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ORIGINAL RESEARCH

Correlation of Haematological Scoring System with C - Reactive Protein and Blood Culture in the Diagnosis and Prognosis of Neonatal Sepsis in A Tertiary Care Hospital, Hyderabad

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ABSTRACT

Background: In this study, we wanted to evaluate the diagnostic utility of the Haematological Scoring System of Rodwell et al in correlation with C-Reactive protein and blood culture and assessing its prognostic value, estimate the Haematological Scoring System of Rodwell et al, compare its correlation with C- reactive protein and blood culture in Neonatal Sepsis, and assess its prognostic value in reflecting the patient's outcome.

Methods: This was a hospital based cross-sectional study conducted among 300 blood samples from clinically suspected cases of neonatal sepsis in the Department of Pathology at Niloufer Hospital, a Tertiary Care Centre in Hyderabad for a period of 2 years, from 2020 to 2022 after obtaining clearance from institutional ethics committee and written informed consent from the study participants.

Results: The sensitivity and specificity of deranged Total Leucocyte count were 58.92% and 84.35% respectively. The sensitivity and specificity of deranged Absolute Neutrophil Count were 86.49% and 46.09% respectively. The sensitivity and specificity of increased Immature Neutrophil Count were 79.46% and 80.87% respectively. The sensitivity and specificity of increased I:T ratio were 80.54% and 83.48% respectively. The sensitivity and specificity of increased I:M ratio were 63.24% and 96.52% respectively. The sensitivity and specificity of Degenerative neutrophil changes were 31.89% and 97.39% respectively. The sensitivity and specificity of reduced platelet count were 65.95% and 55.65% respectively.

When correlated with blood culture,

- The sensitivity and specificity of blood samples with HSS≥3 were 96.55% and 59.23% respectively.
- The sensitivity and specificity of blood samples with HSS≥4 were 92.24% and 71.73% respectively.
- The sensitivity and specificity of blood samples with HSS≥5 were 74.13% and 82.6% respectively.

When correlated with CRP,

- The sensitivity and specificity of blood samples with HSS>3 were 89.18% and 80.86% respectively.
- The sensitivity and specificity of blood samples with HSS>4 were 77.3 and 86.08 respectively.

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- The sensitivity and specificity of blood samples with HSS>5 were 62.16 and 97.39 respectively.

As the HSS scores increased, the specificity increased with a reduction of sensitivity. Thus overall, an HSS score of 4 and above was considered the most reliable indicator for the early diagnosis of Neonatal Sepsis.

There is prolonged duration of hospitalisation with increase in HSS, ranging from 1-3 days in score 0 to 11-32 days in score 7.

The scoring system has come down to <3 with appropriate response to treatment.

Conclusion: HSS not only helps in diagnosis but also helps in predicting the severity and outcome of neonatal sepsis, reflected by prolonged duration of hospitalisation of the patients and reduction in the score with appropriate response to therapy.

Keywords: Correlation, Haematological Scoring System, C-Reactive Protein, Blood Culture, Diagnosis, Prognosis, neonatal sepsis.

INTRODUCTION

Neonatal sepsis can be early onset or late onset. Early onset sepsis is observed within 72 hours of life whereas late onset is after 72 hours. [1] Neonatal sepsis is one of the leading causes of morbidity and mortality in the neonatal period especially in low socio-economic classes. [2] The incidence of neonatal sepsis in India is 30/1000 live births as per the National Neonatal Perinatal Database and contributes up to a quarter of neonatal mortality rate. [3] The incidence of total sepsis is 14.3% in a recent cohort study conducted by Delhi Neonatal Infection Study collaboration in India. Nearly 2/3rd of these cases was EOS.[4] The infection is commonly transmitted from the mother via transplacental route, ascending infection or exposure to infected blood during delivery.[5] Prematurity, low birth weight, chorioamnionitis, premature prolonged rupture of membranes, resuscitation, low APGAR score, prolonged hospital stay, inability to breast feed and invasive procedures are important risk factors for neonatal sepsis.[6] This potentially life-threatening condition is treatable if diagnosed early. But the early clinical features are non-specific and easily confused with other non-infectious causes. [7] Hence, timely diagnosis of sepsis is important as it is rapidly progressive and, in some instances, fatal. [8] The gold standard for the diagnosis of neonatal sepsis is the isolation of organism by blood culture. But it is time consuming and affects the treatment of the neonate.[9] Haematological parameters like abnormal total leucocyte count, abnormal total neutrophil count, elevated immature neutrophil count, elevated immature to total neutrophil ratio, immature to mature neutrophil ratio >0.3, platelet count <1.5 lakhs are used as a combined approach to form a Haematological Scoring System.[10] Haematological Scoring System (HSS) is a simple, quick, cost-effective tool and can be used as a screening test for early diagnosis of neonatal sepsis.[11]

