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Original Article *Özgün Araştırma*

PROGNOSTIC FACTORS IN DEEP NECK INFECTION

Derin Boyun Enfeksiyonunda Prognostik Faktörler

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ABSTRACT

Objective: The present study aimed to evaluate the prognostic importance of hematologic test findings in addition to the neutrophil-to-lymphocyte ratio, platelet-to-lymphocyte ratio, monocyte-to-lymphocyte ratio, systemic inflammation response index, and C-reactive protein in the patients with deep neck infection and to compare these results with healthy subjects.

Material and Methods: The study included 32 patients diagnosed as deep neck infection and treated by surgical intervention and parenteral antibiotics. As none of the patients had life-threatening complications, the prognosis was determined by the length of stay in the hospital. The effect of age, sex, pre-treatment blood parameters, abscess culture results, and medical comorbidities on prognosis were analysed. Pre- and post-treatment blood parameters were compared in each patient. Blood parameters were also compared between healthy subjects and patients.

Results: When comparing patients with length of stay in the hospital ≤7 days and >7 days, significant differences were observed for age (t=-2.568, p=0.015) and red blood cell distribution width values obtained preoperatively (Z=-2.343, p=0.019). The correlation analysis revealed a positive correlation between age and length of stay in the hospital. (r=0.450, p=0.010), and between length of stay in the hospital and comorbidity (r=0.366, p=0.039). *Logistic Regression* analysis revealed that age could be the best marker in the prediction of the patients with worse prognosis (percentage of predicting patients with worse prognosis=73.3%, B=0.054, Wald=4.967, p=0.026).

Conclusion: The present study confirmed that the prognosis was worse in older patients and patients with comorbid disease whereas no relation was observed between the inflammatory markers and prognosis.

***Keywords**: Neck, abscess, prognosis*

ÖZ

Amaç: Çalışmanın amacı derin boyun enfeksiyonu olan hastalarda nötrofil-lenfosit oranı, platelet-lenfosit oranı, monosit-lenfosit oranı, sistemik inflamasyon yanıt indeksi ve C-reaktif proteini de içeren hematolojik testlerin prognostik öneminin incelenmesi ve bu sonuçların sağlıklı bireylerle karşılaştırılmasıdır.

Gereç ve Yöntemler: Çalışmaya, derin boyun enfeksiyonu tanısı almış ve cerrahi ve parenteral antibiyoterapi ile tedavi edilmiş 32 hasta dahil edildi. Hiçbir hastada hayatı tehdit eden komplikasyona rastlanmadı ve prognoz belirteci olarak hastanede kalış süresi değerlendirildi. Yaş, cinsiyet, tedavi öncesi kan parametreleri, apse kültür sonucu ve medikal komorbiditelerin prognoza etkisi araştırıldı. Her hastada cerrahi öncesi ve sonrası kan değerleri kıyaslandı. Ayrıca hasta ve sağlıklı bireylerin kan sonuçları karşılaştırıldı.

Bulgular: Hastanede kalış süresi ≤7 gün ve >7 günden çok olan hastalar karşılaştırıldığında, yaş (t=-2.568, p=0.015) ve cerrahi öncesi eritrosit dağılım genişliği (Z=-2.343, p=0.019) değerleri açısından anlamlı fark saptandı. Korelasyon analizi sonrasında yaş ve hastanede kalış süresi arasında (r=0.450, p=0.010) ve hastanede kalış süresi ve komorbidite arasında (r=0.366, p=0.039) pozitif korelasyon tespit edildi. Lojistik regresyon analizi sonrası yaşın kötü prognozu öngörmede en iyi parametre olabileceği saptandı (kötü prognozlu hastaları öngörme yüzdesi: %73.3, B=0.054, Wald=4.967, p=0.026).

Sonuç: Bu çalışma, ileri yaş ve komorbiditesi olan hastalarda derin boyun enfeksiyonu prognozunun kötü olabileceğini desteklemiştir. İnflamatuar değerler ile prognoz arasında ilişki gözlenmedi.

***Anahtar Kelimeler**: Boyun, apse, prognoz*

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INTRODUCTION

Deep neck infection (DNI) is an infection of the potential anatomical spaces of the neck with the formation of cellulitis, phlegmon, or abscess. It presents as swelling and induration in the neck at the region of the spaces that are involved. The primary sources of DNI are dentition, oropharynx, salivary glands, malignancies, and foreign bodies (1). The commonly cultured organisms from DNI are mostly the organisms of the oral and oropharyngeal flora, including *Streptococci*, *Peptostreptococcus* species, *Staphylococcus aureus*, and anaerobes (2). Suspicion, examination, and radiologic evaluation are the main steps of diagnosis. A neck computed tomography (CT) with contrast is usually adequate for diagnosis and differentiation of cellulitis, phlegmon, and abscess. Treatment options include parenteral antibiotics, airway management, and surgical intervention depending on the process of the infection. Patients with cellulitis, phlegmon, or adenopathy are treated with parenteral antibiotics and discharged on oral treatment with close follow-up (3). Patients with phlegmon are treated with parenteral antibiotics for 48-72 hours and rescanned. If an abscess is diagnosed, patients undergo surgical drainage (3).

