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Dr. Nisha Patel
Department of Pathology, B.J. Medical College and Civil Hospital, Asarwa, Ahmedabad, Gujarat, India

Dr. Shakera Laxmidhar
Associate Professor, Department of Pathology, B.J. Medical College and Civil Hospital, Asarwa, Ahmedabad, Gujarat, India

Corresponding Author:
Dr. Nisha Patel
Department of Pathology, B.J. Medical College and Civil Hospital, Asarwa, Ahmedabad, Gujarat, India

CSF analysis and interpretation in patients of neurological conditions at tertiary care hospital

Nisha Patel and Shakera Laxmidhar

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Abstract

Background: CSF analysis is a critical diagnostic tool in evaluating neurological infections, particularly meningitis. Early identification of biochemical and cytological alterations in CSF significantly improves clinical outcomes. This study aimed to analyse CSF characteristics across age groups and categorize meningitis cases using WHO criteria in tertiary care setting.

Methods: A retrospective observational study was conducted on 500 CSF samples collected from patients of all ages between November 2024 and November 2025. CSF specimens underwent gross, biochemical (protein and glucose), and microscopic (cell counts and differential) examination. Findings were used to classify cases as bacterial meningitis, probable bacterial meningitis, aseptic meningitis, or no meningitis according to WHO recommendations.

Results: Infants(<1year) constituted the largest proportion of cases (40.3%), with an overall male predominance (59.5%). The most frequent clinical presentations were fever (21%), seizures (18.6%), and poor feeding (16.2%). CSF analysis showed elevated protein (>90 mg/dL) in 32.8% and reduced glucose (≤40 mg/dL) in 45.8% of samples. Polymorph dominance correlated strongly with bacterial meningitis, whereas lymphocyte predominance was characteristic of aseptic meningitis. WHO categorization revealed 24.6% bacterial meningitis, 33.4% probable bacterial meningitis, 14.5% aseptic meningitis, and 29.7% non-meningitis cases. Infants showed the highest burden of bacterial and probable bacterial meningitis.

Conclusion: CSF evaluation demonstrates high diagnostic utility in distinguishing meningitis subtypes, particularly among infants. Elevated protein, low glucose, and polymorph predominance remain strong indicators of bacterial etiology. The study underscores the essential role of comprehensive CSF analysis and WHO-based classification in early diagnosis and management of neurological infections.

Keywords: Cerebrospinal Fluid, Meningitis

Introduction

Cerebrospinal fluid (CSF) is a clear fluid which is formed as a ultra filtrate of plasma. CSF is present in both the intracranial and spinal compartments. It is continuously being secreted by the choroid plexus at a constant rate inside the ventricles of the brain and circulates in the subarachnoid space of the brain and spinal cord through CSF pathways. The total volume of CSF in the adult is approximately 140 mL. CSF is produced at a rate of 0.2-0.7 mL per minute or 500- 700 mL per day. Volume of CSF in neonates varies from 10 to 60 ml. Total CSF volume is replaced every 5 to 7 hours. CSF absorption occurs at the arachnoid villi, predominantly along superior sagittal sinus [1, 2].

The main function of the CSF is to reduce buoyancy of the brain. It also supplies nutrients as well as helps in removal of various substances like amino acids, neurotransmitters, metabolic byproducts and cells.

CSF composition and pressure are normally stable but can change in disease conditions. CSF analysis usually consists of measuring opening pressure measurement, biochemical analysis, microscopical examination, cytology and biomarkers assay. Hence analysis of CSF by various methods will help in diagnosis as well as prognosis and response to therapy. It is especially valuable in acute neurological conditions and can also serve as a therapeutic procedure in some cases (e.g., lumbar puncture with CSF drainage) [2, 3].

Materials and Methods

A retrospective study was conducted at B.J Medical College and Civil Hospital, Ahmedabad from November 2025 to November 2025 where a total of 500 cases were included.

Subject selection

Inclusion criteria

1. Patients of all age groups are included. Exclusion criteria:
2. Patients with uncorrected bleeding diathesis and reduced Platelet count.
3. Non-communicating obstructive hydrocephalus
4. Cases with identifiable organic lesion in brain on CT scan

Methodology

Specimen Collection

LP can be performed either in lateral or sitting posture. Usually under sterile precautions, 22-24 G spinal needle is inserted after identifying the lumbar L2-3 or L3-4 space and csf is collected.

