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Evaluation and Diagnostic Effectiveness of Hemogram, Biochemistry and Inflammatory Markers (Immature Granulocyte, Procalcitonin, CRP, NLR, PLR) in Patients with Sepsis

Muhammed Semih GEDIK[1], Muhammed CIFTCIOGLU[2]
[1] Kahramanmaraş Sütçü İmam University, Faculty of Medicine, Department of Emergency Medicine, Kahramanmaras, Turkiye
[2] Kahramanmaraş Sütçü İmam University, Faculty of Medicine, Internal Medicine, Kahramanmaras, Turkiye

Abstract

Background: It was aimed to show the contributions of hemogram values and inflammatory markers involved in the pathology and progression of sepsis, and other biochemical markers like C-reactive protein, procalcitonin, delta neutrophil index (immature granulocyte), calcium and zinc levels to the diagnosis of sepsis, and the relationship of the relevant markers with each other.

Materials and methods: This is a descriptive epidemiological study. Patients aged 18 years and over who received the diagnosis of sepsis in the Emergency Department and Internal Diseases Service of Kahramanmaraş Sütçü Imam University Medical Faculty Hospital between 11.10.2022 - 11.06.2023 were prospectively involved in this study.

Result: In the present study, it was found that leukocyte, neutrophil, platelet lymphocyte ratio, neutrophil lymphocyte ratio, immature granulocyte, copper, phosphorus, blood glucose, C-reactive protein, and procalcitonin values were high in patients with sepsis. Albumin, calcium, zinc and lymphocyte levels were found to be low.

Conclusion: The use of biomarkers in sepsis has increasingly become important in diagnosing, following treatment, determining prognosis and predicting mortality. The biomarkers examined in this study are believed to be a reference for future studies on their use in diagnosing and treating sepsis, and following its prognosis.

Keywords: Sepsis, Hemogram, Biochemistry, Immature granulocyte, Copper, Zinc.

Introduction

Sepsis is a clinical syndrome that most frequently causes mortality and morbidity around the world. Sepsis is a severe organ dysfunction that is induced by an uncontrolled host response to infection (1). Sepsis, which is also referred as systemic inflammatory response syndrome (SIRS), is identified as a severe multi-organ dysfunction. It is crucial to detect significant bacterial infections like sepsis in the early period so that infectious diseases can be treated and controlled. Organ dysfunction in sepsis refers to an acute increase of at least two points in the SOFA (Sequential Organ Failure Assessment) score due to infection. Septic shock is a subcomponent of sepsis and refers to the requirement for vasopressor therapy to increase the serum lactate level above 2 mmol/L and to keep the mean arterial pressure above 65 mmHg. In sepsis, clinical characteristics may vary depending on the conditions such as the infection site, causative microorganism, manifestation of organ dysfunction, and the underlying health status of the host (1, 2). In addition to clinical findings, there are also some laboratory tests such as leukocyte count and C-reactive protein (CRP) in the diagnosis of sepsis, however, sepsis is diagnosed based on clinical and inflammatory markers and blood culture results since these tests are not specific to sepsis. The major issue in the detection of bacterial infections is that the clinical presentation of signs and symptoms usually overlaps with other inflammatory disorders. Despite the widespread use of microbiological, biochemical and molecular methods for diagnosing the infections, they involve some restrictions with regard to sensitivity and specificity. Thus, there is still no gold standard marker. It is necessary to determine the proposed biomarkers by fast, cost-effective, reliable, simple, specific, and sensitive methods (2).

For the assessment of inflammatory processes that included in the progression and pathology of sepsis, CRP, procalcitonin (PCT), and complete blood count tests are employed. White blood cell count (WBC), neutrophil, lymphocyte, platelet

Corresponding Author: Muhammed Semih GEDİK **e-mail:** semihgedik86@hotmail.com
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(PLT) and mean platelet volume (MPV) values, that are among the complete blood count parameters, and the ratios of these values to each other are employed as inflammatory markers (3). A few of the most important of these markers are neutrophil-lymphocyte ratio (NLR) and platelet-lymphocyte ratio (PLR). Furthermore, delta neutrophil index is a recent inflammatory marker which is calculated in routine hemogram examination without causing additional cost. Upon reviewing the literature, delta neutrophil index was not evaluated much in patients with sepsis.

