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Original Research Article

Evaluation of Hematological Scoring System in the Diagnosis of Neonatal Sepsis

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Abstract

Introduction: Neonatal septicemia constitutes one of the major public health problems throughout the world. Early diagnosis of neonatal sepsis poses a great challenge. Hematological scoring system [HSS] formulated by Rodwell et al. can be used to establish early diagnosis of sepsis in neonates.

Objectives: To evaluate the utility of conventional HSS and modified HSS as a diagnostic tool in the setting of neonatal sepsis and to evaluate the role of additional parameters like nucleated RBC count, Neutrophil Lymphocyte Ratio [NLR] and Platelet Lymphocyte Ratio [PLR] in the diagnosis of neonatal sepsis.

Materials and Methods: The study was conducted in hematology section of the department of pathology at a rural tertiary care referral institute. It was a prospective study done over a period of six months from January 2015 to June 2015. Fifty-one cases were analyzed. All high risk neonates admitted to NICU [Neonatal Intensive Care Unit] were included in the study. Clinically, neonates were grouped into three categories. Conventional hematological scoring system [HSS] and Modified hematological scoring system were applied to all the cases. Additional hematological parameters like nucleated RBC count, NLR and PLR were also evaluated.

Results: Both conventional hematological scoring system and modified hematological scoring system were found to be statistically significant by Chi-square test ($P < 0.05$) for clinical correlation. NLR ratio was statistically significant ($P < 0.05$) for clinical correlation. Nucleated RBC count and PLR were found to be statistically not significant ($P > 0.05$) for clinical correlation. Sensitivity of conventional HSS and modified HSS were similar (100%) with respect to total WBC count, immature polymorphonuclear neutrophils (PMN) count, immature: total PMN ratio, immature: mature PMN ratio and degenerative changes in PMN. Specificity of total WBC count was better in conventional HSS. Specificity of platelet count was better in modified HSS.

Conclusion: Hemalotogical scoring system is a useful, simple and reliable tool for evaluating neonatal sepsis. But, modified HSS appears to be more meaningful scoring system than conventional HSS.

Keywords: Diagnostic; Parameter; Neutrophils.

Introduction

Sepsis is a systemic inflammatory response syndrome associated with infection diagnosed on either microbiological culture or strong clinical evidence of infection [1]. Neonatal sepsis is a clinical syndrome resulting from effects of local and system infection during first month of life [2]. Neonatal septicemia constitutes one of the major public health problems throughout the world [3]. According to National Neonatal Perinatal Database [NNPD], the incidence of neonatal sepsis has been reported to be 30/1000 live births [2]. Neonatal infections are causing 1.6 million deaths annually in developing countries [1].

Early diagnosis of neonatal sepsis is a vexing problem and a great challenge [3]. Blood culture is considered to be gold standard for the diagnosis of septicaemia [2]. But, it is a time consuming investigation which requires a minimum of 48 -72 hours. Timely diagnosis of neonatal septicemia is critical because the illness can progress more rapidly in neonates than in adults [3,4]. Newer inflammatory markers like interleukin-6, interleukin-8 and plasma elastase are highly sensitive and specific for diagnosing neonatal sepsis and septic shock. But they require sophisticated and expensive kits [1]. Early diagnosis of sepsis helps the clinician to administer early treatment with appropriate antibiotics [2]. Hematological scoring system [HSS] formulated by Rodwell et al can be used to establish early diagnosis of sepsis in neonates [5]. The present study was undertaken to evaluate the utility of conventional HSS and modified HSS as a diagnostic tool in the setting of neonatal sepsis and to evaluate the role of additional parameters like nucleated RBC count, Neutrophil Lymphocyte Ratio [NLR] and Platelet Lymphocyte Ratio [PLR] in the diagnosis of neonatal sepsis.

Materials and Methods

The study was conducted in hematology section of the department of pathology at a rural tertiary care referral institute. It was a prospective study done over a period of six months from January 2015 to June 2015. Fifty-one cases were analyzed. All high risk neonates admitted to NICU [Neonatal Intensive Care Unit] were included in the study. Those cases, in which complete hematological profile could not be performed, were excluded from the study.

