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Recurrent brain abscess due to pulmonary arteriovenous fistula:a case report and literature review

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Case Report

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Abstract

Background

Brain abscesses are critical infections of the central nervous system, resulting from various pathogens. Common causes of recurrent brain abscesses include immunodeficiency, chronic otitis media, sinusitis, and intracranial infection spread. Although rare, pulmonary arteriovenous fistula (PAVF) is a significant risk factor for brain infections, as it allows pathogens to bypass pulmonary filtration and directly enter systemic circulation via abnormal vascular connections.

Case Presentation:

We report a case of a patient who developed two episodes of brain abscesses over a 35-year period following surgery for pulmonary arteriovenous fistula. The patient was ultimately diagnosed with hereditary hemorrhagic telangiectasia, suggesting a potential link between PAVF and recurrent brain abscess formation.

Conclusions

This case highlights the need to consider PAVF as a possible underlying cause in cases of recurrent brain abscesses. Additionally, we reviewed the literature on brain abscesses associated with pulmonary arteriovenous fistulas to pr**o**vide a more comprehensive understanding of this rare but impactful association.

1. Introduction

A brain abscess is a localized purulent infection within the brain parenchyma, with incidence varying by geographic location and population(1). The annual incidence of brain abscess is approximately 0.4 to 0.9 cases per 100,000 people. Early diagnosis is often challenging due to diverse clinical manifestations and imaging features similar to other intracranial diseases(2). Treatment requires a combination of antibiotic therapy and surgical drainage, yet there is still a risk of recurrence and high mortality(3). The etiology of brain abscesses is diverse, including infections in the ear, nose, and throat, head trauma, and surgical infections(4, 5). However, about 15–30% of cases are cryptogenic, meaning no clear source of infection is found(6). Among cryptogenic brain abscesses, pulmonary arteriovenous fistula (PAVF) is a rare but noteworthy cause(7). PAVF is an abnormal channel between the pulmonary arteries and veins, allowing blood to flow directly from arteries to veins without oxygenation in the alveolar capillaries(8). This connection can lead to insufficiently oxygenated blood, potentially causing clinical symptoms such as cyanosis, exertional dyspnea, and clubbing of the fingers(9). PAVF is a rare cause of brain abscess, with an incidence of about 0.1% among patients(10). Case reports of brain abscess caused by PAVF are relatively few, possibly due to diagnostic challenges and undetected cases.

PAVF can be solitary or multiple, with approximately 70% of cases associated with hereditary hemorrhagic telangiectasia (HHT)(11). HHT is an autosomal dominant genetic disorder characterized mainly by telangiectasia and arteriovenous malformations, classified into types I and II(12). Patients with HHT commonly have pulmonary arteriovenous fistulas, and these malformations may lead to complications such as brain abscess(13). Treatments for HHT include symptomatic management and interventional procedures, such as embolization and surgical resection(14).

This article reports a case of recurrent brain abscess in a patient with hereditary hemorrhagic telangiectasia (HHT) complicated by pulmonary arteriovenous fistula. The patient underwent two craniotomies for brain abscess removal and is currently recovering in a stable condition. This case highlights the importance of early diagnosis and treatment of brain abscess caused by PAVF. We also review the relevant literature to enhance clinicians' awareness of this rare cause.

2. Case report

A 35-year-old man underwent pulmonary arteriovenous fistula surgery in 1989 with an uneventful recovery. However, in subsequent years, he experienced intermittent headaches and neurological symptoms, initially considered sporadic.

On April 10, 1999, he was admitted after a sudden seizure, loss of consciousness, and incontinence. Cranial CT revealed a low-density lesion at the right temporoparietal junction, suggesting an abscess. A left temporal lobectomy was performed on the fifth day, and pathology confirmed a brain abscess(Fig. 1: MRI T1- and T2-weighted images showing chronic lesions in the right temporo-occipital region). In November of the same year, he returned with tinnitus, dizziness, headache, and nausea. Enhanced cranial MRI indicated a 18mm × 20 mm left temporal lobe abscess, which resolved after three weeks of antibiotics.

