

Contents lists available at [ScienceDirect](http://www.sciencedirect.com)

Asian Pacific Journal of Tropical Disease

journal homepage: www.elsevier.com/locate/apjtd

Document heading

doi: 10.1016/S2222-1808(14)60745-3

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Fungal brain abscess: report of three cases and review of literature

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ARTICLE INFO

Article history:

Received 12 Jun 2014

Received in revised form 15 Jun, 2nd

revised form 18 Jun, 3rd revised form 22

Jun 2014

Accepted 10 Jul 2014

Available online 19 Aug 2014

Article history:

Paramphistomes

Prevalence

Hills

Tarai

Ruminants

ABSTRACT

Fungal brain abscess is an unusual but serious complication associated with immunosuppression. The aim of this study is to review our experience, to determine the factors related to the outcome, the pathogenesis and clinical presentation, and to improve the therapeutic strategy for this disease, and also include a review of the relevant literature.

We reviewed three cases of fungal brain abscess in patients who were immunocompromised. The three patients included two males and one female. Their ages ranged from 35 to 53 years (mean, 43.3 years). The mean duration of symptoms before diagnosis of brain abscess was 19 days. The diagnostic of brain abscess were performed in all three cases by histopathology and direct preparation, culture techniques and CT scan or magnetic resonance imaging. Patients were presenting with mild dizziness and unsteady gait, headache, and focal or generalized seizure.

We isolated two cases of *Aspergillus fumigatus* and one *Candida albicans* from cerebral abscess. All patients had predisposing factor to fungal infections. The outcome in our patients was poor, with an overall mortality of 2:3 of patients. Blood and urine culture were negative for fungi in all patients. Early diagnosis, aggressive surgical procedures, and antimicrobial therapy for fungal brain abscess may reduce morbidity and mortality.

1. Introduction

Fungal intracranial abscess (usually referred to as brain abscess) is a complication of immunosuppression and is a rare pathologic condition in immunocompetent patients, which generally affects immunosuppressed patients[1].

Fungal brain abscess has a high incidence of morbidity and mortality caused by several factors and therefore requires accurate diagnosis and appropriate medical management strategies to optimize the outcome[2,3]. This increase in frequency is attributed to the growing use of immunosuppressive therapies and organ transplantation[4–6]. The causative agents of fungal

brain abscesses in immunocompromised patients are *Aspergillus* species, *Candida* species, and rare fungi, including *Cladophialophora bantiana* and *Cladosporium trichoides*, *Pseudallescheria boydii*, *Trichoderma* species, *Chaetomium* species, *Penicillium marneffeii*, and the *Phaeohyphomycosis*[7].

The present study describes the clinical characteristic, and the fungi involved in the patients with brain fungal abscess and therapeutic factors inducing the outcome of brain abscess and improves the treatment strategy by reviewing the cases diagnosed at our institution and also is a review of the relevant literature.

2. Patients and methods

In a retrospective study, three patients with brain abscess entered the study. Predisposing factors were seen

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Foundation Project: Supported by grant number P/142 from Pasteur Institute of Iran.

in all patients. The material for investigations was biopsy specimens from brain abscesses. Diagnosis was established on histopathology, direct preparation and microbiological studies including culture of brain abscess material, CT, and/or magnetic resonance imaging (MRI). Specimens were cultured on Sabouraud dextrose agar, blood agar and brain heart infusion agar, and fluid thioglycolate, anaerobic culture media, and biochemical properties. Duplicate cultures on each medium were incubated at 35 °C and 25 °C regularly, examined up to 4 weeks and identified using standard methods.

Only mass-forming lesions with pathologically proven fungal involvement were included; infections without related mass-forming lesions and abscesses were excluded from this study.

This study was approved by the Ethics Committee of Pasteur Institute of Iran and it conformed to the provisions of the Declaration of Helsinki. All patients were fully informed of the study protocol and gave an informed consent prior to study entrance.

3. Case report

3.1. Case 1

A 35-year-old Iraqi refugee woman was diagnosed with acute lymphatic leukemia (ALL). She was hospitalized in the infection disease section because of fever (38.5 °C) with disturbance and complaining of weakness of the left arm and the left leg, with 5 days of headache, nasal discharge and decreased visual acuity. The neurological examination revealed bilateral papilledema, bitemporal hemianopsia and impairment of visual acuity. MRI of the brain revealed a 2.5-cm multilobular abscess.

