarizes the overall prevalence of hematological abnormalities among neonates evaluated for suspected sepsis. Thrombocytopenia was the most common abnormality, affecting 45% of neonates, followed by an elevated immature-to-total neutrophil (I/T) ratio in 40% and leukopenia in 21%. The predominance of thrombocytopenia and elevated I/T ratio suggests that platelet abnormalities and neutrophil immaturity are common hematological alterations in neonates undergoing evaluation for sepsis.

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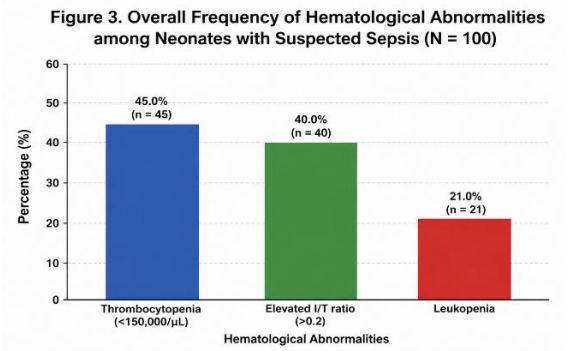

Figure 3: Overall frequency of hematological abnormalities among neonates with suspected sepsis

Table 4: Comparison of hematological abnormalities between blood culture-positive and blood culture-negative neonates

Hematological parameter	Culture Positive (n=38)	Culture Negative (n=62)	Odds Ratio (95% CI)*	p-value
Thrombocytopenia (<150,000/µL)	27 (71.1%)	18 (29.0%)	6.00	<0.001
Elevated I/T ratio (>0.2)	26 (68.4%)	14 (22.6%)	7.43	<0.001
Leukopenia	13 (34.2%)	8 (12.9%)	3.51	0.022

*Odds ratios calculated from the observed frequencies.

Comparison of hematological parameters between culture-positive and culture-negative neonates demonstrated statistically significant differences. Thrombocytopenia was observed in 71.1% of culture-positive neonates compared with 29.0% of culture-negative neonates. Similarly, an elevated I/T ratio was present in 68.4% of culture-positive cases but only 22.6% of culture-negative cases. Leukopenia was also significantly more frequent among culture-positive neonates (34.2% vs. 12.9%). Elevated I/T ratio exhibited the strongest association with culture-proven neonatal sepsis (OR 7.43), followed closely by thrombocytopenia (OR 6.00), while leukopenia showed a moderate but significant association (OR 3.51).

Table 5: Diagnostic significance of hematological parameters for predicting culture-positive neonatal sepsis

Hematological parameter	Culture-positive (%)	Culture-negative (%)	Diagnostic significance
Elevated I/T ratio	68.4	22.6	Strongest predictor
Thrombocytopenia	71.1	29.0	Strong predictor
Leukopenia	34.2	12.9	Moderate predictor

Evaluation of individual hematological parameters demonstrated that elevated I/T ratio and thrombocytopenia were the most informative laboratory markers for identifying culture-positive neonatal sepsis. Although leukopenia also showed a statistically significant association with blood culture positivity, its diagnostic performance was comparatively lower. Collectively, these findings suggest that hematological parameters, particularly platelet count and I/T ratio, may serve as valuable adjunctive screening tools for the early diagnosis of neonatal sepsis while awaiting definitive blood culture reports.

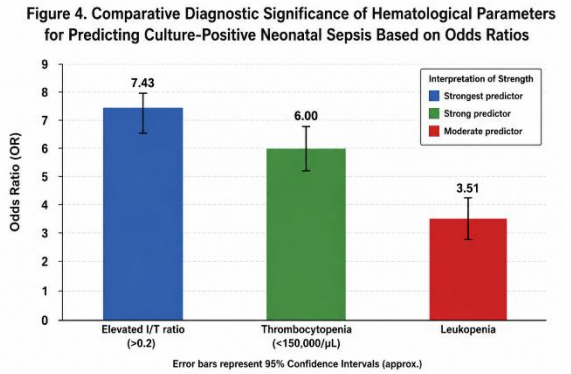

Figure 4: Comparative diagnostic significance of hematological parameters for predicting culture-positive neonatal sepsis based on odds ratios

DISCUSSION

The present study evaluated the correlation between hematological parameters and blood culture findings in neonates with suspected sepsis and demonstrated that elevated immature-to-total neutrophil (I/T) ratio, thrombocytopenia, and leukopenia were significantly associated with culture-proven neonatal sepsis. These findings reinforce the role of

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routine hematological investigations as useful adjunctive tools for the early diagnosis of neonatal sepsis, particularly in settings where blood culture results are delayed.

