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The Effects of NLR on the Diagnosis and Pharmacological Management of Brain Abscesses

NLO'nun Beyin Apselerinin Tanı ve Farmakolojik Tedavi Yönetimine Etkileri

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ABSTRACT

Aim: The present study aims to examine the effectiveness of the neutrophil-to-lymphocyte ratio in the treatment and diagnosis of patients with brain abscesses.
Methods: In this retrospective study, radiological, neurological, and surgical data obtained from the medical records of healthy volunteers (n = 10) who presented to the hospital for check-ups and patients with brain abscesses who were treated (n = 10) were evaluated statistically. Alpha significance value was accepted as <0.05.
Results: Comparisons between groups revealed that the erythrocyte sedimentation rate, C-reactive protein, leukocyte, and neutrophil values were statistically significant (P <0.05) while lymphocyte value was not statistically significant (P >0.05). The preoperative neutrophil-to-lymphocyte ratio in cases diagnosed with brain abscesses showed statistical significance compared to that in the healthy volunteers (P <0.05) and the neutrophil-to-lymphocyte ratio increased 3.31-fold in the study group compared to the healthy volunteers.
Conclusion: A strong positive strong relationship between the neutrophil-to-lymphocyte ratio and abscess size (r = 0.662; P = 0.037) was observed. An increased neutrophil-to-lymphocyte ratio may serve as an early warning signal of brain abscesses.

Keywords: Antibiotic treatment; brain abscess; low-cost diagnosis method; magnetic resonance image; neutrophil-to-lymphocyte ratio

ÖZ

Amaç: Bu makalede; beyin apsesi tanısı alan olgularda, nötrofil-lenfosit oranı (NLO)'nın, tanı ve tedavide önemli olup olmadığının incelenmesi amaçlandı.
Metot: Retrospektif dizayna sahip araştırmada, hastaneye kontrol için gelen sağlıklı bireyler (n=10) ile beyin apsesi olan ve tedavi edilen olgular (n=10)'dan elde edilen radyolojik, nörolojik ve cerrahi veriler istatistiksel olarak değerlendirmeye alındı. Alfa anlamlılık değeri <0,05 olarak kabul edildi.
Bulgular: Gruplar arası karşılaştırmalar sonucunda; eritrosit çökelme oranı (ESR), C-reaktif protein (CRP), lökosit (WBC) ve nötrofil (NEU) değerleri istatistiksel olarak anlamlı iken (P<0,05), lenfosit (LYMPH) değerinde istatistiksel olarak anlamlılık görülmedi (P>0,05). Sağlıklı bireylere oranla beyin apsesi tanısı alan olgulara ait preoperatif NLO değerlerinin istatistiksel olarak anlamlılık (P<0,05) gösterdiği ve NLO değerinin sağlıklı bireylere oranla yaklaşık 3,31 kat artış gösterdiği kaydedildi.
Sonuç: NLO oranı ile abse boyutu arasında (r=0,662; P=0,037) pozitif yönde kuvvetli ilişki bulunmaktadır. Artış gösteren NLO, beyin apsesinin tanısında erken uyarı sinyali olarak hizmet edebilir.

Anahtar Kelimeler: Antibiyotik tedavisi, beyin apsesi, manyetik rezonans görüntüleme, düşük maliyetli tanı metodu, nötrofil-lenfosit oranı.

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INTRODUCTION

Brain abscesses are focal infections of the central nervous system that begin in a localized area of the brain parenchyma and gradually develop into an intra-axial collection of encapsulated pus [1]. Brain abscesses can occur through direct extension, where the infection spreads from a nearby area, or via hematogenous dissemination, where the causative pathogen spreads from distant organs to the cerebral tissue. A brain abscess develops from a suppurative focus of infection (mastoiditis, chronic otitis media, frontoethmoidal sinusitis, or dental infections), or a distant site of infection (lungs, skin, endocarditis, intra-abdominal abscess, urinary tract infection) [2]. It can also occur directly following head trauma or cranial surgical procedures. However, the focus of infection is not identified in 20–30% of cases [2].