Direct microscopic and histopathological examination from brain abscess specimen showed hyaline, branched and septate hyphae compatible with fungal elements (Figure 1). Cultures of the brain abscess specimen grew *Aspergillus fumigatus* (*A. fumigatus*). Although antifungal treatment was started by amphotericin B (1.2 mg/kg/day) with fluconazole (400 mg/day), the patient was poor response to treatment and the patient's condition continued to deteriorate. MRI at that time did not demonstrate any improvement. The patient remained neurologically stable. Finally, the patient died 5 days after the surgery.

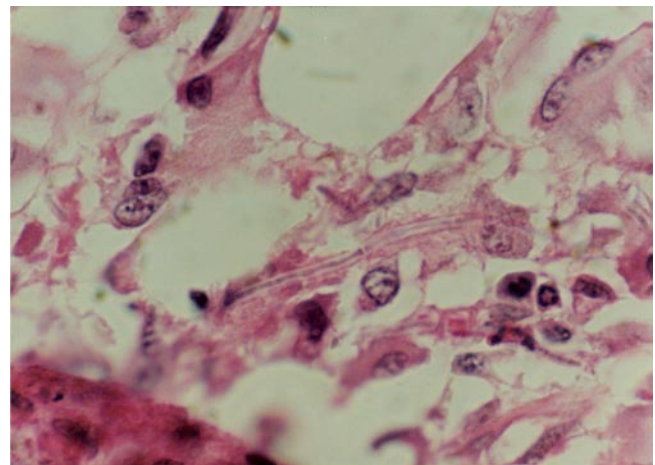


Figure 1. Hematoxylin and eosin stain of biopsy specimen of brain, highlighting *Aspergillus* sp. hyphae in the brain.

3.2. Case 2

The patient was 53-year-old man with a 3 years' history of tuberculosis, which was indicated by brucellosis for 2 months. He was treated by acyclovir metronidazole, rifampin, isoniazid, and **trizianamid**. He had refractory intense headache. Seven days before admission, he presented with painful ophthalmoplegia, ptosis, visual impairments, and occlusion. He had headache, vomiting, generalized tonic-clonic seizures, fever, confusion, and altered sensory.

Directly biopsy specimen of brain microabscesses with 10% potassium hydroxide and Gram stain showed the presence of pseudomycelium and yeast cells. Culture of specimen gave rise to *Candida albicans* (*C. albicans*). It was identified by API 20 C Aux. After the operation, amphotericin B, and fluconazole therapy were started. During a 6-month follow-up period, the patient's headache and nasal discharge disappeared, and his visual acuity improved. The patient was maintained on the antifungal medication until complete radiographic resolution occurred.

3.3. Case 3

A 42-year-old man suffered from chronic sinusitis and a progressive severe headache for a period of over one year. He has been employed as a structure worker for several years. CT scans showed paranasal sinusitis. He was presented with a history of cerebral concussion followed car crushed when he was 14-year-old. His CT scan revealed two lesions in the anterior and basal parts of the right temporal lobe. He had neck stiffness, without any fever, vomiting, Todd's palsy or double vision. Direct examination of cerebral

tissue with 10% potassium hydroxide and histopathological examination of the brain abscess specimen showed the presence of septate hyphae (Figure 2). The brain abscess specimen cultures were positive for *A. fumigatus* (Figure 3). The patient was initially started on liposomal amphotericin B 450 mg (5 mg/kg) intravenously per day and oral voriconazole (400 mg/day). Unfortunately, despite antifungal therapies, the prognosis continued to be very poor in the patient and he died after 3 days.

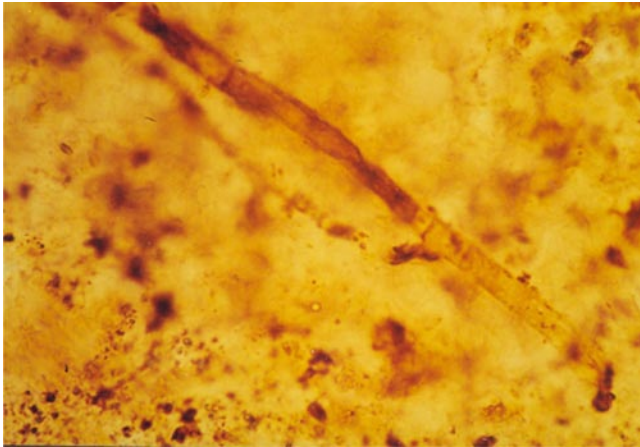


Figure 2. Gomori methenamine silver stain of cerebellar tissue showing fungal elements.