In April 2016, he was readmitted with a six-month history of intermittent fever. Initially, connective tissue disease was suspected, but tests were normal. Abdominal CT revealed a splenic abscess, and he received cefotiam and ornidazole before discharge.

In November 2023, the patient presented with right limb weakness and low-grade fever. Cranial CT revealed multiple cerebral lesions. An enhanced MRI identified a lesion located anterior to the central sulcus, measuring approximately 35 mm by 25 mm, characterized by cystic changes and significant peripheral enhancement(Fig. 2). Concurrently, chest CT revealed high-density lesions in the right lower lobe (basal segment), left upper lobe (anterior segment), and left lower lobe (external basal segment), consistent with vascular malformations, similar to prior findings(Fig. 3). On the ninth day after admission, a left frontal craniotomy was performed to excise the brain abscess(Fig. 4).Postoperative pathology confirmed findings consistent with brain abscess changes(Fig. 5).Following surgery, the patient experienced right upper limb paralysis. Rehabilitation follow-up indicated full recovery of language function, with muscle strength graded as 1 in the right upper limb and 3 in the right lower limb.

Genetic testing later confirmed hereditary hemorrhagic telangiectasia (HHT) as the underlying cause of his pulmonary arteriovenous fistula and recurrent brain abscesses(Table 1 HHT genetic test report).

(□□□1) **Figure 1 is placed here**

Figure 1□MRI T1 and T2 of chronic lesions

Legend: Figure 1. AB. T1 signal right frontal occipital lobe softening foci; CD. T2 signal right frontal occipital lobe softening foci.

(□□□2) Figure 2 is placed here

Figure 2: Brain abscess lesions.

Legend: Figure 2. A. T2FLAIR left frontal lobe brain abscess; B. T2 left frontal lobe edema and fluid level; C. DWI left frontal lobe lesion with limited diffusion; DE. Enhancement shows a ring-enhancing lesion in the left frontal lobe.

(□□□3) Figure 3 is placed here

Figure 3: Pulmonary arteriovenous fistula.

Legend: Figure 3. A. Right lower pulmonary coarctation; B. Bilateral lower pulmonary coarctation shadow.

(□□□4) Figure 4 is placed here

Figure 4: Intraoperative image.

Legend: Figure 4. Intraoperative cortical fistula in the swollen area of brain tissue with complete excision of the abscess outside the wall of the abscess.

(□□□5) Figure 5 is placed here

Figure 5: Postoperative CT and pathology.

Legend: Figure 5. A. Cranial CT scan 24 hours after resection of the left frontal lobe suggests complete resection of the lesion; B. Cranial CT scan 1 week after resection of the left frontal lobe suggests localized edema; C. Postoperative pathology shows infiltration of neutrophils, lymphocytes, and plasma cells, which is consistent with abscess.

(□□□6) Table 1 is placed here

Table 1. Genetic Test Results of HHT-related Gene Variants.

3. Literature review

Using the subject and free words "brain abscess" and "pulmonary arteriovenous fistula," we searched the PubMed and Embase databases, retrieving a total of 603 studies. After reviewing these studies, we selected 39 cases related to brain abscesses caused by pulmonary arteriovenous fistulas, encompassing a total of 39 cases. We collected patient characteristics, including gender, age, the number, location, and size of brain abscesses, the presence of seizures, the type and characteristics of pulmonary arteriovenous fistulas, the diagnosis of hereditary hemorrhagic telangiectasia (HHT) and its subtype, procedures performed throughout the disease process, clinical and radiological outcomes, recurrence after surgery, and any adverse events. This information is systematically tabulated(Table.2).

(□□□7) **Table 2 is placed here**

Table 2. Brain abscesses due to pulmonary arteriovenous fistula reported in the literature.