Diagnosis of a brain abscess is very challenging if the patient does not have clinically evident neurological findings [3]. The most common symptoms are fever, headache, and vomiting [2]. Brain abscesses may initially present clinical symptoms, such as headaches, new epileptic seizures, and focal neurological deficits [2]. The most common symptoms are headache (69%), fever (45%), and nausea and vomiting (40%), respectively [2, 4]. Diagnosis and therapeutic management can sometimes be difficult even in patients with neurological findings [1]. Radiological imaging methods play a primary role in the differential diagnosis of brain abscesses from other intracranial pathologies [1]. The conventional magnetic resonance imaging (MRI) method is an indispensable tool for the identification of lesions and their localization and morphological features, but conventional MRI cannot credibly distinguish brain abscesses from other intracranial mass lesions, such as necrotic tumors [1].

The most common causative pathogens in brain abscesses are associated with paranasal sinusitis, which is generally caused by the Streptococcus milleri group (both aerobic and anaerobic) organisms [5]. Haemophilus, Bacteroides species, Staphylococcus aureus, and Enterobacteriaceae are also described as causative pathogens of brain abscesses [5]. The most common pathogens found in intracerebral abscesses may result from those caused by dental infections due to streptococci, Bacteroides fragilis, and Fusobacterium species [5].

Commonly used pharmaceuticals in the treatment of central nervous system infections are adjuvant corticosteroids and antibiotics, including ampicillin, cefepime, cefotaxime, ceftriaxone, gentamicin, meropenem, metronidazole, nafcillin, penicillin G, rifampin, and vancomycin. Vancomycin is also suitable for intraventricular administration, with an adult dose of 20 mg/day, or a pediatric dose of 10 mg/day [2].

The neutrophil-to-lymphocyte ratio (NLR) has been gaining traction recently, and has widely been accepted as an accurate marker of inflammatory status [6, 7]. The effectiveness of NLR, routinely used as a marker of infection like other markers, such as leukocyte (WBC) count, erythrocyte sedimentation rate (ESR), and C-reactive protein (CRP), has yet to be investigated for brain abscesses in the literature. The role of the NLR has largely remained unexamined. The present study aims to address the NLR in the treatment and diagnosis of patients with brain abscesses.

MATERIALS AND METHODS

Selection Criteria

Neurological and radiological examinations were performed with patients admitted to the clinic with headaches, nausea/vomiting, or epileptic seizures between January 01, 2014, and December 31, 2020. A total of 218 patients with intracranial lesions were operated on. Of the patients who underwent surgery, 14 were diagnosed with brain abscesses and received inpatient treatment. Patients with rheumatoid arthritis (n = 1), patients with membranous glomerulonephritis who received immunosuppressive therapy (n = 1), and patients with brain abscesses who were referred from an external healthcare unit and received oral antibiotic treatment (n = 2) were excluded from the study. Data from the remaining cases (n = 10) were used.

Study Design and Accumulation of Data

Demographic data and clinical features were recorded and listed using Microsoft Excel. Patients with any other condition that could potentially contaminate ESR, CRP, or white blood cell (WBC) data and those with incomplete lab results were excluded. The control group included patients admitted to the hospitals for a routine physical check-up, who did not have any serious disease or malignancy, and no history of glucocorticoid use. The control group was compatible with the brain abscess groups in gender distribution (n = 10). The preoperative and postoperative data of the cases included in the study were compared with the data of the control group.

Neurological Examination

The most common symptoms of the patients with brain abscesses were headache, fever, focal neurological deficit, nausea/vomiting, epileptic seizures, and changes in consciousness.

Radiological Examinations

Radiological examinations were performed using a General Electric (GE) HDxt 1.5 Tesla (1.5T) MRI scanner. The patients were instructed to lie down in the supine position, and a head coil was used before the MRI. The images of T1-weighted, T2-weighted, FLAIR in the axial plane, T1-weighted in the coronal plane, T2-weighted in the sagittal plane, and T1-weighted sequences in the axial and coronal planes after intravenous injection (IV) of gadolinium were then acquired. Diffusion-weighted images (DWI) and apparent diffusion coefficient (ADC) sequences were also obtained.

