JIDC | THE JOURNAL OF INFECTION IN DEVELOPING COUNTRIES

Case Report

Brain abscess caused by *Paenibacillus lactis*

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Abstract

We present a case of a 30-year-old male patient who was admitted to our institution with a 4-month history of persistent headache, pain in the left half of the face and the left ear. The initial magnetic resonance imaging detected an inflammatory process in the left pyramid interpreted as petrous apicitis. Subsequently, he developed generalized seizures. Follow-up computed tomography scanning with contrast enhancement demonstrated newly-formed brain abscess in the basal region of the left temporal lobe. The patient underwent microsurgical evacuation and resection of the abscess. Microbiological examination isolated *Paenibacillus lactis* as a causative microorganism. During the postoperative period, the patient further developed life-threatening meningitis that was successfully managed with prolonged intravenous antimicrobial treatment. Six-months follow-up examination confirmed complete neurological recovery with no signs of recurrence based on Magnetic Resonance Imaging (MRI). To the best of our knowledge, this is the first reported case of brain abscess caused by *Paenibacillus lactis* in the medical literature.

Key words: *Paenibacillus lactis*; brain abscess; infection; CNS; surgery.

J Infect Dev Ctries 2023; 17(3):418-422. doi:10.3855/jidc.17209

(Received 05 August 2022 – Accepted 08 December 2022)

Introduction

The genus *Paenibacillus* represents rod-shaped Gram-positive or Gram-negative variable endospores that differentiate into aerobically or facultatively anaerobic bacteria. These bacilli were originally a part of the genus *Bacillus*. However, as a result of phylogenetic studies of the 16S rRNA gene, these bacilli were removed from the genus *Bacillus* and were reclassified into the new genus *Paenibacillus* [1]. *Paenibacillus* spp. are isolated from a variety of sources, such as soil, fresh water, sewage, sludge, caves, humus, compost, rhizosphere, food, plants, larvae, and clinical specimens [2]. Many *Paenibacillus* spp. produce antimicrobial compounds that are used as pesticides as well as enzymes for bioremediation or the production of valuable chemicals [3]. People can get infected by these bacteria after ingestion, injection, injury, inhalation, or other types of contact with vegetative forms of their spores [4].

We present an extremely rare case of brain abscess caused by *Paenibacillus lactis* (*P. lactis*). To the best of our knowledge, this is the first case reported in the medical literature worldwide.

Case report

A 30-year-old male presented with a 4-month history of persistent headache and hemifacial pain radiating to the left ear. Initial magnetic resonance imaging (MRI) in June 2021 detected an inflammatory process in the region of the apex of the pyramid of the left temporal bone interpreted as petrous apicitis without adjacent brain parenchymal abnormalities (Figure 1A). Considering the MRI findings, conservative treatment with antibiotics and analgesics was prescribed to the patient without improvement of symptoms. One month later, he experienced a sudden onset of gait imbalance. The emergency computed tomography (CT) of the head found no brain abnormalities (Figure 1B). Due to a history of drug use, the patient was transferred to the Clinic of Toxicology. The urine laboratory tests for opiates, cannabinoids, amphetamines, barbiturates, cocaine, and metabolites were negative.

In October 2021, the patient exhibited two generalized epileptic seizures that were successfully treated with broad-spectrum anticonvulsants in the emergency department. The second CT of the head demonstrated a hypodense area in the basal region of the left temporal lobe, suggestive of edema and

incipient cerebritis (Figure 1C). The patient was discharged with a recommendation for oral intake of an anticonvulsant (valproate) with regular neurological and CT monitoring in the ambulatory setting. One month later, the follow-up neurological examination revealed a persistent headache and mild sensory-motor aphasia. The follow-up contrast-enhanced CT of the head performed in November 2021 revealed a ring-enhancing lesion in the basal region of the left temporal lobe (Figure 2).

Based on the clinical and neuroimaging data, the patient was considered a surgical candidate. Following a left temporo-basal craniotomy centered over the lesion, dural, and arachnoid incisions, we visualized a limited area of reddish discoloration of the cortex on the basal surface of the left inferior temporal gyrus. Employing meticulous microsurgical technique, the lesion was dissected free and resected en bloc of the surrounding edematous brain parenchyma. The abscess was well-capsulated, measuring approximately 18 mm in diameter, with a purulent necrotic center.