Table 2 presents several cases of brain abscess associated with pulmonary arteriovenous fistula, underscoring PAVF as a rare but notable pathogenic factor in brain abscess development. Patient ages ranged from 11 to 50 years, with a slight male predominance. Treatment approaches varied: some patients underwent craniotomy and abscess resection, such as an 11-year-old patient who remained recurrence-free after removal of both the abscess and PAVF, and a 27-year-old patient who showed favorable recovery post-resection of a left temporoparietal abscess. Conservative management also demonstrated efficacy, as in a 50-year-old patient who achieved symptom relief through abscess aspiration with no significant adverse reactions. Additionally, a 32-year-old patient received a combined treatment involving craniotomy, abscess aspiration, and PAVF embolization, leading to substantial symptom improvement without recurrence. Over a 6- to 12-month follow-up, most patients exhibited significant symptom relief, with no major neurological deficits. In summary, a combination of tailored surgical and conservative treatments, coupled with continuous follow-up, appears to enhance patient prognosis and lower the recurrence risk.

In summary, significant differences exist in the interventions for patients with recurrent brain abscesses caused by pulmonary arteriovenous fistula (PAVF). The choice of treatment methods directly affects patient prognosis. These cases underscore the complexity of managing recurrent abscesses associated with vascular malformations and the necessity of developing individualized treatment plans.

4. Discussion

This case report describes a 70-year-old male patient with recurrent brain abscesses, ultimately associated with hereditary hemorrhagic telangiectasia (HHT). Brain abscesses are uncommon, accounting for 1%-8% of all intracranial space-occupying lesions(15). The primary mechanisms involve pathogen entry into the central nervous system through hematogenous spread, direct infection, or extension from adjacent structures(1). The recurrence of abscesses in this patient highlights the need to explore underlying causes beyond typical infections. Initially, the abscesses were believed to be related to hematogenous dissemination or direct infection from nearby structures. Following multiple episodes and thorough investigation, genetic testing confirmed HHT, a hereditary condition commonly linked to

pulmonary arteriovenous fistula, as the underlying cause.Studies indicate that frontal lobe abscesses significantly increase the risk of epilepsy, while occipital lobe abscesses present relatively lower risks(16). Despite treatment, the patient did not experience seizures, a finding that warrants further investigation.Treatment for brain abscesses primarily includes antibiotics and surgery, with antibiotics chosen based on the specific pathogen, such as third-generation cephalosporins and vancomycin(5). The largest abscess, measuring approximately 3.5 x 2.5 cm, was classified as medium-sized. Postoperatively, the patient underwent combination therapy with meropenem and vancomycin to control the infection. Recent guidelines recommend glucocorticoids as adjunctive therapy in severe cases but advise against using antiepileptic drugs for primary prevention(17).Modern imaging methods, including CT and MRI, are essential for accurately determining abscess size and location, guiding treatment planning. However, MRI remains the preferred method for diagnosing and differentiating abscesses(18). In this case, high-resolution cranial MRI provided direct evidence of the lesion's nature.The use of artificial intelligence (AI) has markedly enhanced the accuracy and efficiency of brain abscess diagnosis. Studies demonstrate that a radiomics model based on diffusion-weighted imaging (DWI), developed using the Tree-based Pipeline Optimization Tool (TPOT), can effectively differentiate metastatic cysts from brain abscesses(19). This advancement marks a breakthrough in precision medicine, improving the identification and classification of brain lesions and advancing diagnostic medical technologies.