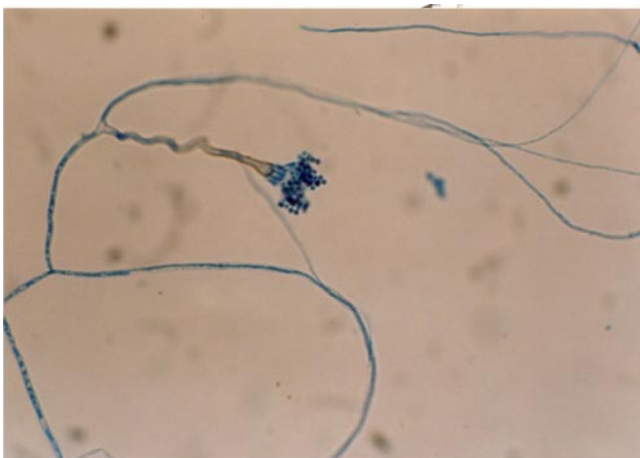


Figure 3. Microscopic morphology of *A. fumigatus* isolate of brain abscess, stained with lactophenol cotton blue.

4. Discussion

Cerebral fungal abscess may occur in both immunocompetent and immunocompromised patients and is illustrated as an acute or chronic course. The mortality rate for fungal brain abscesses in immunosuppressed patients remains high^[6].

In the present study, the predominant fungal brain abscess demonstrated by histopathology and tissue culture was *A. fumigatus* (2/3), followed by *C. albicans* (one case).

Although various fungi have been described as agents of brain abscess mycosis, most fungal brain abscesses can be caused by yeast and *Aspergillus* sp. Fungal brain abscesses are associated with immunocompromised status, and poorly controlled diabetes in the infection by zygomycetes^[8,9]. The central nervous system is the most common secondary site of invasive disease after the lung that is the most common site of primary infection^[10].

The most prevalent fungal etiologic agents of brain abscess in patients undergoing marrow transplantation at the Fred Hutchinson Cancer Research Center in Seattle were *Aspergillus* species (58% of cases), and *Candida* species were second in frequency (33%); sporadic cases were caused by *Rhizopus*, *Absidia*, *Scopulariopsis*, and *Pseudallescheria* species^[10–12]. In present study, all three patients presented with known predisposing factors including ALL in the first case, tuberculosis accompanied with brucellosis in the second case, and chronic sinusitis after a concussion following a car accident in childhood and head fraction in the third case. In our study, the mortality rate of immunocompromised patients with aspergillosis brain abscess was quite high. The cases with *Aspergillus* abscesses had a fatal outcome^[7]. Unfortunately, despite aggressive surgical and antifungal therapies, the prognosis continued to be very poor in the patients with aspergillosis and the two patients with brain aspergillosis died.

Fungal brain abscess is associated with a very poor prognosis and high mortality. Despite antifungal therapy, the mortality in intracranial aspergillosis remains high^[13]. Walsh *et al.* reported that only 1 of 17 patients with this condition was successfully treated^[14]. Therefore, an early and precise diagnosis may prove to be life-saving in patients with the diagnosis of brain abscess^[15]. The accurate diagnosis of this rare disease can only be established by histopathological examination of tissue obtained at surgery. The clinical and laboratory diagnosis of cerebral aspergillosis (CA) is challenging and even in cases receiving appropriate treatment, mortality is very high.

The management of cerebral fungal abscesses is controversial. The optimal treatment is surgical resection combined with antifungal therapy preferably with voriconazole, which has made good prognosis in most cases of fungal brain abscess^[16].

The immunosuppression is a risk factor for fungal brain abscess^[17]. As seen in our study, ALL was present and may

have responded as a predisposing immunosuppression factor in the first case.

In the second case, the patient was treated for tuberculosis with antituberculous agents and steroids for various periods, which could have impaired host immune response.

