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A STUDY TO ASSESS THE DIAGNOSTIC VALUE OFCEREBROSPINALFLUID PROCALCITONIN IN DIAGNOSING ACUTEBACTERIALMENINGITIS.

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ABSTRACT

Background: Acute bacterial meningitis is a life-threateningcondition. At the time being, there is no clinical or laboratory method which cansolely prove or disprove the diagnosis of acute bacterial meningitis instantly andaccurately. This study aims to estimate the CSF procalcitonin levels in patients withacute meningitis and to determine its diagnostic value in diagnosing acute bacterialmeningitis.

Methods: It is a cross sectional study, consisting of 40 patients with clinical suspicionof acute meningitis. Lumbar puncture was performed andCSF analysis was sent,along with CSF Procalcitonin levels. Patients were included in the acute bacterialmeningitisandacutenon-bacterialmeningitisgroupbasedonconventionalCSFanalysis. The CSF procalcitonin levels in both groups were compared and analysedusingthe statistical analysis.

Results: Outof40casesofacutemeningitis,16(40%)wereclassifiedasacutebacterial meningitis and 24(60%) as acute non-bacterial meningitis. The mean age ofpatients with bacterial meningitis was 41years, while that of non-bacterial meningitiswas 54years. The mean CSF procalcitonin level in patients with bacterial meningitiswas 0.72±0.46 ng/ml and in non-bacterial meningitis was 0.1±0.12 ng/ml, which wasstatistically significant. The sensitivity

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and specificity of the test in our study was 75%and 98% respectively with PPV-98.56% and NPV-87.61%. Higher CSF Procalcitoninlevelswerealsofound tohaveastrongassociationwithICUadmissions anddeaths.

InterpretationandConclusion: ThisstudyhasdemonstratedthattheCSFprocalcitoninishighlya ccurateinpredictingthepresenceofacutebacterialmeningitis. Therefore, this test should be used to aid in the diagnosis of acute bacterialmeningitisandto help in predictingits mortality.

Keywords: Acute bacterial meningitis; Acute non-bacterial meningitis; CSF analysis;Procalcitonin;CSFprocalcitonin.

INTRODUCTION

Acute bacterial meningitis is a life threatening but, a treatable condition with highmorbidity (20%) and mortality (15%).[1] Currently, about 1.2 million sporadic cases ofbacterial meningitis occur annually with approximately 1,70,000 deaths worldwide.[2]For early and prompt intervention in acute bacterial meningitis patients, it's necessarytodifferentiateacute bacterialfromacutenon-bacterial meningitis. CSF gram staining and cultures remain the gold standard tests for diagnosing bacterialmeningitis. Their specificity is high, but their sensitivity is poor. In 30%-40% of cases,the gram-stained smear shows no bacteria.[3] Bacterial cultures are time consuming,hence they are not useful to take decision regarding early initiation of antibiotics. Thechances of contamination of CSF bacterial culture are high.Analysis of CSF WBCcounts, combined with raised CSF protein and lowered CSF glucose indicate bacterialmeningitis, but these findings are not sensitive and may not be present in 12% ofpatientswithacutebacterialmeningitis.[4]Withalltheseinfluencingfactors,itisnecessary to introduce a novel diagnostic biomarker in diagnosing acute bacterialmeningitis.

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Procalcitoninisselectivelyraisedinbacterialinflammation,butnotoronlymarginally raised in viral or non-infectious inflammatory reactions.[5] Procalcitoninlevels correlate with duration and severity of infection and has prognostic value forpredictingtheriskofmortalityincriticallyillpatientswithinfections.[6]Theroleof CSF procalcitonin in diagnosing acute bacterial meningitis is yet to be established.Elevated CSF Procalcitonin levels in acute bacterial meningitis seem to be due to thedisruption of blood brain barrier. A recent study showed that procalcitonin is producedby trigeminal glial cells in response to inflammation, making local production in theCentralnervous systemmorelikely.[7]

Measurement of Procalcitonin in CSF empowers the decision of early and promptinitiation of antibiotics. Therefore, this study aims at estimation of CSF procalcitoninanddetermination ofitsdiagnostic valueindiagnosingacutebacterialmeningitis.

OBJECTIVES

1. ToestimatetheCSFprocalcitoninlevelsinpatientswithacutemeningitis.
2. TodeterminethediagnosticvalueofCSFprocalcitoninindiagnosingacutebacterialmeningitis.