Pulmonary arteriovenous fistula (PAVF) is a rare vascular malformation characterized by abnormal connections between the pulmonary artery and pulmonary vein(20). Normally, blood is directed to the lungs via the pulmonary artery for oxygenation and returns to the left atrium through the pulmonary vein. However, PAVF allows some arterial blood to circumvent pulmonary capillaries and directly enter the venous system, resulting in unfiltered microorganisms entering the systemic circulation, thereby increasing the risk of infections, including brain abscesses(21). PAVF can be classified as either simple or complex. The simple type is characterized by a single fistula, while the complex type is characterized by multiple abnormal vascular connections. Based on the complexity and size of the fistula, PAVF is further classified into grades I to III(22). Grade I represents a small, isolated fistula, while grade III denotes multiple or complex fistulas. The patient’s PAVF in this case was complex, graded as III, likely contributing to the recurrence of brain abscesses,. PAVF may be congenital, frequently associated with hereditary hemorrhagic telangiectasia (HHT), or acquired, often caused by trauma, infection, or lung surgery(23). The choice of treatment is contingent upon the grade, type, size, and location of the fistula, as well as the patient's specific condition. Observation or medical management is typically employed for small fistulas, while larger or complex fistulas require interventional treatments such as catheter embolization or surgery(24). Postoperative monitoring is essential to assess treatment efficacy and prevent thrombosis or recurrence. PAVF management necessitates collaboration among a multidisciplinary team to develop individualized treatment plans, maximizing outcomes and minimizing complications.

Hereditary hemorrhagic telangiectasia (HHT) is a genetic disorder defined by abnormal dilation and fragility of capillaries in multiple organs throughout the body(25). In this case, the patient with HHT reports no family history of the condition and mainly presents with pulmonary arteriovenous fistulas and

recurrent brain abscesses, without other hallmark HHT features, such as recurrent nosebleeds or capillary telangiectasias on the skin or mucous membranes. Genetic testing revealed a mutation in the ENG gene, corresponding to type 1 HHT(26). The ENG gene encodes endoglin, a protein critical for vascular development and repair. Mutations result in endothelial dysfunction, leading to abnormal vascular development, capillary dilation, and visceral arteriovenous malformations, which significantly increase the risk of hematogenous infections and brain abscesses(27). Research indicates that the risk of brain abscess formation in individuals with HHT is approximately 30-fold higher than in the general population(28). Although arteriovenous malformations associated with HHT are most commonly observed in the lungs, their potential impact on the cranial system cannot be disregarded(29). Consequently, comprehensive screening for latent arteriovenous malformations in individuals with HHT is essential for the prevention of complications.

The treatment of patients with this condition remains highly challenging, with most cases showing unfavorable prognoses. This case report aims to offer valuable insights and reference points for clinicians. Notably, despite undergoing aggressive PAVF surgery, individuals with HHT gene mutations may continue to experience recurrent brain abscesses. Given the rarity of such cases, systematic analysis of additional cases in the future is expected to enhance our understanding of the disease.

Declarations

Ethics approval and consent to participate

Written informed consent was obtained from the patient and a family member for study participation. The research protocol received approval from the Ethics Committee of the First Affiliated Hospital of Dalian Medical University.

Consent for publication

Written informed consent was obtained from the patient and a family member for the publication of any potentially identifiable images or data included in this article.

Competing interests

The authors declare no competing interests.

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Author Contribution

R.W. contributed to conceptualization, data curation, investigation, methodology, project administration, and software, and drafted the original manuscript. X.H. and X.Q.H. contributed to investigation and methodology. X.Q.H. and S.Z. contributed to data curation, formal analysis, and visualization. Z.W. and Y.L. acquired funding and provided resources. X.Q.H., Z.W., and Y.L. contributed to writing – review and editing. All authors reviewed the manuscript.

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Not applicable.

Data Availability

The datasets generated or analyzed during the current study are available in the PubMed and Embase repositories. The data included in this article and supplementary material support the findings of this study. Additional data and inquiries can be directed to the corresponding author upon reasonable request.

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Tables

Tables 1 and 2 are available in the Supplementary Files section.