Immature granulocytes in the peripheral circulation is indicated by delta neutrophil index (DNI). Studies revealing that DNI generally increases in cases of inflammation are available (4). Immature/total granulocyte ratio or neutrophil band count is increased by stress, infection, and systemic inflammation, so it is possible to employ DNI as a measure of the existence of immature granulocytes and also as an indicator of a granulocyte shift to the left (5).

It was reported that hypocalcemia was observed in sepsis patients with critical condition. Nevertheless, the significance of hypocalcemia in sepsis has not been studied thoroughly. Hypocalcemia is frequently seen in patients with sepsis and is considered to be significantly related to organ dysfunction and sepsis-related mortality (6).

It was aimed to show the contributions of inflammatory markers involved in the pathology and progression of sepsis, and other biochemical markers such as CRP, PCT, complete blood count parameters, delta neutrophil index, calcium, zinc levels to the diagnosis of sepsis and the relationship of relevant markers with each other.

Material and Method

This is a descriptive epidemiological study. Patients aged 18 years and over who received the diagnosis of sepsis in the Emergency Department and Internal Diseases Service of Kahramanmaraş Sütçü Imam University Medical Faculty Hospital between 11.10.2022 - 11.06.2023 were prospectively involved in this study. No sample was selected.

Sepsis patients' sociodemographic data like age and gender and laboratory tests in blood such as hemogram, biochemistry, inflammatory markers and electrolyte levels were analyzed. Hemogram, biochemistry, routine inflammatory markers, complete blood count parameters, CRP, PCT, WBC, neutrophil, lymphocyte, NLR, PLT, PLR, immature granulocyte level, and zinc, copper, magnesium, sodium, potassium, calcium, chloride, phosphate, pH, and glucose levels were taken within the scope of laboratory tests. The patients' data were received from the hospital automation system and patient files and saved in an excel file. Then, the statistical evaluation was performed.

SPSS v.23.0 package program (SPSS Inc, Chicago, Illinois, USA) was employed to statistically evaluate the data obtained in the study. During the evaluation of the data, descriptive statistics were given as frequency and percentages for qualitative data, and as frequency, mean, and standard deviation for numerical data. The suitability of the parameters to the normal distribution was assessed using analytical methods (Kolmogorov-Smirnov and Shapiro-Wilks tests). Since parametric assumptions could not be met in the comparison of quantitative data, the Mann-Whitney U test, which is a non-parametric method, was employed to compare means between two independent groups. A p-value of <0.05 was considered as the level of statistical significance. The values were expressed as mean and standard deviation.

Ethical committee approval was obtained for the study from Kahramanmaraş Sütçü İmam University Faculty of Medicine Clinical Research Ethics Committee with session no: 2022/28, decision no: 03, dated 11.10.2022. The study is consistent with the Declaration of Helsinki.

Results

Table 1: Sociodemographic characteristics of the patients diagnosed with sepsis in the study

	Number	%
Gender		
Female	23	63,9
Male	13	36,1
Total	36	100
Age		
18 – 64	3	8,3
65 – 79	18	50,0
80 and above	15	41,7
Total	36	100

A total of 36 participants, consisting of males by 36.1% (n=13) and females by 63.9%, were included in the study. While 8.3% (n=3) of the participants were aged between 18-64 years, 50% (n=18) and 41.7% (n=15) of them were aged between 65-79 years and 80 years and above, respectively (Table 1).

The mean leukocyte count and the mean neutrophil count of the patients diagnosed with sepsis in the study were found to be 16.45 (SD:7.7) and 14.79 (SD:7.4), respectively. Leukocyte and neutrophil levels of sepsis patients were found to be higher than normal (Table 2).

It was found that patients' mean platelet lymphocyte ratio and mean neutrophil lymphocyte ratio were 479.382 (SD: 792.268) and 28,629 (SD:39.768), respectively. These values were found to be higher than normal limits (Table 2).