Surgical Technique

All patients were operated on by the same surgeon, and different surgical methods were used. In the first surgical method, a burr-hole was made in the calvarium, and then the dura mater was incised so that the pus could be aspirated out. In the second surgical method, patients underwent craniotomy, the abscess was reached through a dural incision or trans-cortical or trans-sulcal resection, and the aspiration of liquid pus was performed. In the third surgical method, the capsule of the abscess was also excised, along with the procedure described for the second surgical method. In cases with intracranial multiple abscesses, successful abscess drainage was achieved by performing two different craniotomies in the same session. One patient underwent craniotomy and abscess drainage. However, upon the recurrence of the abscess, this patient was operated on twice. The follow-up of the same patient revealed the development of hydrocephalus, and an external ventricular drainage catheter was placed.

Statistical Analysis

Data management and statistical analysis were performed using Minitab Software (Version 22.0). Demographic data are presented as mean ± standard deviation (SD). Tukey's honestly significant difference test was used after the one-way analysis of variance (ANOVA) for comparisons between groups. The direction and strength of the linear association between the data were evaluated using the Pearson correlation coefficient. The alpha significance value was accepted as $P < 0.05$.

RESULTS

Of the initial cohort of 218 patients, 14 (6.4%) were diagnosed with brain abscess. The average age of the control group patients (n = 10), of whom 30% were female, was 40.0 ± 18.87 years. The average age of the study group patients (n = 10), of whom 30% were female, was 39.1 ± 22.33 years. The average body temperature of the study group patients was 37.58 ^{o}C.

Neurological Findings

Four patients had epileptic seizures, two patients had headaches, three patients had vomiting, one patient had a fever, and one patient had cranial nerve involvement. Six patients were conscious, two patients were unconscious, and two patients had somnolence. Two patients who were unconscious and sleeping prone died, and the state of consciousness and neurological dysfunction at the time of the first presentation affected mortality in patients with brain abscesses (Table 1).

Radiological Findings

Table 2 shows the locations and sizes of the abscesses in the patients. Figure 1 presents the MRI sections of a 38-year-old male patient with a multifocal abscess in the brain (Table 2, Figure 1).

Table 1. Data on Neurological Assessment.

Presenting Complaint	Loss of Consciousness	Meningeal Irritation Sign	Cranial Nerve Involvement	Motor Deficits	Predisposing Factors
Seizure	None	None	None	None	Chronic renal failure
Vomiting, fever	Somnolence	Stiff Neck	None	None	Otitis media*
Vomiting, ear pain	None	None	None	None	Beta thalassemia + Otitis media*
Headache	None	None	None	None	Sinusitis
Seizure, headache	None	None	None	None	None
Seizure	None	None	None	None	Membranous granulonephritis + T2DM
Ataxia, vomiting	Yes	None	None	None	Otitis media *
Seizure	None	None	None	Left hemiparesis	Operated frontal tumour
Diplopia, dysphagia	Somnolence	None	Ptosis, diplopia	None	Myasthenia gravis + T2DM
Loss of Consciousness	Yes	None	None	No motor response	Trauma

*: Patients died.

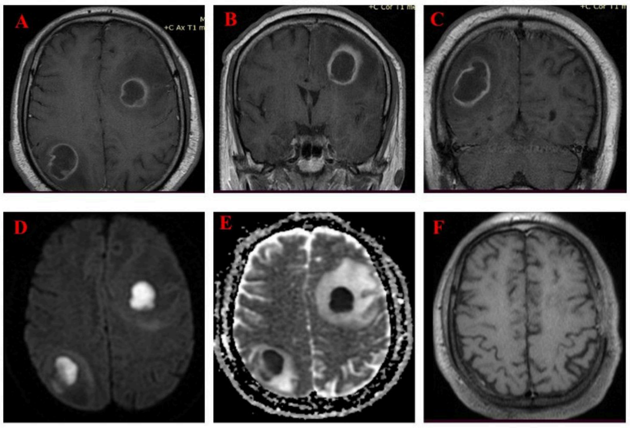

Figure 1. MRI Findings.