Clinically, neonates were grouped into three categories. Category of "No Sepsis" included neonates presenting with clinical signs of sepsis and any of the microbiological cultures [Blood or CSF or urine] were negative and ancillary laboratory investigations were not significant. Category of "Probable sepsis" included neonates presenting with clinical signs of sepsis, microbiogical cultures [Blood or CSF or urine] were negative, but and ancillary laboratory investigations were significant. Category of "Definite Sepsis" included neonates presenting with clinical signs of sepsis and any of the microbiological cultures [Blood or CSF or urine] were positive. Ancillary laboratory investigations included investigations like C-Reactive protein [CRP] and serum bilirubin levels.

Complete blood count parameters were obtained from Autoanalyser Sysmex K21. Autoanalyser values were verified by peripheral smear examination. Peripheral smears were interpreted and reported according to the standard reference range values in neonates. Convention hematological scoring system [HSS] and modified hematological scoring system were applied to all the cases. The criteria and parameters used in conventional HSS and modified HSS are depicted in Table 1. Additional hematological parameters like nucleated RBC count, NLR and PLR were also evaluated

Statistical Analysis

Socio-demographic variables were represented using frequencies and percentages. Chi-square test exact test was used for categorical variables. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and efficacy of individual parameters were evaluated. All statistical analysis was performed by STATA version 13.

Results

Fifty-one cases of high risk neonates admitted to NICU [Neonatal Intensive Care Unit] were analyzed. The age of high risk neonates admitted to NICU ranged from new born baby to 26 days with a mean of 2.29 days. Most of the neonates were new born [31 cases (60.78%)]. Male neonates [33 cases (64.71%)] constituted predominant population with a male to female ratio of 1.8:1. Term neonates [29 cases (56.86%)] constituted predominant population in comparison with preterm neonates [22 cases (43.14%)].

Clinically high risk neonates were categorized as no sepsis [19 cases (37.25%)], probable sepsis [28 cases (54.9%) and definite sepsis [4 cases (7.84%)]. Neonates affected by sepsis [including both probable sepsis and definite sepsis] constituted 32 cases (62.75%). Early onset sepsis [21 cases (65.63%) was predominantly seen in comparison with late onset sepsis [11 cases (34.38%)]. Male neonates [25 cases (78.13%) were predominantly affected by sepsis with a male to female ratio of 3.6:1. Term neonates [24 cases (75%)] were predominantly affected by sepsis in comparison with preterm neonates [8 cases (25%)]. Culture was positive in four cases (12.5%). Blood culture was positive in three cases (9.68%). The organisms isolated from blood sample included Streptococci, Klebsiella and Non-fermenting gram negative bacilli. Urine culture was positive in one case

(3.13%)]. Fungi (candida) was isolated from urine sample constituting one case (3.13%)].

Conventional HSS proposed by Rodwell et al. was applied to evaluate all the cases. Based on the scoring system, cases were categorized into three groups. Group 1 [score 0-2] represented the category with interpretation of "sepsis is very unlikely" and constituted 5 cases (9.8%). Group 2[score 3-4] represented the category with interpretation of "sepsis is suspected" and constituted 39 cases (76.47%). Group 3 [score ≥ 5] represented the category with interpretation of "sepsis is very likely" and constituted 7 cases (13.73%). Conventional HSS was found to be statistically significant by Chi-square test ($P < 0.05$) for clinical correlation [Table 2]. The scoring system was statistically significant for detecting early onset sepsis and late onset sepsis ($P < 0.05$).

Similarly, modified HSS was applied to all the cases. Based on the scoring system, cases were categorized into three groups. Group 1 [score 0-2] represented the category with interpretation of "sepsis is very unlikely" and constituted 9 cases (17.65%). Group 2 [score 3-4] represented the category with interpretation of "sepsis is suspected" and constituted 25 cases (49.02%). Group 3 [score ≥ 5] represented the category with interpretation of "sepsis is very likely" and constituted 17 cases (33.33%). Modified HSS was found to be statistically significant by Chi-square test ($P < 0.05$) for clinical correlation [Table 3].

NLR was in normal range in 12 cases (23.53%), increased in 29 cases (56.86%) and decreased in 10 cases (19.61%). The values were statistically significant ($P < 0.05$) for clinical correlation. PLR was in normal range in 28 cases (54.9%), increased in 7 cases (13.73%) and decreased in 16 cases (31.37%). The values were statistically not significant ($P > 0.05$) for clinical correlation. Nucleated RBC count was increased in 32 cases (62.74%) and was statistically not significant ($P > 0.05$) for clinical correlation. It had sensitivity of 50%, specificity of 36.17%, PPV of 6.9% and NPV of 89.47%.