In the third case, the patient had evidenced of a paranasal sinus involvement. There were occupation factor (structure worker), cerebral concussion and chronic sinusitis as disposing factors. A hot, dry climate and a high content of *Aspergillus* spores in an atmosphere full of dust where he works may be responsible for its infection. Fungal brain abscess is specifically soil-associated occupations such as mining[18].

The infection originates in the palate or paranasal sinuses and spreads through the orbit and adjacent sinuses into the brain. The way of infection from *Aspergillus* has been described as via hematogenous means, direct extension, or

as a primary intracranial lesion[19].

Table 1 indicates some cases reported fungal brain abscess with respect to age, sex and predisposing factor, date of survey publication and fungal isolate in patients with brain abscess. CA in the immunosuppressed patients, with haematological malignancies, progressed with a mortality rate of over 95%[20].

Clinical symptoms of CA are nonspecific, and an accurate diagnosis of this rare disease can only be established by tissue histopathology and positive biopsy culture[15].

In our study, contiguous infections, hematogenous spread from other foci, and immunocompromised conditions were the most reason for aspergillosis and unfortunately both patients with *Aspergillus* brain abscess died.

In immunocompromised patients, when there is involvement of the central nervous system with *Aspergillus* infection, mortality may be as high as 95%. The clinical and

Table 1

Cases reported fungal brain abscess with respect to age, sex and predisposing factor, date of survey publication and fungal isolate in patients with brain abscess.

Author	Date and region of survey	Age and sex	Predisposing factor	Causative agents	Treatment	Outcome
Yoo <i>et al.</i> [25]	1985/USA	54/M	Malignant lymphoma	<i>Pseudallescheria boydii</i>	Chemotherapy and/or radiotherapy	Failed
Loeys <i>et al.</i> [26]	1999/Belgium	5Y/M	Mucocutaneous candidiasis	<i>C. albicans</i>	Itraconazole and fluconazole	Cured
Endo <i>et al.</i> [27]	2001/Japan	55Y/M	transsphenoidal surgery for a pituitary adenoma	<i>A. fumigatus</i>	Amphotericin B and fluconazole	Failed
Lee <i>et al.</i> [28]	2003/Singapore	65Y/F	Cadaveric liver transplant for autoimmune hepatitis	<i>Xylophlypha bantiana</i>	Amphotericin, itraconazole and flucytosine	Cured
Singh <i>et al.</i> [29]	2004/India	20Y/M	Tuberculosis	<i>Cladosporium bantianum</i>	Amphotericin B and fluconazole	Cured
Lyons <i>et al.</i> [30]	2005/USA	64Y/M	Uncertain immune function	<i>Cladophialophora bantiana</i>	Amphotericin B and voriconazole	Cured
Roche <i>et al.</i> [31]	2005/Ireland	26Y/M	X-linked isolated T-cell deficiency (probably Duncan's syndrome)	<i>Cladophialophora bantiana</i>	Intravenous liposomal amphotericin B and flucytosine	Failed
Tsai <i>et al.</i> [10]	2006/Taiwan	48Y/F	Psoriasis for 20 years, treated with UV light, and cervical carcinoma	<i>Aspergillus</i> species	Amphotericin B	Failed
Chakrabarti <i>et al.</i> [32]	2006/India	14–M/M	Unknown	<i>Aspergillus nidulans</i>	Surgical drainage and amphotericin B	Failed
Metellus <i>et al.</i> [33]	2008/France	42Y/F	Hepatitis C	Zygomycetes	Surgical endoscopic debridment and amphotericin B	Cured
Garzoni <i>et al.</i> [4]	2008/Switzerland	60 Y/F	Immunosuppressive therapies and organ transplantation	<i>Cladophialophora bantiana</i>	Posaconazole	Cured
Iannotti <i>et al.</i> [34]	2009/USA	53Y/M	mixed aphas hypertension, benign prostatic hypertrophy, gastroesophageal reflux, and hematuria	<i>Nocardia farcinica</i>	Trimethoprim sulfamethoxazole, imipenem	Cured
Liu <i>et al.</i> [35]	2010/China	65Y/F	Unknown	<i>Aspergillus</i> sp.	Voriconazole	Cured
Liu <i>et al.</i> [35]	2010/China	53Y/M	Unknown	<i>Aspergillus</i> sp.	Voriconazole	Cured
Liu <i>et al.</i> [35]	2010/China	56Y/F	Unknown	<i>Aspergillus</i> sp.	Voriconazole	Cured
Yampolsky <i>et al.</i> [23]	2010/Argentina	51Y/M	Diabetes mellitus	<i>C. albicans</i>	Fluconazole, amphotericin B and radical surgery	Cured
Turgut <i>et al.</i> [36]	2010/Turkey	22Y/F	Aplastic anemia	<i>A. fumigatus</i>	Liposomal amphotericin B and itraconazole	Cured
McNeil <i>et al.</i> [37]	2011/USA	24Y/M	Chronic granulomatous disease	<i>Phaeoacremonium parasiticum</i>	Voriconazole and trimethoprim sulfamethoxazole	Cured
Chen <i>et al.</i> [38]	2011/China	46Y/F	Unknown	<i>A. fumigatus</i>	Voriconazole	Cured
Tammer <i>et al.</i> [12]	2011/Germany	31/F	AIDS	<i>Scedosporium</i> and <i>Pseudallescheria</i> sp.	Caspofungin	Cured
Hoenigl <i>et al.</i> [9]	2013/Austria	59/M	Diabetes mellitus	<i>Schizophyllum commune</i>	Posaconazole	Cured
Present study	Iran	42/M	chronic sinusitis and history of cerebral concussion followed car crushed	<i>Aspergillus flavus</i>	Liposomal amphotericin B, itraconazole and voriconazole	Failed
Present study	Iran	35/F	ALL	<i>A. fumigatus</i>	Amphotericin B and fluconazole	Failed
Present study	Iran	53/M	Tuberculosis and brucellosis	<i>C. albicans</i>	Amphotericin B and fluconazole	Cured