Figure 1A: A 38-year-old male patient's axial T1-weighted MRI sections at the supraventricular show the lesions in the left frontal lobe at the level of white matter and at the posterior of the right parietal lobe in the junction of white matter and gray matter. The lesions compatible with abscesses are smooth-lobule-contoured, accompanied by millimetric mural enhancement on the posterior wall, a rather smooth inner wall, and a peripheral ring-shaped enhancement pattern. The central portion of the lesions is relatively homogeneous and hypointense, and a diffuse signal loss due to vasogenic edema and effacement of adjacent sulci in the periphery of the lesion are observed. A minimal shift is also seen in the midline structures due to the left frontal lesion.

Figure 1B: The coronal plane images of the abscess in the left frontal lobe described in Figure 1A show that the inner wall of the abscess is smooth, and the outer wall is partially thick and partially uniformly contrasting. A diffuse signal loss in the white matter due to vasogenic edema

Table 2. Locations of abscesses and size of the abscesses drained out.

Abscess Location	Abscess Size (mm)
Right Parietal	20x10
Left Frontal + Left Caudate Nucleus	19x8.5
Right Temporal	6,5x4.5
Left Frontal	30x19
Left Frontal + Right Occipital	32x28
Left Frontal	28x17
Right Cerebellar	45x35
Right Frontoparietal	38x25
Right Parietal + Left Parietal	43x28
Left Occipital	37x29

and effacement of adjacent sulci in the periphery of the lesion are observed. A minimal compression in the lateral ventricle of the left frontal horn and a slight right shift in the midline structures are also seen.

Figure 1C: The coronal plane images of the abscess in the right parietal lobe described in 1A show the abscess with irregular lobule-contoured and peripheral ring-shaped enhancement. A diffuse signal loss in the white matter due to vasogenic edema, effacement of adjacent sulci in the periphery of the lesion, and narrowing of the lateral ventricle of the right occipital horn are also observed.

Figures 1D and E: An increased signal in the left frontal lobe and central right parietal lesion is observed in the left DWI sequence. A decreased signal on the ADC map indicates diffusion restriction, which is a significant sign in the diagnosis of an abscess. Extensive edema is also seen around the lesion.

Figure 1F: Axial T1-weighted MR images obtained following gadolinium IV in the sixth postoperative month of the same patient reveal disappearance of the abscesses in the left frontal and right parietal portion. No edema is observed in the brain parenchyma. The normal configuration of sulci and a postoperative craniectomy defect are also seen in the left frontal bone.

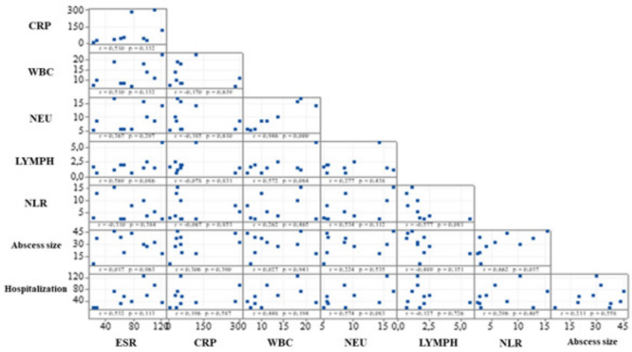

Figure 2. Statistical evaluation of all biochemical parameters and Pearson correlation in the patients with brain abscess

Evaluation of Biochemical Data

The mean values of ESR, CRP, WBC, NEU, LYMPH, and NLR in the control group were 7.6 ± 5.21, 1.39 ± 1.13, 7.01 ± 2.45, 4.23 ± 1.79, 2.13 ± 0.54, and 2.02 ± 0.66, respectively. The mean preoperative values of ESR, CRP, WBC, NEU, LYMPH, and NLR in the study group patients were 72.8 ± 33.94, 96.00 ± 106.54, 12.45 ± 5.49, 9.55 ± 4.38, 1.95 ± 1.45, and 6.69 ± 4.66, respectively (Table 3).