Sensitivity

Sensitivity of conventional HSS and Modified HSS were similar with respect to total WBC count, immature PMN count, immature: total PMN ratio, immature: mature PMN ratio and degenerative changes in PMN. [Figure 1 and

Table 1: Comparison of Conventional HSS and Modified HSS

Parameters	Conventional HSS Criteria	Score	Parameters	Modified HSS Criteria	Score
Total WBC Count	≤ 5000/µl	1	**Total WBC Count**	Increased or decreased for the given age	1
	≥ 25000//µl	1		Normal for the given age	0
	≥ 30000/µl for 12 to 24 hrs	1			
	≥ 21000//µl for Day 2 onwards	1			
Total PMN count	No Mature PMN seen	2	**Total PMN count**	No Mature PMN seen	2
	Increased or Decreased	1		Increased or decreased for the given age	1
	1800- 5400 /µl	0		Normal for the given age	0
Immature PMN count	> 600	1	**Immature PMN count**	> 600	1
	<600	0		< 600	0
Immature: Total PMN ratio	≥ 0.12	1	**Immature: Total PMN ratio**	≥ 0.2	1
	< 0.12	0		< 0.2	0
Immature: Mature PMN ratio	≥ 0.3	1	**Immature: Mature PMN ratio**	≥ 0.3	1
	< 0.3	0		< 0.3	0
Degenerative Changes in PMN	Toxic granules or cytoplasmic vacuoles	1	**Degenerative Changes in PMN**	Toxic granules or cytoplasmic vacuoles	1
	No Toxic granules or cytoplasmic vacuoles	0		No Toxic granules or cytoplasmic vacuoles	0
Platelet Count	≤ 150000/µl	1	**Platelet Count**	Decreased for the given age	1
	> 150000/µl	0		Normal for the given age	0
Interpretation of scores			**Interpretation of scores**		
≤ 2	Sepsis is very unlikely		≤ 2	Sepsis is very unlikely	
3 or 4	Sepsis is suspected		3 or 4	Sepsis is suspected	
≥ 5	Sepsis is very likely		≥ 5	Sepsis is very likely	
Minimum score	0		Minimum score	0	
Maximum score	8		Maximum score	8	

Figure 2] Modified HSS showed better sensitivity with respect to total PMN count and platelet count. According to both conventional HSS and modified HSS, sensitivity was highest for immature PMN count, immature: total PMN ratio, immature: mature PMN ratio and degenerative changes in PMN [Table 3].

Specificity

Specificity of conventional HSS and modified HSS were similar with respect to immature PMN count, immature: mature PMN ratio and degenerative changes in PMN. Modified HSS showed lower sensitivity with respect to total WBC count. However, modified HSS showed better sensitivity with respect to total PMN count, immature: total PMN ratio and platelet count. According to conventional HSS, specificity was highest for total WBC count and least for immature: total PMN ratio. According to modified HSS, specificity was highest for platelet count and least for immature PMN count [Table 3].

Positive Predictive Value [PPV]

PPV of conventional HSS and modified HSS were similar with respect to immature PMN count, immature: mature PMN ratio and degenerative changes in PMN. Modified HSS showed lower PPV with respect to total WBC count. However, modified HSS showed better PPV with respect to total PMN count, immature: total PMN ratio and platelet count. According to conventional HSS, PPV was highest for degenerative changes in PMN and least for total PMN count. According to modified HSS, PPV was highest for platelet count and least for total WBC count [Table 3].