Properly labelled CSF Samples in plain sterile plastic tube with mentioning relevant patient's information is received at the laboratory.

Laboratory investigation

CSF Laboratory Tests

1. Gross Examination

Quantity b) Colour c) Appearance d) Clot formation e) Viscosity f) Xanthochromia

2. Biochemical Examination

- Glucose (CSF/plasma ratio)
- Total protein

3. Wet Mount Procedure
4. Total cell count (WBC and RBC)
5. Stain used to differentiate cell count

Observations and results

An observational study was conducted on 500 cerebrospinal fluid (CSF) samples collected from patients with neurological conditions. Each CSF sample was analyzed for gross appearance, biochemical examination, total cell count and differential white blood cell (WBC) count.

Table 1: Demographic distribution of CSF samples according to Age and Gender:

Age (years)	Male (n)	Male (%)	Female (n)	Female (%)	Total (n)	Total (%)
<1	126	25.3%	75	15.0%	201	40.2%
1-10	55	11.0%	47	9.4%	102	20.4%
11-20	23	4.6%	18	3.6%	41	8.2%
21-30	26	5.2%	17	3.4%	43	8.6%
31-40	22	4.4%	13	2.6%	35	7.0%
41-50	17	3.4%	14	2.8%	31	6.2%
51-60	14	2.8%	9	1.8%	23	4.6%
61-70	8	1.6%	7	1.4%	15	3.0%
71-80	5	1.0%	3	0.6%	8	1.6%
>81	1	0.2%	0	0.0%	1	0.2%
Total	297	59.5%	203	40.5%	500	100%

The above Table describes the study subjects according to their ages. The maximum number of CSF samples were collected from infants (less than 1 year of age), accounting for 126 male and 75 female cases. The least number of CSF samples were from patients aged more than 81 years. Among the study population, male patients predominated (59.5%), while females constituted 40.5%. Overall, this trend suggests that younger patients, particularly infants, are more frequently investigated for neurological conditions requiring CSF examination.

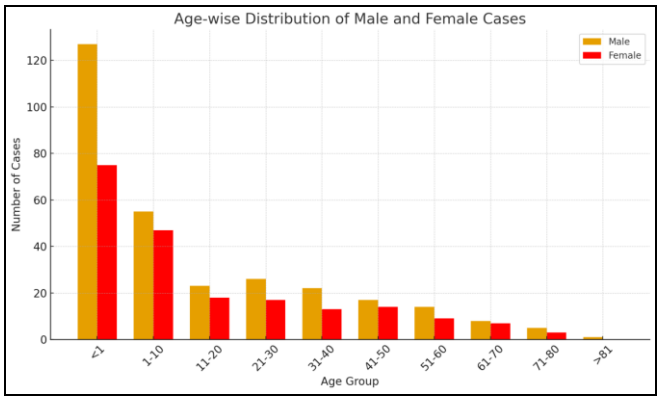


Table 2: Colour of CSF

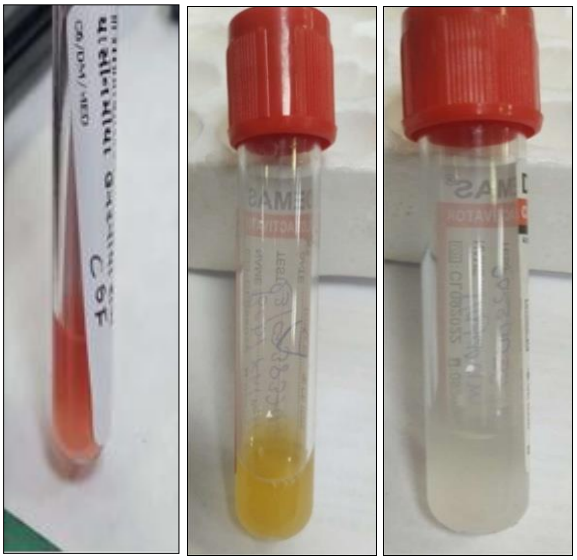
Colour	No. of cases	Percentage
Colorless	388	77.6%
Reddish	60	12.0%
Yellowish	52	10.4%
Total	500	100%

Above table shows 77.6% CSF samples were colorless, 12.0% were reddish and 10.4% yellowish in color [36].