Although the incidence of DNI has been diminished with the availability of antimicrobial therapy and radiologic techniques, life-threatening complications can still be seen including mediastinitis, upper airway stress, tracheotomy, sepsis, and jugular vein thrombosis (4). It is important to predict the patients with a poor prognosis initially. Although DNI is an inflammatory disease, a few reports have been focused on the effect of hematologic and inflammatory markers including neutrophil-to-lymphocyte ratio (NLR), leukocyte count, and C-reactive protein (CRP) (5-7). In addition, according to our literature search, the effect of inflammatory markers including NLR, platelet-to-lymphocyte ratio (PLR), monocyte to lymphocyte ratio (MLR), systemic inflammation response index (SIRI) on prognosis of DNI has not been investigated.

The present study aimed to evaluate the prognostic importance of hematologic test findings in addition to NLR, PLR, MLR, SIRI, and CPR in the patients with DNI and to compare these results with healthy subjects. The effect of patients' demographic features on prognosis was also analysed.

MATERIALS AND METHODS

The study was designed as a retrospective case-control study. All procedures performed in this study were compliant with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The study was approved by the local ethics committee (Kırıkkale University Ethics Committee of Non-interventional Research, date: 21.10.2021, issue number: 2021.10.18).

The study included 32 patients diagnosed as DNI and treated by surgical intervention and parenteral antibiotics between April 2017 and August 2021. Cases of peritonsillar abscess treated by transoral incision without cervical drainage and DNI patients treated medically were not included. None of the patients needed second surgical intervention. All the data were provided retrospectively from patients' medical files. All patients were submitted to clinical examination. A neck CT was performed in all cases to find the potential focus of infection and evaluate the extension of the suppurative process.

Age, gender, comorbidity, microbiological culture results, and length of stay in the hospital (LSH) were recorded for all patients. In addition, the venous blood samples taken from the patients on the first admission to the hospital and before discharge from the hospital were examined and the blood hemoglobin level (reference range:10-18 g/dL), leukocyte (reference range:4400-11300/uL), neutrophil (reference range:1500-9600/uL), lymphocyte (reference range: 1000-6000/uL), monocyte (reference range:100-1400/uL), and platelet (reference range: 150,000-500,000/uL) count values were

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determined using an analysis device (Mindray BC-6800, Shenzen, China). Furthermore, CRP (reference range: 0.15-5 mg/dL) levels were obtained using original kits (Roche) on an automatic device (Roche Diagnostic COBAS c501). NLR, PLR, MLR, and SIRI values were examined.

Surgical treatment was performed within 72 hours after admission in all cases. All patients received intravenous antibiotics (ampicillin-sulbactam 1.5 g every 6 hours + metronidazole 500 mg every 12 hours) from admission to discharge. The surgical treatment provided was incision and drainage either under local or general anaesthesia.

Since the changes depending on ethnic origin could be seen in hematologic data and normative values of SIRI had not been established, 24 healthy subjects who had no infection, history of systemic disease, and medication were included in the study to present the normative values.

As none of the patients had life-threatening complications, the prognosis was determined by LSH. The average LSH of the patients was found to be 7 days. So, the patients were grouped as the patients with LSH ≤7 days, representing the good prognosis, and the patients with LSH >7 days, representing the poor prognosis. The effect of age, sex, pre-treatment blood parameters, abscess culture results, and medical comorbidities on prognosis were analysed. Pre- and post-treatment blood parameters were compared in each patient. Blood parameters were also compared between healthy subjects and patients.

Statistical Analysis

The *Kolmogorov-Smirnov* test was used to determine whether the study parameters were normally distributed among the groups. The categorical variables were analysed using *Pearson's chi-square* test ($p<0.05$). The parametric study findings were analysed using the *Independent Samples t-test* ($p<0.05$). Non-parametric study findings were statistically analysed using the *Mann-Whitney U* test ($p<0.05$).

Preoperative and postoperative continuous variables were analysed using the Paired Samples t-test and the Wilcoxon Signed-Rank test ($p<0.05$). *Spearman's rho Correlation* test was used to determine the presence of correlation between parameters belonging to patients ($p<0.05$). The *ROC-Curve* test was used to determine which study parameters predict the patients' prognosis, and the sensitivity and specificity rates of the parameters were determined by obtaining "cut-off" values. In addition, the *Logistic Regression* test was used to determine the "best parameter" ($p<0.05$).

