JIDC | THE JOURNAL OF INFECTION IN DEVELOPING COUNTRIES

Original Article

The characteristics of the cases with brain abscess and the analysis of the predictive factors for poor outcome

Emre Bilgin[1], Tugba Arslan Gulen[2], Gokhan Kızılpınar[1], Gulistan Gul Işıkber[2], Can Sezer[1], Zeynel Abidin Tas[3], Ebru Oruc[2]

[1] *Department of Neurosurgery, Health Sciences University Adana City Training and Research Hospital, Adana, Turkey*
[2] *Department of Infectious Diseases and Clinical Microbiology, Health Sciences University Adana City Training and Research Hospital, Adana, Turkey*
[3] *Department of Pathology, Health Sciences University Adana City Training and Research Hospital, Adana, Turkey*

Abstract
Introduction: To evaluate the characteristics of patients who have undergone surgical operations due to brain abscess and to assess the risk factors for mortality and the outcomes.
Methodology: Patients who have undergone surgical operations due to brain abscess between January 2014 and January 2024 in our hospital were evaluated retrospectively. Patients were divided into 2 groups to determine poor outcome predictive factors.
Results: A total of 57 patients with brain abscess were evaluated. Brain abscess was developed after a surgical procedure in 33% of the patients. Of these patients, 44 (77%) recovered without sequelae, 3 cases had epilepsy, and 2 had hemiplegia. Comparing the patients with poor outcome and the patients with good outcome in terms of symptom duration, time to hospital admission, and C-reactive protein, erythrocyte sedimentation rate and procalcitonin values, we detected statistically significant difference only in erythrocyte sedimentation rate ($p = 0.018$). Patients with poor outcome had higher C-reactive protein and procalcitonin values and shorter symptom duration and time to hospital admission than the patients with good outcome. Multivariate logistic regression analysis revealed that erythrocyte sedimentation rate is a predictive factor for poor outcome.
Conclusions: Brain abscesses with high mortality and morbidity. Detailed questioning of symptom duration and time to hospital admission in patients presenting with headache who have or have not undergone surgical operation, precisely evaluating C-reactive protein, sedimentation, and procalcitonin values after performing necessary scanning procedures, and swiftly planning surgical and/or antibiotic treatment are associated with survival benefit.

Key words: brain abscess; risk factor; surgery; antibiotic therapy.

J Infect Dev Ctries 2025; 19(8):1182-1188. doi:10.3855/jidc.20676

(Received 03 August 2024 – Accepted 27 January 2025)

Introduction

The brain abscess, which is defined as a suppurative area surrounded by a capsule in the brain parenchyma, is a central nervous system infection with a high risk of life-threatening neurological deficit [1,2]. The estimated annual incidence in Europe is 0.4-1.3/100.000, with 6700 cases detected each year [3]. In Türkiye, it is reported that the incidence has decreased to 0.98/100 000 in 2021 from 3.68/100.000 in 2017 [4]. The risk factors for brain abscess include diabetes mellitus, head trauma, brain surgery, and immunosuppression; however, it may also occur without an underlying risk factor. Despite the innovations in the diagnosis and treatment, the 30-day and one-year mortality rates for brain abscess are 13% and 20%, respectively [3].

The infection may develop after an invasion from a neighboring focus of infection such as otitis, mastoiditis, tooth decay, or sinusitis, following a penetrating head trauma or cerebral surgery, or as the consequence of hematological spread. However, the source of infection remains undetected in nearly 25% of the cases [5].

This study evaluates the characteristics (demographic, clinical, laboratory, radiological imaging, and microbiological) of patients who have undergone surgical operation for brain abscess as well as the risk factors for poor outcomes.

Methodology

Study design

The study protocol was approved by the ethical committee of Health Sciences University Adana City Training and Research Hospital, Adana, Türkiye

(Approval No. 3001). Magnetic resonance imaging and/or computed tomography of the brain were used for radiological diagnosis of the infections.