Blood culture positivity was observed in 38% of clinically suspected neonates, which is comparable to the observations of Milton et al. who reported a substantial burden of culture-confirmed neonatal sepsis across multiple low- and middle-income countries, although culture positivity varies depending on prior antibiotic exposure, timing of sampling, and microbiological techniques employed.[2] Shane et al. emphasized that despite remaining the gold standard, blood culture has limited sensitivity because of low bacterial load and inadequate blood sample volume, highlighting the importance of adjunctive laboratory markers for early diagnosis.[5] Similarly, Celik et al. noted that no single laboratory investigation can independently diagnose neonatal sepsis, necessitating the combined interpretation of clinical findings and hematological parameters.[4]

In the present study, Klebsiella pneumoniae was the predominant isolate, accounting for 42.1% of culture-positive cases, followed by Escherichia coli, Staphylococcus aureus, and coagulase-negative Staphylococci. This predominance of Gram-negative organisms is consistent with the findings of Milton et al. and Dramowski et al., who reported Klebsiella species as major pathogens responsible for neonatal bloodstream infections in resource-limited settings, reflecting the continuing challenge of healthcare-associated neonatal infections.[2,3]

Thrombocytopenia was the most common hematological abnormality observed and demonstrated a strong association with culture-positive sepsis (OR 6.00). Similar findings were reported by Arif et al., who demonstrated that thrombocytopenia is frequently associated with neonatal bacterial sepsis because of increased platelet consumption, endothelial activation, disseminated intravascular coagulation, and suppression of platelet production during systemic infection.[15] Likewise, Worku et al. identified platelet count as one of the important hematological parameters contributing to the diagnosis of neonatal sepsis when interpreted alongside other laboratory indices.[13]

Among all hematological parameters, an elevated I/T ratio exhibited the strongest association with culture-proven sepsis (OR 7.43). This finding agrees with the observations of Hornik et al., who demonstrated that neutrophil indices, particularly the I/T ratio, have greater diagnostic utility than isolated total leukocyte counts in early-onset neonatal sepsis.[14] Celik et al. also emphasized that the I/T ratio is one of the earliest hematological markers of bacterial infection because inflammatory stimulation leads to accelerated release of immature neutrophils from the bone marrow.[4] The high odds ratio observed in the present study further supports the usefulness of the I/T ratio as an early screening marker while awaiting blood culture reports.

Leukopenia was significantly more common among culture-positive neonates, although its predictive value was lower than that of thrombocytopenia and the I/T ratio. Similar observations have been reported by Hornik et al., who concluded that isolated leukocyte abnormalities possess relatively limited sensitivity because leukocyte responses vary according to gestational age, disease severity, and timing of infection.[14] Therefore, leukocyte count should be interpreted in conjunction with platelet count and neutrophil indices rather than as an independent diagnostic marker.

Recent reviews by Boscarino et al. and Rees et al. have highlighted the increasing role of biomarkers such as procalcitonin, cytokines, and molecular diagnostics in neonatal sepsis; however, these investigations remain costly and are not universally available, particularly in resource-constrained healthcare settings.[10,12] Consequently, routine hematological parameters continue to offer a practical, economical, and readily accessible approach for the early evaluation of suspected neonatal sepsis.

The present study is limited by its retrospective design, single-center setting, and relatively small sample size, which may limit the generalizability of the findings. Furthermore, inflammatory biomarkers such as C-reactive protein and procalcitonin were not evaluated. Nevertheless, the study demonstrates that thrombocytopenia, elevated I/T ratio, and leukopenia correlate significantly with blood culture positivity. These readily available hematological parameters should be considered valuable adjunctive screening tools that facilitate early diagnosis and timely initiation of appropriate therapy while awaiting definitive microbiological confirmation.