The mean immature granulocyte level and the percentage of immature granulocyte of the patients with sepsis were

found to be 329.17 (SD:399.49) and 1.739 (SD: 1.918), respectively. The relevant value was found to be higher than normal limits (Table 2).

It was found that the mean RDW value of the patients with sepsis was high by 55.66 (SD: 12.50) (Table 2).

The mean C reactive protein value of the patients was found to be 163.84 (SD:93.3). It was found that patients diagnosed with sepsis had high levels of C-reactive protein (Table 2).

The mean procalcitonin levels of the patients with sepsis were found to be 33.23 (SD:59.84). It was found that the procalcitonin levels were high in patients with sepsis (Table 2).

The mean albumin value of the sepsis patients included in our study was found to be low by 26.30 (SD: 5.90) (Table 2).

In patients with sepsis, the mean calcium value and the mean zinc value were found to be low by 7.90 (SD:0.66) and 48.93 (SD:18.53), respectively (Table 2).

It was found that the mean glucose level of the patients with sepsis was 154.94 (SD:73.29) (Table 2).

Table 2: Laboratory Results of the Patients

	n	Mean ± SD	Normal Values*
WBC (10^9/L)	36	16,45 ± 7,7	3,39 – 8,86
Neutrophil (10^9/L)	36	14,79 ± 7,4	1,5 – 5
Neutrophil percentage (%)	36	87,91 ± 9,61	40,1 – 71,4
Platelet (10^9/L)	36	239,56 ± 141,09	150 – 400
Lymphocyte (10^9/L)	36	0,911 ± 0,551	1,05 – 3,17
Lymphocyte percentage (%)	36	7,24 ± 7,37	21,6 – 49
NLR (%)	36	28,629±39,768	0,91 – 5,6
PLR (%)	36	479,382±792,268	40 - 140
RDW (fL)	36	55,66 ± 12,50	38,9 – 50
MCV (fL)	36	90,36 ± 6,83	87 – 102,2
MPV (fL)	36	10,74 ± 0,97	9,2 – 12,2
IG count	36	329,17 ± 399,49	10 – 40
IG percentage (%)	36	1,739 ± 1,918	0,16 – 0,62
Na (mmol/L)	36	138,67 ± 7,56	132 – 146
K (mmol/L)	36	4,31 ± 0,78	3,5 – 5,5
Ca (mg/dL)	36	7,90 ± 0,66	8,6 – 10
P (mg/dL)	36	4,42 ± 2,44	2,5 – 4,5
Cl (mmol/L)	36	106,17 ± 5,69	96 – 106
pH	36	7,34 ± 0,11	7,35 – 7,45
CO2 (mmHg)	36	34,89 ± 13,47	35 – 45
PCT (µg/l)	36	33,23±59,84	<0.1
CRP (mg/L)	36	163,84 ± 93,3	<5
Albumin (g/L)	36	26,30 ± 5,90	39,7 – 49,4
Zn (µg/dL)	36	48,93 ± 18,53	50 – 150
Mg (mg/dL)	36	1,77 ± 0,39	1,6 – 2,6
Cu (µg/dL)	36	96,17 ± 35,40	70 – 140
Glucose (mg/dL)	36	154,94±73,29	74 – 100

Ca: calcium, Cl: chlorine, CO2: carbon dioxide, CRP: c-reactive protein, Cu: copper, IG: immature granulocyte, K: potassium, MCV: mean corpuscular volume, Mg: magnesium, MPV: mean platelet volume, n: number of patients, Na: sodium, NLR: neutrophil-lymphocyte ratio, P: phosphorus, PCT: procalcitonin, PLR: platelet-lymphocyte ratio, RDW: red blood cell distribution width, SD: standard deviation, WBC: white blood cell count, Zn: zinc

* The relevant variables were compared with the normal values in the literature. During comparison with the normal values, the parameters that increased with sepsis were compared with upper limit of normal while the parameters that decreased with sepsis were compared with lower limit of normal. No correlation was investigated for the parameters within normal limits.