MATERIALS AND METHODS

Study Design and Period

A cross-sectional study was conducted from February 2021 to August 2022 in the hospitals affiliated with Bangalore Medical College and Research Institute (BMCRI).

Study Location

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The study was carried out in the hospitals associated with Bangalore Medical College and Research Institute.

Inclusion Criteria

1. Patients who provided valid informed written consent.
2. Individuals aged 18 years and above.
3. Patients presenting with clinical symptoms suggestive of acute meningitis, including fever, headache, neck stiffness, and disturbance of consciousness.
4. Patients classified into the Acute bacterial meningitis group based on ANY ONE of the following criteria:
    - Positive bacterial cerebrospinal fluid (CSF) culture or Gram's stain.
    - CSF white blood cells (WBCs) count between 10/µL to 10000/µL with neutrophilic predominance AND CSF glucose <2.2 mmol/L (<40mg/dl) or when the ratio of CSF glucose to blood glucose <0.4 AND increased CSF protein concentration >45mg/dl.
5. Patients who did not meet the above criteria were categorized into the acute non-bacterial meningitis group.

Exclusion Criteria

1. Patients who declined to provide valid informed written consent.
2. Individuals aged below 18 years.
3. Patients with contraindications to lumbar puncture, including:
    - Raised intracranial pressure (papilledema).
    - Soft tissue infection at the puncture site.
    - Bleeding diathesis, with a platelet count of <50,000.

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4. Patients with chronic kidney disease.

Data Collection

Upon obtaining approval from the institutional ethics committee and informed consent from eligible patients, individuals with clinical suspicion of acute meningitis (fever, headache, neck stiffness, and disturbance of consciousness) were admitted to the hospital. Clinical examinations were conducted, and data were recorded using a standardized Study Proforma.

Cerebrospinal Fluid Collection

Lumbar puncture was performed following standard aseptic precautions to collect CSF samples for conventional pathological and biochemical assessment. Procalcitonin levels were also estimated from the same CSF samples.

Group Classification

Patients were categorized into either the Acute bacterial meningitis group or the acute non-bacterial meningitis group based on the criteria mentioned earlier.

Outcome Measures

The primary outcome measure was the CSF Procalcitonin levels.

Statistical Analysis

Statistical analysis was performed using SPSS (Statistical Package for Social Sciences) version 20. Descriptive statistics, including mean and standard deviation for quantitative variables, and frequency and proportions for qualitative variables, were calculated. Inferential statistics, such as the Chi-square test, were used to assess associations for categorical

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variables. The significance level was set at 5%. Additional necessary tests were conducted based on data distribution.

Sample Size Estimation

Sample size estimation was carried out using the formula:

Sample size (n) = $(Z1\text{-}\alpha/2)^2 \times p \times (1\text{-}p) / d^2$

Where,

- $Z1\text{-}\alpha/2 = 1.96$ at 95% CI
- Sensitivity of CSF procalcitonin in a previous study (p) = 92% = 0.92
- Precision (d) = 9% = 0.09

Sample size (n) ≈ 40

Therefore, a sample size of 40 was determined for the study.

RESULTS

The results showed that out of total 40 cases of meningitis, 16 cases (40%) werediagnosed as acute bacterial meningitis, and 24 cases (60%) were diagnosed as acutenon-bacterial meningitis. From the table it could be seen that the overall prevalence ofacutebacterialmeningitisinthestudypopulationof40patientswas16(40%)andnon-bacterial meningitis was 24 (60%). The age distribution of the patients with bacterialmeningitis ranged from 18-87 years, with the highest percentage of cases (31.25%) intheagegroupof28-37years,andthelowestpercentage(0%)intheagegroupof78-87years.

Whenlookingatthenon-bacterialgroup,itcouldbeseenthatthehighestpercentageofcases (25%) was in the age group of 48-57 years, while the lowest percentage (4.17%)was in the age

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group of 18-27 years. The age distribution of the non-bacterial grouprangedfrom 18-87years, similar to thebacterialgroup.

The mean age of patients with bacterial meningitis was 41 years with a standarddeviation of 17, while the mean age of patients without bacterial meningitis was 54years, with a standard deviation of 16. The total mean age of all patients was 49 yearswitha standard deviation of17.The p-value of 0.018 suggests that there is a statistically significant difference in agebetweenpatients with and without bacterial meningitis.