The microbiological examination isolated anaerobic *P. lactis*. The latter was identified via the Vitek®MS device (bioMérieux Inc., La Balme les Grottes, France), which uses the Matrix-Assisted Laser Desorption/Ionization Time of Flight Mass Spectrometry (MALDI-TOF MS) technology.

Based on the microbiological result, intravenous antimicrobial therapy with high dosages of meropenem and vancomycin was initiated. During the fourth post-operative day, the patient developed altered consciousness, meningeal irritation, and fever. Early postop CT scan was negative for intracranial hemorrhage and dislocation phenomena (Figure 3A). The clinical diagnosis of meningitis was confirmed by lumbar puncture, that evacuated dense, purulent cerebrospinal fluid (CSF) (Figure 4A). The laboratory examination of the initial CSF sample revealed total protein levels of 28.8 g/L (normal value, < 0.45g/L), glucose level of 0.0 mmol/L (normal value, > 2.2 mmol/L), CSF white blood cell count of 63,000 (normal value, < 25 × 10^6/L). The peripheral blood testing established red blood cell count of 3.9 × 10^{12}/L (normal value, > 4.5 × 10^{12}/L), hemoglobin 126 g/L (normal value, > 140 g/L) leukocytosis of 30.7 × 10^9/L (normal value, < 10.5 × 10^9/L), erythrocyte sedimentation rate of 73 mm/h (normal value, < 15mm/h), fibrinogen 7.4

Figure 2. A: Non-enhanced and **B:** enhanced CT showing capsulated brain abscess (arrow) with perifocal edema in the basal region of the left temporal lobe.

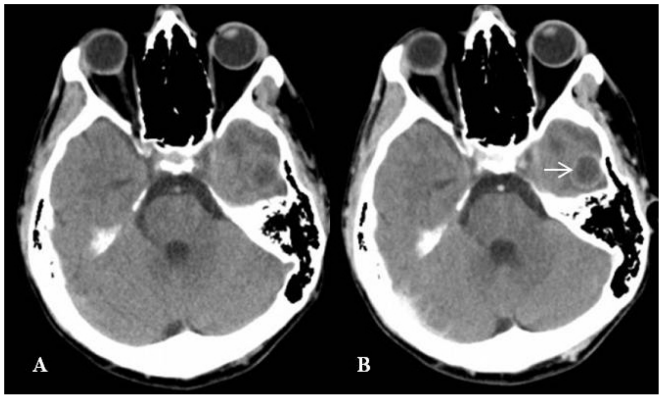


Figure 1. A: Initial axial T2-weighted MRI demonstrating hyperintensity of the pyramidal apex of the left temporal bone, suggestive of petrous apecitis (arrow); **B:** emergency axial CT scan shows no pathological cerebral findings; **C:** axial CT scan demonstrating hypodensity in the left temporo-basal region (arrow).

