Section: Pediatrics

Original Research Article

# A PROSPECTIVE STUDY ON INCIDENCE RISK FACTORS AND OUTCOME OF BACTERIAL MENINGITIS IN NEONATES WITH SUSPECTED SEPTICEMIA ADMITTED IN NEONATAL INTENSIVE CARE UNIT IN TERTIARY CARE HOSPITAL

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ABSTRACT

**Background:** The aim is to study the incidence, risk factors and outcome for bacterial meningitis in neonates with clinical suspicion of sepsis in Neonatal Intensive Care Unit (NICU) of tertiary care hospital.

**Materials and Methods:** It was a prospective observational study. 100 neonates with clinical suspicion of sepsis are included. The current study was conducted in the Department of Pediatrics, Guntur Medical College, Guntur, Andhra Pradesh, India. Patients includes neonates who got admitted in the NICU with symptoms and clinical features suggestive of sepsis.

**Results:** 18% of the neonates had meningitis. There is significant difference in term of babies between two groups of neonates. Neonates below 37 weeks are more likely to develop meningitis, and there is significant association seen. In the present study, there is significant difference in the presence of altered sensorium in between two groups of neonates. Overall, 23 neonates had altered sensorium. There is significant association between AF bulge and meningitis. There is significant association between seizures and meningitis. We found there is no significant difference in RESP distress in the presence of between two groups of neonates. We observed that there is significant difference in CSF analysis and CSF cell count in between two groups of neonates. There is significant difference in organism isolated in between two groups of neonates. There is significant difference in outcome till 1 month in between two groups of neonates. 2 neonates had post meningitic sequelae and rop 1 had abnormal oae.

**Conclusion:** The present study concluded that, prolonged labor and PROM were found to be linked with the development of neonatal meningitis along with preterm birth and low gestational age. We recommend routine CSF analysis for all neonates suffering from sepsis irrespective of clinical features. Early diagnosis and treatment may reduce neonatal meningitis-associated complications. Further multicenter studies with intense methods are needed to develop better evidence.

**Keywords:** Neonates, Meningitis, CSF, Sensorium,

## INTRODUCTION

Neonatal meningitis is most commonly seen in infants during their first month of age. It is the major cause of morbidity and mortality around the globe. Furyk et al,[1] found that in developed countries, the occurrence of this condition is between 0.2 and 0.5 cases for every 1,000 live births. Developing nations experience much higher rates, with estimates ranging from 1.1 to 1.9 cases per 1,000 live births.[2] In India, the incidence of neonatal sepsis is reported at 0.5 per

1,000 live births. Globally, around 126,000 cases of neonatal meningitis are estimated annually, with over 50,000 resulting in death. Daoud et al,[3] says that mortality rates differ by region, with Sub-Saharan Africa reporting rates ranging from 0.7 to 1.9 per 1,000 live births, the Middle East and North Africa showing rates between0.33 and 1.5, and the Americas and Caribbean having rates from 0.4 to 2.8.

Developing nations bear the greatest burden of neonatal sepsis and meningitis. According to WHO estimates, around 5 million neonatal deaths occur annually, with 98% happening in developing countries. Weber.[4,5] Informed that neonatal meningitis contributes to this burden. The other causes of the rising neonatal deaths include infections, prematurity, and birth asphyxia. The actual incidence of neonatal bacterial meningitis may be underreported in resource-limited settings due to diagnostic challenges, disparities between hospital and community data, regional variations, and unregistered deaths in areas with limited healthcare access.

A well-documented link exists between bacterial sepsis and meningitis, in which neonates experiencing sepsis at greater risk for developing meningitis. Research suggests that meningitis complicates around 20% of early-onset sepsis and 10% of late-onset sepsis cases.[6] This risk is more in preterm neonates, who are two to three times more likely to develop meningitis compared to term neonates and constitute the majority of late-onset cases. Hristeva et al,[7] reported that Meningitis is undoubtedly more prevalent during the neonatal period compared to any other stage of life. Delouvois et al,[8] reported that neonates who experience sepsis face an increased risk of developing meningitis. In view of less literature on same topic in South India, the current study was undertaken.

**Aims and Objectives**

**Aim:** To study the incidence, risk factors and outcome for bacterial meningitis in neonates with clinical suspicion of sepsis in Neonatal Intensive Care Unit (NICU) of tertiary care hospital.

**Objectives:**

1. To estimate the incidence of bacterial meningitis in neonates with suspected sepsis.
2. To evaluate the risk factors for bacterialmeningitis.
3. To analyze the outcome of neonates with bacterial meningitis.