Table 3: Hemogram, biochemistry, inflammatory markers and electrolyte levels of the patients diagnosed with sepsis in the study by gender

	Gender						
	Male				Male		P
	n	Mean	SD	n	Mean	SD	P
WBC (10^9/L)	13	14,48	1,24	23	17,56	1,88	0,193
Neutrophil (10^9/L)	13	12,80	1,13	23	15,91	1,81	0,193
Neutrophil percentage (%)	13	88,10	1,68	23	87,80	2,35	0,348
Platelet (10^9/L)	13	230,46	31,97	23	244,70	32,53	0,908
Lymphocyte (10^9/L)	13	0,945	0,174	23	0,892	0,107	0,856
Lymphocyte percentage (%)	13	7,05	1,34	23	7,35	1,79	0,553
Neutrophil/Lymphocyte Ratio	13	38,28	17,48	23	23,17	3,39	0,705
Platelet/Lymphocyte Ratio	13	715,47	350,2	23	345,9	58,0	0,633
RDW (fL)	13	51,31	3,17	23	58,12	2,64	0,063
MCV (fL)	13	89,41	1,47	23	90,90	1,59	0,633
MPV (fL)	13	10,59	0,23	23	10,83	0,22	0,542
IG count	13	186,15	55,27	23	410,00	39,31	0,106
IG percentage (%)	13	1,21	0,28	23	2,04	0,47	0,198
Na (mmol/L)	13	141,46	2,16	23	137,09	1,49	0,109
K (mmol/L)	13	4,34	0,24	23	4,29	0,16	0,895
Ca (mg/dL)	13	8,00	0,19	23	7,84	0,14	0,498
P (mg/dL)	13	3,68	0,63	23	4,85	0,52	0,182
Cl (mmol/L)	13	106,69	1,78	23	105,87	1,12	0,596
pH	13	7,36	0,31	23	7,33	0,22	0,339
CO2 (mmHg)	13	33,82	2,52	23	35,49	3,25	0,974
Procalcitonin	13	39,56	20,71	23	29,66	10,67	0,729
CRP (mg/L)	13	189,16	31,22	23	149,53	16,61	0,270
Albumin (g/L)	13	27,01	1,65	23	25,90	1,25	0,610
Zn (µg/dL)	13	49,25	4,85	23	48,75	4,06	0,792
Mg (mg/dL)	13	1,84	0,12	23	1,73	0,08	0,517
Cu (µg/dL)	13	105,94	7,77	23	90,65	8,01	0,229
Glucose	13	150,08	18,69	23	157,70	16,21	0,780

Ca: calcium, Cl: chlorine, CO2: carbon dioxide, CRP: c-reactive protein, Cu: copper, IG: immature granulocyte, K: potassium, MCV: mean corpuscular volume, Mg: magnesium, MPV: mean platelet volume, Na: sodium, NLR: neutrophil-lymphocyte ratio, P: phosphorus, PCT: procalcitonin, PLR: platelet-lymphocyte ratio, RDW: red blood cell distribution width, SD: standard deviation, WBC: white blood cell count, Zn: zinc
The P value was found using Mann–Whitney U test and/or Student's t test.

In sepsis patients, it was determined that leukocyte count, neutrophil count, platelet count, lymphocyte percentage, RDW, immature granulocyte count/percentage, phosphorus and glucose levels were higher in female patients compared to male patients, however, it was found that calcium, zinc and albumin values were lower in female patients compared to male patients. No statistically significant difference was observed between genders in terms of other parameters (Table 3).

Table 4: Hemogram, biochemistry, inflammatory markers and electrolyte levels of the patients diagnosed with sepsis in the study by age