Figures

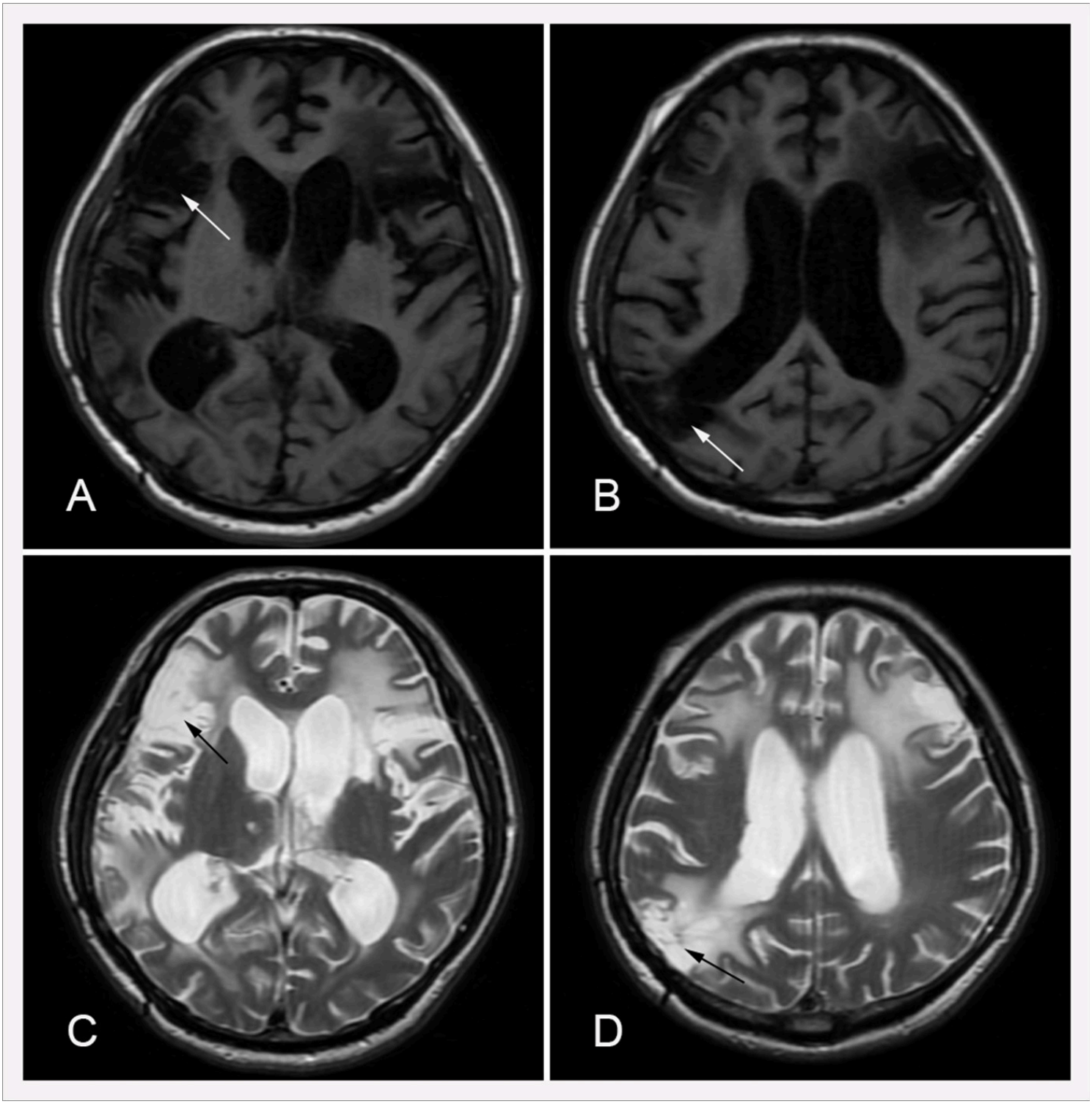


Figure 1

MRI T1 and T2 of chronic lesions

AB. T1 signal right frontal occipital lobe softening foci; CD. T2 signal right frontal occipital lobe softening foci.