laboratory diagnosis of CA is problematic and mortality is quite high, even in cases receiving appropriate treatment. Therefore, an early and accurate diagnosis may prove to be life-saving in patients with the diagnosis of CA^[15].

Candida meningitis can occur spontaneously as a complication of disseminated candidiasis or as a complication of an infected wound or direct inoculation of the organism into the central nervous system. The majority of brain abscesses due to *Candida* species are associated with other infections including the lungs, heart, spleen, kidneys and liver. Few surviving patients with intracranial infection due to *Candida* have been reported^[21]. Fungal brain abscess caused by *Candida* spp. is a rare disease, a nonspecific presentation, with few data on treatment, and generally poor outcomes. Diagnosis requires to be highly accurate, as clinical presentations and laboratory data can be nonspecific and difficult to diagnosis of bacterial brain abscesses. The mortality rate of the non-autopsy cases reviewed by Fennelly *et al.* was 69%^[22]. The patient reported in this paper received amphotericin B with intravenous fluconazole. Treatment with amphotericin B and fluconazole, led to a favorable outcome. In patients with *Candida* brain abscess, radical excision and prolonged antifungal therapy based on fluconazole or amphotericin B are necessary to improve the prognosis of this type of patients^[23].

In vivo study has shown that voriconazole has high penetration into brain tissue and cerebrospinal fluid, with steady-state drug levels in the central nervous system twice those of plasma levels, and limited human data have suggested favorable pharmacokinetics^[24].

Outcome of *Aspergillus* brain abscesses is poor. The present study illustrated that outcome of brain abscesses due to *C. albicans* was better than *Aspergillus* sp. Brain aspergillosis is often rapidly fatal, even with surgical intervention. In the current study, both patients with *Aspergillus* brain abscess died.

5. Conclusion

Understanding the pathogenesis of brain abscesses is important in determining the causative microorganisms and treatment. Although outcome is frequently fatal in patients with fungal brain abscess, delay in the diagnosis also contributes to the high mortality.

Early diagnosis, aggressive surgical procedures, and

antibiotic therapy for fungal brain abscess may reduce morbidity and mortality.

Conflict of interest statement

We declare that we have no conflict of interest.

Acknowledgements

This work was supported by grant number P/142 from Pasteur Institute of Iran.