## MATERIALS AND METHODS

The current study was conducted in the Department of Pediatrics, Guntur Medical College, Guntur, Andhra Pradesh, India.

**Study period: 24 months:** March 2023 to February 2025

**Type of study:** Prospective Observational Study

**Source of data:** Neonates with sepsis

**Sampling procedure:** Convenience sampling

**Sample size:** 100 neonates with clinical suspicion of sepsis are included.

**Inclusion criteria:**

- Neonates who got admitted in the NICU with symptoms and clinical features suggestive of sepsis
- Parents who agree to give consent for this study

**Exclusion Criteria**

- Majorcongenital anomalies like tef, cdh, spinabifida and Myelomeningocele, meningocele.
- Neonates with suspected IEM
- Neonates with incomplete data

**Methodology or procedure**

- After getting approval from the IEC, this study was conducted.
- Assurance was provided regarding the maintenance of confidentiality.
- Thorough history from every parent was taken.
- Demographics were recorded.
- Clinical examination findings were noted.
- Data was entered in a case record form designed for the study and it was subjected to statistical analysis.

**Table 1. Bacterial meningitis was confirmed using CSF analysis through lumbar puncture as per the following table**

| Values | Term Neonates (<28 days) | Preterm Neonates (<28 days) |
|---|---|---|
| WBC(Count/mm3) | 6 (0 to 21) | 9 (0 - 30) |
| Neutrophils | Below 60% | 80 to 100% |
| Glucose- mg/dl | 54 (27 to 99) | 54 (27 to 99) |
| Protein mg/dl | 60 (30 to 200) | 100(50 to 250) |
| CSF CULTURE | +/- | +/- |

**Statistical Analysis:** The data were analyzed with the following assumptions:

1. The dependent variables were assumed to be normally distributed.
2. Variables showing skewness were transformed using log values to achieve a normal distribution.

Data analysis was performed using Microsoft Excel and the free version of Epi Info software (version 7.2.6).

Frequencies and percentages were reported, and means along with standard deviations (SD) were used to summarize the data.

1st incidence of bacterial meningitis was assessed. Then numerical parameters between neonates with and without meningitis was done using students T test and categorical parameters were compared with chi sqaure test P value below 0.05 is significant.

**Ethical Considerations:** Approval for the study was obtained from the Institutional Ethics Committee (IEC) at Guntur Medical College, Guntur
Each parent was informed about the study's purpose and the benefits of their data being used for research. Parents were assured that their data would be kept confidential. After explaining the details, an informed consent form was provided in the local or an understandable language, which the participants signed or marked with a thumbprint.
Parents were reassured that any questions or concerns they had could be addressed at any time.

## RESULTS

**Table 2: Age at Presentation**

| **Means** | | | |
|---|---|---|---|
| **Meningitis group** | **NO.** | **Mean** | **Std Dev** |
| No | 82.0000 | 21.4 | 6.9474 |
| Yes | 18.0000 | 20.32 | 8.7636 |
| **T-Test** | | | |
| **DF** | **t Value** | **P Value** | |
| 98 | 0.82 | 0.4159 | |

There is no significant difference in mean age in between two groups of neonates. Mean age of neonates with meningitis was 20 days.

**Table 3: Term of Babies**

| | **Meningitis** | | |
|---|---|---|---|
| **Term** | **No** | **Yes** | **Total** |
| Above 37 weeks | 43 | 7 | 50 |
| Below 37 weeks | 39 | 11 | 50 |
| Total | 82 | 18 | 100 |
| **Chi-square** | **P Value** | | |
| 1.0840 | 0.02 | | |

Neonates below 37 weeks are more likely to develop meningitis, there was significant association.

**Table 4: Gender of neonates**

| | **Meningitis** | | |
|---|---|---|---|
| **Gender** | **No** | **Yes** | **Total** |
| F | 43 | 10 | 53 |
| M | 39 | 8 | 47 |
| Total | 82 | 18 | 100 |
| **Chi-square** | **P value** | | |
| 0.0576 | 0.8104088338 | | |

There is no significant difference in gender in between two groups of neonates.

**Table 5: Birth Weight: Range**

| **Means** | | | |
|---|---|---|---|
| **Meningitis group** | **No.** | **Mean** | **Std Dev** |
| No | 82.0000 | 2.8037 | 0.3889 |
| Yes | 18.0000 | 2.297 | 0.3556 |
| **T-Test** | | | |
| **DF** | **t Value** | **P-value** | |
| 98 | 1.09 | 0.02 | |

There is significant difference in mean birth weight in between two groups of neonates.