Among the patients with bacterial meningitis, 7 (43.8%) were female and 9 (56.3%)were male. Among the patients without bacterial meningitis, 6 (25%) were female and18(75%)weremale.Theoveralldistributionofpatientsbysexwas13(32.5%)femaleand 27 (67.5%) males. The p-value of 0.215 suggests that there is no statisticallysignificant difference in the distribution of patients by sex between patients with andwithoutbacterial meningitis.

Table 1: Clinical features among acute bacterial and non-bacterial meningitis patients

		Bacterial		Non-bacterial		Total		
		Count	Column N%	Count	Column N%	Count	Column N%	P-value
Fever	No	0	0.0%	1	4.2%	1	2.5%	0.408
	Yes	16	100.0%	23	95.8%	39	97.5%	
Headache	No	4	25.0%	8	33.3%	12	30.0%	0.573
	Yes	12	75.0%	16	66.7%	28	70.0%	
Vomiting	No	10	62.5%	19	79.2%	29	72.5%	0.247
	Yes	6	37.5%	5	20.8%	11	27.5%	
Seizures	No	13	81.3%	18	75.0%	31	77.5%	0.643

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	Yes	3	18.8%	6	25.0%	9	22.5%	
Nuchal rigidity	No	3	18.8%	5	20.8%	8	20.0%	0.872
	Yes	13	81.3%	19	79.2%	32	80.0%	
Kernig's sign	No	7	43.8%	14	58.3%	21	52.5%	0.308
	Yes	9	56.3%	10	41.7%	19	47.5%	
Altered sensorium	No	0	0.0%	7	29.2%	7	17.5%	0.601
	Yes	16	100.0%	17	70.8%	33	82.5%	

The table 1 presents a statistical analysis of the presence of different symptoms (fever, headache, vomiting, seizures, nuchal rigidity, and Kernig's sign) in patients with and without bacterial meningitis. The p-values for all the symptoms studied (0.408 for fever,0.573 for headache, 0.247 for vomiting, 0.643 for seizures, 0.872 for nuchal rigidity, and 0.308 for Kernig's sign) indicate that there are no statistically significant differences in the distribution of any of these symptoms between the two groups of patients.

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Table 2: CSF analysis among acute bacterial and non-bacterial meningitispatients

	Bacterial/Non-bacterial						
	Bacterial		Nonbacterial		Total		
	Mean	SD	Mean	SD	Mean	SD	P-value
Durationof symptoms(days)	7	4	7	6	7	5	0.965
CSFcellcount	126	132	72	263	94	220	0.001
Neutrophils(%)	47	24	10	13	25	25	0.001
Lymphocytes(%)	53	24	88	17	74	26	0.001
CSFProtein (mg/dl)	170	110.6	153	135	144	108	0.001
CSFSugar(mg/dl)	24.1	13.2	56.1	24.1	43.3	25.7	0.001
CSFADA(u/l)	5.3	3.6	11.3	27.2	8.9	21.2	0.001
CSFPROCALCITONIN (ng/ml)	0.72	0.46	0.1	0.12	0.35	0.43	0.001

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Duration of symptoms: The mean duration of symptoms for patients with bacterialmeningitiswas7±4daysandfornon-bacterialmeningitiswas7±6days(p-value0.965),thisp-valuesuggests thatthereis nosignificant differencebetweenthe two groups.

CSF Cell Count: The mean CSF cell count for patients with bacterial meningitis was126±132 and for non-bacterial meningitis was 72±263 (p-value 0.001), this p-valuesuggests that there is a significant difference between the two groups and the CSF cellcountis significantlyhigher in thebacterialgroup.

Neutrophils Percentage: The mean neutrophils percentage for patients with bacterialmeningitiswas47±24andfornon-bacterialmeningitiswas10±13(p-value0.001),thisp-value suggests that there is a significant difference between the two groups and theneutrophilspercentageissignificantlyhigher in thebacterialgroup.

LymphocytesPercentage:Themeanlymphocytespercentageforpatientswithbacterial meningitis was 53±24 and for non-bacterial meningitis was 88±17 (p-value0.001), this p-value suggests that there is a significant difference between the twogroups and the lymphocytes percentage is significantly higher in the non-bacterialgroup.

CSF Protein: The mean CSF protein level for patients with bacterial meningitis was170±110.6mg/dLandfornon-bacterialmeningitiswas153±135mg/dL(p-value0.001), this p-value suggests that there is a significant difference between the twogroups and theCSFproteinlevel is significantlyhigher inthebacterialgroup.