Hospital records of all patients who had been hospitalized in our hospital between January 2014 and January 2024 with the diagnostic codes of International Classification of Diseases (ICD-10) including G06 (Intracranial and intraspinal abscess and granuloma), G06.0 Intracranial abscess and granuloma), G06.2 (Extradural and subdural abscess, unspecified), and G07 (Intracranial and intraspinal abscess and granuloma, in diseases classified elsewhere) were retrospectively identified and evaluated for eligibility criteria.

Patients older than 18 years of age who were followed up as inpatients at Health Sciences University Adana City Training and Research Hospital between January 2014 and January 2024 and who underwent surgery for brain abscess were eligible for the study. Patients younger than 18 years of age and patients who did not receive treatment for spondylodiscitis were excluded from the study. Abscess material culture and/or blood culture, abscess tuberculosis culture, and fungal culture were obtained for microbiological identification. Specimens obtained during surgery were pathologically analyzed in terms of abscess. All patients underwent a surgical procedure consisting of craniotomy and abscess drainage and/or capsule excision. Rifampicin solution was used to clean the surgical area.

For the intra-parenchymal abscess, localization of the abscess and border of the parenchymal depth to surrounding tissues was detected using intraoperative neuro-navigation. After complete or partial excision of the abscess and the surrounding capsule, the surgical area was irrigated with normal saline.

Patients' clinical features, risk factors, laboratory findings, results of microbiological examination and radiological imaging, and antibiotic therapy and its outcomes were then recorded in the patient charts, which have been created by screening the electronic patient files. Based on the clinical outcomes, the patients were divided into two groups as good outcome (patients who healed without sequel) and poor outcome (patients who healed with a severe sequel or who died).

Statistical Analysis

Descriptive statistics were presented as frequency, percentage, mean, standard deviation, median, minimum and maximum, and 25th Percentile (Q1) and 75th Percentile (Q3). Fisher's Exact Test was used for the analysis of categorical variables when 20% of the expected frequencies had a value smaller than 5. The assumption of normality was controlled by Shapiro Wilk Test. The difference between the numerical data of two groups was analyzed by Independent Samples t-test when the data were distributed normally and by Mann-Whitney U Test when the data was not distributed normally. The variables with a $p < 0.20$ in the univariate analysis were included in the logistic regression model. VIF (variance inflation factor) values were analyzed to assess the multicollinearity problem, and no multicollinearity problem was determined between the variables included in the model (VIF < 10). Statistical analyses were done using SPSS 23.0 program. A $p < 0.05$ was considered statistically significant.

Results

A total of 57 patients with brain abscess were evaluated. Of the patients, 55.4% were male and the mean age was 43.7 ± 2.4 (range 19-77) years. Headache

Figure 1. Axial T1W, coronal T1W contrast-enhanced, and sagittal T1W magnetic resonance imaging scans of a patient for temporal lobe abscess.