AIMS AND OBJECTIVES

- To evaluate the diagnostic utility of the Haematological Scoring System of Rodwell et al. in correlation with C-Reactive protein and blood culture and assessing its prognostic value.

MATERIALS & METHODS

This was a hospital based cross-sectional study conducted among 300 blood samples from clinically suspected cases of neonatal sepsis in the Department of Pathology at Niloufer Hospital, a Tertiary Care Centre in Hyderabad for a period of 2 years, from 2020 to 2022 after obtaining clearance from the institutional ethics committee and written informed consent from the study participants.

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Inclusion Criteria
Patients suspected with neonatal sepsis.

Exclusion Criteria
Critically ill newborns who were not able to undergo necessary laboratory evaluations.

Statistical Methods
Statistical data collected and entered in MS Excel sheet. The data were represented in descriptive manner, graphs, tables and pie charts.
Considering blood culture as the gold standard for the diagnosis of septicaemia, Sensitivity (Sen), Specificity (Spe), Positive Predictive Value (PPV) and Negative Predictive Value (NPV) of each parameter were taken into account to determine the diagnostic value, using the cut-off values according to previously cited literature.

RESULTS

Haematological Profile [10]

Abnormal total leukocyte count	**Sepsis positive**	**Sepsis negative**	**Total**
Present	109	18	127
Absent	76	97	173
Total	185	115	300
Distribution of cases: Total Leukocyte Count			
Abnormal total leukocyte count	**Sensitivity**	**Specificity**	**Positive predictive value (PPV)**	**Negative predictive value (NPV)**
	58.92	84.35	85.83	56.07
Total Leukocyte Count: Diagnostic value			
Abnormal Total polymorphonuclear neutrophil Count		**Sepsis +**	**Sepsis -**
Present		160	62
Absent		25	53
Total		185	115
Absolute Neutrophil Count- Distribution of cases			
Abnormal total neutrophil count	**Sensitivity**	**specificity**	**PPV**	**NPV**
	86.49	46.09	72.07	67.95
Absolute Neutrophil Count - Diagnostic Value			
Increased immature neutrophil count		**Sepsis +**	**Sepsis -**
Present		147	22
Absent		38	93
Total		185	115
Immature Neutrophil Count- Distribution of cases			
Increased immature neutrophil count	**Sensitivity**	**Specificity**	**PPV**	**NPV**
	79.46	80.87	86.98	70.99
Immature Neutrophil Count - Diagnostic value			
Table 1			

The assessment of the changes in total leucocyte count was done based on the normal cut-off ranges used in the study by Rodwell et al.[10]
A Total leucocyte count falling anywhere in the below mentioned criteria was considered abnormal:

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<5000/mm3 at any given time
≥25000/mm3 at birth
≥30000/ mm3 after 12-24 hours
≥21000/ mm3 day 2 onwards
Total leucocyte count was deranged in 127 of all the blood samples. Out of these, sepsis positive cases were 109 and the remaining 18 were sepsis negative. The sensitivity was 58.92% and the specificity was 84.35%.
Sepsis positive -both blood culture and CRP positive

Absolute Neutrophil Count (ANC)[12]
The diagnostic value of abnormal Absolute Neutrophil count was estimated keeping in mind the criteria for normal ANC values, as set forth by Monroe et al:
1800 – 5400/ mm3at birth
6800- 11700/ mm3 at day 1
2800- 5400/ mm3 from day 5 onwards.
Deranged absolute neutrophil count was found in 222 cases, out of which culture and CRP positive cases were 160.
The sensitivity and specificity were 86.49% and 46.09% respectively.