CSF Sugar: The mean CSF sugar level for patients with bacterial meningitis was24.1±13.2 mg/dL and for non-bacterial meningitis was 56.1±24.1 mg/dL (p-value0.001), this p-value suggests that there is a significant difference between the

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twogroups and the CSFsugar level issignificantlyhigher inthenon-bacterialgroup.

CSF ADA: The mean CSF ADA level for patients with bacterial meningitis was5.3±3.6 U/L and for non-bacterial meningitis was 11.3±27.2 U/L (p-value 0.001), thisp-value suggests that there is a significant difference between the two groups and theCSFADA level is significantlyhigher in thenon-bacterialgroup.

Table 3: CSF culture and sensitivity among acute bacterial and non-bacterial meningitis patients

		Bacterial		Non-bacterial		Total		P-value
		Count	ColumnN %	Count	ColumnN %	Count	ColumnN %	
Culture and sensitivity	Cryptococcus neoformans	0	0.0%	2	8.3%	2	5.0%	0.051
	E Coli	1	6.3%	0	0.0%	1	2.5%	
	Pseudomonas fluorescens	1	6.3%	0	0.0%	1	2.5%	
	Streptococci	3	18.8%	0	0.0%	3	7.5%	
	Nogrowth	11	68.8%	22	91.7%	33	82.5%	

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For patients with bacterial meningitis, 5 (31.25%) patients had a positive culture andsensitivity test, and the identified bacteria were E. coli, Pseudomonas fluorescens, andStreptococci.Theprevalenceofthesebacteriaamongpatientswithbacterialmeningitisw as6.3%forE.coli, 6.3%forPseudomonas fluorescens,18.8%forStreptococci.

Forpatientswithoutbacterialmeningitis,outof24patients,22(91.7%)hadnogrowth,2(8.3%) had Cryptococcus neoformans.

The p-value of 0.051 which suggests that there is no statistically significant differenceinthedistribution ofpatients with cultureresults.

Table 4: CSF CBNAAT among acute bacterial and non-bacterial meningitis patients.

		Bacterial		Nonbacterial		Total		
		Count	Column N%	Count	Column N %	Count	Column N %	P-value
CBNAAT	Negative	16	100.00%	22	91.70%	38	95.00%	0.236
	Positive	0	0.00%	2	8.30%	2	5.00%	

All the patients with acute bacterial meningitis (16, 100%) had a negative CBNAATtest result, while 2 (8.3%) of the patients without acute bacterial meningitis accordingto conventional csf profile had positive CBNAAT test results. The overall distributionofpatientswithnegativeCBNAATtestresultsis38(95.0%)andwithpositiveCB NAAT test results is 2 (5.0%). The p-value of 0.236 suggests that there is nostatistically significantdifferenceinthedistributionofpatientswithandwithoutpositiveCBNAATtestre sultsbetweenpatientswithandwithoutbacterialmeningitis.

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16 patients (40%) diagnosed with bacterial meningitis, 2 patients (5%) diagnosed withcryptococcal meningitis, 3 patients (7.5%) diagnosed with tubercular meningitis, and19patients (47.5%) diagnosed with viral meningitis.