A strong positive correlation was observed between NEU and WBC (r = 0.946; P = 0.05) and between NLR and abscess size (r = 0.662; P = 0.037).

Biochemical parameters were higher in patients with preoperative brain abscesses (Figure 3).

The comparisons between groups revealed that ESR (F = 17.99; P = 0.00), CRP (F = 3.43; P = 0.047), WBC (F = 3.60; 0.041), and NEU (F = 5.20; P = 0.012) were statistically significant (P <0.05), while LYMPH (F = 0.40; P = 0.677) was not statistically significant (P >0.05).

The preoperative NLR values (Adj SS = 115.5; Adj MS = 55.76; F = 5.28; P = 0.012) of the patients with brain abscesses were statistically significant as compared to those of the healthy volunteers (P <0.05) (Table 4).

The histopathological evaluations of a 38-year-old male patient who underwent craniotomy and abscess drainage were presented demonstratively (Figure 4).

The culture results of the study group revealed no bacterial growth in two cases and the growth of anaerobic gram-positive cocci in two cases. Gram-negative anaerobe and beta-hemolytic Streptococcus growth were observed in one case. The growth of gram-positive diplococcus (n = 1), Streptococcus spp (n = 1), Nocardia (n = 1), Pseudomonas aeruginosa (n = 1), and Coryneform-like bacteria (n = 1) were seen in the remaining cases.

Table 3. Comparison of biochemical parameters between groups.

Groups	Age (years)	Sex	ESR (mm/hour)	CRP (mg/L)	WBC (µl/ml)	NEU (µl/ml)	LYMPH (µl/ml)	NLR
Volunteers (n=10)	28	M	6	1.39	6.9	4.06	2.34	1.73
	38	F	10	3.86	6.56	4.3	1.69	2.54
	36	M	4	1.81	6.82	4.03	2.23	1.80
	33	M	5	0.53	6.84	3.78	2.46	1.53
	31	M	9	0.59	6.08	2.75	2.7	1.01
	40	M	21	0.84	13.59	8.85	3.13	2.82
	47	M	8	1.68	6.59	3.98	1.86	2.13
	59	M	5	2.52	5.26	3.43	1.35	2.54
	47	F	5	0.24	6.96	4.88	1.7	2.87
	41	F	3	0.45	4.48	2.23	1.84	1.21
Preoperative cases (n=10)	51	M	66	55.8	8.31	5.59	2.03	2.75
	3	F	121	118	22.24	14.2	5.72	2.48
	16	F	22	6.6	7.47	5.15	1.73	2.97
	22	M	94	50.1	18.01	15.5	1.51	10.26
	38	M	111	299.05	11	8.51	1.5	5.67
	56	M	99	30.4	13.7	10.02	2.48	4.04
	62	M	51	36.81	18.92	16.5	1.08	15.27
	43	F	61	50.5	8.3	5.75	2.06	2.79
	74	M	77	282	6.7	5.61	0.71	7.90
	26	M	26	30.76	9.8	8.68	0.68	12.76
Postoperative Cases (n=10)	51	M	32	14.9	8.31	4.55	2.21	2.05
	3	F	31	290	1.11	0.22	0.84	0.26
	16	F	42	173	20.47	15.3	3.83	3.99
	22	M	29	1.1	5.5	2.41	1.91	1.26
	38	M	55	12.39	5.04	2.6	1.75	1.48
	56	M	89	1	12.57	8.76	2.15	4.07
	62	M	48	103.41	9.37	7.48	1.09	6.86
	43	F	33	7.7	5.9	3.33	1.73	1.92
	74	M	1	89.8	4.8	3.53	0.69	5.11
	26	M	9	0.6	11.8	10.1	0.97	10.41