Immature Neutrophil Count [12]
The levels of immature neutrophils were evaluated by the criteria of Monroe et al.
The normal levels were as follows:
<1000/mm3 at birth
<1300/mm3 at day 1
<750/mm3 at day 2
<600/mm3 from day 5 onwards.
A positive test result, i.e. an increased immature cell count was seen in 169 cases, out of which blood culture and CRP positive cases were 147.
The sensitivity and specificity of this test were 79.46% and 80.87% respectively.

Immature to total neutrophil ratio [12]
The diagnostic value of I:T ratio was done based on the criteria put forward by Monroe et al, i.e. I:T ratio ≥ 0.12.
In our study, an increased I:T ratio was observed in 168 cases out of which, blood culture and CRP positive cases were 149.
The sensitivity and specificity of this test were 80.54% and 83.48 % respectively.

Haematological profile[10]

I:T Neutrophil ratio ≥ 0.12		**Sepsis +**	**Sepsis -**	
Present		149	19	
Absent		36	96	
Total		185	115	
I:T Ratio- Distribution of cases				
I :T ratio ≥ 0.12	**Sensitivity**	**Specificity**	**PPV**	**NPV**
	80.54	83.48	88.69	72.72
I:T Ratio: Diagnostic Value				
I:M ratio ≥ 0.3		**Sepsis +**	**Sepsis -**	
Present		117	4	
Absent		68	111	
Total		185	115	

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Immature to mature Neutrophil Ratio: Distribution of cases				
I:M ratio ≥ 0.3	Sensitivity	Specificity	PPV	NPV
	63.24	96.52	96.69	62.01
I:M ratio: diagnostic value				
Table 2				

Immature to mature neutrophil ratio [10]

The diagnostic value of I:M ratio was seen by noting an increase from its normal value. According to Rodwell et al, value of I:M ratio ≥ 0.3 is considered abnormal. An increased I:M ratio was observed in 121 cases, out of which blood culture and CRP positive cases were 117.

The sensitivity and specificity were 63.24% and 96.52% respectively.

Haematological profile[10]

Degenerative changes	**Sepsis +**			**Sepsis -**	
Present	59			3	
Absent	126			112	
Total	185			115	
Degenerative changes in neutrophils: Distribution of cases					
Degenerative changes in neutrophils	Sensitivity	Specificity	PPV	NPV	
	31.89	97.39	95.16	47.06	
Degenerative changes: Diagnostic value					
Platelet count < 1.5 lakhs.	Sepsis +			Sepsis -	
Present	122			51	
Absent	63			64	
Total	185			115	
Thrombocytopenia- Distribution of cases					
thrombocytopenia	Sensitivity	specificity	PPV	NPV	
	65.95	55.65	70.52	50.39	
Thrombocytopenia:- Diagnostic value					
Type of abnormality		Sensitivity	Specificity	PPV	NPV
Deranged total leukocyte count		58.92	84.35	85.83	56.07
Abnormal absolute neutrophil count		86.49	46.09	72.07	67.95
Increased immature neutrophil count		79.46	80.87	86.98	70.99
I:T ratio ≥ 0.12		80.54	83.48	88.69	72.72
I:M ratio ≥ 0.3		63.24	96.52	96.69	62.01
Degenerative changes		31.89	97.39	95.16	47.06
Platelet count <150,000 /Cu.mm		65.95	55.65	70.52	50.39
Comparison of diagnostic value of various parameters					
Table 3					

Degenerative Changes in neutrophils [13]

Neutrophils were observed for any morphological changes due to impending sepsis, namely toxic granulations and vacuolations. The changes were noted with respect to the criteria set forth by Zipursky et al.

Degenerative changes were observed in 62 cases out of which blood culture and CRP positive cases were 59.

The sensitivity and specificity of this test were 31.89% and 97.39% respectively.

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Platelet Count [14]

The normal value is considered to be 150000 – 450000/ mm3. Thus any value ≤150000/ mm3 has been considered by many studies as thrombocytopenia. A reduced platelet count was seen in 173 cases, out of which culture and CRP positive cases were 122.