Table 3: Appearance of CSF

Appearance	No. of cases	Percentage
Clear	230	46%
Slightly Turbid	224	44.8%
Turbid	46	9.2%
Total	500	100%

A majority of the CSF samples were either clear (46%) or slightly turbid (44.8%), with no major difference between the two groups [37]. Turbid CSF was observed in 9.2% of cases, typically associated with significant infection or inflammation, such as bacterial meningitis.



Yellowish, Slightly turbid Hemorrhagic, Turbid Colourless, Clear

This Table shows the distribution of associated clinical signs and symptoms observed in patients undergoing CSF examination. The most common clinical feature was fever, present in 21.0% of cases, followed by seizures in 18.6% and poor feeding in 16.2% of patients. Other frequently

observed symptoms included irritability (12.1%), headache (10.7%), and neck stiffness (8.5%), reflecting the classical presentation of central nervous system infections. Less common findings included bulging of fontanelle (5.5%), confusion (4.8%), and alterations of the sensorium (2.6%).

Table 4: Associated Sign and Symptoms

Clinical Feature	No. of Cases	Percentage
Fever	103	21.0%
Seizure	93	18.6%
Poor feeding	81	16.2%
Irritability	61	12.1%
Headache	54	10.7%
Neck stiffness	43	8.5%
Bulging of fontanelle	28	5.5%
Confusion	24	4.8%
Alterations of the sensorium	13	2.6%
Total	500	100%

Pie Chart showing associated sign and symptoms

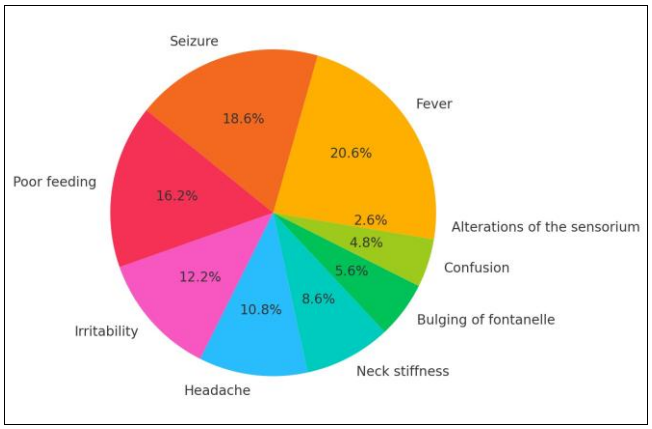


Table 5: Biochemical parameters of CSF

	No. of cases	Percentage
Protein		
≤50mg/dl	79	15.8%
51-90mg/dl	257	51.4%
>90mg/dl	164	32.8%
Glucose		
≤40mg/dl	229	45.8%
>40mg/dl	271	54.2%

The table summarizes the distribution of CSF protein and glucose levels among 500 cases. Regarding protein levels, the majority of cases, 257 (51.4%), had protein between 51-90 mg/dl, while 164 cases (32.8%) showed elevated protein levels >90 mg/dl, and 79 cases (15.8%) had protein ≤50 mg/dl.

For glucose levels, 229 cases (45.8%) had low CSF glucose (≤40 mg/dl), whereas 271 cases (54.2%) had glucose >40 mg/dl.

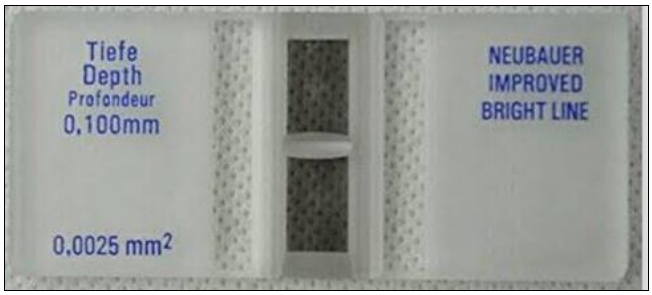
These findings highlight that more than half of the cases exhibited both moderate protein elevation and low glucose levels, patterns typically suggestive of bacterial meningitis [2, 4].