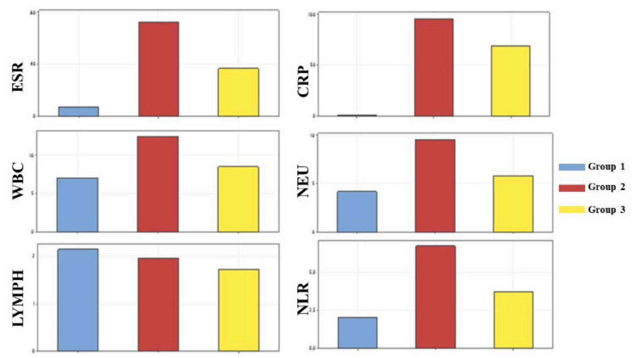

Figure 3. Group 1; healthy volunteers, group 2; preoperative evaluation of patients, and group 3: postoperative evaluation of patients

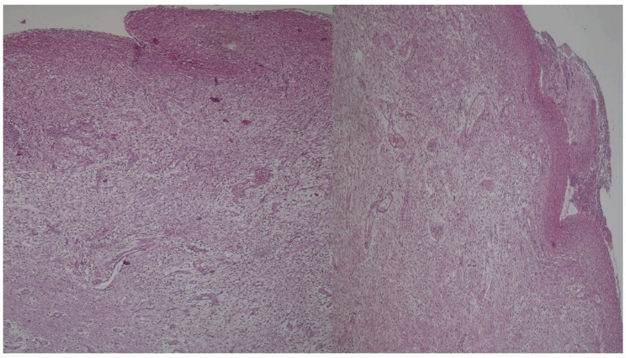

Figure 4. Haematoxylin&Eosin (H&E) staining is examined under a light microscope at a magnification of 40X and an image of gliosis.

Table 4. Comparison of intergroup NLR values with Tukey's HSD test after one-way ANOVA. Grouping information using the Tukey Method and 95% confidence interval.

Groups	N	Mean	Grouping
Group 1 (Volunteers)	10	2.02322	B
Group 2 (Preoperative cases)	10	6.69268	A
Group 3 (Postoperative cases)	10	3.74530	A B

Antibiotherapy and combined corticosteroid therapy were administered to all patients during their hospital stay. The surgical procedure performed and duration of hospital stay are presented in Table 5.

Acyclovir 80 mg / kg / day, ceftriaxone 50 mg / kg / dose IV q12h and vancomycin 17.5 mg / kg / dose IV q6h were administered to the three-year-old patient. The remaining cases were given the following adult doses of antibiotherapy: imipenem (3 g / day), linezolid (30 mg / kg / daily), metronidazole (2000 mg / day), meropenem (6 g / day), ceftriaxone (4 g / d), teicoplanin (400 mg once daily intravenously), cotrimoxazole (15 mg / kg iv of the trimethoprim component per day in three or four divided doses), and vancomycin (60 mg / kg / day). Dexamethasone was given 16 mg / day for 7–14 days with 3–4 dose intervals in adults. In pediatric use, it started with an initial dose of 0.02–0.3 mg / kg with a dose interval of 3–4 and was administered as a maintenance dose of 0.01–0.1 mg / kg.

Table 5. The surgical procedure performed, and duration of hospital stay.

Cases	Applied treatment			Length of Hospital Stay (days)
	Craniotomy	Burr-hole drainage	Antibiotherapy	
Case 1	+	-	Metronidazole + Ceftriaxone + Vancomycin	56
Case 2	+	+	Acyclovir + Ceftriaxone + Vancomycin	37
Case 3	-	+	Metronidazole + Meropenem + Vancomycin	17
Case 4	+	-	Metronidazole + Meropenem + Vancomycin	125
Case 5	+	-	Metronidazole + Ceftriaxone + Vancomycin	94
Case 6	+	-	Metronidazole + Ceftriaxone + Imipenem + Trimethoprim / sulfamethoxazole	59
Case 7	+	-	Metronidazole + Meropenem + Teicoplanin	75
Case 8	+	-	Ceftriaxone	32
Case 9	+	-	Metronidazole + Ceftriaxone + Vancomycin	38
Case 10	+	-	Meropenem + Linezolid	18