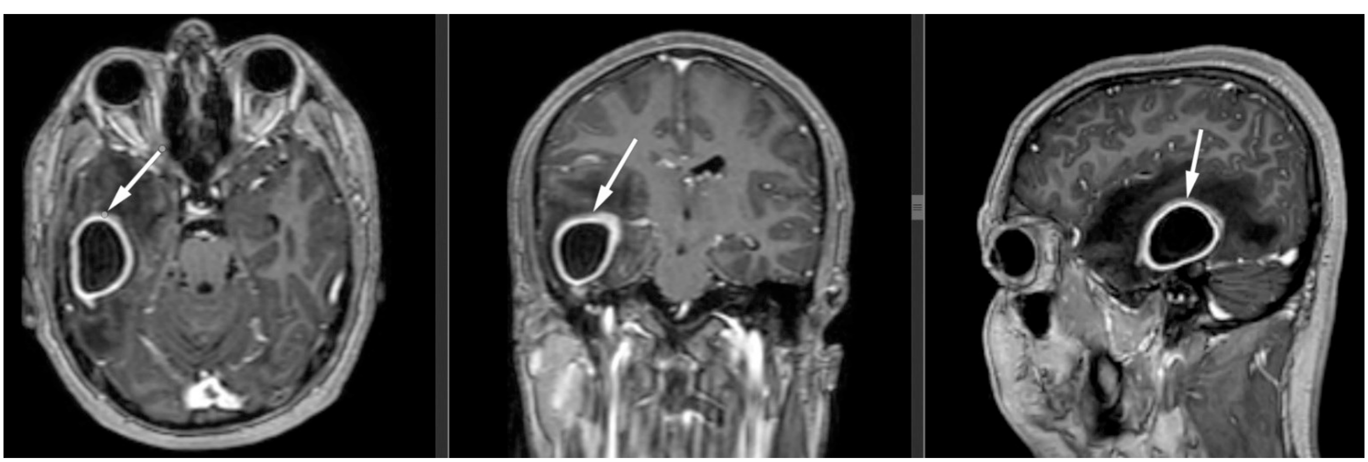
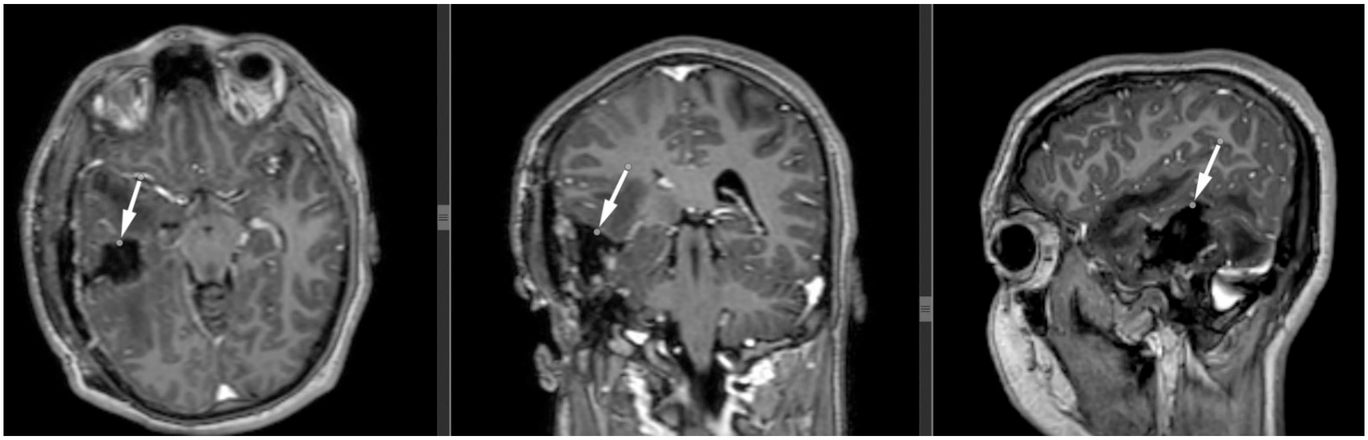


Figure 2. Axial T1W, coronal T1W, and sagittal T1W magnetic imaging scans of the surgical cavity in the first 24 hours after surgery for temporal lobe abscess.



was the most common symptom (93%). The classical triad consisting of headache, fever and focal neurological deficit was detected in only 7% of the patients. Diabetes mellitus was the most frequent comorbidity (n = 16). In our series, 33.3% patients had a history of previous surgery (Figure 1, 2). The frontal lobe (42%) was the most common site of involvement. All but two of the patients received parenteral antibiotic therapy as inpatient over the treatment course. It was found that 44 patients (77%) recovered without sequel. However, 3 patients had epilepsy and 2 patients had hemiplegia as a sequel. The characteristics of the patients with good outcome and poor outcome are presented in Table 1. Comparison of the groups is summarized in Table 2. Multivariate logistic regression analysis for the predictive factors of poor outcome is presented in Table 3.

Tissue culture was obtained from all but 5 patients, and growth was detected in only 28.8% of them. Gram-positive bacteria were detected in 73.3%, *M. tuberculosis* was detected in 6.7%, and Gram-negative bacteria was detected in 20% of tissue cultures showing growth. The Gram-positive bacteria in the order of frequency of growth were Viridans streptococci (6), MRSA (2), and *E. fecalis* (2), and the Gram-negative bacteria in the order of frequency of growth were *Enterobacteriacea*e (3) and *S. maltophiliae* (1) (Table 4).