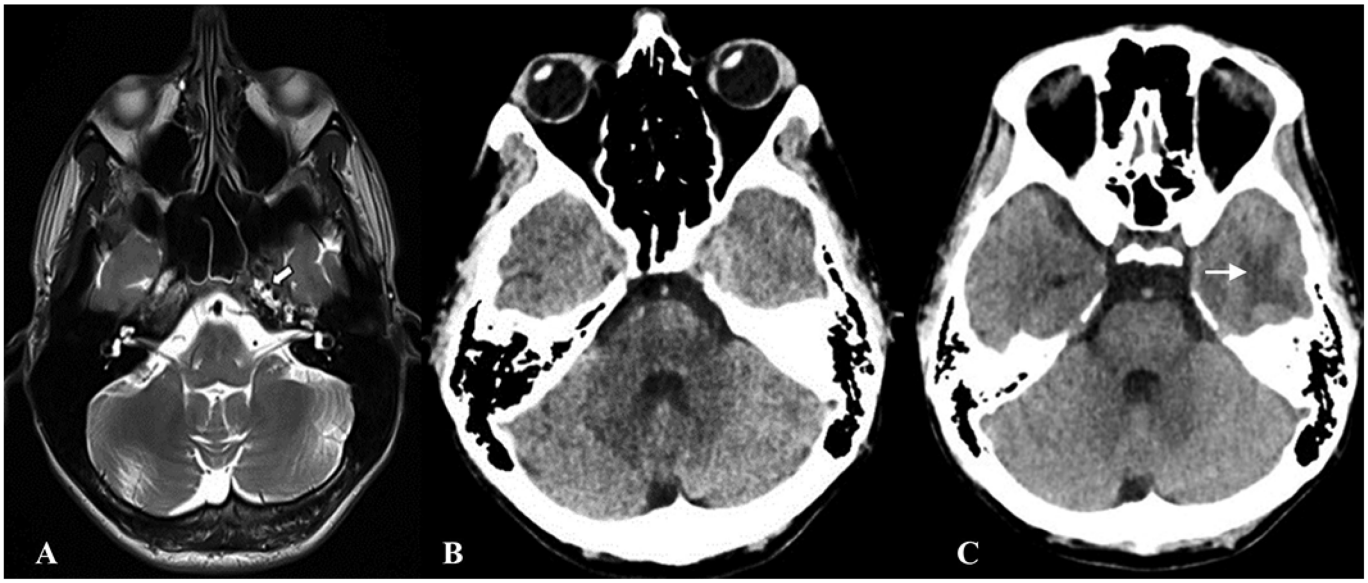
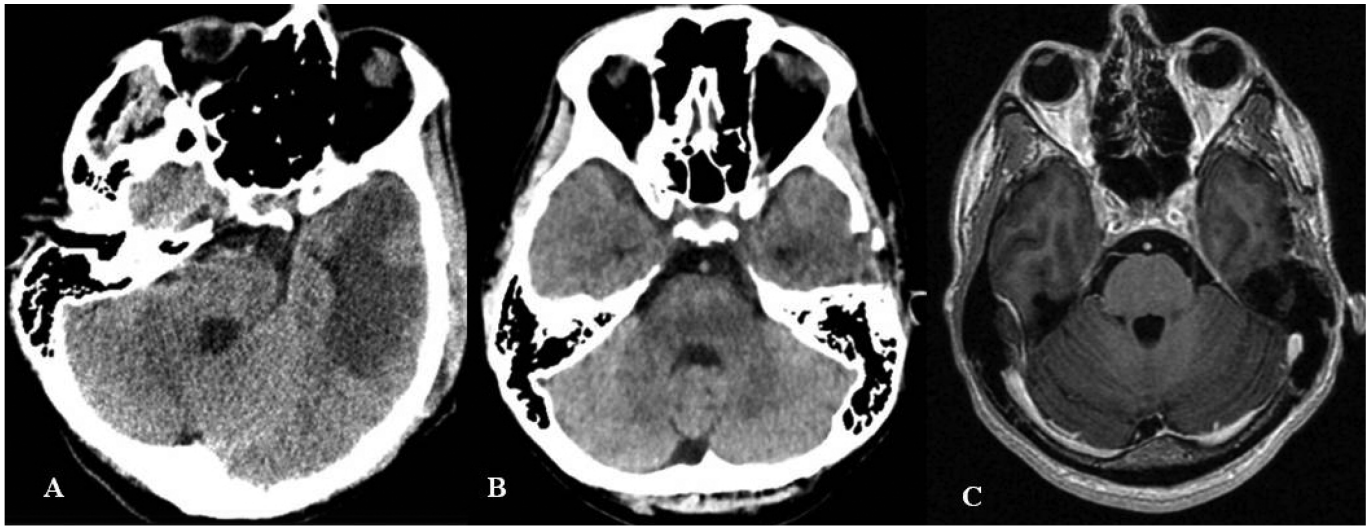


Figure 3. Postoperative CT and MRI images.