DISCUSSION

Brain abscesses affect all age groups and are not specific to a particular country, race, or geographic place [8]. It is a disease that had a high morbidity and mortality rate in the past [8], but advances in medical technology and expertise in this field have significantly improved outcomes. The causal organisms are diverse and have evolved [8]. The treatment of brain abscesses is primarily based on antimicrobial therapy, but surgical intervention and abscess drainage play pivotal roles in achieving positive results [8].

Brouwer et al. [9] argued that many studies in this field were restricted by methodology and that the outcomes were less beneficial for clinical practice. The authors suggested that advancements in brain imaging methods, surgical procedures, and antibiotic treatment had significantly improved the outcomes of patients with brain abscesses [9]. However, it is important to make a correct and rapid diagnosis to start treatment as soon as possible.

Today, radiological imaging techniques are frequently used in the differential diagnosis of cerebral abscesses. In particular, contrast-enhanced cranial MRI is a highly useful radiological examination in the diagnosis of cerebral abscesses [10]. The peripheral ring-like enhancement pattern is considered a characteristic finding in the diagnosis of cerebral abscesses, but this is insufficient in the differential diagnosis of primary malignant cerebral tumors with dense necrotic areas. Therefore, DWI and MR spectroscopy are used extensively in the differential diagnosis of cerebral abscesses. Despite the advances and developments in all these imaging methods, both early differential diagnosis and urgent treatment of the disease, which have a direct effect on the prognosis, remain a major problem. Moreover, the difficulties in the diagnosis of cerebral abscesses may delay microbiological evaluations of the causative pathogens involved in the development of the abscess. Therefore, the question of NLR's importance in the diagnosis and treatment of patients with brain abscesses must be examined.

Afari et al. [11] stated that NLR is now considered a low-cost biomarker with effective clinical predictability and a positive effect on prognosis, even though it was described decades ago. Some studies have reported an incidence of brain abscesses between 0.4 and 2.7 per 100,000 [9, 12–14]. A total of 14 out of 218 cases were diagnosed with brain abscesses (6.4%) in the present study.

MRI is a more sensitive radiological examination than CT in the detection of brain abscess. MRI is a very sensitive method that allows visualization of the changes in the tissue water content, creates a distinct contrast between the edematous brain and normal brain tissue, and helps in the diagnosis of cerebritis and abscess [15]. Characteristic features of the brain abscess observed in MRI are that the central part of the abscess is hyperintense on the T2-weighted sequence and hypointense on the T1-weighted sequence compared to the cerebrospinal fluid. Vasogenic edema encircling the lesion is described by surrounding hypointensity on the T1-weighted sequence and hyperintensity on the T2-weighted sequence [15, 16]. It also has a smooth capsule surrounding the abscess. This capsule is observed as iso-hypointense on the T2-weighted sequence and has an enhanced contrast in postcontrast images. The classic ring-like enhancement of the abscess capsule is a characteristic finding in CT and conventional MRI, but it is not an abscess-specific finding. It can also be seen in brain tumors, metastases, infarcts, hematoma, and, more rarely, thrombosed giant aneurysms, radiation necrosis, and demyelinating diseases. Common radiological features of abscesses include a 2–7 mm thick, continuous, smooth wall, T2 hypointense capsule, and a smooth thin medial wall. However, these features may not be present in all abscesses, and none of them are 100% specific [15, 16].

DWI helps distinguish neoplasm from a pyogenic abscess. The restricted diffusion within the central non-enhancing portion of the abscess is pathognomonic, but not specific. This is rarely seen in brain cystic or necrotic tumors.

Some researchers have suggested that restricted diffusion in brain abscesses occurs due to necrotic debris, macromolecules, and pus viscosity [15, 17]. Some studies have reported that an increased ADC value may be seen in treated abscesses, and persistent or recurrent ADC may be an indicator of inadequate treatment or reactivation of infection [15, 18].