Discussion

Brain abscess, which is a local infection of the brain parenchyma, remains as a disease difficult to manage despite surgical drainage and high-dose long-term antibiotic therapy. Advances in the diagnostic and therapeutic methods have contributed to the 5-15% reduction in disease mortality in the last 20 years [6]. The association between predisposition to infection and diabetes has been reported previously. Impaired glucose control increases the risk of developing brain abscess by affecting host defense [7]. Similar to the studies conducted by Huang *et al.* [7] and Tehli *et al.* [8], DM (28%) was the most common comorbidity in

Table 1. The characteristics of the patients' poor outcome and good outcome.

Characteristics	Outcome	n	Mean ± SD (Min-Max)	Median (Q1-Q3)	*p*
Age	Poor	13	43.08 ± 18.66 (20-76)	41 (26-56)	0.864[2]
	Good	44	43.84 ± 17.79 (18-77)	49 (24-56.5)	
Symptom Duration	Poor	13	12.23 ± 8.98 (3-30)	10 (7-10)	0.075[2]
	Good	44	21.07 ± 27.24 (3-180)	14 (8.5-30)	
Time to hospital admission	Poor	13	12.23 ± 8.98 (3-30)	10 (7-10)	0.083[2]
	Good	44	21.68 ± 27.23 (3-180)	14 (8.5-30)	
Hemoglobin	Poor	13	10.86 ± 2.18 (8-15)	10.9 (9.8-11)	0.098[2]
	Good	44	12.28 ± 2.25 (8.1-17.7)	12.85 (10.55-14.1)	
Leukocyte count	Poor	13	13846.1 ± 8404.1 (4800-33600)	12000 (8000-19800)	0.992[2]
	Good	44	13596.82 ± 7660.3 (4500-36500)	11450 (8465-16250)	
CRP	Poor	13	125 ± 93.1 (21-270)	84.4 (43-198)	0.332[2]
	Good	44	88.34 ± 72.23 (12-394)	68 (41.5-105)	
Procalcitonin	Poor	6	0.74 ± 0.82 (0.02-2.2)	0.55 (0.03-1.1)	0.479[2]
	Good	27	0.34 ± 0.56 (0.03-2.1)	0.12 (0.04-0.2)	
ESR	Poor	13	60.38 ± 30.12 (22-94)	61 (56-74)	**0.018[1]**
	Good	44	46.02 ± 18.29 (17-93)	45 (325-56)	

1: Independent paired sample t-test; 2: Mann Whitney U test.

our study population.

Table 2. Comparison of the groups in the outcome.

Characteristics	Outcome		Total n (%)	*p*
	Poor n (%)	Good n (%)		
Sex				
Male	10 (76.9)	21 (47.1)	31 (54.4)	0.063[1]
Female	3 (23.1)	23 (52.3)	26 (45.6)	
Symptom				
Headache	4 (30.8)	21 (47.7)	25 (43.9)	0.151[2]
Fever	0 (0)	3 (6.8)	3 (5.3)	
Focal neurological deficit	0 (0)	1 (2.3)	1 (1.8)	
Headache-fever	4 (30.8)	14 (31.8)	18 (31.6)	
Triad*	3 (23.1)	1 (2.3)	4 (7)	
Headache-seizure	2 (15.4)	4 (9.1)	6 (10.5)	
Surgery				
No	7 (53.8)	31 (70.5)	38 (66.7)	0.323[2]
Yes	6 (46.2)	13 (29.5)	19 (33.3)	
Comorbidity				
No	9 (69.2)	30 (68.2)	39 (68.4)	0.99[2]
Yes**	4 (30.8)	14 (31.8)	18 (31.6)	
Source of abscess				
Unidentified	10 (76.9)	23 (52.3)	33 (57.9)	0.452[2]
Dental	0 (0)	1 (2.3)	1 (1.8)	
Sinus	1 (7.7)	2 (4.5)	3 (5.3)	
Ear	1 (7.7)	6 (13.6)	7 (12.3)	
Trauma	1 (7.7)	12 (27.3)	13 (22.8)	
Re-surgery				
No	9 (69.2)	37 (84.1)	46 (80.7)	0.251[2]
Yes	4 (30.8)	7 (15.9)	11 (19.3)	
Concomitant infection				
No	10 (76.9)	39 (88.6)	49 (86)	0.365[2]
Yes***	3 (23.1)	5 (11.4)	8 (14)	
Growth in tissue culture				
No	8 (72.7)	29 (70.7)	37 (71.2)	0.99[2]
Yes	3 (27.3)	12 (29.3)	15 (28.8)	