	Age						
	Below 80 years				80 years and above		P
	n	Mean	SD	n	Mean	SD	P
WBC (10^9/L)	21	14,76	1,32	15	18,80	2,42	0,205
Neutrophil (10^9/L)	21	12,95	1,23	15	17,36	2,32	0,163
Neutrophil percentage (%)	21	85,62	2,36	15	91,10	1,74	**0,009**
Platelet (10^9/L)	21	232,86	28,11	15	248,93	41,55	0,835
Lymphocyte (10^9/L)	21	0,982	0,107	15	0,811	0,163	0,194
Lymphocyte percentage (%)	21	8,37	1,81	15	5,67	1,50	**0,050**
NLO	21	16,73	2,63	15	45,28	14,69	**0,033**
PLO	21	300,58	59,42	15	729,70	299,8	0,163
RDW (fL)	21	56,58	3,00	15	54,37	2,81	0,665
MCV (fL)	21	88,78	1,40	15	92,58	1,80	0,116
MPV (fL)	21	10,75	0,22	15	10,73	0,24	0,797
IG count (109/L)	21	273,33	65,14	15	407,33	131,7	0,470
IG percentage (%)	21	1,87	0,46	15	1,55	0,43	0,847
Na (mmol/L)	21	138,62	1,78	15	138,73	1,79	0,797
K (mmol/L)	21	4,50	0,17	15	4,03	0,18	0,131
Ca (mg/dL)	21	8,11	0,14	15	7,60	0,16	0,021
P (mg/dL)	21	4,05	0,46	15	4,95	0,73	0,404
Cl (mmol/L)	21	106,33	1,40	15	105,93	1,21	0,628
pH	21	7,35	0,21	15	7,33	0,33	0,552
CO2 (mmHg)	21	34,73	1,72	15	35,10	4,93	0,360
Procalcitonin	21	24,32	10,41	15	45,71	19,01	0,574
CRP (mg/L)	21	187,75	20,94	15	130,38	20,91	0,075
Albumin (g/L)	21	26,54	1,28	15	25,97	1,59	0,898
Zn (µg/dL)	21	52,30	4,55	15	44,21	3,62	0,260
Mg (mg/dL)	21	1,74	0,09	15	1,81	0,09	0,356
Cu (µg/dL)	21	105,29	7,59	15	83,41	8,58	0,080
Glucose	21	140,10	13,77	15	175,73	21,52	0,158

Ca: calcium, Cl: chlorine, CO2: carbon dioxide, CRP: c-reactive protein, Cu: copper, IG: immature granulocyte, K: potassium, MCV: mean corpuscular volume, Mg: magnesium, MPV: mean platelet volume, Na: sodium, NLR: neutrophil-lymphocyte ratio, P: phosphorus, PCT: procalcitonin, PLR: platelet-lymphocyte ratio, RDW: red blood cell distribution width, SD: standard deviation, WBC: white blood cell count, Zn: zinc

In sepsis patients, it was determined that leukocyte count, neutrophil count, neutrophil percentage, platelet count, PLR, NLR, immature granulocyte count, procalcitonin, phosphorus and glucose values were higher in patients aged above 80 years compared to patients aged below 80 years, however, it was found that calcium, zinc and albumin values were lower in patients aged above 80 years compared to patients aged below 80 years. No statistically significant difference was observed between the ages in terms of other parameters (Table 4).

Discussion

Despite the availability of many screening tests used in the early diagnosis of sepsis, the sensitivity of these tests varies between 30% and 90% (7). This study attempted to evaluate

the hemogram, biochemical and inflammatory markers involved in the diagnosis, pathology and progression of sepsis and to determine the relationship between these markers.

In their study, Yalınbaş et al. determined that leukocyte levels, neutrophil levels, PLR and NLR values were higher in sepsis patients compared to the healthy control group (7).

In their study, Alkan et al. found that immature granulocyte, leukocyte and neutrophil values were higher in patients with sepsis (8)

In another study conducted by Arcagok et al., it was found that PLR values were higher in patients with sepsis (9)

In the study of Can et al., it was observed that PLR and NLR values were higher in sepsis patients (10).

In our study examining patients with sepsis, it was determined that leukocyte, neutrophil, PLR, and NLR values were high in patients with sepsis, in consistent with the literature. Lymphocyte levels were observed to be low in sepsis patients.

In studies carried out by Jong Wan et al. and Ha et al, delta neutrophil index, which reflects immature granulocyte levels and immature granulocyte, was indicated as a biomarker that could be used in the diagnosis of sepsis patients, in the evaluation of prognosis, in the prediction of mortality and in the evaluation of the severity of sepsis (11, 12).