References

- [1] Singh N, Husain S. Infections of the central nervous system in transplant recipients. *Transpl Infect Dis* 2000; **2**(3): 101–111.
- [2] Raman Sharma R. Fungal infections of the nervous system: current perspective and controversies in management. *Int J Surg* 2010; **8**: 591–601.
- [3] Bernardini GL. Diagnosis and management of brain abscess and subdural empyema. *Curr Neurol Neurosci Rep* 2004; **4**(6): 448–456.
- [4] Garzoni C, Markham L, Bijlenga P, Garbino J. *Cladophialophora bantiana*: a rare cause of fungal brain abscess. Clinical aspects and new therapeutic options. *Med Mycol* 2008; **46**(5): 481–486.
- [5] Scully EP, Baden LR, Katz JT. Fungal brain infections. *Curr Opin Neurol* 2008; **21**: 347–352.
- [6] Wilson HL, Kennedy KJ. *Scedosporium apiospermum* brain abscesses in an immunocompetent man with silicosis. *Med Mycol Case Rep* 2013; **2**: 75–78.
- [7] Lakshmi V, Umabala P, Anuradha K, Padmaja K, Padmasree C, Rajesh A, et al. Microbiological spectrum of brain abscess at a tertiary care hospital in South India: 24-year data and review. *Patholog Res Int* 2011; doi: 10.4061/2011/583139.
- [8] Reus-Bañuls S, Bustos Terol S, Caro-Martínez E, Cama-Barbieri J. [Cerebral aspergillosis in an human immunodeficiency virus infected patient]. *Enferm Infecc Microbiol Clin* 2012; **30**(6): 350–351. Spanish.
- [9] Hoenigl M, Aspeck E, Valentin T, Heiling B, Seeber K, Krause R, et al. Sinusitis and frontal brain abscess in a diabetic patient caused by the basidiomycete *Schizophyllum commune*: case report and review of the literature. *Mycoses* 2013; **56**(3): 389–393.
- [10] Tsai HC, Lee SS, Wann SR, Chen YS, Wang JS, Liu YC. Invasive pulmonary aspergillosis with cerebral abscess in a patient with