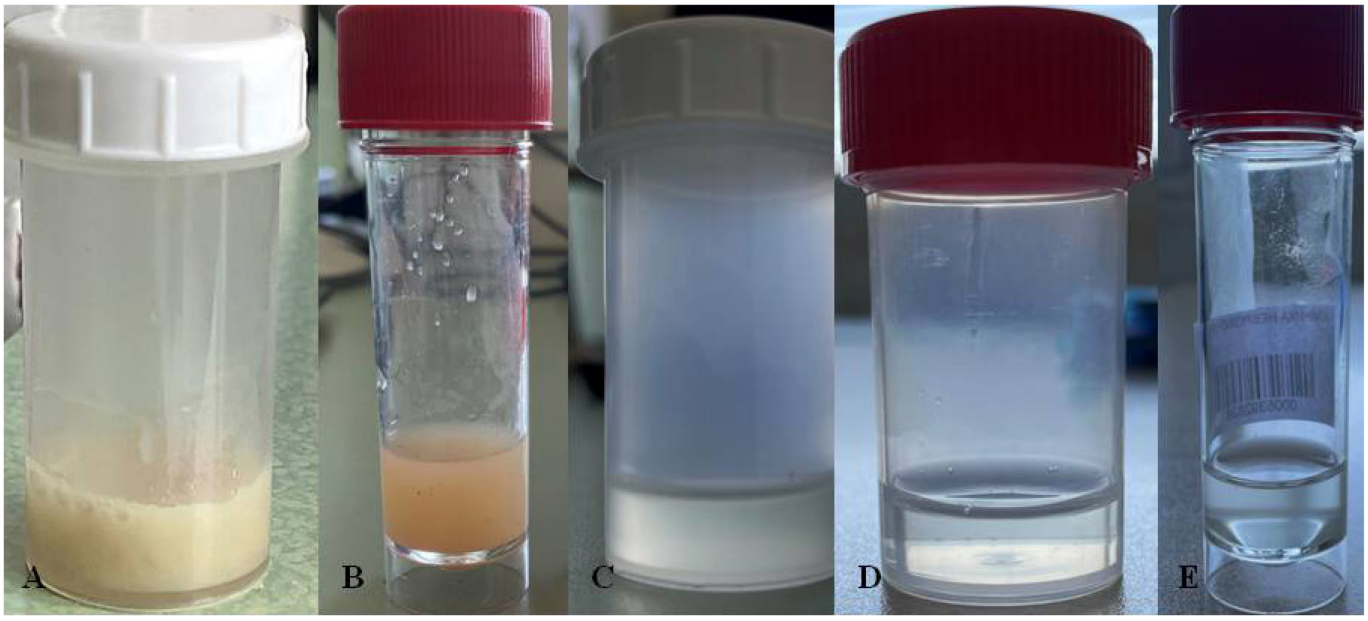
A: early postop CT scan showing a vast hypodense area in the left temporal lobe; **B:** CT scan one month after surgery demonstrating brain healing with no signs of recurrence; **C:** axial postoperative T1-weighted MRI with gadolinium enhancement at the sixth postoperative month confirmed no signs of abscess recurrence.

g/L (normal value, < 4.5 g/L), and C-reactive protein 122 mg/L (normal value, < 10 mg/L).

The microbiological CSF sample was negative for microorganisms. The anti-anaerobic drug Metronidazole (Bad Homburg, Germany) was added in the form of intravenous infusions after a recommendation from an infectious disease specialist. Additionally, the patient was tested for hepatitis B and C, human immunodeficiency virus (HIV) via enzyme-linked immunoassay (ELISA), and syphilis via venereal disease research laboratory test (VDLR), but the results were negative.

In the following days, the patient`s condition gradually improved with complete resolution of the clinical symptoms of active central nervous system (CNS) infection. Within the next 30 days five monitoring lumbar punctures were performed revealing a gradual macroscopic clearance of the CSF (Figure 4

Figure 4. Dynamics of the macroscopic appearance of the CSF during the hospital stay.



A: initial lumbar puncture; **B:** after 7 days; **C:** after 15 days; **D:** after 22 days; **E:** after 30 days.

B–D). The laboratory deviations of the CSF and the peripheral blood tests gradually returned to normal limits. Follow-up CT of the head at the first post-operative month confirmed total abscess removal and reduction of the brain edema (Figure 3B). The patient was discharged home on the 48th post-operative day without complaints and neurologically intact.

The 6-month follow-up examination confirmed normal neurological status with no signs of brain abscess recurrence in the post-operative MRI (Figure 3C).