**Table 6: Mode of Delivery**

| | **Meningitis** | | |
|---|---|---|---|
| **Mode of delivery** | **No** | **Yes** | **Total** |
| LSCS | 32 | 7 | 39 |
| NVD | 50 | 11 | 61 |
| TOTAL | 82 | 18 | 100 |
| **Chi-square** | **P-value** | | |
| 0.0001 | 0.9914842792 | | |

There is no significant difference in mode of delivery in between two groups.

**Table 7. Apgar score at 1 min**

| Means | | | |
|---|---|---|---|
| **Meningitis group** | **No.** | **Mean** | **Std Dev** |
| No | 82.0000 | 7.3415 | 1.1990 |
| Yes | 18.0000 | 6.9444 | 1.2113 |
| **T-Test** | | | |
| **DF** | **t Value** | **P-value** | |
| 98 | 1.27 | 0.2071 | |

There is no significant difference in mean APGAR score at 1min in between two groups of neonates.

**Table 8: APGAR SCORE AT 5 MINS.**

| Means | | | |
|---|---|---|---|
| **Meningitis group** | **No.** | **Mean** | **Std Dev** |
| No | 82.0000 | 8.1098 | 1.5396 |
| Yes | 18.0000 | 8.3333 | 1.2367 |
| **T-Test** | | | |
| **DF** | **t Value** | **P-Value** | |
| 98 | -0.58 | 0.5660 | |

There is no significant difference in mean APGAR score at 5 mins in between two groups of neonates.

**Table 9: Type of sepsis**

| | **Meningitis** | | |
|---|---|---|---|
| **Type of sepsis** | **No** | **Yes** | **Total** |
| EOS | 6 | 4 | 10 |
| LOS | 76 | 14 | 90 |
| Total | 82 | 18 | 100 |
| **Chi-square** | **P-Value** | | |
| 1.31 | 0.961 | | |

**Table 10: Maternal Risk Factors for Sepsis:**

| | **Meningitis** | | |
|---|---|---|---|
| **Maternal risk factor** | **No** | **Yes** | **Total** |
| Anemia | 4 | 4 | 8 |
| GDM | 2 | 3 | 5 |
| NIL | 54 | 0 | 54 |
| Maternal fever and foul smelling liqour | 3 | 2 | 5 |
| Repeated vaginal exams | 1 | 0 | 1 |
| Preeclampsia | 1 | 3 | 4 |
| Prolonged labour | 2 | 1 | 3 |
| Prom | 3 | 1 | 4 |
| Thyroid disorder | 10 | 3 | 13 |
| UTI | 2 | 1 | 3 |
| Total | 82 | 18 | 100 |
| **Chi-Squared** | **df** | **P-Value** | |
| 14.67 | 7 | 0.014 | |

There is significant difference in maternal risk factors in between two groups. Mothers with comorbidities delivered more neonates with meningitis.

**Table 11: Neonatal risk factors for sepsis**

| | **Meningitis** | | |
|---|---|---|---|
| **Neonatalrisk factor** | **No** | **Yes** | **Total** |
| LBW | 6 | 3 | 9 |
| SUPERFICIAL SKIN INFECTIONS | 3 | 1 | 4 |
| FORMULA FEEDS | 3 | 1 | 4 |
| INVASIVE VENTILATION | 6 | 1 | 7 |
| INVASIVE PROCEDURES | 8 | 1 | 9 |
| PREMATURITY | 39 | 11 | 50 |
| NIL | 17 | 0 | 17 |
| Total | 82 | 18 | 100 |
| **Chi-Squared** | **df** | **P-Value** | |
| 70.0743 | 7 | 0 | |

**Table 12: Refusal of feeds**

| | Meningitis | | |
|---|---|---|---|
| **Refusal to feed** | **No** | **Yes** | **Total** |
| No | 39 | 6 | 45 |
| Yes | 43 | 12 | 55 |
| Total | 82 | 18 | 100 |
| **Chi-square** | **P-Value** | | |
| 6.23 | 0.02 | | |

There is significant difference in refusal of feeds in between two groups of neonates. Overall 55 neonates had failure to take feed.