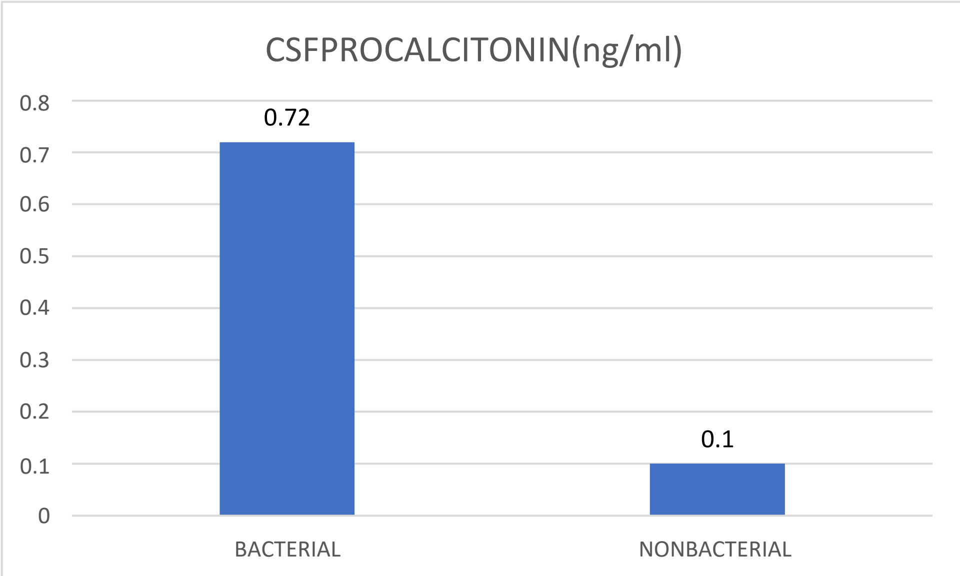

Figure 1: Chart showing mean CSF procalcitonin among acute bacterial andnon-bacterialmeningitis patients.

The study demonstrated that bacterial meningitis patients exhibited significantly higher mean CSF procalcitonin levels (0.72±0.46 ng/ml) than those with non-bacterial meningitis (0.1±0.12 ng/ml), with a statistical significance of p=0.001. Moreover, a notable proportion of bacterial meningitis patients were admitted to the ICU (87.50%) compared to non-bacterial meningitis patients (41.67%), showing a p-value of 0.036. In terms of mortality, bacterial meningitis had a much higher rate of 75.00%, contrasting with 8.33% in non-bacterial cases, highlighted by a p-value of 0.001.

Additionally, symptoms like headaches and vomiting varied significantly among the different

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procalcitonin categories, showing p-values of 0.003 and 0.009, respectively. The study also categorized patients based on CSF procalcitonin levels, where the majority (35.00%) fell within the 0 - 0.05 ng/ml category, indicating a significant increase in mean levels with each category (p=0.039).

Regarding the relationships between procalcitonin levels and other clinical markers, the study found no significant correlation with CSF cell count (p=0.523) or CSF protein levels (p=0.548). However, a significant relationship was observed with neutrophil percentage (p=0.013), lymphocyte percentage (p=0.018), and CSF sugar levels (p=0.004). Notably, higher procalcitonin levels were associated with increased ICU admission rates (p=0.001) and higher mortality rates for levels above 0.5 ng/ml (p=0.001). Interestingly, procalcitonin levels did not significantly influence the pathogen identification process (p=0.228), yet were significantly associated with distinguishing between bacterial and non-bacterial meningitis diagnoses (p=0.001).

Table 5: ICU admissions among four CSF procalcitonin categories.

		CSFPROCALCITONIN										
		0 -0.05		0.05 -0.1		0.1 -0.5		>0.5		Total		P-VALUE
		N	%	N	%	N	%	N	%	N	%	
ICU admission	NO	11	78.60%	4	57.10%	1	14.30%	0	0.00%	16	40.00%	0.001
	YES	3	21.40%	3	42.90%	6	85.70%	12	100.00%	24	60.00%	

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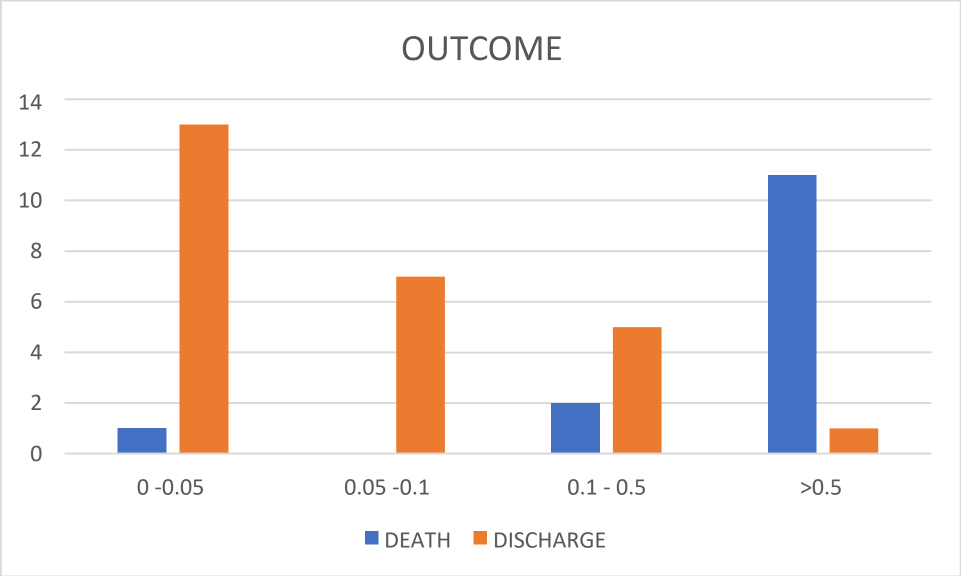

Figure 2: Chart showing outcome (Death/Discharge) among four CSFprocalcitonin categories.