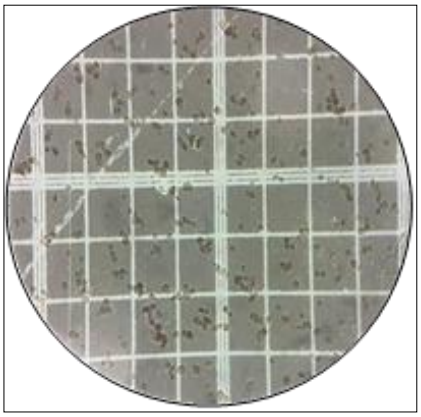
This Table shows Total 500 Sample out of that 96 CSF samples (19.2%) had leukocyte counts ≤100 cells/mm³. 69 samples (13.8%) had leukocyte counts between 101-1000 cells/mm³, and Plenty of leukocytes were reported in 134 samples (26.8%), while 201 samples (40.2%) had no leukocytes. Polymorphs ≤50% were observed in 165 samples (33.0%), while >50% polymorphs were seen in 133 samples%). Lymphocytes ≤50% were found in 138 samples (27.6%), and >50% in 160 samples (32.0%). Monocytes ≤50% were reported in 226 samples (45.2%), and >50% in 73 samples (14.6%).

RBC counts ≤100 cells/hpf were seen in 229 samples (45.8%). RBC counts between 101-1000 cells/hpf were present in 15 samples (3.0%), and plenty of RBCs in 17 samples (3.4%). No RBCs were found in 239 samples (47.8%).

Table 6: CSF (TC, DC, RBCs) parameters

WBCs	No.	Percentage
≤100cells/mm3	96	19.2%
>100-1000 cells/mm3	69	13.8%
Plenty	134	26.8%
Null	201	40.2%
Polymorphs		
≤50%	165	33.0%
>50%	133	26.6%
Null	202	40.4%
Lymphocytes		
≤50%	138	27.6%
>50%	160	32.0%
Null	202	40.4%
Monocytes		
≤50%	226	45.2%
>50%	73	14.6%
Null	201	40.2%
RBCs		
≤100cells/hpf	229	45.8%
>100-1000 cells/hpf	15	3.0%
Plenty	17	3.4%
Null	239	47.8%





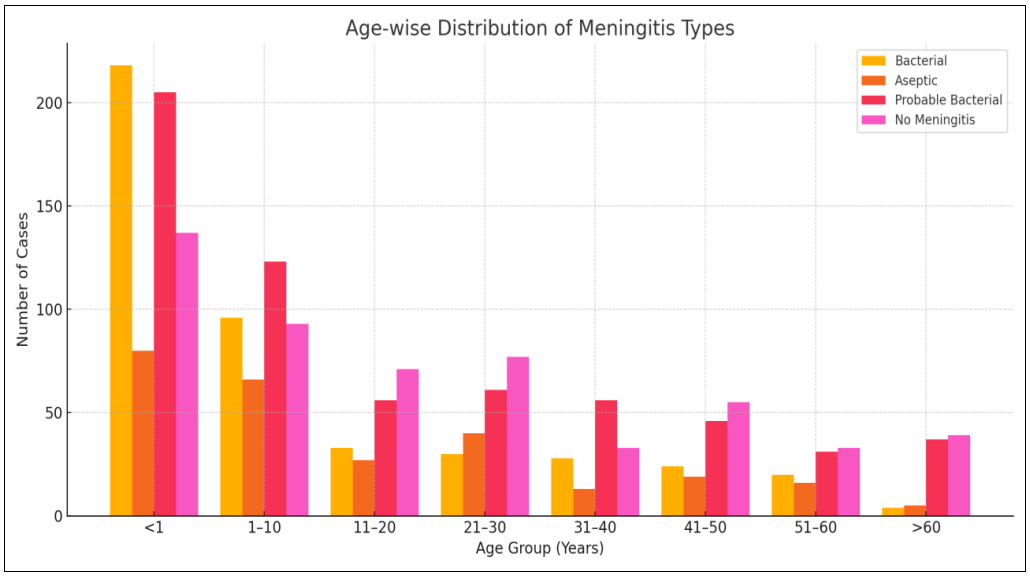
Categorization of CSF Samples

Study had further categorized CSF samples into Aseptic meningitis and Probable bacterial meningitis, and No Meningitis according to WHO recommendation [4].