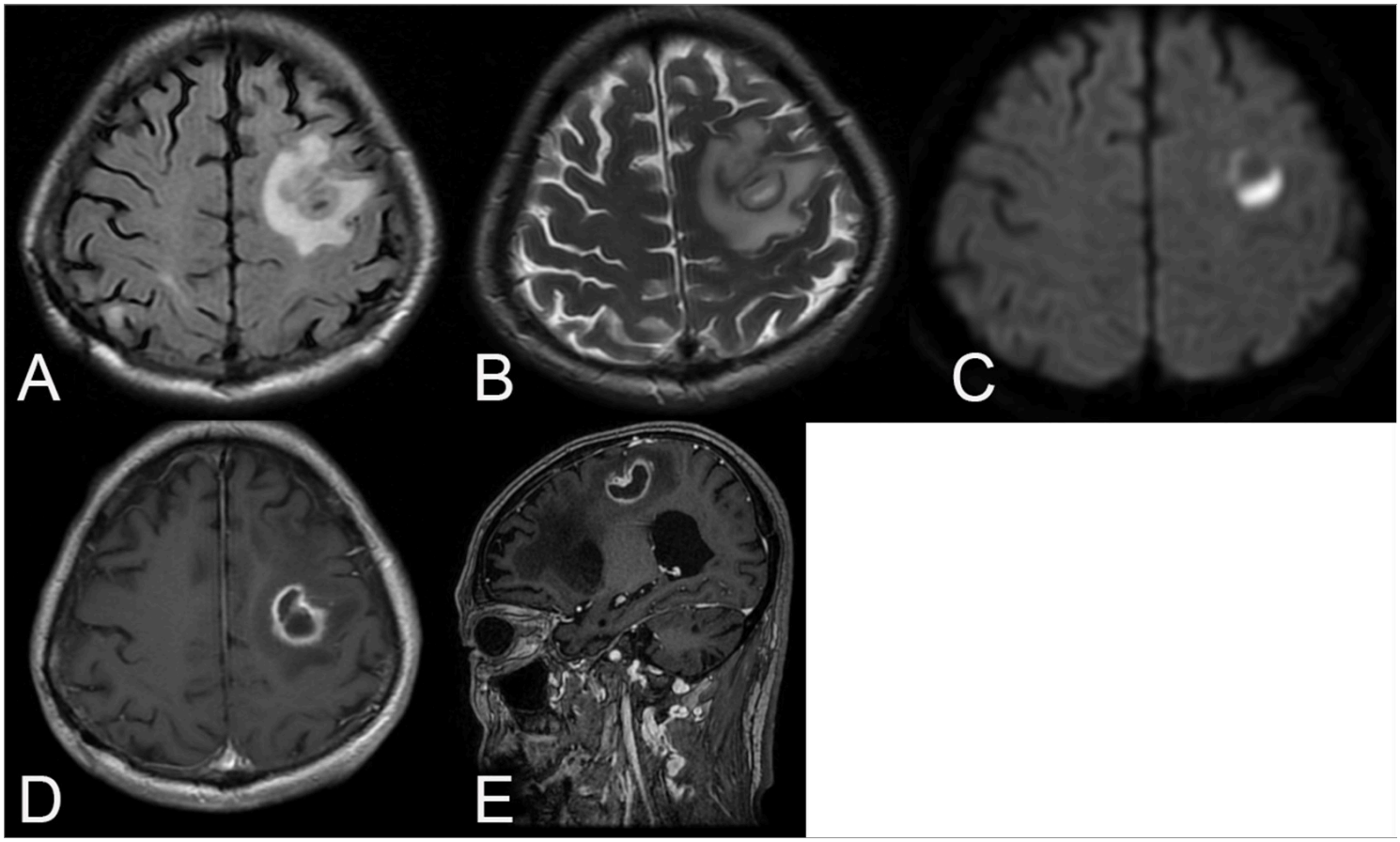


Figure 2

Brain abscess lesions.

A. T2FLAIR left frontal lobe brain abscess; B. T2 left frontal lobe edema and fluid level; C. DWI left frontal lobe lesion with limited diffusion; DE. Enhancement shows a ring-enhancing lesion in the left frontal lobe.