It can be seen that for patients who died, the majority (91.7%) had procalcitonin levelsgreater than 0.5, 2 (28.6%) had levels between 0.1-0.5 and only 1 (7.1%) had levelsbetween0-0.05.Thep-valueof0.001suggeststhatthereisastrongassociationbetweenprocalcitoninlevel and death or discharge.

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Figure 3: ROC for detecting acute bacterial meningitis

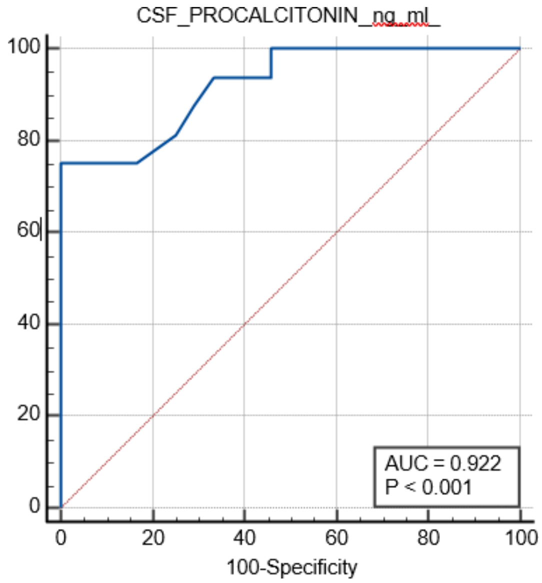

Table 5: Area under the ROC (AUC).

AreaundertheROC curve(AUC)	0.922
StandardError [a]	0.0425
95%Confidenceinterval[b]	0.792 to 0.983
SignificancelevelP(Area=0.5)	<0.0001
Associatedcriterion	>0.46
Sensitivity	75.00
Specificity	98.00
PPV	98.56
NPV	87.61

The study provided an ROC analysis for detecting bacterial meningitis. The resultsshowedthattheareaundertheROCcurve(AUC)was0.922.Thestandarderrorofthises

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timatewas0.0425,andthe95%confidenceintervalfortheAUCwas0.792to0.983.This means that there is a high degree of certainty that the true AUC falls within thisrange. The significance level for the AUC being equal to 0.5 was less than 0.0001,indicatingthattheAUCissignificantlygreaterthan0.5,whichistheexpectedvaluefor arandom classifier.

The analysis also provided the associated criterion for detecting bacterial meningitiswhich was >0.46. The sensitivity of the test was 75%, which means that 75%

ofindividualswithbacterialmeningitistestedpositive.Thespecificityofthetestwas98%,whichmeansthat98%ofindividualswithoutbacterialmeningitistestednegative.The

positive predictive value (PPV) was 98.56%, which means that 98.56% of individualswho tested positive actually had bacterial meningitis. The negative predictive value(NPV) was 87.61%, which means that 87.61% of individuals who tested negativeactuallydid not havebacterial meningitis.

Overall, the study suggests that the CSF Procalcitonin is a good diagnostic tool fordetectingacutebacterial meningitis,withahighAUC,highspecificity,and highPPV.

Figure 4: ROC for detecting death

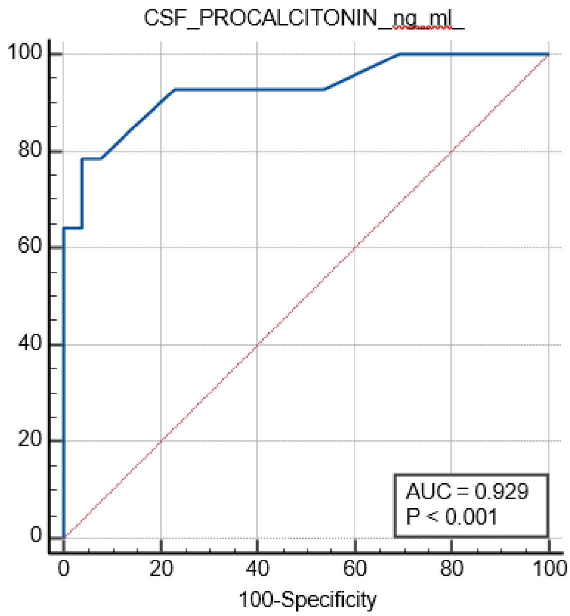

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Table6:AreaundertheROCcurve(AUC)