The sensitivity and specificity of this test were 65.95% and 55.65% respectively.

Haematological scoring system (HSS)

The Haematological Scoring System was devised with the intention of using as sepsis screen for the early detection of neonatal sepsis. The criteria used were the same as that used by Rodwell et al[10] as have already been mentioned earlier.

To recapitulate, the parameters used were:

1. Total leucocyte count <5000/mm3 at any given time, or ≥25000, ≥30000 and ≥21000/ mm3 at birth, 12-24 hours and from day 2 onwards respectively.
2. Deranged Absolute Neutrophil count (Normal values: 1800 – 540/mm3 at birth, 6800-11700/ mm3 at day 1 and 2800-5400 mm3 from day 5 onwards).
3. Increased immature neutrophil count (Normal values: <1000/ mm 3 at birth, <1300 at day 1, <750/ mm 3 at day 2, <600/mm 3 from day 5 onwards.)
4. Immature to total neutrophil ratio ≥0.12
5. Immature to Mature neutrophil ratio ≥0.3
6. Degenerative changes present. E.g.: Toxic granules, vacuolations and Dohle bodies
7. Platelet count <150000 /mm3.

Haematological scoring system (HSS)

HSS score	**Culture +**	**CRP +**	**Culture –**	**CRP -**
Score 0	0	0	14	14
Score 1	0	4	61	57
Score 2	4	16	34	22
score 3	5	22	23	6
Score 4	21	28	20	13
score 5	41	66	28	3
Score 6	30	34	4	0
Score 7	15	15	0	0
Total cases	116	185	184	115
Correlation of Haematological Scoring System with blood culture and CRP				
HSS		**Blood Culture +**		**CRP +**
6		30		34
7		15		15
Definite Sepsis (blood culture + and CRP +)				
HSS		**Blood Culture +**		**CRP +**
3		5		22
4		21		28
5		41		66
Probable Sepsis (blood culture- and CRP+)				
HSS		**Blood Culture +**		**CRP+**
0		0		0
1		0		4
2		4		16
No Sepsis				

Table 4

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- Out of the total 300 cases evaluated, 113 cases had a HSS score of 0-2, out of which, 96% were found to be culture negative.
- 138 cases were found to be in the category of HSS score 3-5. Out of this, 48.5% cases were found to be culture positive.
- 49 were found to have a score of 6-7. Out of this, 91% showed culture positivity.

Definite Sepsis includes blood culture positive cases. 100% of the cases with HSS 7 were culture and CRP positive.

Among HSS 6 cases, 88.24% of cases were culture positive and 100% cases were CRP positive.

Of the HSS score 3-5, 84% of the cases were CRP positive. Culture positive proportion gradually increased from score 3-5. But culture negative counts were also relatively high (51.45%).

Of the HSS score 0-2, 96.46% of the cases were culture negative and 82.3% cases were CRP negative.

Haematological scoring system (HSS)

HSS score	**Sensitivity**	**Specificity**	**PPV**	**NPV**
Score ≥ 1	100	7.6	40.55	100
Score ≥ 2	100	40.76	51.56	100
score ≥3	96.55	59.23	59.89	96.46
Score ≥4	92.24	71.73	67.29	93.61
Score ≥5	74.13	82.6	72.88	83.51
Score ≥6	38.79	97.82	91.83	71.71
score ≥ 7	12.93	100	100	64.56
Diagnostic value: Haematological Scoring System in correlation with blood culture				
HSS score		**CRP +**		**CRP –**
Score 0		0		14
Score 1		4		57
Score 2		16		22
score 3		22		6
Score 4		28		13
score 5		66		3
Score 6		34		0
Score 7		15		0
Total cases		185		115
Correlation of Haematological Scoring System with CRP				
HSS score	**Sensitivity**	**Specificity**	**PPV**	**NPV**
Score > 1	100	12.17	64.69	100
Score > 2	97.84	61.74	80.44	94.67
Score > 3	89.19	80.87	88.24	82.3
Score > 4	77.30	86.09	89.94	70.71
Score > 5	62.16	97.39	97.46	61.54
Score > 6	26.49	100	100	45.81
Score > 7	8.11	100	100	40.35
Diagnostic value: Haematological Scoring System in correlation with CRP				
Table 5				

It was observed that by increasing the cut-off values for HSS, the sensitivity dropped but the specificity kept increasing.