RESULTS

Odontogenic (n=13, 40.6%), upper airway (n=12, 37.5%) and salivary gland infections (n=7, 21.9%) were the causes of DNI. The concomitant comorbid disease was detected in 14 patients. Of these patients, 2 had the chronic obstructive pulmonary disease, 7 had hypertension, 7 had diabetes mellitus, 1 had chronic renal failure and 1 had hypothyroidism. Growth in abscess culture was seen in 10 patients. *Staphylococcus aureus* was the most commonly isolated organism. *Staphylococcus epidermidis*, coagulase-negative *Staphylococcus*, *Staphylococcus hominis*, and *Corynebacterium matruchotii* were the others isolated from abscess culture. Twenty-five (78%) patients had one space involvement including submandibular (n=14), level II (n=8), submental (n=3) whereas 2-3 neck spaces were involved in 7 patients (22%) including level II and parapharyngeal space (n=3), level II and submandibular space (n=2) and submandibular and submental space (n=2).

Table 1: The demographic data, growth in culture, length of stay in the hospital, and preoperative and postoperative hematologic results of the DNI patients and healthy subjects.

		DNI	**Healthy Subjects**		
Variable		Mean ± SD/ Median (min-max) n (%)	Mean ± SD/ Median (min-max)/ n (%)	t/Z/X^2	p
Age (year)		47.28±18.55	43.67±14.20	0.795*	0.430
Gender	Male	15 (26.3%)	12 (21.4%)	0.054‡	0.817
	Female	17 (30.4%)	12 (21.4%)		
Comorbidity	No	18 (56.2%)	-	-	-
	Yes	14 (43.8%)	-	-	-
Culture	Negative	22 (68.8%)	-	-	-
	Positive	10 (31.2%)	-	-	-
Length of stay in hospital (day)		7 (2-20)	-	-	-
Hemoglobin level-preoperative		12.85±2.39	13.40±1.62	-0.969*	0.337
Leukocyte count-preoperative		14393±4719.01	8182±2907.71	5.682*	<0.001
Neutrophil count-preoperative		11270±4683.20	4648±1715.99	6.591*	<0.001
Lymphocyte count-preoperative		2015±712.82	2243±597.63	-1.266*	0.211
Monocyte count-preoperative		893±507.18	448±166.73	4.124*	<0.001
MPV-preoperative		10.18±1.50	9.83±0.96	0.986*	0.329
RDW-preoperative		13.15 (22-24)	13.40 (12-17)	-0.572†	0.567
Platelet count-preoperative (^10^3)		318.5 (185-489)	266.5(189-398)	-1.250†	0.211
NLR-preoperative		5.21 (1.96-30.47)	1.93 (1.17-6.42)	-5.033†	<0.001
PLR-preoperative		172.56 (76.49-406.90)	111.97 (85.52-232.75)	-2.616†	0.009
MLR-preoperative		0.38 (0.15-2.14)	0.18 (0.10-0.48)	-4.206†	<0.001
SIRI-preoperative		3925.68 (983.32-34947.20)	727.61 (361.09-4940.43)	-4.313†	<0.001
CRP-preoperative		110.98±85.25	1.83±0.93	6.258*	<0.001
Hemoglobin level-postoperative		12.80±2.02	13.40±1.62	-1.189*	0.240
Leukocyte count-postoperative		8440 (4250-17820)	7270 (5070-15800)	-1.200†	0.230
Neutrophil count-postoperative		4790 (2370-11870)	4205 (2630-10330)	-0.480†	0.631
Lymphocyte count-postoperative		2538±727.89	2243±597.63	1.617*	0.112
Monocyte count-postoperative		505 (37-2870)	400 (270-770)	-1.433	0.152
MPV-postoperative		9.86±1.26	9.83±0.96	-0.088*	0.930
RDW-postoperative		13.45 (0-19)	13.40 (12-17)	-0.746†	0.456
Platelet count-postoperative (^10^3)		332.9±93583.62	276.7±53452.67	2.636†	0.011
NLR-postoperative		2.02(1.15-4.29)	1.93 (1.17-6.42)	-0.480†	0.631
PLR-postoperative		136.92±44.20	130.12±38.29	0.603*	0.549
MLR-postoperative		0.20 (0.02-1.04)	0.18 (0.10-0.48)	-0.149†	0.882
SIRI-postoperative		940.09 (91.29-12298.52)	727.61 (361.09-4940.43)	-1.275†	0.202
CRP-postoperative		10.32 (0-125.90)	1.65 (0.33-4.52)	-3.527*	<0.001

(*) Independent Samples t-test; (†) Mann Whitney U test; (‡) Pearson's chi-square test; p<0.05
DNI: deep neck infection, SD: standard deviation, min: minimum, max: maximum, N: number of participants, MPV: mean platelet volume, RDW: red blood cell distribution width, NLR: neutrophil to lymphocyte ratio, PLR: platelet to lymphocyte ratio, MLR: monocyte to lymphocyte ratio, SIRI: systemic inflammatory response index, CRP: C-reactive protein