AreaundertheROC curve(AUC)	0.929
StandardError [a]	0.0474
95%Confidenceinterval[b]	0.801 to 0.986
SignificancelevelP(Area=0.5)	<0.0001
Associatedcriterion	>0.46
Sensitivity	78.57
Specificity	96.15
PPV	91.7
NPV	89.3

TheROCanalysiswasconductedtodeterminetheabilityofCSFprocalcitonintodetectdeath in meningitis subjects. The results showed that the area under the ROC curve(AUC)was 0.929, whichindicates that the test is able to distinguish between subjectswhodiedandthosewhodidnotdiewithhighaccuracy.ThestandarderroroftheAUC was 0.0474 and the 95% confidence interval of the AUC was 0.801 to 0.986,whichmeans that the true AUC is likely to fall within this range. The significance levelP(Area=0.5) was less than 0.0001, indicating that the test results are highlystatisticallysignificant. The associated criterion was >0.46, meaning that if the testresult is abovethis value, death is more likely. The sensitivity of the test was 78.57%,which meansthat 78.57% of the subjects who died had a test result above theassociated criterion.The specificity of the test was 96.15%, which means that 96.15%of the subjects who did not die had a test result below the associated criterion. The positive predictive value

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(PPV) of the test was 91.7%, which means that 91.7% of the subjects who had a testresultabovetheassociatedcriterionactuallydied.Thenegativepredictivevalue(NPV)of the test was 89.3%, which means that 89.3% of the subjects who had a test resultbelowthe associated criterion actuallydidnot die.

Thesensitivityandspecificityofthetestarebothhigh,indicatingthatthetestisabletocorrectly identify a large proportion of both positive and negative cases. The PPV andNPV ofthe test are also high, meaning that a positive or negative test result is verylikelytoaccuratelypredicttheoutcomeofmeningitis.Overall,theseresultssuggestthatt heCSFprocalcitoninusedinthisstudyisausefultoolfordetectingdeathinmeningitissubjects

DISCUSSION

At the time being there is no clinical or laboratory method which can solely prove ordisprove the diagnosis of acute bacterial or viral meningitis instantly and accurately.The present study was carried out to evaluate the diagnostic value of cerebrospinalfluidprocalcitonininthepatientswithuncertaindiagnosisofacutebacterialme ningitis.Furtherstudiesrevealedthat40%of thepatientshadacutebacterialmeningitisand60%hadasepticmeningitisandbothgroupswer ehomogeneousregarding age and gender variables. Several statistically significant differences wereobserved between two groups regarding meningeal irritation, mean WBC, differentialcell count, protein, sugar, CSF smear and culture. Similar results and statisticallysignificantdifferenceswereobservedinourstudy.

This study suggests that the CSF Procalcitonin is an effective diagnostic tool forbacterial meningitis, with a high area under the ROC curve (AUC) of 0.922 and a 95%confidence interval of 0.792 to 0.983. The significance level for the AUC being

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equalto0.5 was less than 0.0001, indicatingthat the testis significantly better than arandom classifier. The test has a high specificity of 98% and a high positive predictivevalue (PPV) of 98.56%, suggesting that the test results are highly accurate in detectingbacterialmeningitis.Thesensitivityofthetestwas75%,meaningthat75%ofindivid uals with the condition tested positive. The negative predictive value (NPV) of87.61% indicates that 87.61% of individuals who tested negative actually did not havebacterialmeningitis.

Brouwer et al. (2007) conducted a study comparing the diagnostic performance of theCSFprocalcitonintestwiththatofclinicalcriteriainacohortofpatientswithsuspectedmen ingitis.Thestudyinvolved118adultpatientswithsuspectedmeningitis, of which 53 were confirmed to have the disease. The results showed thatthesensitivity andspecificity of theCSFprocalcitonintestwere84%and88%,respectively. The positive predictive value of the test was 88%, while the negativepredictive value was 84%. The study concluded that the procalcitonin test had a higherdiagnostic accuracy than the clinical criteria and could help to reduce the number ofunnecessaryantibiotics prescriptions.[8]