**Table 13: FEVER**

| | MENINGITIS | | |
|---|---|---|---|
| **Fever** | **No** | **Yes** | **Total** |
| No | 70 | 3 | 73 |
| Yes | 12 | 15 | 27 |
| Total | 82 | 18 | 100 |
| **Chi-square** | **P-Value** | | |
| 35.3430 | 0.000000 | | |

There is significant difference in the presence of fever in between two groups of neonates. Overall, 27 neonates had fever. Fever is commonly seen among neonates with meningitis.

**Table 14: LETHARGY:**

| | Meningitis (Y/N) | | |
|---|---|---|---|
| **LETHARGY (Y/N)** | **N** | **Y** | **Total** |
| N | 37 | 5 | 42 |
| Y | 45 | 13 | 58 |
| Total | 82 | 18 | 100 |
| **Chi-square** | **2-tailed p** | | |
| 1.8227 | 0.1769916781 | | |

There is no significant association between lethargy and meningitis

**Table 15: Vomiting**

| | Meningitis | | |
|---|---|---|---|
| **Vomiting** | **No** | **Yes** | **Total** |
| No | 68 | 4 | 72 |
| Yes | 14 | 14 | 28 |
| Total | 82 | 18 | 100 |
| **Chi-square** | **P-value** | | |
| 26.9798 | 0.0000002056 | | |

There is significant difference in the presence of vomiting in between two groups of neonates. Overall, 28 neonates had vomiting.

**Table 16: Altered Sensorium:**

| | Meningitis | | |
|---|---|---|---|
| **Altered sensorium** | **No** | **Yes** | **Total** |
| No | 74 | 3 | 77 |
| Yes | 8 | 15 | 23 |
| Total | 82 | 18 | 100 |
| **Chi-square** | **P-value** | | |
| 45.1185 | 0.00000 | | |

There is significant difference in the presence of altered sensorium in between two groups of neonates. Overall, 23 neonates had altered sensorium.

**Table 17: Anterior fontanelle bulge:**

| | Meningitis (Y/N) | | |
|---|---|---|---|
| **AF Bulge(Y/N)** | **N** | **Y** | **Total** |
| N | 82 | 4 | 86 |
| Y | 0 | 14 | 14 |
| Total | 82 | 18 | 100 |
| **Single Table Analysis** | | | |
| **Chi-square** | **2-tailed p** | | |
| 74.1602 | 0.0000000000 | | |

There is significant association between AF bulge and meningitis

**Table 18: Seizures.**

| | Meningitis | | |
|---|---|---|---|
| **Seizures** | **No** | **Yes** | **Total** |
| Nil | 82 | 10 | 92 |
| Yes | 0 | 8 | 8 |
| Total | 82 | 18 | 100 |
| **Chi-square** | **P-value** | | |
| 2.34 | 0.04 | | |

There is significant difference in the presence of seizures in between two groups of neonates. Overall, 8 neonates had seizures.

**Table 19: Respiratory Distress**

| | Meningitis | | |
|---|---|---|---|
| **Resp distress** | **No** | **Yes** | **Total** |
| NIL | 81 | 8 | 89 |
| Yes | 1 | 10 | 11 |
| Total | 82 | 18 | 100 |
| **Chi-square** | **P-value** | | |
| 2.14 | 0.32 | | |

There is no significant difference in the presence of resp distress in between two groups of neonates. Overall, 11 neonates had respiratory distress.

**Table 20: CRP.**

| CRP | Frequency | Percent |
|---|---|---|
| N | 25 | 25.00% |
| P | 75 | 75.00% |
| Total | 100 | 100.00% |

75% of the patients had Positive CRP

**Table 21: Organism Isolated-Sepsis.**

| | Meningitis | | |
|---|---|---|---|
| **Blood organism** | **No** | **Yes** | **Total** |
| CONS | 9 | 4 | 13 |
| E COLI | 3 | 2 | 5 |
| ENTEROCOCCUS | 2 | 0 | 2 |
| GBS | 6 | 3 | 9 |
| KP | 10 | 3 | 13 |
| MRSA | 3 | 2 | 5 |
| MSSA | 1 | 2 | 3 |
| NIL | 46 | 0 | 46 |
| Pseudomonas | 1 | 1 | 2 |
| Streptococcus pneumoniae | 1 | 1 | 2 |
| Total | 82 | 18 | 100 |
| **Chi-Squared** | **df** | **Probability** | |
| 27.5126 | 9 | 0.0012 | |

There is significant difference in organism isolated in between two groups of neonates. Overall, 13 patients had CONS. Among them, 4 had meningitis.