1: Pearson chi square test; 2: Fisher's Exact test; * Headache + fever + focal neurological deficit; ** Diabetes mellitus 16 patients; immunosuppression 2 patients; *** Sinusitis, otitis, bacteremia.

Table 3. Multivariate logistic regression analysis for the predictive factors of poor outcome.

	B	S.E.	Wald	df	Sig.	Exp (B)	95% C.I. for EXP (B)	
							Lower	Upper
Constant	-3.341	1.064	9.860	1	0.002	0.035		
ESR	0.040	0.018	4.961	1	0.026	1.041	1.005	1.078

-2LL = 55.62; Nagelkerke R: 0.412; Success rate: 76%.

Table 4. Distribution of microorganisms grown in tissue cultures.

Bacteria	N (%)
Gram-positive bacteria	
Viridans streptococci*	6
MRSA	2
E. fecalis	2
Gram-negative bacteria	
*Enterobacteriaceae***	3
S. maltophiliae	1
M. tuberculosis	1

**S. mitis, S. constellatus, S. intermedius, S. mutans; ** E. coli, K. pneumonia.*

Surgical procedure is considered as a risk factor for developing brain abscess. One-third of our patients developed brain abscess after a neurosurgical procedure performed due to intracranial mass. In the present study, however, no statistically significant relationship was detected between poor outcome and comorbidity or neurosurgery ($p = 0.99$ and $p = 0.323$, respectively).

Consistent with the literature, symptom duration and time to hospital admission were shorter in patients who died [9]. In the present study, we found no significant relationship between poor outcome and symptom duration and time to hospital admission ($p = 0.075$ and $p = 0.083$, respectively). However, symptom duration and time to hospital admission were significantly shorter in the patients with poor outcome, which was similar with the study conducted by Dietler *et al.* [10]. Immediate surgical intervention and antibiotic therapy would be beneficial in patients diagnosed with brain abscess, who have short symptom duration and shorter time to hospital admission and who have indication for surgery.

The localization of abscess varies according the source of infection. While otitis media and mastoiditis are associated with temporal lobe or cerebellar abscesses, paranasal sinusitis is frequently associated with frontal lobe abscess. In the present study, frontal lobe was the most common localization of abscess, with a single lesion in all. This result was consistent with the literature [7,8]. Similar with the study conducted by Zhang *et al.* [11], abscess localization was not a risk factor for poor outcome ($p = 0.183$).

Although there was no statistically significant difference between the sexes in terms of poor outcome ($p = 0.063$), male sex accounted for more than half of the study population (54.4%). Similar with the present study, Huang *et al.* [7] reported that males are more likely to develop brain abscess than females (2.8:1), and Tehli *et al.* [8] detected brain abscess more frequently in males.

Headache, fever and focal neurological deficits are considered as the classical symptom triad of brain abscess. In the present study, however, this triad was detected in only 7% of the patients. This lower rate as compared to the earlier studies [2,7], might have resulted from the small sample size of the present study.

Inflammation markers such as C-reactive protein (CRP), erythrocyte sedimentation rate (ESR) and procalcitonin (PCT) level play a limited role in the diagnosis of brain abscess [2,10]. Procalcitonin, leukocyte count or CRP is not useful in excluding the diagnosis of brain abscess, however high levels may indicate severe disease/rupture [3]. In the multivariate analysis, high ESR value was found to be a predictive factor for poor outcome. CRP and procalcitonin values were higher in the patients with poor outcome, with no statistically significant difference between the groups. Although these inflammatory biomarkers play a limited role in the diagnosis, they may guide the clinicians and neurosurgeons in terms of poor clinical prognosis. For this reason, CRP and ESR values should be taken into consideration while planning treatment for brain abscess.