CONCLUSION

The present study demonstrates that routine hematological parameters, particularly an elevated immature-to-total neutrophil (I/T) ratio and thrombocytopenia, show a significant association with culture-proven neonatal sepsis and can serve as valuable adjunctive markers for its early diagnosis. Although blood culture remains the diagnostic gold standard, its delayed results and limited sensitivity necessitate the use of readily available screening tools to facilitate timely clinical decision-making. Leukopenia also showed a significant association with neonatal sepsis but exhibited comparatively lower diagnostic utility. The predominance of Klebsiella pneumoniae among culture-positive isolates highlights the continued burden of Gram-negative neonatal infections in tertiary care settings. Overall, routine hematological investigations, when interpreted alongside clinical findings, can improve the early identification of neonatal sepsis, enabling prompt initiation of appropriate antimicrobial

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therapy while awaiting definitive microbiological confirmation. Larger prospective multicenter studies incorporating conventional hematological parameters with newer biomarkers are warranted to further enhance the diagnostic accuracy of neonatal sepsis.

REFERENCES

1. Fleischmann-Struzek C, Goldfarb DM, Schlattmann P, Schlapbach LJ, Reinhart K, Kissoon N. The global burden of paediatric and neonatal sepsis: a systematic review. Lancet Respir Med. 2018 Mar;6(3):223-230.
2. Milton R, Gillespie D, Dyer C, Taiyari K, Carvalho MJ, Thomson K, et al. Neonatal sepsis and mortality in low-income and middle-income countries from a facility-based birth cohort: an international multisite prospective observational study. Lancet Glob Health. 2022 May;10(5):e661-e672.
3. Dramowski A, Bolton L, Fitzgerald F, Bekker A; NeoNET AFRICA Partnership. Neonatal Sepsis in Low- and Middle-income Countries: Where Are We Now? Pediatr Infect Dis J. 2025 Jun 1;44(6):e207-e210.
4. Celik IH, Hanna M, Canpolat FE, Mohan Pammi. Diagnosis of neonatal sepsis: the past, present and future. Pediatr Res. 2022 Jan;91(2):337-350.
5. Shane AL, Sánchez PJ, Stoll BJ. Neonatal sepsis. Lancet. 2017 Oct 14;390(10104):1770-1780.
6. Klingenberg C, Kornelisse RF, Buonocore G, Maier RF, Stocker M. Culture-Negative Early-Onset Neonatal Sepsis - At the Crossroad Between Efficient Sepsis Care and Antimicrobial Stewardship. Front Pediatr. 2018 Oct 9;6:285.
7. Singh M, Alsaleem M, Gray CP. Neonatal sepsis. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2024.
8. Cotten CM. Adverse consequences of neonatal antibiotic exposure. Curr Opin Pediatr. 2016 Apr;28(2):141-9.
9. Flannery DD, Puopolo KM. Neonatal Early-Onset Sepsis. Neoreviews. 2022 Nov 1;23(11):756-770.
10. Boscarino G, Migliorino R, Carbone G, Davino G, Dell'Orto VG, Perrone S, et al. Biomarkers of Neonatal Sepsis: Where We Are and Where We Are Going. Antibiotics (Basel). 2023 Jul 26;12(8):1233.
11. Vasilescu DI, Dan AM, Stefan LA, Vasilescu SL, Dima V, Cîrstoiu MM. Assessment of Culture-Negative Neonatal Early-Onset Sepsis: Risk Factors and Utility of Currently Used Serum Biomarkers. Children. 2025; 12(3):355
12. Rees CA, Lim J, Westbrook AL, El Helou R, Schmid A, Rubin-Smith J, et al. Systematic review and meta-analysis of the diagnostic value of four biomarkers in detecting neonatal sepsis in low- and middle-income countries. BMJ Paediatr Open. 2023 Jan;7(1):e001627. doi: 10.1136/bmjpo-2022-001627. PMID: 36649385; PMCID: PMC9835957.
13. Worku M, Aynalem M, Biset S, Woldu B, Adane T, Tigabu A. Role of complete blood cell count parameters in the diagnosis of neonatal sepsis. BMC Pediatr. 2022 Jul 13;22(1):411.
14. Hornik CP, Benjamin DK, Becker KC, Benjamin DK Jr, Li J, Clark RH, et al. Use of the complete blood cell count in early-onset neonatal sepsis. Pediatr Infect Dis J. 2012 Aug;31(8):799-802
15. Arif SH, Ahmad I, Ali SM, Khan HM. Thrombocytopenia and bacterial sepsis in neonates. Indian J Hematol Blood Transfus. 2012 Sep;28(3):147-51.

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