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- Out of total 300 cases evaluated, 113 cases had HSS score of 0-2, out of which 82% cases were CRP negative.
- 138 cases were between the score 3-5. Out of which, 84% were found to be CRP positive.
- 49 cases were found to have a score of 6-7. Out of this, 100% showed culture positivity.

It was observed that, by increasing the cut-off values for HSS, the sensitivity dropped but the specificity kept increasing.

DISCUSSION

Early diagnosis and treatment of neonatal septicaemia is essential because of the high mortality and morbidity associated with this condition. .

Early onset sepsis is mainly due to vertical transmission of pathogens from the female genital tract to the newborn or the foetus. Neonates can get infected in utero or during the delivery while passing through the vaginal canal. Maternal factors that increase the risk of developing sepsis include chorioamnionitis, preterm labour, prolonged rupture of membranes more than 18 hours, group B streptococcus colonisation.

Late onset sepsis occurs due to the transmission of infection from the surrounding environment post-delivery, including contact from the healthcare workers. Infants requiring intravascular catheterisation, invasive procedures that disrupt the mucosa are at increased risk of developing late onset sepsis.[15]

In early onset sepsis, they may have foetal distress in peripartum period including foetal tachycardia. Post-delivery, there may be meconium stained liquor and low APGAR scores.

History of irritability, feeding intolerance, excessive sleepiness may be present. Vital sign derangements including hypothermia or fever may be seen. There may be tachycardia or bradycardia, signs of poor perfusion, respiratory distress and some neurological symptoms and signs.

Gastrointestinal signs include decreased feeding, vomiting, diarrhoea, jaundice and abdominal distension.[16]

- Blood culture is the gold standard for diagnosis of Neonatal Sepsis. But it requires a minimum of 48-72 hours and yields a positive result in up to 60% of cases only. It is of utmost importance that a proper treatment is initiated when there is a strong suspicion of sepsis, keeping in mind the poor prognostic effects that may follow due to delay in treatment.

Delay in diagnosis can lead to untoward complications such as brain damage or neurodevelopmental delay. Hence, this study was done to evaluate the early diagnostic and prognostic utility of haematological scoring system.

Age distribution

- Zawar M.P. et al observed that 61% of neonates had early onset sepsis and 39% had late onset sepsis. [18] Varsha et al reported that 74% of the neonates belonged to early onset category where as 26% belonged to late onset category. [19]
- Ahmed et al reported that 65% of the neonates had early onset sepsis and
- 35% had late onset sepsis. [20]
- In the present study also, we found that out of 185 cases of sepsis, 105 were of the age group < 3 days (56.76%), whereas 80 were between 4-28 days (43.24%). Thus the observations made in our study are in concordance with those made in the previous studies.

Maximum neonatal sepsis cases were seen in neonates less than 3 days of age (early onset septicaemia) as compared to neonates aged more than 3 days (late onset septicaemia) in the present study.

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Sex distribution

- It has been postulated in many studies that there is a strong predilection for male neonates when it comes to neonatal sepsis. [21]. [22]
- Slight male preponderance was noted in the blood culture and CRP positive cases (103 males and 82 females) with ratio of 1.26:1.

The ratio of culture positive neonatal septicaemia cases was higher among males than the females in the present study, showing a ratio of 1.26:1.

These results are comparable with the observations made by Narasimha et al[11] Guclu et al[23] Majumdar et al[8] and Saleem et al[24] M:F ratio in these studies are 1:1, 1.4:1, 2:1, 1.5:1 respectively.

The male preponderance in neonatal septicaemia may be linked to the X- linked immuno regulatory gene factor resulting in the host's susceptibility to infections in males.[25]

Diagnostic value of the tests used for screening of sepsis:

Neonatal sepsis, presents with a plethora of varying and inconsistent signs and symptoms making it difficult to put across one single test which can be reliably used in the spot-on diagnosis of sepsis. sepsis. [26,27,28,29]

Parameters used in haematological profile

Total leucocyte count

Sensitivity, specificity, positive predictive value and the negative predictive values of total leucocyte count in our study were 58.92, 84.35, 85.83, and 56.07 respectively.