- idiopathic thrombocytopenic purpura. *J Chin Med Assoc* 2006; **69**(6): 278–281.
- [11] Hagensee ME, Bauwens JE, Kjos B, Bowden RA. Brain abscess following marrow transplantation: experience at the Fred Hutchinson Cancer Research Center, 1984–1992. *Clin Infect Dis* 1994; **19**(3): 402–408.
- [12] Tammer I, Tintelnot K, Braun–Dullaues RC, Mawrin C, Scherlach C, Schlüter D, et al. Infections due to *Pseudallescheria/Scedosporium* species in patients with advanced HIV disease—a diagnostic and therapeutic challenge. *Int J Infect Dis* 2011; **15**(6): e422–e429.
- [13] Bhaskar N, Mohammad K, Kaur V. *Aspergillus* brain abscess. *J Ark Med Soc* 2013; **110**(2): 41–42.
- [14] Walsh TJ, Hier DB, Caplan LR. Fungal infections of the central nervous system: comparative analysis of risk factors and clinical signs in 57 patients. *Neurology* 1985; **35**(11): 1654–1657.
- [15] Sav H, Atalay MA, Demir G, Akif Ozdemir M, Nedret Koc A. Early diagnosis of cerebral aspergillosis with various methods: a case report. *Infez Med* 2013; **21**(2): 134–138.
- [16] Liu J, You C, Tang J, Chen L. Fungal pituitary abscess: case report and review of the literature. *Neurol India* 2013; **61**: 210–212.
- [17] Shoham S, Marr KA. Invasive fungal infections in solid organ transplant recipients. *Future Microbiol* 2012; **7**: 639–655.
- [18] Sipsas NV, Kontoyiannis DP. Occupation, lifestyle, diet, and invasive fungal infections. *Infection* 2008; **36**(6): 515–525.
- [19] Hall WA. Neurosurgical infections in the compromised host. *Neurosurg Clin N Am* 1992; **3**(2): 435–442.
- [20] Coleman JM, Hogg GG, Rosenteld JV, Waters KD. Invasive central nervous system aspergillosis: cure with liposomal amphotericin B, itraconazole, and radical surgery – case report and review of the literature. *Neurosurgery* 1995; **36**: 858–863.
- [21] Lipton SA, Hickey WF, Morris JH, Loscalzo J. Candidal infection in the central nervous system. *Am J Med* 1984; **76**: 101–108.
- [22] Fennelly AM, Slenker AK, Murphy LC, Moussouttas M, DeSimone JA. *Candida* cerebral abscesses: a case report and review of the literature. *Med Mycol* 2013; **51**(7): 779–784.
- [23] Yampolsky C, Corti M, Negroni R. Fungal cerebral abscess in a diabetic patient successfully treated with surgery followed by prolonged antifungal therapy. *Rev Iberoam Micol* 2010; **27**(1): 6–9.
- [24] Denes E, Pichon N, Debette–Gratien M, Bouteille B, Gaulier JM. Pharmacokinetics of voriconazole in the cerebrospinal fluid of an immunocompromised patient with a brain abscess due to *Aspergillus fumigatus*. *Clin Infect Dis* 2004; **39**: 603–604.
- [25] Yoo D, Lee WH, Kwon–Chung KJ. Brain abscesses due to *Pseudallescheria boydii* associated with primary non–Hodgkin’s lymphoma of the central nervous system: a case report and literature review. *Rev Infect Dis* 1985; **7**(2): 272–277.
- [26] Loeys BL, Van Coster RN, Defreyne LR, Leroy JG. Fungal intracranial aneurysm in a child with familial chronic mucocutaneous candidiasis. *Eur J Pediatr* 1999; **158**: 650–652.
- [27] Endo T, Numagami Y, Jokura H, Ikeda H, Shirane R, Yoshimoto T. *Aspergillus* parasellar abscess mimicking radiation–induced neuropathy. Case report. *Surg Neurol* 2001; **56**: 195–200.
- [28] Lee YM, Tambyah PA, Lee KH, Tan KC, Lim SG. Successful treatment of *Xylohypha bantiana* brain abscess mimicking invasive cerebral aspergillosis in a liver transplant recipient. *J Infect* 2003; **47**: 348–351.
- [29] Singh S, Singh P, Sarkar C, Goel V, Srivastava T, Sharma MC, et al. Fungal granuloma of the brain caused by *Cladosporium bantianum*—a case report and review of literature. *J Neurol Sci* 2005; **228**(1): 109–112.
- [30] Lyons MK, Blair JE, Leslie KO. Successful treatment with voriconazole of fungal cerebral abscess due to *Cladophialophora bantiana*. *Clin Neurol Neurosurg* 2005; **107**: 532–534.
- [31] Roche M, Redmond RM, O’Neill S, Smyth E. A case of multiple cerebral abscesses due to infection with *Cladophialophora bantiana*. *J Infect* 2005; **51**: e285–e288.
- [32] Chakrabarti A, Marak RSK, Singhi S, Gupta S, Hurst SF, Padhye AA. Brain abscess due to *Aspergillus nidulans*. *J Med Mycol* 2006; **16**(2): 100–104.
- [33] Metellus P, Laghmari M, Fuentes S, Eusebio A, Adetchessi T, Ranque S, et al. Successful treatment of a giant isolated cerebral mucormycotic (zygomycotic) abscess using endoscopic debridement: case report and therapeutic considerations. *Surg Neurol* 2008; **69**(5): 510–515.
- [34] Iannotti CA, Hall GS, Procop GW, Tuohy MJ, Staugaitis SM, Weil RJ. Solitary *Nocardia farcinica* brain abscess in an immunocompetent adult mimicking metastatic brain tumor: rapid diagnosis by pyrosequencing and successful treatment. *Surg Neurol* 2009; **72**(1): 74–79.
- [35] Liu W, Chen H, Cai B, Li G, You C, Li H. Successful treatment of sellar *aspergillus* abscess. *J Clin Neurosci* 2010; **17**: 1587–1589.
- [36] Turgut M. Fungal granuloma of the brain caused by *Aspergillus* in an adolescent boy with chronic granulomatous disease. *Childs Nerv Syst* 2010; **26**(6): 733–734.
- [37] McNeil CJ, Luo RF, Vogel H, Banaei N, Ho DY. Brain abscess caused by *Phaeoacremonium parasiticum* in an immunocompromised patient. *J Clin Microbiol* 2011; **49**(3): 1171–1174.
- [38] Chen S, Pu JL, Yu J, Zhang JM. Multiple *Aspergillus* cerebellar abscesses in a middle–aged female: case report and literature review. *Int J Med Sci* 2011; **8**(7): 635–639.