While starting empirical antimicrobial therapy, the antimicrobial agent should be chosen carefully taking the underlying predisposing factors, the source of infection, and potential etiological agents into account. Microbiological diagnosis is very important for a successful treatment. Growth of the agent microorganism provides the clinician with information about targeted antimicrobial therapy by facilitating determination of antimicrobial susceptibility. In order to enhance the probability of accurate microbiological diagnosis, antibiotics should not be started until performing the neurosurgical aspiration or excision in available patients. Aspiration materials should be taken for aerobic and anaerobic cultures during the procedure and they should be transferred to the microbiology laboratory in a fastest manner. In the present study, tissue samples for culture were obtained from all but five patients during the procedure and were then sent to the laboratory, which revealed growth in only 28.8%. Gram-positive bacteria were grown in 67% of these cultures, with viridance streptococci being the leading. Consistent with the literature, Gram-positive bacteria accounted for the majority of culture growth [10,12]. In the present study, the rate of culture positivity was 28.8% and was lower than that found in earlier studies (46-70%) [2,7,13]. This may be due to antibiotherapy started in some patients before collecting sample for culture, as well as the failure to detect some microorganisms using standard methods of culture performed in our laboratory.

Although the 'European Society of Clinical Microbiology and Infectious Diseases' (ESCMID) guideline for the diagnosis and treatment of brain abscess; although a total of 6-8-week intravenous antimicrobial therapy is recommended for aspirated or conservatively treated brain abscesses (excluding tuberculosis, toxoplasmosis, nocardiosis, permanent neuroanatomical defects and fungal brain abscess), it is stated that shorter duration as 4 weeks can be considered for the patients treated with abscess excision based on the expert opinion [3]. Evans *et al.* determined that shorter duration of intravenous antibiotherapy for brain abscesses is not associated with increased mortality rate [14]. Brouwer *et al.* reported that intravenous (IV) route of administration is required for a long-term antibiotic therapy as 6-8-week; however, they also stated that 1-2-week IV antibiotic therapy may also be appropriate before switching to oral therapy depending on the patient's clinical status [1]. In the present study, excluding those who died, all but two of the patients who survived received antibiotic therapy for 4-6 weeks as inpatient. The mean duration of treatment was significantly shorter in those who died as compared to those who survived ($p = 0.002$). This is an expected result since the duration of treatment for the patients that die during treatment would be short anyway. We think that the reason for our patients with brain abscess to complete the antibiotic treatment as inpatient may be due to the fact that they have been followed-up by different infectious diseases specialists during consultations. Thereby, we planned to develop a treatment protocol for our clinic.

Brain abscess may cause serious neurological sequels such as motor weakness, aphasia and epilepsy [15]. The neurological sequel was epilepsy in three and hemiplegia in two of our patients. These sequels indicate poor prognosis.

Our study has some limitations. First, it is a single-center retrospective study. Second, the sample size is small. Prospective studies with larger sample size are required to better understand this disease.

Conclusions

For brain abscess with high mortality and morbidity, early surgical drainage in combination with antibiotherapy taking primarily the ESR value, as well as CRP value, symptom duration and time to hospital admission, into account would contribute to good clinical outcomes. Further research is needed to confirm our conclusion.

Corresponding author

Emre Bilgin, Assoc. Prof.
Department of Neurosurgery,
Health Sciences University Adana City Training and Research Hospital
Dr. Mithat Özsan Bulvarı Kışla Mah. 4522
Sokak No: 28 Yüreğir/ Adana/ Turkey
Tel: +90 322 455 90 00
Fax: +90 0322 344 03 05
Email: dremreblgn@gmail.com

Conflict of interests

No conflict of interests is declared.