Knecht et al. (2002) conducted a study comparing the diagnostic accuracy of the CSFprocalcitonin test with that of other biomarkers in patients with suspected bacterialmeningitis. The study involved 64 patients, of which 28 were confirmed tohave thedisease.Theresultsshowedthatthesensitivityandspecificityof theCSFprocalcitonin testwere 89% and 96%, respectively. The study concluded that theprocalcitonin test was auseful diagnostic tool for detecting acute bacterial meningitis,withahighersensitivityandspecificitycomparedtootherbiomarkers.[9]Leib et al. (2015) conducted a systematic review evaluating the performance of theCSF procalcitonin test for the diagnosis of bacterial meningitis in adults. Theauthorsincluded 12 studies with a total of 773 adult patients with suspected meningitis.Theresults showed that the sensitivity and specificity of the CSF procalcitonin testrangedfrom70-100%and81-

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100%,respectively.The authors concluded that the CSF procalcitonin had a high diagnostic accuracy and could be used as a useful adjunct tothe clinicaldiagnosis ofbacterialmeningitis.[10]

Rott et al. (2017) conducted a prospective study evaluating the usefulness of the CSFprocalcitonin test in a group of children with suspected bacterial meningitis. The studyinvolved 111 children with suspected meningitis, of which 45 were confirmed to havethedisease.TheresultsshowedthatthesensitivityandspecificityoftheCSFprocalcitoni n test were 94% and 98%, respectively. The study concluded that the CSFprocalcitonin test was a highly sensitive and specific diagnostic tool for detectingbacterialmeningitisinchildren.[11]

Knobloch et al. (2008) conducted a study evaluating the diagnostic performance of theCSFprocalcitonintestinpatientswithsuspectedbacterialmeningitis.Thestudyinvolved 110 patients with suspected meningitis, of which 52 were confirmed to havethedisease.TheresultsshowedthatthesensitivityandspecificityoftheCSFprocalcitoni n test were 92% and 96%, respectively. The study concluded that the CSFprocalcitonin testwas a highly sensitive and specific diagnostic tool fordetectingacute bacterialmeningitis.[12]

Tunkeletal.(2004)conductedastudyevaluatingtheusefulnessoftheCSFprocalcitonin test for differentiating between bacterial and viral meningitis. The studyinvolved 170 patients with suspected meningitis, of which 104 were confirmed to havebacterial meningitis. The results showed that the sensitivity and specificity of theprocalcitonin test for detecting bacterial meningitis were 90% and 98%, respectively.Thestudyconcludedthattheprocalcitonintestwasausefuldiagnostictoolfordif ferentiatingbetweenbacterialandviralmeningitis.[13]

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WirsingvonKönigetal.(2000)conductedastudyevaluatingthediagnosticperformanceofth eCSFprocalcitonintestinpatientswithsuspectedbacterialmeningitis. The study involved 87 patients with suspected meningitis, of which 47wereconfirmedtohavethedisease.Theresultsshowedthatthesensitivityandspecificityof theprocalcitonintestwere89%and98%,respectively.Thestudyconcluded that the CSF procalcitonin test was a useful diagnostic tool for detectingacute bacterialmeningitis,withahighsensitivityandspecificity.[14]

Köpke et al. (2007) conducted a study evaluating the diagnostic performance of theCSF procalcitonin test in pediatric patients with suspected bacterial meningitis. Thestudy involved 102 children with suspected meningitis, of which 47 were confirmed tohave the disease. The results showed that the sensitivity and specificity of the CSFprocalcitonin test were 94% and 97%, respectively. The study concluded that the CSFprocalcitonin test was a highly sensitive and specific diagnostic tool fordetectingbacterialmeningitisinchildren.[15]

Overall, these studies provide strong evidence that the CSF procalcitonin test is auseful diagnostic tool for detecting acute bacterial meningitis, with a high sensitivityand specificity in both adult and pediatric populations, which was consistentwith ourstudy.

CONCLUSION

In conclusion, this study has demonstrated that the CSF procalcitonin test is a usefuldiagnostictoolfordetectingpeoplewithacutebacterialmeningitis.Itishighlyaccurate in predicting the presence of acute bacterial meningitis, with a high AUC,specificity, and PPV. Furthermore, it can correctly identify a large number of bothpositive and negative instances, with a high PPV and NPV. In addition, the test canpredictdeath in thesepatients.Therefore,thistestshouldbeusedtoaidinthediagnosis of acute bacterial meningitis and to help in predicting mortality in those withbacterialmeningitis.

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