Negative Predictive Value [NPV]

NPV of conventional HSS and modified HSS were similar with respect to immature PMN count, immature: total PMN ratio, immature: mature PMN ratio and degenerative changes in PMN. Modified HSS showed lower NPV with respect to total WBC count. However, modified HSS showed better NPV with respect to total PMN count

Table 2: Comparison of distribution of cases according to Conventional HSS and Modified HSS in relation to clinical categories

	Conventional Hematological Scoring system				
Clinical category	**Group 1**	**Group 2**	**Group 3**	**Total**	**P Value**
No sepsis	4	14	1	19	
Probable sepsis	1	25	2	28	P<0.05
Definite sepsis	0	0	4	4	
Total	5	39	7	51	
	Modified Hematological Scoring system				
Clinical category	**Group 1**	**Group 2**	**Group 3**	**Total**	**P Value**
No sepsis	8	8	3	19	
Probable sepsis	1	17	10	28	P<0.05
Definite sepsis	0	0	4	4	
Total	9	25	17	51	

Table 3: Comparison of performance of individual hematological parameters of Conventional HSS and Modified HSS

	Conventional Hematological Scoring system				
Parameters	**Sensitivity [%]**	**Specificity [%]**	**PPV [%]**	**NPV [%]**	**Efficacy [%]**
Total WBC Count	50	91.49	33.33	95.56	88.24
Total PMN count	50	21.28	5.13	83.33	23.53
Immature PMN count	100	12.77	8.89	100	19.61
Immature: Total PMN ratio	100	4.26	8.16	100	11.76
Immature: Mature PMN ratio	100	42.55	12.9	100	47.06
Degenerative Changes in PMN	100	85.11	36.36	100	86.21
Platelet Count	50	80.85	18.18	95	78.43
	Modified Hematological Scoring system				
Parameters	**Sensitivity [%]**	**Specificity [%]**	**PPV [%]**	**NPV [%]**	**Efficacy [%]**
Total WBC Count	50	44.68	7.14	91.30	45.10
Total PMN count	75	40.43	9.68	95	43,14
Immature PMN count	100	12.77	8.89	100	19.61
Immature: Total PMN ratio	100	56.67	11.76	100	41.17
Immature: Mature PMN ratio	100	42.55	12.9	100	47.06
Degenerative Changes in PMN	100	85.11	36.36	100	86.21
Platelet Count	75	89.36	37.5	97.67	88.24

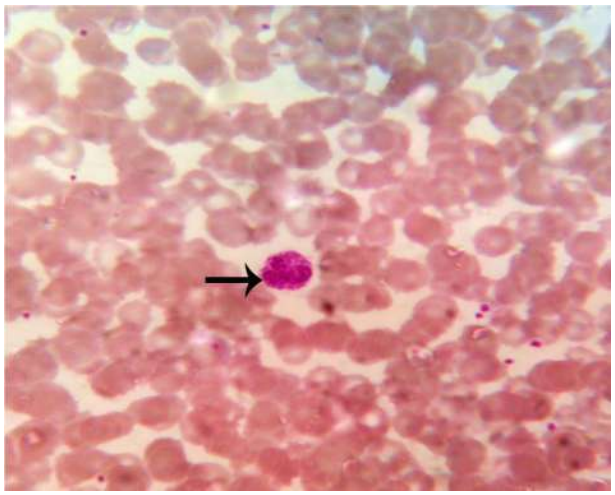

Fig. 1: Microphotograph of peripheral smear showing toxic granules (Arrow) in neutrophil. [Leishman stain, X1000]

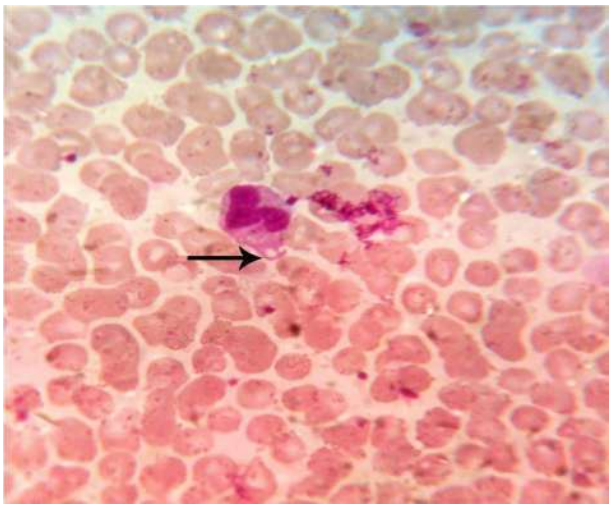

Fig. 2: Microphotograph of peripheral smear showing cytoplasmic vacuolation (Arrow) in neutrophil. [Leishman stain, X1000]

Table 4: Comparison of performance of hematological parameters in various studies