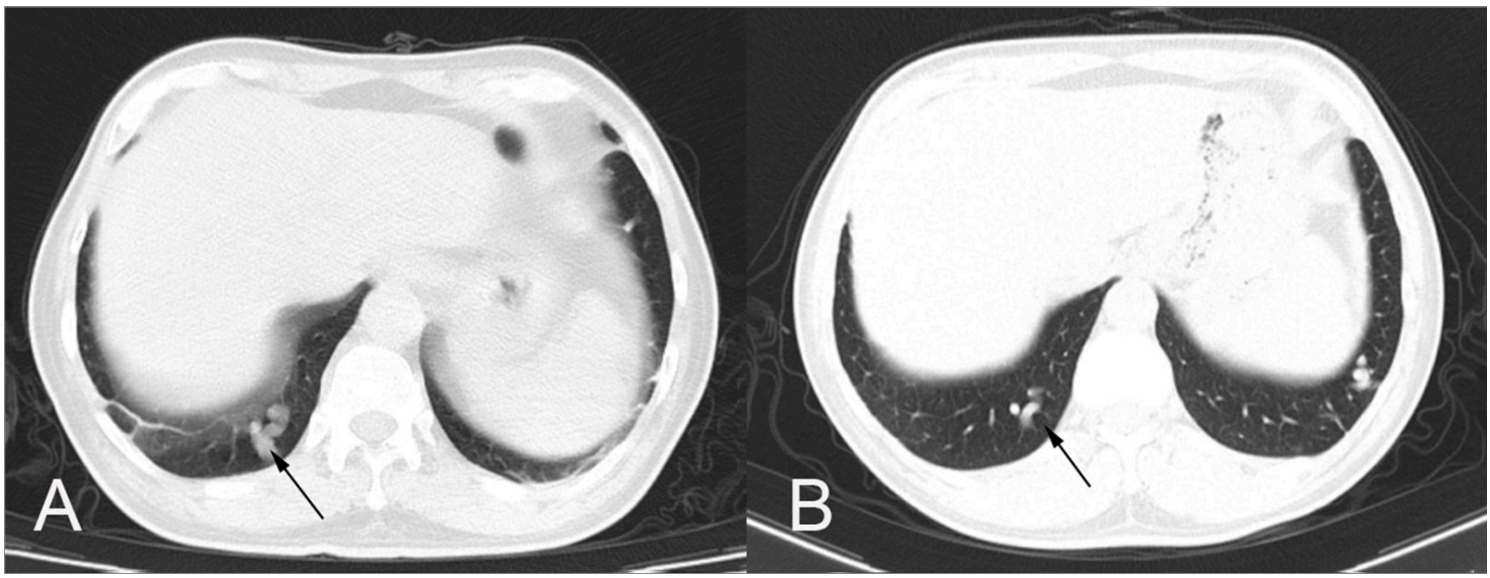


Figure 3

Pulmonary arteriovenous fistula.