1. **CSF-GLUCOSE (mg/dl):** The mean CSF glucose level was 42.11 mg/dl with a standard deviation of 4.80, ranging from 30 to 49 mg/dl, suggesting moderately low variation among patients.
2. **CSF-PROTEIN (mg/dl):** The mean CSF protein level was 221.78 mg/dl with a standard deviation of 17.98, ranging from 204 to 267 mg/dl, indicating slightly wider variability in protein concentration.
3. **CSF-CELL COUNT (cells/mm³):** The mean CSF cell count was 22.61 cells/mm³ with a standard deviation of 3.35, ranging from 18 to 30 cells/mm³, showing relatively low variability in cellular content.

**Table 22: CSF glucose**

| **Means** | | | |
|---|---|---|---|
| **Meningitis group** | **No** | **Mean** | **Std Dev** |
| N | 82.0000 | 85.7927 | 2.6515 |
| Y | 18.0000 | 42.2778 | 4.8484 |
| **T-Test** | | | |
| **DF** | **t Value** | **P-value** | |
| 98 | 53.16 | 0.0000 | |

There is significant difference in mean CSF glucose between two groups of patients

**Table 23: CSF- Protein**

| Means | | | |
|---|---|---|---|
| **Meningitis group** | **No.** | **Mean** | **Std Dev** |
| N | 82.0000 | 47.0122 | 3.9079 |
| Y | 18.0000 | 221.0556 | 18.8101 |
| **T-Test** | | | |
| DF | t Value | P-value | |
| 98 | -77.73 | 0.0947 | |

There is no significant difference in mean CSF protein between two groups of patients

**Table 24: CSF- CELL COUNT:**

| Means | | | |
|---|---|---|---|
| **Meningitis group** | **No.** | **Mean** | **Std Dev** |
| N | 82.0000 | 1.5488 | 1.0202 |
| Y | 18.0000 | 23.0000 | 3.5480 |
| **T-Test** | | | |
| **DF** | **t Value** | **P-value** | |
| 98 | -47.24 | 0.0000 | |

There is significant difference in mean CSF cell count between two groups of patients

**Table 25: Organism isolated-csf culture:**

| CSF Organism | Frequency | Percent |
|---|---|---|
| CONS | 4 | 4.00% |
| E COLI | 2 | 2.00% |
| GBS | 3 | 3.00% |
| KP | 3 | 3.00% |
| MRSA | 2 | 2.00% |
| MSSA | 2 | 2.00% |
| NO | 82 | 82.00% |
| PSEUDOMONAS | 1 | 1.00% |
| SP | 1 | 1.00% |
| Total | 100 | 100.00% |

4% of the patients had CONS.

**Table 26: Meningitis.**

| Meningitis | Frequency | Percent |
|---|---|---|
| No | 82 | 82.00% |
| Yes | 18 | 18.00% |
| Total | 100 | 100.00% |

18% of the neonates had meningitis.

**Table 27: Outcome till 1 month.**

| | MENINGITIS | | |
|---|---|---|---|
| **Outcome till 1 month** | **No** | **Yes** | **Total** |
| DISCHARGED | 71 | 12 | 83 |
| EXPIRED | 11 | 1 | 12 |
| OAE | 0 | 1 | 1 |
| ROP | 0 | 2 | 2 |
| POST MENINGITIC SEQUELAE | 0 | 2 | 2 |
| Total | 82 | 18 | 100 |
| **Chi-Squared** | **df** | **P-Value** | |
| 31.24 | 4 | 0 | |

There is significant difference in outcome till 1 month in between two groups of neonates. 1 neonate with meningitis expired. 9 expired due to sepsis.

## DISCUSSION

The current study was done on 100 neonates with sepsis.1st incidence of meningitis was identified using CSF analysis. Then all parameters were seen to know the risk factors for the development of meningitis.

Current study result interpretation and comparison with other studies:

**Prevalence of Meningitis:** 18% of neonates had meningitis in this study. As per CP SINGH et al,[11] Meningitis prevalence in neonatal sepsis was 22.0%. Among EOS cases, the rate was 18.0%, late neonatal sepsis cases showed a rate of 32.6%.

A study done in Australia by Isaacs et al,[2] reviewed 320 episodes of sepsis in neonatal units, affecting 294 newborns. Objective was to study regional variations in incidence of late onset neonatal infections. Of these episodes, 31% were early- onset, and 3.0% of newborns admitted to six tertiary neonatal units

developed late-onset sepsis. Meningitis was identified in 13 cases (5.9%) of LOS,

A study by SONI9on 1,075 neonates who were evaluated for eligibility, out of which 191 neonates who underwent LP and had complete CSF parameter data were included in their study. All enrolled neonates presented with symptoms at admission, with respiratory distress as the most common symptom, occurring in 82.2% of cases. Among the 191 neonates, 64 were diagnosed with meningitis.