Table 7: Age distribution of Meningitis.

Age (years)	No. of Cases	%	Bacterial Meningitis	%	Aseptic Meningitis	%	Probable Bacterial Meningitis	%	No Meningitis	%
<1	210	42.0%	58	28.9%	21	10.6%	55	27.2%	37	18.1%
1-10	102	20.4%	26	25.1%	18	17.3%	33	32.4%	25	24.3%
11-20	41	8.2%	9	21.6%	7	17.6%	15	36.6%	19	46.4%
21-30	43	8.6%	8	18.9%	11	25.2%	16	38.4%	21	48.4%
31-40	35	7.0%	8	21.4%	3	9.9%	15	42.7%	9	25.2%
41-50	31	6.2%	6	20.5%	5	16.2%	12	39.3%	15	47.0%
51-60	23	4.6%	5	23.0%	4	18.4%	8	35.6%	9	37.9%
>60	15	3.0%	1	7.2%	1	9.1%	10	67.3%	10	69.1%
Total	500	100%	121	24.6%	71	14.5%	164	33.4%	144	29.7%

The table presents the age-wise distribution of meningitis cases among 500 CSF samples analyzed. The highest proportion of meningitis cases was observed in infants less than 1 year of age (40.3%), followed by the 1-10 years age group (20.4%). Among children under 1 year, bacterial meningitis was the most common type (28.9%), with a considerable proportion of probable bacterial meningitis (27.2%). In the 1-10 years group, probable bacterial meningitis constituted the highest share (32.4%), followed by bacterial (25.1%) and aseptic meningitis (17.3%). The adolescent and young adult group (11-30 years) showed an increasing trend in probable bacterial meningitis, with more than one-third of cases in each age subgroup falling into this category. Notably, individuals over 60 years had a markedly higher proportion of probable bacterial (67.3%) and no meningitis (69.1%) findings, suggesting atypical or subclinical presentations in the elderly. Overall, probable bacterial meningitis was the most frequently diagnosed category (33.4%), followed by bacterial meningitis (24.6%), no meningitis (29.7%), and aseptic meningitis (14.5%).



Age wise distribution of Meningitis

Discussion

This was an observational study undertaken at Tertiary Care Hospital during the period from November 2024 to November 2025. In the present study, 500 CSF samples of all aged groups patients were analysed and compared

Table 8: Comparison of Demographic distribution with other studies

Study	Age group (years)	Male	Female	M:F Ratio
Patel *et al* (2023) [5]	0-60	60%	40%	1.5:1
Joshi *et al* (2022) [6]	1-50	63%	37%	1.7:1
Sharma *et al* (2023) [7]	0-55	58%	42%	1.4:1
Kumar *et al* (2024) [8]	0-60	65%	35%	1.8:1
Present study	0-63 yr	61.5%	38.5%	1.6:1

In the present study, the age of patients ranged from 0 to 63 years, which is the widest
range compared to the other studies. Other studies had slightly smaller age ranges, such as 0-60 years in the study by Patel *et al*. and 1-50 years in the study by Joshi *et al*. There is 61.5% of patients were male, and 38.5% were female, resulting in a male- to-female ratio of 1.6:1. While Other studies show a similar male predominance, with the highest male proportion seen in Kumar *et al*. (65%) and the lowest in Sharma *et al*. (58%). The M:F ratios range from 1.4:1 to 1.8:1, indicating a consistent trend of higher male incidence across all studies [5-8].

Table 9: Comparison of Associated Sign and Symptoms with other studies

Clinical Feature	Patel *et al* [5] (%)	Joshi *et al* [6] (%)	Sharma *et al* [7] (%)	Kumar *et al* [8] (%)	Present Study (%)
Fever	25	20	32	24	21
Seizure	23	19	18	20	18.6
Poor Feeding	15	20	14	17	16.2
Irritability	13	12	20	14	12.1
Headache	19	10	12	9	10.7
Neck Stiffness	9	8	5	8	8.5
Bulging of Fontanelle	7	5	5	4	5.5
Confusion	5	5	4	4	4.8
Alterated Sensorium	3	2	2	3	.6

The clinical features observed in the present study are consistent with classical presentations of meningitis.