Ethics Statement

Informed consent was obtained from all individual participants included in this study.

Discussion

The genus *Paenibacillus* contains 211 known species [5], 22 of which have been isolated from human samples (Table 1) [2].

In 2004 Scheldeman *et al*. isolated a new species of the genus *Paenibacillus* in raw and heat-treated milk, which they named *Paenibacillus lactis* [6]. In the cases of immunocompromised patients, some of these species are known to become pathogenic and cause opportunistic infections [3]. According to Grady *et al.*, *Paenibacillus*-related infections are reported in patients with impaired mechanisms of natural and acquired resistance, such as chronic interstitial nephropathy, Whipple disease, sickle cell anemia, premature birth, hydrocephalus, acute lymphoblastic leukemia and others [3]. *Paenibacillus* isolates are also often found in the elderly, whose immune system is generally weaker.

Some authors recommend the utilization of stereotactic biopsy instead of microsurgical resection due to its minimal invasiveness, reduced risk for dissemination of the infection, and the possibility for local antibiotic application. It is also suitable for patients in poor general condition with comorbidities [7,8].

On the other hand, there is inconclusive evidence to support the superiority of stereotactic aspiration over microsurgical excision for the management of brain abscesses. While some authors favor stereotactic aspiration, others disagree and point out that microsurgical excision is the better treatment option because of lower post-operative residual abscess rate, lower re-operation rate, higher rate of improvement in neurological status, shorter duration of post-operative antibiotics and average length of hospital stay [9,10]. In the present case, microsurgical resection of the abscess was performed because the abscess was encapsulated, superficial and located in the non-dominant area of the brain.

Paenibacillus lactis was isolated from the brain abscess sample via MALDI-TOF MS, that is known to successfully identify a wide range of bacteria, including *Paenibacillus* spp. as well as their antimicrobial resistance [11,12]. The inclusion of intravenous metronidazole and its positive effect on the infection course in our patient further supports the diagnosis.

There is one reported case of brain abscess caused by *Paenibacillus macerans* as a result of penetrating brain injury and the presence of an alien body in the brain [13]. In the present case, the transmission route was not established. However, we can propose some possible sources based on the literature. According to Szaniawski and Spivak, a preceding head trauma may lead to inoculation of inactive *Paenibacillus* spores, which can lead to active infection due to an immunocompromising concomitant disease [14]. Benitez-Paez *et al.* identified different species of *Paenibacillus* in oral samples. In cases of poor dental status, as was in the present case, it is possible for the pathogen to penetrate into the host body and cause infection [15]. In our opinion, this is a possible route of transmission as the CSF is the second most common place for isolation of *Paenibacillus* spp [16]. Loong *et al.* found that *Paenibacillus* spp. can be transmitted through tick or other insect bites [17]. In most reported cases of *Paenibacillus* spp. infections, the applied antibiotic treatment was effective and successful. Nevertheless, some cases of meningoencephalitis caused by *Paenibacillus* spp. can provoke a protracted clinical course and extensive brain damage with neurological deficit, similar to our case [18].

Table 1. 22 Paenibacillus species, isolated from human samples.

P. alvei	*P. pasadenensis*	*P. timonensis*
P. faecis	*P. polymyxa*	*P. turicensis*
P. ihumii	*P. provencensis*	*P. urinalis*
P. konsidensis	*P. residui*	*P. vulneris*
P. larvae	*P. sanguinis*	*P. honkongensis*
P. lautus	*P. sputi*	*P. dakarensis*
P. macerans	*P. thiaminolyticus*	*P. antibioticophila*
P. massiliensis		

A limitation of our report is the lack of genome sequencing of the isolated bacteria.

Conclusions

Infections caused by *Paenibacillus* spp. are rare and, usually cause opportunistic infections in immunocompromised patients. Although there is an insufficient number of reports concerning the clinical course and management of these infections, the current case report suggests that long-term intravenous antibiotic therapy with a combination of broad-spectrum antibiotics and anti-anaerobic agents for at least 6-8 weeks should be applied to patients with CNS infection caused by *P. lactis*.

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Conflict of interests: No conflict of interests is declared.