Authors	Cases	Sensitivity Highest	Lowest	Specificity Highest	Lowest	PPV Highest	Lowest	NPV Highest	Lowest
Khair BK et al[3] [2010]	12/100	I:T ratio (>0.2), I:M ratio [100%]	Total WBC count [50%]	Total WBC count [91%]	I:T ratio (>0.2) [4%]	Total WBC count [43%]	I:M ratio [11%]	I:T ratio (>0.2), I:M ratio [100%]	Immature PMN count [80%]
Narasimha A et al[4] [2011]	12/50	Total PMN count [89.87%]	Total WBC count [10.52%]	Total WBC count [91.66%]	Immature PMN count [8.3%]	I:T ratio (≥ 0.12) [88.88%]	Degenerative changes [66.66%]	Degenerative changes [40%]	Immature PMN count [11.11%]
Makkar M et al[6] [2013]	42/110	Immature PMN count [96.87%]	I:M ratio [53.12%]	I:M ratio [97.22%]	Total PMN count [72.22%]	I:M ratio [94.44%]	Total PMN count [74.35%]	Immature PMN count [97.05%]	I:M ratio [70%]
Majumdhar A et al[7] [2013]	20/60	I:T ratio (>0.2), I:M ratio [100%]	Total WBC count [45%]	Total WBC count [85%]	I:T ratio (>0.2) [5%]	Degenerative changes [55%]	I:M ratio [12%]	I:T ratio (>0.2), I:M ratio [100%]	Degenerative changes [50%]
Meirina F et al[5] [2015]	10/40	I:T ratio (≥ 0.12), Total PMN count [100%]	Degenerative changes [0%]	Degenerative changes [100%]	Total PMN count [20%]	I:M ratio [63%]	Degenerative changes [0%]	I:T ratio (≥ 0.12), Total PMN count [100%]	Degenerative changes [75%]
Debroy A et al[9] [2016]	10/40	I:T ratio (≥ 0.12) [90%]	Total PMN count [40%]	I:T ratio (≥ 0.12) [96.6%]	Degenerative changes [53%]	I:T ratio (≥ 0.12) [100%]	Degenerative changes [26.13%]	I:T ratio (≥ 0.12) [96.6%]	Total PMN count [76%]
Bhalodia MJ et al[2] [2017]	48/150	I:M ratio [93.7%]	Total PMN count [45.8%]	I:M ratio [94.44%]	Platelet count [55.9%]	I:M ratio [93%]	Total PMN count [46%]	I:M ratio [94%]	Platelet count [58%]
Present study									
Conventional HSS	4/51	Immature PMN count, I:T ratio (≥ 0.12), IM ratio, Degenerative changes [100%]	Total WBC count, Total PMN count, Platelet count [50%]	Total WBC count [91.49%]	I:T ratio (>0.2) [4.26%]	Degenerative changes [36.36%]	Total PMN count [5.13%]	Immature PMN count, IT ratio, IM ratio, Degenerative changes [100%]	Total PMN count [83.33%]
Modified HSS	4/51	Immature PMN count, IT ratio (≥ 0.2), IM ratio, Degenerative changes [100%]	Total WBC count [50%]	Platelet count [89.36%]	Immature PMN count [12.77%]	Platelet count [37.5%]	Total WBC count [7.14%]	Immature PMN count, IT ratio, IM ratio, Degenerative changes [100%]	Total WBC count [91.30%]

and platelet count. According to both conventional HSS and modified HSS, NPV was highest for immature PMN count, immature: total PMN ratio, immature: mature PMN ratio and degenerative changes in PMN [Table 3].

Efficacy

Efficacy of conventional HSS and modified HSS were similar with respect to immature PMN count, immature: mature PMN ratio and degenerative changes in PMN. Modified HSS showed lower efficacy with respect to total WBC count. However, modified HSS showed better efficacy with respect to total PMN count, immature: total PMN ratio and platelet count. According to conventional HSS, efficacy was highest for total WBC count and least for immature: total PMN ratio. According to Modified HSS, efficacy was highest for platelet count and least for immature PMN count [Table 3].