Total leucocyte count had moderate sensitivity and NPV that is similar to studies conducted by Makkar et al, Buch et al.[30] other parameters like specificity, PPV are moderately high that are similar to studies conducted by Makkar et al, Khair et al, Bhalodia[31] and Rodwell et al..

An increased or decreased WBC count had low sensitivity in detecting neonatal sepsis when used alone.

The low sensitivity may be attributed to the immature immune responses in neonates or any prior steroid therapy to the neonate or the mother.

Absolute Neutrophil count

Sensitivity, specificity, positive predictive value and the negative predictive values of total neutrophil count in our study were 86.49%, 46.09%, 72.07%, and 67.95% respectively.

The sensitivity in our study is high which is in concordance to many of the previous studies conducted by Monroe, Makkar, Rodwell and Majumdar and Khair et al.

The differences in the results of this parameter as shown by different studies may be due to- different reference ranges used in various studies, the blood sampling time ,as the count differs in hourly basis in neonates, o Gestational age, o Site of sampling, o Stress factor, o Any prior steroid therapy to neonate and maternal factors.

Immature neutrophil count

Sensitivity, specificity, positive predictive value and the negative predictive values of total immature neutrophil count in the present study are 79.46, 80.87, 86.98, and 70.99% respectively.

similar to previous studies conducted by Ghosh et al, Makkar et al and Debroy et al.[32]

The differences in the results of this parameter as shown by different studies may be due to the o Severity of infection, o The age of neonate and o The diagnostic criteria followed.

As the body demands more leucocytes to defend any invading pathogen, the time that is usually spent by an immature neutrophil for the process of maturation inside the bone

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marrow, is reduced. Owing to early release, immature forms are spilled into the circulation, leading to their increased numbers in the peripheral smear. [33]

Immature to Total neutrophil ratio

Sensitivity, specificity, positive predictive value and negative predictive values of I:T ratio in our study were 80.54%, 83.48%, 88.69% and 72.72% respectively.

Which are in concordance with previous studies conducted by Makkar et al, Buch et al and Debroy et al and Rodwell et al.

As the NPV of this parameter is high in majority of the studies, this can be helpful in ruling out cases of sepsis.

The differences in the results of this parameter as shown by different studies may be due to- o Interobserver variation in counting immature forms, o Blood sampling time, o Site of the sampling (as capillary specimens have relatively more neutrophils than arterial or venous), o The severity of infection, o The age of neonate.

Immature to mature neutrophil ratio

Sensitivity, specificity, positive predictive value and the negative predictive values of total immature PMN count in our study were 63.24%, 96.52%, 96.69%, and 62.01% respectively.

same as that of studies conducted by Makkar et al, Misquth et al and Debroy et al and Narasimha et al.

Specificity and PPV of this test are very high which are in concordance with the previous studies conducted by Makkar et al, Misquith et al Debroy et al.

The NPV is moderate which is similar to Makkar et al and Misquith et al.

The specificity of various studies ranges from moderate to high, this difference could be due to- o various comorbid non-infective conditions which can affect the neutrophil morphology and o The subjectivity of deciding which cell is immature.

This test had very few false positive cases, thus it is good in detecting culture negative cases.

Degenerative changes

The sensitivity, specificity, PPV and NPV are 31.89%, 97.39%, 95.16% and 47.06% respectively.

This test showed very few false positive cases which is similar to the studies made by Rodwell et al and Makkar et al.

Platelet Count

The sensitivity, specificity, positive predictive value and negative predictive value in the present study are 65.95, 55.65, 70.52 and 50.39 respectively.

This test had a large number of false positives and false negatives which account for low sensitivity and specificity of the test similar to the study conducted by Bhalodia et al.

Low sensitivity was also seen in studies conducted by Rodwell et al and Narsimha et al, however the specificity was high in these studies.