In the present study, the diagnosis of brain abscesses was made using some pathognomonic but non-specific findings described for abscesses during radiological examinations. The walls of the abscess were thin, and the inner walls were smooth. The images obtained following the contrast agent injection revealed a peripheral enhancement pattern of the smooth, thin capsule in all lesions. Reduced loss of signal intensity was observed on the T1-weighted sequence, which was compatible with vasogenic edema around the lesions. An increase in the signal intensity on the DWI sequence, which was compatible with restricted diffusion, and a loss of signal intensity on the ADC sequence were also observed.

In recent studies, genetic variation has been associated with the risk of brain abscess [9]. A study in this field reported that single nucleotide polymorphisms in the ICAM-1 and MCP-1 genes escalated susceptibility [9]. However, no genetic testing was performed to evaluate the genetic variation. Many studies have investigated bacterial brain abscesses, and the reported studies on nonbacterial brain abscesses are limited. One meta-analysis revealed that the causative organism could be identified in 68% of brain abscess cases, and in 23% of positive cultures, multiple bacteria were identified. Most culture-positive cases were due to streptococcal (34%) and staphylococcal species (18%) [9].

In this study, the culture results revealed no bacterial growth in two cases and the growth of anaerobic gram-positive cocci in two cases. Gram-negative anaerobe and beta-hemolytic Streptococcus growth were observed in one case. The growth of gram-positive diplococcus (n = 1), Streptococcus spp (n = 1), Nocardia (n = 1), Pseudomonas aeruginosa (n = 1), and Coryneform-like bacteria (n = 1) were seen in the remaining cases.

Empirical therapy is preferred to treat gram-positive and gram-negative bacteria because of the wide variety of potential pathogens causing brain abscesses. Therefore, an extended-spectrum cephalosporin, such as cefotaxime or ceftriaxone, in combination with metronidazole, is administered to all patients [9]. In patients with immunosuppressive disorders, voriconazole, trimethoprim-sulfamethoxazole, or sulfadiazine are used to cover fungi, yeasts, and toxoplasmosis while awaiting further diagnostics [9].

In the present study, acyclovir, imipenem, linezolid, metronidazole, meropenem, ceftriaxone, teicoplanin, trimethoprim/sulfamethoxazole, and vancomycin were administered intravenously. The advised duration of intravenous antimicrobial therapy in bacterial brain abscess patients is 6–8 weeks [19]. In this study, the average duration of intravenous antimicrobial therapy was seven weeks (55.1 days). In addition to the use of antibiotics, adjuvant corticosteroid treatment was applied [20–22]. A form of corticosteroid, mostly dexamethasone, was also used in the treatment.

Some studies have reported that the duration of antibiotic therapy is determined with the help of MRI and DWI results [23]. It has been suggested that, along with the antibiotic regimen, MRI and DWI are helpful tools in the diagnosis of brain abscesses [1, 24, 25]. In the present study, MRI and DWI were used to diagnosis the brain abscess. However, no data were found in the patients' medical records about whether MRI and DWI were used to determine the duration and regimen of antibiotic therapy.

As a result, the biochemical parameters obtained from the cases included in this study showed that the mean NLR was 2.023 in the control group (healthy volunteers), while this rate was 6.69 in cases with brain abscess. The NLR value, which increased approximately 3.31-fold in the study group compared to the healthy individuals, was statistically significant (P = 0.012). A strong positive relationship was observed between the NLR value and abscess size (r = 0.662; P = 0.037).

Limitations: The retrospective design of our study may be considered as limitations. However, it may contribute to the systematic reviews and meta-analyzes [26] and also clinical practise guidelines which will be done together with other same studies about ıssue [27].

Conclusion: NLR may be used as a cost-effective and reliable biomarker in the diagnosis of brain abscess, along with other infection markers such as WBC, CRP, and ESR. However, further prospective studies and randomized clinical trials are needed to substantiate this conclusion.

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