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Comparison of DNI patients with healthy subjects revealed significant difference with respect to leukocyte (t=5.682, p<0.001), neutrophil (t=6.591, p<0.001) and monocyte counts (t=4.124, p<0.001), NLR (Z=-5.033, p<0.001), PLR (Z=-2.616, p=0.009), MLR (Z=-4.206, p<0.001), SIRI (Z=-4.313, p<0.001) and CRP values (t=6.258, p<0.001) preoperatively. In the postoperative period, significant differences existed only among platelet count (Z=2.636, p=0.011) and CRP values (t=-3.527, p<0.001) (Table 1).

Significant difference existed among leukocyte (Z=-4.862, p<0.001), neutrophil (Z=-4.824, p<0.001), lymphocyte (t=-3.281, p=0.003) and monocyte count (Z=-3.806, p<0.001), SIRI (Z=-4.712, p<0.001) NLR (Z=-4.693, p<0.001), PLR (Z=-2.861, p=0.004), MLR (Z=-4.151, p<0.001), and CRP values (Z=-4.684, p<0.001) when comparing preoperative and postoperative periods (Table 2).

When DNI patients were divided into two groups as patients with and without comorbidity, significant differences were observed in regard to LSH (Z=-2.040, p=0.041) and lymphocyte count (t=-2.426, p=0.22) (Table 3). Furthermore, culture growth ratios were different between these groups (X^2=4.073, p=0.044).

When DNI patients were divided into two groups according to LSH, significant differences were observed in regard to age (t=-2.568, p=0.015) and RDW values obtained preoperatively (Z=-2.343, p=0.019) (Table 4).

When DNI patients were divided into two groups as age ≤51 and age >51, significant differences were observed for LSH (Z=-2.540, p=0.011), RDW level obtained preoperatively (Z=-3.074, p=0.002), and platelet count measured postoperatively (Z=2.136, p=0.041) (Table 5).

The correlation analysis applied to the data of all DNI patients revealed a positive correlation between age and LSH (r=0.450, p=0.010), between age and comorbidity (r=0.352, p=0.048), between age and RDW level values measured preoperatively (r=0.531, p=0.002), between LSH and comorbidity (r=0.366, p=0.039), and between LSH and RDW level values (r=0.459, p=0.008).

ROC-Curve test results revealed that the prognosis could be worse in patients older than 51-year-old (area=0.778, p=0.007, 73% sensitivity, 71% specificity), and in patients whose preoperative RDW level value was greater than 13.15 (area=0.743, p=0.019, 73% sensitivity, 71% specificity) (Table 6). *Logistic Regression* analysis revealed that the age of the patient could be the best marker in the prediction of the patients with worse prognosis (percentage of predicting patients with worse prognosis=73.3%, B=0.054, Wald=4.967, p=0.026) (Figure 1).

Table 2: Comparison of preoperative and postoperative hematologic test results and inflammatory markers. *Independent Samples t-test, Mann Whitney U* test, and *Pearson's Chi-S-square* test (p<0.05).

Variable	t / Z	p
Leukocyte-preoperative/ Lymphocyte-postoperative	-4.862†	<0.001
Neutrophil-preoperative/ Neutrophil-postoperative	-4.824†	<0.001
Lymphocyte-preoperative/ Lymphocyte-postoperative	-3.281*	0.003
Monocyte-preoperative/ Monocyte-postoperative	-3.806†	<0.001
Platelet-preoperative/ Platelet-postoperative	-0.842†	0.400
MPV-preoperative/ MPV-postoperative	1.481*	0.149
RDW-preoperative/ RDW-postoperative	-0.941†	0.347
NLR-preoperative/NLR-postoperative	-4.693†	<0.001
PLR-preoperative/PLR-postoperative	-2.861†	0.004
MLR-preoperative/MLR-postoperative	-4.151†	<0.001
SIRI-preoperative/SIRI-postoperative	-4.712†	<0.001
CRP-preoperative/CRP-postoperative	-4.684†	<0.001

(*) t value, Paired Samples t-test; (†) Z value, Wilcoxon Signed Ranks test; p<0.05. MPV: mean platelet volume, RDW: red blood cell distribution width, NLR: neutrophil to lymphocyte ratio, PLR: platelet to lymphocyte ratio, MLR: monocyte to lymphocyte ratio, SIRI: systemic inflammatory response index, CRP: C-reactive protein