Discussion

Neonatal sepsis is a serious public health problem with significant morbidity and mortality [2]. The neonates are more prone to bacterial invasion than the older children and adults because of their weaker immune system [6]. Even though it is a life threatening condition; it is treatable by timely administration of antibiotics. The limitations in the diagnosis of neonatal sepsis are quiet frustrating and a vexing problem for the clinician. Although, the blood culture is considered as gold standard diagnostic test, it has low sensitivity A rapid diagnostic tool with greater sensitivity are desirable [2]. The hematological scoring system is a simple, quick, reliable and cost effective tool which can be used as screening test for the early diagnosis of neonatal sepsis [1,2]. The current study deals with evaluation of the utility of conventional HSS and modified HSS as a diagnostic tool in the setting of neonatal sepsis and evaluation of the role of additional parameters like nucleated RBC count, NLR and PLR in the diagnosis of neonatal sepsis.

In the present study, most of the neonates presented on day 1 of their life. Makkar M et al. [6] also documented similar observation. Khair KB et al. [3] observed that most of the neonates presented in first week of their life. Males were predominantly affected in the present study. Similarly, Bhalodia MJ et al. [2], Khair KB et al. [3], Merina F et al.[5], Majumdhar A et al.[7] and Saleem M et al.[8] observed that males were predominantly affected in their study. In contrast, females were predominantly affected in a study conducted by Makkar M et al [6]. Narasimha A et al.[4] documented equal distribution among both sexes in their study. In the present study, term neonates were predominantly affected. Bhalodia MJ et al [2]. also documented similar finding. Merina F et al [5]. recorded equal distribution in their study. In contrast, Khair KB et al [3], Makkar M et al.[6] and Saleem M et al.[8] found that preterm neonates were predominantly affected.

The present study was compared with other studies with respect to the performance of seven parameters of HSS. [Table 4] In contrast to other studies, the number of cases of proven sepsis was very less [only four cases]. The reason may be mainly due to contamination interfering with growth of the organisms. Most of the studies considered only positive blood culture as the criteria to clinically categorize a case as definite sepsis. In contrast, Kar SS et al. [10] included positive blood culture and positive Cerebrospinal fluid [CSF] culture as criteria to clinically categorize a case as definite sepsis in their study. Similarly, even in the present study, any positive microbiogical cultures [Blood or CSF or urine] was considered as a criteria to clinically categorize a case as definite sepsis. This is because, the neonatal sepsis is considered as a clinical syndrome resulting from effects of local and system infection during first month of life [2].

In the present study, Immature PMN count showed very high sensitivity and NPV in both conventional and modified HSS. Similarly, Makkar M et al.[6] observed highest senstivity and NPV with respect to Immature PMN count. Sensitivity and NPV for I:T ratio was very high in both conventional and modified HSS, in the present study. Khair KB et al.[3], Merina F et al.[5], Majumdhar A et al.[7] and Debroy A et al.[9] also documented similar observation in their study. I: M Ratio had very high sensitivity and NPV in both conventional and modified HSS in the present study. Bholodia MJ et al. [2] also recorded similar observation. In the present study, degenerative changes also had very high sensitivity and NPV in both conventional and modified HSS. In contrast, Meirina F et al. [5] documented lowest sensitivity and NPV.

In the present study, total WBC count showed highest specificity and a low sensitivity by Conventional HSS. Khair KB et al.[3], Narasimha A et al.[4] and Majumdhar A et al.[7] also made similar observations. I: T ratio had lowest specificity by convention HSS in the present study. Khair KB et al.[3] and Majumdhar A et al.[7] documented similar findings. In contrast, Debroy A et al.[9] observed highest specificity for I:T ratio. In the present study, platelet count had highest specificity in modified HSS. In contrast, Bholodia MJ et al.[2] observed lowest specificity for platelet count. Immature PMN count showed lowest specificity by modified HSS in the present study. Narasimha A et al.[4] also documented similar finding in their study.

In the present study, degenerative changes in PMN showed highest PPV by conventional HSS. Similarly, Majumdhar A et al. [7] observed highest PPV for degenerative changes in PMN. In contrast, Narasimha A et al.[4], Merina F et al.[5] and Debroy A et al.[9] documented lowest PPV for degenerative changes in PMN. Total PMN

count showed lowest PPV by conventional HSS in the present study. Bholodia MJ et al. [2] and Makkar M et al. [6] also recorded similar observation in their study. In the present study, platelet count showed highest PPV and total WBC count showed lowest PPV by modified HSS. In contrast, Khair KB et al. [3] documented highest PPV for total WBC count in their study.