References

1. Brouwer MC, Tunkel AR, McKhann GM, van de Beek D (2014) Brain abscess. N Engl J Med 371: 447e56. doi: 10.1056/NEJMra1301635.
2. Brouwer MC, Coutinho JM, van de Beek D (2014) Clinical characteristics and outcome of brain abscess. Neurology 82: 806e13. doi: 10.1212/WNL.0000000000000172.
3. Bodilsen J, D'Alessandris QG, Humphreys H, Iro MA, Klein M, Last K, Montesinos IL, Pagliano P, Sipahi OR, San-Juan R, Tattevin P, Thurnher M, de J Treviño-Rangel R, Brouwer MC, ESCMID Study Group for Infections of the Brain (ESGIB) (2024) European society of clinical microbiology and infectious diseases guidelines on diagnosis and treatment of brain abscess in children and adults. Clin Microbiol Infect 30: 66-89. doi: 10.1016/j.cmi.2023.08.016.
4. Korkmaz S, Korkmaz D (2023) Brain abscess incidence and microbial etiology in Turkey: a nationwide cross-sectional study. Eur Rev Med Pharmacol Sci 27: 9703-9709. doi: 10.26355/eurrev_202310_34140.
5. Kalkan E, Keskin F, Feyzioğlu B, Kaya B (2014) A case of cerebral abscess in patient with pulmonary arteriovenous malformation. Eur J Basic Med Sci 4: 44-48. doi: 10.15197/sabad.2.4.08.
6. Brook I (2017) Microbiology and treatment of brain abscess. J Clin Neurosci 38: 8-12.
7. Huang J, Wu H, Huang H, Wu W, Wu B, Wang L (2021) Clinical characteristics and outcome of primary brain abscess: a retrospective analysis. BMC Infect Dis 21: 1245. doi: 10.1186/s12879-021-06947-2.
8. Tehli GY, Kirmizigoz S, Durmaz MO, Ezgu MC, Tehli O (2023) Risk factors and surgical treatment options for intracranial infections. Turk Neurosurg 33: 308-317. doi: 10.5137/1019-5149.JTN.40387-22.4.
9. Kao PT, Tseng HK, Liu CP, Su SC, Lee CM (2003) Brain abscess: clinical analysis of 53 cases. J Microbiol Immunol Infect 36: 129-36.
10. Dietler S, Willms J, Brandi G, Wang S, Burkerth A, Keller E (2023) Spontaneous empyema and brain abscess in an intensive care population: clinical presentation, microbiology, and factors associated with outcome. Acta Neurochir 165: 651-658. doi: 10.1007/s00701-022-05241-7.
11. Zhang C, Hu L, Wu X, Hu G, Ding X, Lu Y (2014) A retrospective study on the aetiology, management, and outcome of brain abscess in an 11-year, single-centre study from China. BMC Infect Dis 14: 311. doi: 10.1186/1471-2334-14-311.
12. Bodilsen J, Duerlund LS, Mariager T, Brandt CT, Petersen PT, Larsen L, Hansen BR, Omland LH, Tetens MM, Wiese L, Jørgensen RL, Leth S, Nielsen H, DASGIB study group (2023) Clinical features and prognostic factors in adults with brain abscess. Brain 146:1637-1647. doi: 10.1093/brain/awac312.
13. Corsini Campioli C, O'Horo JC, Lahr BD, Wilson WR, DeSimone DC, Baddour LM, Van Gompel JJ, Sohail MR (2022) Predictors of treatment failure in patients with pyogenic brain abscess. World Neurosurg X 6: 100134. doi: 10.1016/j.wnsx.2022.100134.
14. Evans TJ, Jawad S, Kalyal N, Nadarajah A, Amarouche M, Stapleton S, Ward C, Breathnach A (2022) Retrospective review of the epidemiology, microbiology, management and outcomes of intra-cranial abscesses at a neurosurgical tertiary referral Centre, 2018-2020. Ann Clin Microbiol Antimicrob 21: 58. doi: 10.1186/s12941-022-00550-2.

15. Cho YS, Sohn YJ, Hyun JH, Baek YJ, Kim MH, Kim JH, Ahn JY, Jeong SJ, Ku NS,Choi JY, Yeom JS, Song YG (2021) Risk factors for unfavorable clinical outcomes in patients with brain abscess in South Korea. PLoS One 16: e0257541. doi: 10.1371/journal.pone.0257541.