Table 3: Comparison of DNI patients with and without comorbidity

		Comorbidity (-)	**Comorbidity (+)**		
Variable		Mean ± SD/ Median (min-max) n (%)	Mean ± SD/ Median (min-max)/ n (%)	t/Z/X^2	p
Age (year)		41.89±16.61	54.21±19.19	-1.946*	0.061
Gender	Male	10 (31.2%)	5 (15.6%)	1.245‡	0.265
	Female	8 (25.0%)	9 (28.1%)		
Culture	Negative	15 (46.9%)	7 (21.9%)	4.073‡	0.044
	Positive	3 (9.4%)	7 (21.9%)		
Prognosis	Good	12 (37.5%)	5 (15.6%)	3.030‡	0.082
	Worse	6 (18.8%)	9 (28.1%)		
Length of stay in hospital (day)		7 (4-12)	9 (2-20)	-2.040†	0.041
Hemoglobin level-preoperative		13.33±	12.23±2.78	1.304*	0.202
Leukocyte count-preoperative		14223±4635.20	14611±4991.60	-0.227*	0.822
Neutrophil count-preoperative		1102±4484.92	11586±5079.97	-0.331*	0.743
Lymphocyte count-preoperative		2062±797.07	1954±611.44	0.417*	0.680
Monocyte count-preoperative		917±428.51	863±609.53	0.293*	0.771
MPV-preoperative		10.34±1.52	9.96±1.50	0.695*	0.492
RDW-preoperative		13.05 (0-19)	14 (0-22)	-1.464†	0.143
Platelet count-preoperative (^10^3)		263 (185-456)	333 (215-489)	-0.836†	0.403
NLR-preoperative		5.21 (1.96-30.47)	5.88 (2.01-17.97)	-0.266†	0.790
PLR-preoperative		171.28 (76.49-406.90)	177.37 (89.73-344.07)	-0.684†	0.494
MLR-preoperative		0.43 (0.16-1.00)	0.28 (0.15-2.14)	-0.760†	0.447
SIRI-preoperative		4730.29 (1020.58-20260.00)	2707.84 (983.32-34947.20)	-0.266†	0.790
CRP-preoperative		107.53±88.37	115.42±84.15	-0.256*	0.800
Hemoglobin level-postoperative		13.04±1.73	12.49±2.37	0.755*	0.456
Leukocyte count-postoperative		7725 (5200-16050)	8920 (4250-17820)	-1.045†	0.296
Neutrophil count-postoperative		4790 (2710-11380)	4950 (2370-11870)	-1.481†	0.138
Lymphocyte count-postoperative		2282±501.94	2866±852.54	-2.426*	0.022
Monocyte count-postoperative		450 (37-1220)	540 (250-2870)	-0.837†	0.403
MPV-postoperative		9.89±1.15	9.81±1.43	0.192*	0.849
RDW-postoperative		13.40 (12-19)	14.10 (0-17)	-0.760†	0.447
Platelet count-postoperative (^10^3)		323000±90858.65	345643±98885.02	-0.673*	0.506
NLR-postoperative		2.21 (1.15-3.81)	1.76 (1.28-4.29)	-1.481†	0.138
PLR-postoperative		144.36±43.17	127.36±45.24	1.082*	0.288
MLR-postoperative		0.21 (0.02-0.37)	0.17 (0.09-1.04)	-1.330†	0.184
SIRI-postoperative		1027.09 (91.29-4219.94)	940.09 (392.13-12298.52)	-0.494†	0.621
CRP-postoperative		14.29 (0-125.90)	6.63 (0-46.03)	-1.445†	0.149

(*) Independent Samples t-test; (†) Mann Whitney U test; (‡) Pearson's chi-square test; p<0.05

DNI: deep neck infection, SD: standard deviation, min: minimum, max: maximum, N: number of participants, MPV: mean platelet volume, RDW: red blood cell distribution width, NLR: neutrophil to lymphocyte ratio, PLR: platelet to lymphocyte ratio, MLR: monocyte to lymphocyte ratio, SIRI: systemic inflammatory response index, CRP: C-reactive protein

Table 4: Comparison of DNI patients with respect to length of stay in hospital (prognosis)