A. Right lower pulmonary coarctation; B. Bilateral lower pulmonary coarctation shadow.

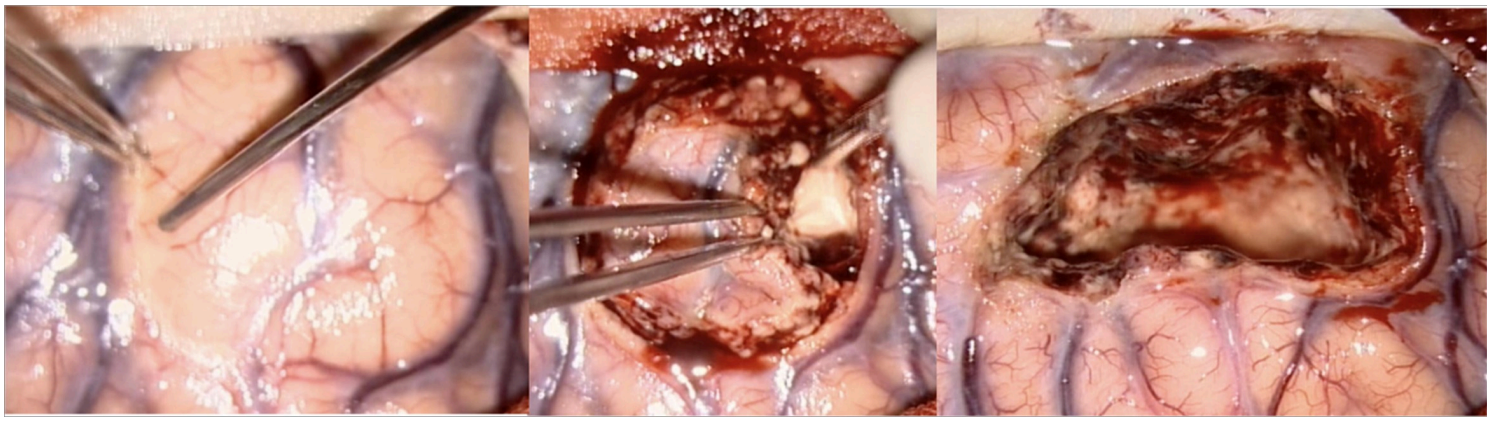


Figure 4

Intraoperative image.

Intraoperative cortical fistula in the swollen area of brain tissue with complete excision of the abscess outside the wall of the abscess.

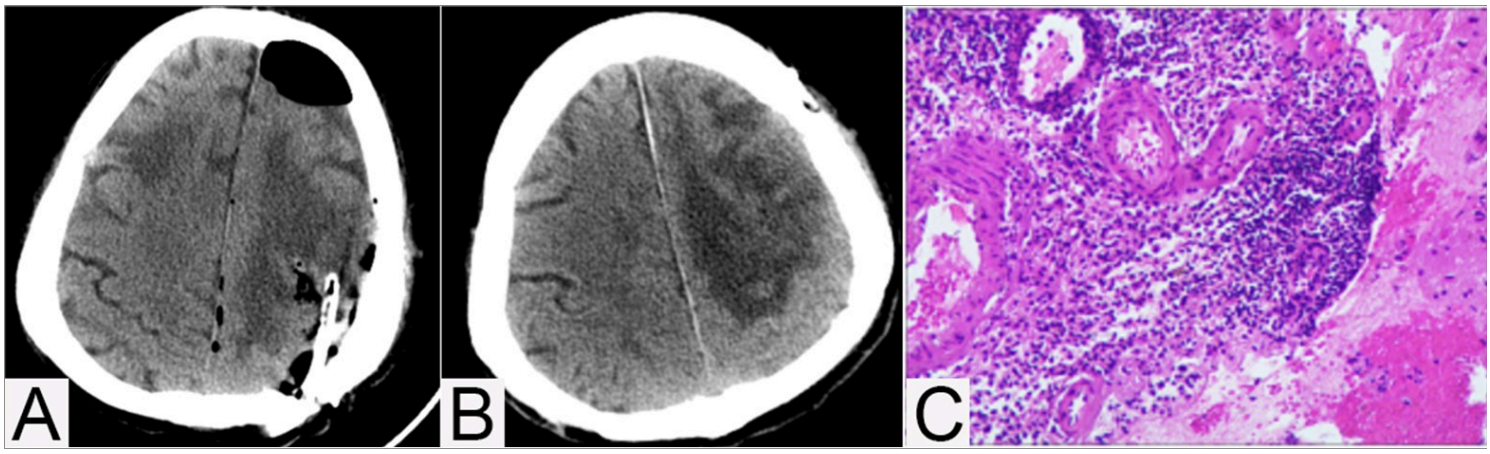


Figure 5

Postoperative CT and pathology.

A. Cranial CT scan 24 hours after resection of the left frontal lobe suggests complete resection of the lesion; B. Cranial CT scan 1 week after resection of the left frontal lobe suggests localized edema; C. Postoperative pathology shows infiltration of neutrophils, lymphocytes, and plasma cells, which is consistent with abscess.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Table1.GeneticTestResultsofHHTrelatedGeneVariants.xlsx
- Table2.Brainabscessesduetopulmonaryarteriovenousfistulareportedintheliterature..xlsx