Additional parameters like NLR, PLR and nucleated RBC count, were also evaluated in the present study. Neutrophil lymphocyte ratio was increased in 29 cases (56.86%) and the values were found to be statistically significant ($P < 0.05$) for clinical correlation. But the PLR was increased in only 7 cases (13.73%) and the values were statistically not significant ($P > 0.05$) for clinical correlation. Omran A et al. [11] also made similar observations in their study in their study. NLR showed significant difference between sepsis group and control group. But, the difference in PLR between both the groups were not significant [11]. In the present study, nucleated RBC count was increased in 32 cases (62.74%) and was statistically not significant ($P > 0.05$) for clinical correlation. In contrast, Abhishek MG et al. [12] documented lower sensitivity, lower NPV, higher specificity and higher PPV. It was concluded that nucleated RBC was a reliable marker than other hematological markers like total WBC count, ESR and toxic granulation in neutrophils [12]. But nucleated RBC count may also be increased in conditions like birth asphyxia, which needs to be considered.

The table 4 reveals considerable variations in the findings in different studies. This is because, the criteria used for analyzing seven parameters was not uniform. Narasimha A et al.[4], Merina F et al.[5], Makkar M et al.[6] and Debroy A et al.[9] considered I:T ratio of ≥ 0.12 in their study. While Khair KB et al.[3], Bholodia MJ et al. [2] and Majumdhar A et al.[7] considered I:T ratio of ≥ 0.2 in their study. In the present study, when both the values were compared, it was found that I:T ratio of ≥ 0.12 (Conventional HSS) has more false positives than I:T ratio of ≥ 0.2 (Modified HSS). Hence I:T ratio of ≥ 0.2 appears to be a better parameter.

Majority of the study applied a platelet count of $\leq 150000/\mu l$ as a criterion for considering sepsis. In contrast, Majumdhar A et al. [7] applied a platelet count of $\leq 100000/mm^3$ as a criterion for considering sepsis. In the present study, a platelet count of $\leq 150000/mm^3$ was used as a criterion for considering sepsis in conventional HSS. Platelet count "decreased for the given age of the neonate" was applied as a criterion in modified HSS. This is because; the platelet count reference range may vary in neonates of different age groups and also among males and females.

Similarly, even Total WBC count may vary in neonates of different age groups and also among males and females. Saleem M et al. [8] had considered CRP as one of the criterion for assessing neonatal sepsis in their study.

The basis for using modified HSS in the present study is that, the peripheral smear report should correspond with reference range used in the hematology laboratory. In the present study, hematological reference range given by AACC (American Association for clinical chemistry) press [Fifth edition] was used. By using modified HSS, the scoring system, the reference range used in a laboratory and the peripheral smear report, all the three would correspond and correlate. In the conventional HSS, the scoring system may not correspond to the reference range used in the laboratory or the peripheral smear report. For instance, the neonate may not have thrombocytopenia according to the reference range, but it may correspond to a score of 1, if conventional HSS is used.

Each laboratory may have their own reference range. It may not be possible to have fixed value for platelet count and fixed range for total WBC count. By considering this, in the present study, when both the scoring systems were compared, modified HSS appeared to be more meaningful than conventional HSS. Additional parameters like NLR may also be incorporated into scoring system, if proved to be useful by future studies.

Limitations of the Study

The number of cases of proven sepsis was very less and constituted only four cases. The cause for such less culture positivity can be attributed to technical difficulties encountered in isolating the organisms and contamination. Though the blood culture is considered a gold standard for the diagnosis of neonatal septicaemia, it is time consuming, has low yield (8-73%) and low sensitivity [1,2].

Furthermore, the suspected sepsis group is a difficult diagnostic group and could not be ignore, because fatal infection has been reported even in the absence of positive blood culture [3].

Conclusion

Hematological scoring system is a useful, simple and reliable tool for evaluating neonatal sepsis. HSS helps the clinician to stratify high risk neonates efficiently and institute appropriate treatment. Both conventional HSS and modified HSS were found to be statistically significant. But, modified HSS appears to be more meaningful scoring system than conventional HSS. Additional parameters like NLR needs to be explored and may be incorporated into the scoring system, if proved to be useful by future studies.

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