The differences in various other studies may be due to- o Error in timing of sampling collection since neonates usually show low count in the 1st week of life and increased count after 1 week, o Sampling method, o Maternal and neonatal factor influence.

It has been postulated that a decrease in platelet count in neonatal sepsis is mainly due to disseminated intravascular coagulation due to the effect of endotoxins. [34]

Haematological scoring system

- In the present study, if HSS: 0-1, sepsis is absent. Blood culture and CRP are negative in these cases.
- If HSS: 6-7, sepsis is present. Blood culture and CRP are positive in these cases.

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- If HSS: 3-5, CRP is positive in 84% of the cases, culture negative cases are 51.45%.
- So, when HSS is high and CRP is found to be positive, blood culture positivity is not mandatory for the diagnosis and treatment of neonatal sepsis.
- Hence, it can be concluded that as the Scoring System increases, the probability of neonatal sepsis increases and it can be correlated with blood culture and CRP levels.
- Therefore, it helps the physician in early diagnosis, treatment and helps to improve the patient's outcome.

The parameter with highest sensitivity is abnormal absolute neutrophil count followed by elevated immature to total neutrophil ratio.

The parameter with highest specificity is degenerative changes in neutrophils and immature to mature neutrophil ratio.

The single parameter with highest positive predictive value is elevated immature to mature neutrophil ratio and the one with highest negative predictive value is elevated immature to total neutrophil ratio.

Over the years many studies on tests for neonatal sepsis have been carried out. Most of these scoring systems use the changes in quality and quantity of WBCs along with changes in platelets as their criteria. Some other studies have also included micro-ESR and CRP as part of their scoring system. [35,36]

The present study incorporated the seven aforementioned parameters. The values of all the Haematological scoring systems were as follows.

Correlation of HSS with blood culture

As no single haematological parameter is superior in comparison to another to capably predict neonatal sepsis, a combination of all these parameters is used for Haematological Scoring System.

HSS when correlated with blood culture, a cut-off value of >=4 yielded a sensitivity of 92% and specificity of 72%.

The variations in the scoring system may be due to different cut-off values used for various parameters and the scoring system, the time of collection of sample and the processing time.

In the present study, among 300 cases, culture positivity was seen in 116 cases yielding a positive result of 38.67%. It was comparable with the study done by Ahmad et al[37] and Tallur et al.[38]

The low culture positivity may be due to inadequate sampling, pre incubation delay, fastidious organisms and use of anti-microbial agents.

Correlation of Haematological Scoring System with CRP

- When correlated with CRP, the Haematological Scoring System with a cut-off value of >4 had a sensitivity of 77.3% and specificity of 86%.
- HSS can be used as an adjunct to CRP in the diagnosis of sepsis cases.
- The advantage of HSS when compared to CRP is the ability to predict the prognosis of the patient. The higher the scoring system, the more is the severity of the sepsis and more prolonged is the duration of hospitalisation.

HSS in prognosis of Neonatal Sepsis

- HSS helps not only in the diagnosis of Neonatal sepsis but also in predicting the severity and outcome of sepsis.
- Higher is the scoring system, more severe is the disease.

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- In the present study, the duration of hospitalisation increased in higher score patients, up to 21 days in score 5, maximum of 30 days in score 6 and up to 32 days in score 7, reflecting the severity of the disease.
- The scoring system had reduced to <3 in majority of cases, with appropriate antibiotic therapy by day 5.

Haematological Scoring System helps in ruling in or out Neonatal Sepsis, thereby, o decreasing the hospital stay, o Alleviating the anxiety of parents and o Helps preventing development of antibiotic resistant pathogenic strains. o. [39]

However, it should be borne in mind that even though higher scores of HSS point towards increased chances of sepsis, standardisation and simplification of this global test is required.

CONCLUSION

Our study shows that, as the Haematological Scoring increases, the probability of neonatal sepsis also increases and it can be correlated with blood culture and CRP levels. Therefore, it helps the physician in early diagnosis, treatment and hence, a better outcome. HSS also helps in predicting the severity and outcome of neonatal sepsis, as reflected by prolonged duration of hospitalisation of the patients and reduction in the score with appropriate response to therapy.

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