**Risk factors of meningitis:** There is significant difference in maternal risk factors in between two groups of neonates. Overall, 13 mothers had thyroid disorder 3 had meningitis. Overall, 8 mothers had anemia, among them, 4 had meningitis. 5 mothers had GDM, 3 of them neonates had meningitis. 4 mothers had preeclampsia. 3 of their neonates had meningitis. 3 mothers had prolonged labour, 1 of their neonates had meningitis. 4 mothers had PROM. 1 of them had meningitis in the current study. Maternal co morbidities are found to be risk factors for neonatal meningitis Maternal chorioamniotis, is identified as a risk factor.

There is no significant difference in mode of delivery in between two groups of neonates. Among them, 11 had NVD type of delivery in the current study. So, mode of delivery is not a risk factor.

There is no significant difference in mean age in between two groups of neonates. Mean age of neonates with meningitis was 20.3 days. There is no significant difference in gender in between two groups of neonates. Overall, 47 neonates were males. Among them, 8 neonates had meningitis. So, gender is not a risk factor. There is significant difference in term of babies between two groups of neonates. So, preterm is a risk factor. There is significant difference in mean birth weight in between two groups of neonates. So birth weight is a risk factor for the development of meningitis. In a study by pong et al,[14] the risk factors for neonates with meningitis is more likely to be premature end of low birth weight . In Parlakay Study (2023):13118 neonates were diagnosed with meningitis during the study period. Retrospective study for 6 yrs.[12] were with early sepsis and 106 were with late sepsis. Median gestational age of the patients was 32 weeks Parlakay found that Median birth weight was 1987 gramsamong 118 neonates with sepsis.

In the current study, low birth weight was found to be a significant risk factor for meningitis development. The following risk factors were identified by Soni et al,[9] In the meningitis group, PPROM (lasting more than 18 hours) was twice as common as the non-meningitis group (18% vs. 9.4%; P = 0.067), but this difference did not have statistical significance.

As per CP Singh et al,[11] factors associated with an increased risk of meningitis in early neonatal sepsis included twin birth, PROM, inadequate antenatal care (ANC) visits, and acid-base imbalance. In LOS, low platelet counts and chest X-ray findings indicative of pneumonitis were linked to a higher risk of meningitis.

According to Furyk et al,[1] neonatal meningitis risk factors in developing regions include LBW and prematurity on the part of the newborn. Maternal risk factors include PROM, PPROM, maternal colonization with GBS, chorioamnionitis, and low socioeconomic status.

**Clinical features:** There is significant difference in refusal of feed in between two groups of neonates. Overall, 55 neonates were refused to feed. Among them, 12 had meningitis. There is no significant difference in the presence of respiratory distress in between two groups of neonates. There is significant difference in the presence of seizures in between two groups of neonates.

Seizures are more commonly seen in neonates with meningitis. There is significant difference in the presence of fever in between two groups of neonates. Overall, 27 neonates had fever. Among them, 15 had meningitis.

There is significant difference in vomiting in between two groups of neonates. Overall, 28 neonates had vomiting. Among them 14 had meningitis. There is significant difference in altered sensorium in between two groups of neonates. Overall, 23 neonates had altered sensorium. Among them 15 had meningitis in the current study.As per SONI9 study on 191 neonates with 64 having meningitis.

Symptoms including lethargy, poor feeding, apnea, seizures, and bulging fontanelles may indicate meningitis.

There were no variations in clinical signs or symptoms, indicating that the evaluated clinical features did not effectively differentiate meningitis cases.

But, the study findings showed that none of these symptoms are specific to meningitis and can reliably identify at-risk neonates. These results are same as recent study in which researchers sought to identify low-risk neonates for whom LP could be safely avoided as per DALAI R,et al12The findings also showed that the chance of meningitis is similar in early- and late-onset sepsis. Therefore, their study stressed that LPs should not be restricted to cases of LOS butshould be done in all symptomatic neonates suspected of having sepsis, regardless of symptom type or timing of onset.

**Type of sepsis:** There is no significant difference in type of sepsis in between two groups of neonates. Overall, 10 neonates had EOS. 90 neonates had LOS. 14 had neonatal meningitis among 90 LOS.