In present study Fever (21%) and seizures (18.6%) were the most common findings, comparable to studies by Patel *et al*. (25%, 23%) and Kumar *et al*. (24%, 20%) indicating systemic and neurological involvement.

Poor feeding and irritability were observed in 16.2% and 12.1% of cases, respectively, in the present study. Similar findings were reported by Sharma *et al*. (14%, 20%) and Joshi *et al*. (20%, 12%). These symptoms, especially common in pediatric cases, are considered early indicators of central nervous system infection.

Headache was reported in 10.7% of cases, slightly lower than Patel *et al*. (19%) and Joshi *et al*. (15%), but still indicating meningeal irritation. Neck stiffness was observed in 8.5% of present study cases, similar to Sharma *et al*. (5%) and Patel *et al*. (9%).

Comparison of Associated Sign and Symptoms with other studies.

Table 10: Comparison of categorization of CSF samples in Present study with other studies.

Study	Bacterial Meningitis (%)	Probable Bacterial Meningitis (%)	Aseptic Meningitis (%)	No Meningitis (%)
Chaudhary N. *et al*. (2022) [9]	28.6%	31.0%	36.2%	4.2%
Patel V. *et al*. (2021) [10]	31%	26%	30%	13%
Present Study	24.6%	14.5%	33.4%	29.7%

The distribution of CSF sample categorization in the present study was compared with studies by Chaudhary N. *et al*. (2022) and Patel V. *et al*. (2021). In the present study, bacterial meningitis was observed in 24.6% of cases, which is slightly lower than Chaudhary *et al*. (28.6%) and Patel *et al*. (31%). Probable bacterial meningitis accounted for 14.5% in the present study, which was variable from Chaudhary *et al*. (31%) and Patel *et al*. (26%). Aseptic meningitis was the most common category in all three studies, with the present study reporting 33.4%, again similar to Chaudhary *et al*. (36.2%) and Patel *et al*. (30%). Cases classified as 'No Meningitis' were noted in 29.7% of the present study, 4.2% by Chaudhary *et al*., and 13% by Patel *et al*.

Summary and conclusion

This hospital-based observational study was conducted on 500 cerebrospinal fluid (CSF) samples from patients of all age groups with suspected neurological conditions at Tertiary Care Hospital carried between November 2024 to November 2025. Each sample underwent gross, microscopic and biochemical analysis.

In the present study comprising 500 cerebrospinal fluid (CSF) samples, the majority of patients were infants below 1 year of age, accounting for 40.3% of the total cases. A male predominance was observed, with a male-to-female ratio of approximately 1.5:1. The most common clinical features among patients included fever (21%), seizures (18.6%), and poor feeding (16.2%), indicating the typical presentation of central nervous system infections in pediatric and adult populations [5-10].

According to WHO criteria, CSF analysis revealed that 45.8% of the samples had glucose levels ≤40 mg/dl, while 32.8% had protein levels exceeding 90 mg/dl.

According to WHO criteria, 24.6% of cases were diagnosed with bacterial meningitis, 33.4% with probable bacterial meningitis, 14.5% with aseptic meningitis and No meningitis in 29.7% of cases. CSF protein was elevated and glucose was low in the majority of bacterial meningitis cases, with polymorph dominance in cell count. In contrast, aseptic meningitis cases showed lymphocyte dominance, near-normal glucose levels, and moderately elevated protein levels, supporting their differentiation based on CSF findings [4-8]. This study emphasizes the critical role of CSF analysis in the diagnosis of neurological infections. Bacterial meningitis remains the most prevalent diagnosis, especially among infants, characterized by elevated protein, decreased glucose, and polymorph predominance. The study supports the use of WHO guidelines in classifying meningitis types and reinforces the value of combining biochemical and microscopic findings for accurate diagnosis and management [4].

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Conflict of Interest

There are no conflict of Interest

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