Similar to the literature, it was found that immature granulocyte levels were high in sepsis patients in our study. Immature granulocyte level stands out as a new biomarker that can be tested in routine hemogram examination without additional cost and examination. We believe that immature granulocyte levels, which have been increasingly used recently and increase in sepsis patients and inflammatory conditions, will provide convenience in the diagnosis of sepsis.

Leukocyte, neutrophil, NLR, PLR and immature granulocyte values, which are considered as the markers of systemic inflammation, are simple and easy parameters that can be calculated in complete blood count, one of the routine laboratory data, without the need for an additional technique and no additional cost to the health system (13). Therefore, hemogram parameters with easy access can also be considered as suitable parameters that can be used for diagnosing sepsis.

In their study, Liu et al. reported that acidosis, hypoalbuminemia, hypocalcemia and hyperphosphatemia were observed in sepsis patients (6).

In their study, Fatih et al. found that the magnesium level was low, but the platelet and lymphocyte counts were low in patients with sepsis. It was found that leukocyte, procalcitonin and C-reactive protein levels were high (14).

In their study, İdris et al. determined that copper levels were high and zinc levels were low in patients with sepsis (15).

In this study in which we examined the hemogram and biochemical values of sepsis patients, it was found that copper values and phosphorus values were high, while calcium and zinc values were low in sepsis patients. No difference was found in other elements. Acidosis was found in the blood pH levels. It is believed that serum copper, phosphorus, calcium and zinc values as well as hemogram parameters can be used in the diagnosis of patients with sepsis.

In their study, it was reported by Ece et al. that serum CRP and procalcitonin levels increased in patients with sepsis and that they were a reliable prognostic factor in sepsis (2).

In consistent with the literature, it was determined that procalcitonin levels were high in sepsis patients in this study. It was found that CRP levels, which are positive acute phase reactants, were high, but albumin values, which are negative acute phase reactants, were low.

In their study, Levent D. indicated that stress hyperglycemia and insulin resistance were common in sepsis and were associated with mortality (16)

In the present study, blood glucose levels of sepsis patients were also found to be high. It is possible to achieve improvements in the prognosis of sepsis patients by controlling the blood glucose level.

In this study, it was determined that leukocyte values, neutrophil values, platelet values, immature granulocyte count and percentage, phosphorus and glucose levels were higher in female patients compared to male patients. Lymphocyte, NLR, PLR, procalcitonin, CRP, albumin, zinc and copper values were found to be lower in female patients.

In this study, it was determined that leukocyte values, neutrophil values, neutrophil percentage, platelet values, immature granulocyte count, NLR, PLR, phosphorus, procalcitonin and glucose levels were higher in patients aged above 80 years compared to patients aged below 80 years. It was determined that lymphocyte, calcium, CRP, albumin, zinc and copper values were lower in patients aged above 80 years.

Conclusion

The use of biomarkers in sepsis has increasingly become important in diagnosing, following treatment, determining prognosis and predicting mortality. In our study, leukocyte, neutrophil, NLR, PLR, immature granulocyte, copper, phosphorus, blood glucose, CRP and procalcitonin values were found to be high in patients with sepsis. Albumin, calcium, zinc and lymphocyte levels were found to be low. The biomarkers examined in this study are believed to be a reference for future studies on their use in diagnosing and treating sepsis, and following its prognosis.