- AS PER STUDY BY Parlakay44 found that 90% of the meningitis cases were associated with late-onset sepsis, similar to the current study, where more number of LOS are seen though the difference is not different.
- The diagnosis day was significantly later for neonates with poor prognosis ( p = 0.03).

**As Per Soni Study-** Among symptomatic neonates included in the study, the frequency of meningitis was comparable between early-onset and late-onset sepsis groups (32.6% vs. 35.6%; P = 0.7).

**Outcomes:** There is significant difference in outcome till 1 month in between two groups of neonates. Overall, 83 neonates were discharged. Among them, 12 had meningitis. 1 neonate was expired. That 2 neonate had postmeningitic sequelae. 1 neonate was found abnormal OAE. 2 neonates developed ROP.Where as IN PARLAKAY study in long term followup have neuromotor retardation and hearing problems.

All babies had a good outcome with no neurodevelopmental impairment as perHristeva et al.[7]

There is significant difference in organism isolated in between two groups of neonates in the current study.

**CSF Analysis:** Among 18 neonates with meningitis, the organism isolated are 11 had gram positive organism. 4 had CONS 2 had MRSA, 2 had MSSA, 3 had GBS, 2 had E. coli

**Blood culture:** There is a significant difference in the blood organisms isolated between neonates with and without meningitis. Klebsiella pneumoniae (KP) was present in 3 neonates. Other isolated are Pseudomonas and Streptococcus pneumoniae (SP) in CSF culture.

Among the 100 neonates, 54% had organism in Blood. Most common was KP. It was seen in 13 neonates CONS was seen in 13 neonates GBS was seen in 9 neonates, MRSA in 5 neonates, MSSA in 3 neonates, E coli in 5 neonates in the current study.

Enterococcus was found in blood not in CSF in the current study.

1. **CSF-GLUCOSE (mg/dl):**

The mean CSF glucose level was 42.11 mg/dl with a standard deviation of 4.80, ranging from 30 to 49 mg/dl, suggesting moderately low variation among patients.

2. **CSF-PROTEIN (mg/dl):**

The mean CSF protein level was 221.78 mg/dl with a standard deviation of 17.98, ranging from 204 to 267 mg/dl, indicating slightly wider variability in protein concentration.

3. **CSF-CELL COUNT (cells/mm³):**

The mean CSF cell count was 22.61 cells/mm³ with a standard deviation of 3.35, ranging from 18 to 30 cells/mm³, showing relatively low variability in cellular content in the current study

In Parlakay Study (2023)13Various correlations with CSF findings and outcomes were seen: CSF leukocytes were significantly more among term babies with abnormal cranial MRI findings ($p = 0.03$) and hearing loss ($p = 0.04$). CSF glucose levels were significantly less among preterm babies with:

- Neuromotor retardation ($p = 0.001$)
- History of seizures ($p = 0.003$)
- Abnormal cranial MRI findings ($p = 0.008$)
- Hearing loss ($p = 0.005$)

These findings indicate that prematurity, more CSF leukocyte counts, and abnormal neuroimaging are main markers for poor prognosis in neonates with meningitis.

In a study by CP Singh,[11] identified three cases (13%) of bacterial meningitis with positive (CSF) cultures but negative blood cultures, which included one probable Group B Streptococcal case, one confirmed S.mitis case.

The findings from lumbar punctures guided the antibiotic selection and duration of treatment.

IN A STUDY BY Isaacs et al,[2] reported that coagulase-negative Staphylococci were the most common cause of late-onset sepsis, with 26 episodes of S. aureus septicemia, only one of which was due to MRSA. and the mortality rate was 7.7%. Research by Pong et al,[14] highlighted that diagnosing neonatal meningitis requires CSF sampling. Bacterial culture remains the definitive diagnostic method, with gram-stained smears offering early indications of the causative agent.

A STUDY BY SONI9on 191 neonates with 64 having meningitis. Of these, five cases were culture-confirmed meningitis caused by Acinetobacter spp. (3 cases), Klebsiella (1 case), Achromobacter (1 case), and 59 cases were classified as probable meningitis. No variations in risk factors were observed between individuals with meningitis and those without it.

7.8% of meningitis cases were confirmed through culture, reflecting a low output of organisms. Risk factors and clinical signs could not differentiate infants with meningitis from those without the condition.

Patients with Gram-negative sepsis showed a slightly higher rate of meningitis than those with Gram-positive sepsis (43.2% vs. 22.5%; $P = 0.07$), though this difference was not statistically significant.