		Good Prognosis	Poor Prognosis		
Variable		Mean ± SD/ Median (min-max) n (%)	Mean ± SD/ Median (min-max)/ n (%)	t/Z/X^2	p
Age (year)		40.00±18.78	55.53±14.89	-2.568*	0.015
Gender	Male	10 (31.2%)	5 (15.6%)	2.079‡	0.149
	Female	7 (21.9%)	10 (31.2%)		
Comorbidity	No	12 37.5%)	6 (18.8%)	3.030‡	0.082
	Yes	5 (15.6%)	9 (28.1%)		
Culture	Negative	12 (37.5%)	10 (31.2%)	0.057‡	0.811
	Positive	5 (15.6%)	5 (15.6%)		
Pathological evaluation	Negative	7 (21.9%)	11 (34.4%)	3.348‡	0.067
	Positive	10 (31.2%)	4 (12.5%)		
Length of stay in hospital (day)		7 (2-7)	11 (8-20)	-4.879†	<0.001
Hemoglobin level-preoperative		12.95±2.36	12.73±2.51	0.248*	0.806
Leukocyte count-preoperative		13992±5066.07	14846.00±4423.10	-0.504*	0.618
Neutrophil count-preoperative		10752±4931.91	11858.00±4479.88	-0.661*	0.514
Lymphocyte count-preoperative		2124±729.21	1891.33±697.64	0.917*	0.366
Monocyte count-preoperative		899±618.27	886.67±364.20	0.067*	0.947
MPV-preoperative		10.02±1.59	10.35±1.42	-0.626*	0.536
RDW-preoperative		12.90 (0-19)	13.60 (0-22)	-2.343†	0.019
Platelet count-preoperative (^10^3)		265 (213-489)	332 (185-456)	-0.567†	0.571
NLR-preoperative		4.60 (2.01-30.47)	7.16 (1.96-17.97)	-1.114†	0.265
PLR-preoperative		169.44 (76.49-406.90)	186.40 (89.73-344.07)	-1.227†	0.220
MLR-preoperative		0.28 (0.16-2.14)	0.52 (0.15-0.95)	-0.963†	0.336
SIRI-preoperative		2741.90 (1067.13-34947.20)	7291.67 (983.32-14551.83)	-1.038†	0.299
CRP-preoperative		91.45±79.06	133.12±89.22	-1.401*	0.171
Hemoglobin level-postoperative		12.41±2.11	12.25±1.87	-1.185*	0.245
Leukocyte count-postoperative		8730 (5200-17820)	7530 (4250-16160)	0.755†	0.450
Neutrophil count-postoperative		5320 (2710-11870)	4540 (2370-11010)	-1.190†	0.234
Lymphocyte count-postoperative		2467±538.63	2617±910.37	-0.576*	0.569
Monocyte count-postoperative		500 (240-2870)	510 (37-940)	-0.435†	0.664
MPV-postoperative		9.81±1.03	9.91±1.24	-0.238*	0.814
RDW-postoperative		13.10 (0-19)	13.90 (12-18)	-1.550†	0.121
Platelet count-postoperative (^10^3)		326.6±78931.98	340.0±110312.20	-0.401*	0.691
NLR-postoperative		2.09 (1.15-4.29)	1.98 (1.28-2.54)	-1.190 †	0.234
PLR-postoperative		133.96±26.87	140.29±58.97	-0.399*	0.693
MLR-postoperative		0.21 (0.12-1.04)	0.17 (0.02-0.47)	-0.925†	0.355
SIRI-postoperative		941.75 (392.13-12289.52)	938.44 (91.29-1875.92)	-0.925†	0.355
CRP-postoperative		13.57 (0-125.90)	2.75 (0-37.00)	-1.644†	0.100

(*) Independent Samples t-test; (†) Mann Whitney U test; (‡) Pearson's chi-square test; p<0.05

SD: standard deviation, min: minimum, max: maximum, N: number of participants, MPV: mean platelet volume, RDW: red blood cell distribution width, NLR: neutrophil to lymphocyte ratio, PLR: platelet to lymphocyte ratio, MLR: monocyte to lymphocyte ratio, SIRI: systemic inflammatory response index, CRP: C-reactive protein

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Table 5: Comparison of DNI patients according to age