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References

1. Meltem Malkoç, Birgül Vanizor Kural. Presepsin: Sepsis Tespiti İçin Umut Verici Yeni Bir Biyobelirteç. CBU-SBED, 2021, 8(3): 553-557. DOI: 10.34087/cbusbed.887818
2. Cem Ece, İlkin Çankayali, Canan Bor, Kubilay Demirağ, Mehmet Uyar, Ali Reşat Moral. Yoğun bakım hastalarında serum CRP düzeylerinin sepsis değerlendirmesindeki yeri. Ege Tıp Dergisi / Ege Journal of Medicine 2020; 59 (3): 174-180. https://doi.org/10.19161/etd.790461
3. Sönmezer MÇ, Tülek N. Bakteriyel İnfeksiyonlarda ve Sepsiste Biyobelirteçler. Klimik Dergisi 2015; 28(3): 96-102. DOI: 10.5152/kd.2015.20
4. Seok Y, Choi JR, Kim J, Kim YK, Lee J, Song J, et al. Delta neutrophil index: a promising diagnostic and prognostic marker forsepsis. Shock. 2012 Mar;37(3):242-6. doi: 10.1097/SHK.0b013e3182454acf
5. Nilgün Eroğlu, Gülseren Şahin, Ferda Özbay Hoşnut, Gürses Şahin. Çölyak Hastalığı Diyet Uyumunda Yeni Bir Belirteç: Delta Nötrofil İndeks? Kocatepe Medical Journal 22:294-299/Temmuz 2021. https://doi.org/10.18229/kocatepetip.864099
6. Yalan Liu, Yannan Chai, Zhihui Rong, Yan Chen. Prognostic Value of Ionized Calcium Levels in Neonatal Sepsis. Ann Nutr Metab. 2020;76(3):193-200. doi: 10.1159/000508685
7. Emine Esin Yalınbaş, Hüseyin Bilgin. Geç Neonatal Sepsis Tanısında Trombosit Parametreleri Ve Nötrofil Lenfosit Oranlarının Değerlendirilmesi. Kocatepe Tıp Dergisi. 21:104-109/2020 Özel Sayısı (1). https://doi.org/10.18229/kocatepetip.557896
8. Alkan Baylan F., Orak F., Doğaner A., Güler S., İnal Ş., Sağer H. İmmatür Granülositler; Gerçek Bakteriyemiyi Kontaminasyondan Ayırabilir Mi? JHS. 2022; 31(2): 164-168. https://doi.org/10.34108/eujhs.860436
9. Arcagok BC, Karabulut B. Platelet to Lymphocyte Ratio in Neonates: A Predictor of Early onset Neonatal Sepsis. Mediterr J Hematol Infect Dis. 2019 Sep 1;11(1):e2019055. doi: 10.4084/MJHID.2019.055
10. Can E, Hamilcikan Ş, Can C. The Value of Neutrophil to Lymphocyte Ratio and Platelet to Lymphocyte Ratio for Detecting Early-onset Neonatal Sepsis. J Pediatr Hematol Oncol. 2018 May;40(4):e229-e232. doi: 10.1097/MPH.0000000000001059
11. Kim JW, Park JH, Kim DJ, Choi WH, Cheong JC, Kim JY. The delta neutrophil index is a prognostic factor for postoperative mortality in patients with sepsis caused by peritonitis. PLoS One. 2017 Aug 1;12(8):e0182325. doi: 10.1371/journal.pone.0182325
12. Ha SO, Park SH, Park SH, Park JS, Huh JW, Lim CM, et al. Fraction of immature granulocytes reflects severity but not mortality in sepsis. Scand J Clin Lab Invest. 2015 Jan;75(1):36-43. doi: 10.3109/00365513.2014.965736
13. Omran A, Maaroof A, Saleh MH, Abdelwahab A. Salivary C-reactive protein, mean platelet volüme and neutrophil lymphocyte ratio as diagnostic markers for neonatal sepsis. J Pediatr (RioJ).2018;94(1):82-87. DOI: 10.1016/j.jped.2017.03.006
14. Fatih Aygün. Çocuk yoğun bakımda magnezyum düzeyi prognoz ve enfeksiyon ile ilişkili midir? Online Türk Sağlık Bilimleri Dergisi 2019, Cilt 4, Sayı 1, 37-46. https://doi.org/10.26453/otjhs.442454
15. İdris Akkaş. Sepsis hastalarında eser elementlerin araştırılması/Investigation of trace elements in sepsis patients. (Tıpta Uzmanlık Tezi). Düzce Üniversitesi / Tıp Fakültesi / Enfeksiyon Hastalıkları ve Klinik Mikrobiyoloji Ana Bilim Dalı, 2018, 99s.
16. Levent Döşemeci. Sepsis Ve Kan Şekeri Kontrolü. ANKEM Derg. 2006;20(Ek2):67-69.