The pathogen profile and rates of MDR were consistent with prior studies done in similar populations. In Jajoo et al,[15] Candida species (22.7%) and Klebsiella pneumoniae (12.5%) were the most commonly isolated pathogens in the outborn cohort of the Delhi Neonatal Infection Study. IN CHAURASIA ET AL,[16] alarming multidrug resistance rates were identified among Gram-negative pathogens, especially Acinetobacter baumannii and CoNS.

An Indian study by Aggarwal at et al,[16] in 2001 recommended perfermoing lumbar puncture (lp) in cases of EOS with a poistive blood culture or clinical symptoms of specticemia.for late-onset sepsis ,lp should be done in all newborns showing symptoms before initiating anitbiotic treatment.

## CONCLUSION

The current study was done on 100 neonates with sepsis admitted at our tertiary care center Prolonged labor and PROM were found to be linked with the development of neonatal meningitis along with preterm birth and low gestational age. We recommend routine CSF analysis for all neonates suffering from sepsis irrespective of clinical features. Early diagnosis and treatment may reduce neonatal

meningitis-associated complications. Further multicenter studies with intense methods are needed to develop better evidence.

## REFERENCES


1. Furyk JS, Swann O, Molyneux E. Systematic review: neonatal meningitis in the developing world. Trop Med Int Health. 2011;16(6):672-9.
2. Isaacs D, Barfield C, Clothier T, Darlow B, Diplock R, Ehrlich J, et al. Late- onset infections of infants in neonatal units. J Paediatr Child Health. 1996;32(2):158-61.
3. Daoud AS, al-Sheyyab M, Abu-Ekteish F, Obeidat A, Ali AA, El-Shanti H. Neonatal meningitis in northern Jordan. J Trop Pediatr. 1996;42(5):267-70.
4. Stoll BJ. The globalimpact ofneonatal infection. Clin Perinatol.1997;24(1):1-21.
5. Weber MW, Carlin JB, Gatchalian S, Lehmann D, Muhe L, Mulholland EK, WHO Young Infants Study Group. Predictors of neonatal sepsis in developing countries. Pediatr Infect Dis J. 2003;22(8):711-7.
6. Osrin D, Vergnano S, Costello A. Serious bacterial infections in newborn infants in developing countries. Curr Opin Infect Dis. 2004;17(3):217-24.
7. Hristeva L, Booy R, Bowler I, Wilkinson AR. Prospective surveillance of neonatal meningitis. Arch Dis Child. 1993;69(1):14-8.
8. De Louvois J, Blackbourn J, Hurley R, Harvey D. Infantile meningitis in England and Wales: a two-year study. Arch Dis Child. 1991;66(5):603-7.
9. Soni PK, Kumar J, Angrup A, et al. Meningitis among neonates with suspected sepsis presenting to pediatric emergency. Pediatr Infect Dis J. 2023 Apr 1;42(4):e124-7. doi: 10.1097/INF.0000000000003816.
10. Pong A, Bradley JS. Bacterial meningitis and the newborn infant. Infect Dis Clin North Am. 1999;13:711–733. doi: 10.1016/s0891-5520(05)70102-1.
11. Singh CP, Seep S. Assessment of the prevalence of meningitis in clinically suspected cases of early and late onset neonatal sepsis. Int J Contemp Pediatr. 2024;11:157-61.
12. Dalai R, Dutta S, Pal A, et al. Is lumbar puncture avoidable in low-risk neonates with suspected sepsis? Am J Perinatol. 2022;39:99–105.
13. Parlakay G, Çakır SÇ, Dorum BA, Özkan H, Çelebi S, Hacımustafaoğlu M, Köksal N. Evaluation of risk and prognostic factors in neonatal meningitis. J Curr Pediatr. 2023 Apr;21(1):16-22. doi:10.4274/jcp.2022.16878.
14. Pong A, Bradley JS. Bacterial meningitis and the newborn infant. Infect Dis Clin North Am. 1999;13:711–733. doi: 10.1016/s0891-5520(05)70102-1.
15. Jajoo M, Manchanda V, Chaurasia S, et al. Alarming rates of antimicrobial resistance and fungal sepsis in outborn neonates in North India. PLoS One. 2018;13:e0180705.
16. Chaurasia S, Sivanandan S, Agarwal R, et al. Neonatal sepsis in South Asia: huge burden and spiraling antimicrobial resistance. BMJ. 2019;364:k5314.