Variable		Age ≤51-year-old Mean ± SD/ Median (min-max) n (%)	Age >51-year-old Mean ± SD/ Median (min-max)/ n (%)	t/Z/X^2	p
Age (year)		31.75±10.24	62.81±9.59	-	-
Gender	Male	9 (28.1%)	6 (18.8%)	1.129‡	0.288
	Female	7 (21.9%)	10 (31.2%)		
Comorbidity	No	11 (34.4%)	7 (21.9%)	2.032‡	0.154
	Yes	5 (15.6%)	9 (28.1%)		
Culture	Negative	12 (37.5%)	10 (31.2%)	0.582‡	0.446
	Positive	4 (12.5%)	6 (18.8%)		
Prognosis	Good	12 (37.5%)	5 (15.6%)	6.149‡	0.013
	Worse	4 (12.5%)	11 (34.4%)		
Length of stay in hospital (day)		7 (2-15)	10 (5-20)	-2.540†	0.011
Hemoglobin level-preoperative		12.86±2.37	12.84±2.49	0.022*	0.983
Leukocyte count-preoperative		13186±4551.84	15599±4711.63	-1.473*	0.151
Neutrophil count-preoperative		9974±4283.80	12567±4836.28	-1.605*	0.119
Lymphocyte count-preoperative		2133±651.67	1896±771.68	0.938*	0.356
Monocyte count-preoperative		843±366.18	944±626.15	-0.558*	0.581
MPV-preoperative		9.74±1.21	10.61±1.67	0.921*	0.364
RDW-preoperative		12.80 (0-17)	14.00 (0-22)	-3.074†	0.002
Platelet count-preoperative (^10^3)		339.50 (185-489)	261.00 (213-456)	-0.848†	0.396
NLR-preoperative		4.21 (2.01-14.07)	7.08 (1.96-30.47)	-1.508†	0.132
PLR-preoperative		171.28 (76.49-226.09)	177.37 (82.65-406.90)	-0.151†	0.880
MLR-preoperative		0.29 (0.19-1.00)	0.47 (0.15-2.14)	-0.226†	0.821
SIRI-preoperative		3188.46 (983.32-20260.00)	5827.62 (1020.58-34947.20)	-0.905†	0.366
CRP-preoperative		96.77±85.60	125.19±85.21	-0.941*	0.354
Hemoglobin level-postoperative		12.49±2.08	13.11±1.96	-0.874*	0.389
Leukocyte count-postoperative		7990 (5700-16050)	8735 (4250-17820)	-0.057†	0.955
Neutrophil count-postoperative		4690 (2710-11380)	5030 (2370-11870)	-0.075†	0.940
Lymphocyte count-postoperative		2494±615.04	2581±844.23	-0.330*	0.743
Monocyte count-postoperative		435 (37-1220)	520 (240-2870)	-0.604†	0.546
MPV-postoperative		9.58±1.37	10.13±1.11	-1.251*	0.221
RDW-postoperative		13.20 (0-17)	13.80 (0-19)	-1.622†	0.105
Platelet count-postoperative (^10^3)		366.34±80722.47	299.43±95884.63	2.136*	0.041
NLR-postoperative		2.04 (1.15-3.81)	2.03 (1.20-4.29)	-0.075†	0.940
PLR-postoperative		151.80±42.04	122.05±42.40	1.993*	0.055
MLR-postoperative		0.20 (0.02-0.37)	0.20 (0.09-1.04)	-0.226†	0.821
SIRI-postoperative		880.20 (91.29-4219.94)	1036.86 (468.68-12298.52)	-0.377†	0.706
CRP-postoperative		10.30 (0-125.90)	11.35 (0-52.23)	-0.075†	0.940

(*) Independent Samples t-test; (†) Mann Whitney U test; (‡) Pearson's chi-square test; p<0.05

SD: standard deviation, min: minimum, max: maximum, N: number of participants, MPV: mean platelet volume, RDW: red blood cell distribution width, NLR: neutrophil to lymphocyte ratio, PLR: platelet to lymphocyte ratio, MLR: monocyte to lymphocyte ratio, SIRI: systemic inflammatory response index, CRP: C-reactive protein

Table 6: ROC-Curve test and Logistic Regression analysis results.

ROC-Curve test for prediction of the Prognosis					
Variable	Area	p	Cut-off value	Sensitivity	Specificity
Age	0.778	0.007	>51-year-old	73%	71%
RDW	0.743	0.019	>13.15	73%	71%

Logistic Regression test for prediction of the best marker of the Prognosis					
Variable			Predicted		
Age			Good	Poor	Percentage
	Observed	Good	12	5	70.6%
		Poor	4	11	73.3%
	Overall Percentage				71.9%
			B	Wald	p
			0.054	4.967	0.026

RDW: red blood cell distribution width

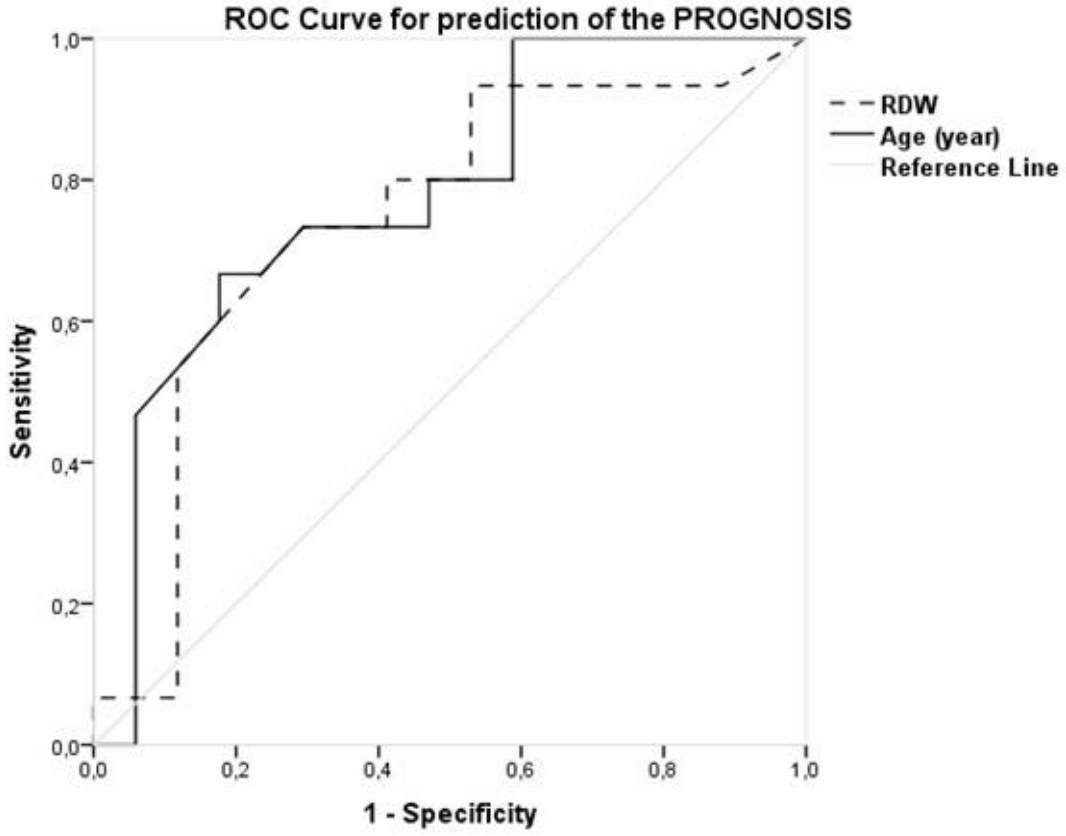

Figure 1: The *ROC-Curve* plot showing the parameters that can predict the prognosis in deep neck infection, preoperatively.

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DISCUSSION

Many reports focus on the prognostic factors in DNI. As the DNI-related mortality decreased over the years with the use of antibiotics, early diagnosis, and surgery (2), complications and LSH are analysed as prognostic factors (5,8). Especially LSH is found to be associated with repeated surgery, the presence of comorbidities, and complications (9,10). The median hospitalization of DNI is reported as 6-7 days (11,12). Compatible with the literature, the median hospitalization was found 7 days in our study.

NLR, PLR, and MLR are the parameters that are calculated from blood count. They reflect the general inflammatory condition of a patient and have been reported as useful prognostic indicators of various pathologies such as infection and oncologic inflammation (13). SIRI is also a hematologic inflammatory marker based on the counts of peripheral neutrophils, monocytes, and lymphocytes (14). As DNI is an infectious condition, the initial point of this study is to identify correlations between the prognosis of DNI and these hematologic markers. In addition, we investigated the effect of other parameters that are presented as prognostic factors in recent literature like age, comorbidities and culture growth.

Many reports focus on the significance of inflammatory markers on the recovery of upper airway infections and related DNI (5,15). NLR and CRP are the main markers that have prognostic value in the literature. A significant increase in NLR is detected in patients with acute bacterial tonsillitis and DNI with a cut-off value of 5.4 (15). In the study of Gallagher et al, NLR and CRP levels are used as diagnostic tests to predict LSH and a cut-off value for NLR of 4.65 and CRP of 82.5 are presented as predictors of long LSH (5). Age, the presence of comorbidities, a non-odontogenic site of origin, leukocyte counts higher than 11.0 cells $\times 10^9$/L at presentation and the need for both medical and surgical treatment, days elapsing between hospitalization and surgery were also presented as predictors of LHS (8,16).

Additionally, a cut-off value for NLR of 11.75 and CRP of 180 is determined as predictors of intensive care unit (ICU) admission (8,13). Age >55 and CRP >15 mg/dL emerged as factors correlated with persistent discharge after surgery (17). The presence of systemic disease, diabetes mellitus, involvement of multiple neck spaces, body temperature, leukocyte count, and CRP >100 µg/mL were reported as predictors of complication (6, 7).

Our results supported that the inflammatory cells (leukocyte, neutrophil, lymphocyte, monocyte) and markers including CRP, SIRI, NLR, PLR, and MLR were higher in DNI patients than those of the healthy subjects. All these parameters decreased significantly after they were treated surgically except platelet count and CRP values which were measured still slightly higher than the healthy subjects. Patients with the comorbid disease had a poor prognosis when compared with patients without comorbid disease and growth in abscess culture was more frequent in patients with the comorbid disease. Our results revealed that patients with long LSH were older than patients with short LSH, and they have higher RDW values. Concurrently, most of the older patients had a poor prognosis and they stayed in the hospital longer. *Logistic Regression* analysis revealed that the age of the patient could be the best marker in the prediction of the patients with poor prognoses.

The main drawback of the present study is the limited number of the patient group. To have a homogeneous group and provide accuracy in our results, we did not include peritonsillar abscess, DNI with cellulitis, and phlegmon. We only included patients with DNI and abscess formation treated with surgery in addition to antibiotherapy.

In conclusion, the present study confirmed that the prognosis was worse in older patients and patients with comorbid disease whereas no relation was observed between the inflammatory markers and prognosis.

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