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Primary intraventricular brain abscess: a systematic review of risk factors, etiology, and management

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Abstract

Objective Primary intraventricular brain abscesses (PIAs) are rare, with no established treatment guidelines. Despite advancements in imaging, neurosurgical techniques, and antimicrobial therapies, PIAs remain challenging. This systematic review aims to synthesize literature on PIAs to inform clinical decision-making.

Methods Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines, PubMed, Google Scholar, Embase, and SCOPUS databases were searched to examine PIA.

Results 13 PIA cases were identified, with a mean age of 34.5 ± 25.3 years (range: 10–80, median: 23), and a slight male predominance (7/13). Predisposing factors were present in 61.5% (8/13) of cases, including chronic otitis media (15.4%, 2/13) and immunocompromised (7.7%, 1/13). Fever (69.2%, 9/13) and headache (53.8%, 7/13) were the most common symptoms. Hydrocephalus was present in 61.5% (8/13) of cases, with six patients (41.2%) requiring ventriculoperitoneal (VP) shunting. Abscesses were located mostly in the lateral ventricles (left 38.5%, right 30.1%, bilateral 23.1%). *Streptococcus* species were identified in 23.1% of cases, *Staphylococcus* species in 15.4%, gram-negative bacteria (including *Escherichia coli* and *Klebsiella oxytoca*) in 30.8%, and *Mycobacterium tuberculosis, Cladophialophora bantiana,* or acid-fast bacilli in 7.7% of cases each. Surgical management included craniotomy or craniectomy with excision (38.5%), stereotactic aspiration (23.1%), and external ventricular drain (EVD) (23.1%). All patients received antibiotics guided by the species identified. Mortality occurred in 15.4% of cases, while 84.6% had resolution or were discharged with varying degrees of recovery.

Conclusion PIAs are rare and require surgical intervention and targeted antimicrobial therapy for optimal outcomes.

Keywords Primary intraventricular abscess, PIA, Central nervous system infections, CNS, Cerebral abscess, Infection

Introduction

A Brain abscess is a severe, life-threatening infection characterized by a localized area of necrosis in the brain parenchyma, typically enclosed by a membrane [1]. It often arises from contiguous spread (ear, dental, or sinus infections), hematogenous spread, or direct inoculation through trauma or surgery [2, 3]. Prior to the late 1800 s, it was almost universally fatal and rarely diagnosed before autopsy [4]. Brain abscesses remain a common neurological emergency, particularly in developing countries, accounting for 8% of intracranial space-occupying lesions

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compared to 1–2% in developed nations [5]. Approximately 25% of brain abscesses occur in children aged 4 to 7 years [6, 7].

Primary intraventricular brain abscesses (PIA) are extremely rare [8, 9]. In most cases, the presence of pus in the ventricular system results from the rupture and extension of an intraparenchymal abscess into the ventricles, an event with a mortality rate as high as 80% that leads to rapid clinical deterioration [10, 11]. However, "primary intraventricular abscess" refers to a distinct clinical entity where the pus is contained within a capsule within the ventricular system [1–3, 9]. The clinical presentation of PIAs in such cases tends to be more gradual, with symptoms developing over a longer period, which allows for earlier intervention and potentially better outcomes.

In the advent of minimally invasive procedures and targeted antimicrobial therapy, the mortality of brain abscess has been reduced to less than 10% [12]. These advancements in medical treatment and surgical techniques have greatly improved outcomes for many types of brain abscesses, allowing for more effective management and recovery. However, existing data on PIAs remain sparse, with the majority of literature limited to single case reports. This lack of comprehensive data makes it challenging to establish clear treatment guidelines or predict outcomes for this rare condition. To address this gap, this systematic review aims to identify and analyze all reported cases of PIAs to date, evaluating their clinical presentations, microbial etiologies, diagnostic workups, and management outcomes. By synthesizing these cases, this review seeks to provide valuable insights into the best practices for diagnosing and managing PIAs, as well as offering guidance for clinicians dealing with these rare and often complex cases.

Methods

Search strategy

A search strategy was conducted using methodology according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Articles were extracted up to October 2024 from the online databases PubMed/MEDLINE, SCOPUS, Embase, Cochrane, Web of Sciences, and Google Scholar. The following MeSH terms were used: ("intraventricular"[All Fields] AND ("abscess"[MeSH Terms] OR "abscess"[All Fields] OR "abscesses"[All Fields] OR "abscessation"[All Fields] OR "abscessed"[All Fields] OR "abscessing"[All Fields])) (("primaries"[All Fields] OR "primary"[All Fields]) AND "intraventricular"[All Fields] AND ("abscess"[MeSH Terms] OR "abscess"[All Fields] OR "abscesses"[All Fields] OR "abscessation"[All Fields] OR "abscessed"[All Fields] OR "abscessing"[All Fields])). Additionally, we conducted a comprehensive manual review using the following search terms with Boolean operators AND/OR: "primary intraventricular brain abscess", "intraventricular abscess", "neurosurgery", "microbiology", "diagnosis", "treatment", "outcome", "surgical management", "antimicrobial therapy", "pediatric", "adult", "outcome". No time frame limit was applied to the search strategy. We included original articles, including case to investigate patient characteristics, clinical presentation, and diagnosis of primary intraventricular brain abscesses. Secondary objectives aimed to outline microbial etiology, management strategies, surgical interventions, post-management complications, and outcomes, with a particular emphasis on neurological recovery and long-term follow-up. Exclusion criteria included literature reviews, non-original articles not published in English, correspondences, commentaries, book chapters, animal studies, opinion pieces, case reports, systematic reviews, and meta-analyses.

Data extraction

Three authors (**K.D., S.A.,** and **S.O.**) independently conducted database searches, followed by title, abstract, and full-text reviews, to determine inclusion based on the predetermined criteria. Bibliographies of included articles were examined to identify additional articles that might have been missed in the original search. The following variables were extracted from the included articles: patient demographics, predisposing factors, signs and symptoms, location of the intraventricular abscess, associated microorganisms, management strategies, and outcomes at the last follow-up.

Statistical analysis

All extracted data were summarized using descriptive statistics appropriate for a small case-based dataset. Means and standard deviations were calculated for continuous, and categorical variables were presented as frequencies and percentages. Given that the final sample was small, no formal inferential or comparative statistical tests were performed. Instead, a qualitative synthesis was conducted to identify patterns in clinical presentation, management, and outcomes across the included studies.

Results

Electronic search yield

Our literature review identified 202 citations through database searches (Fig. 1). Twenty-one citations were removed due to duplicates. One hundred and eighty-one citations were then screened in full for eligibility. Ultimately, we included 13 case reports [8, 9, 13–23] (Table 1).

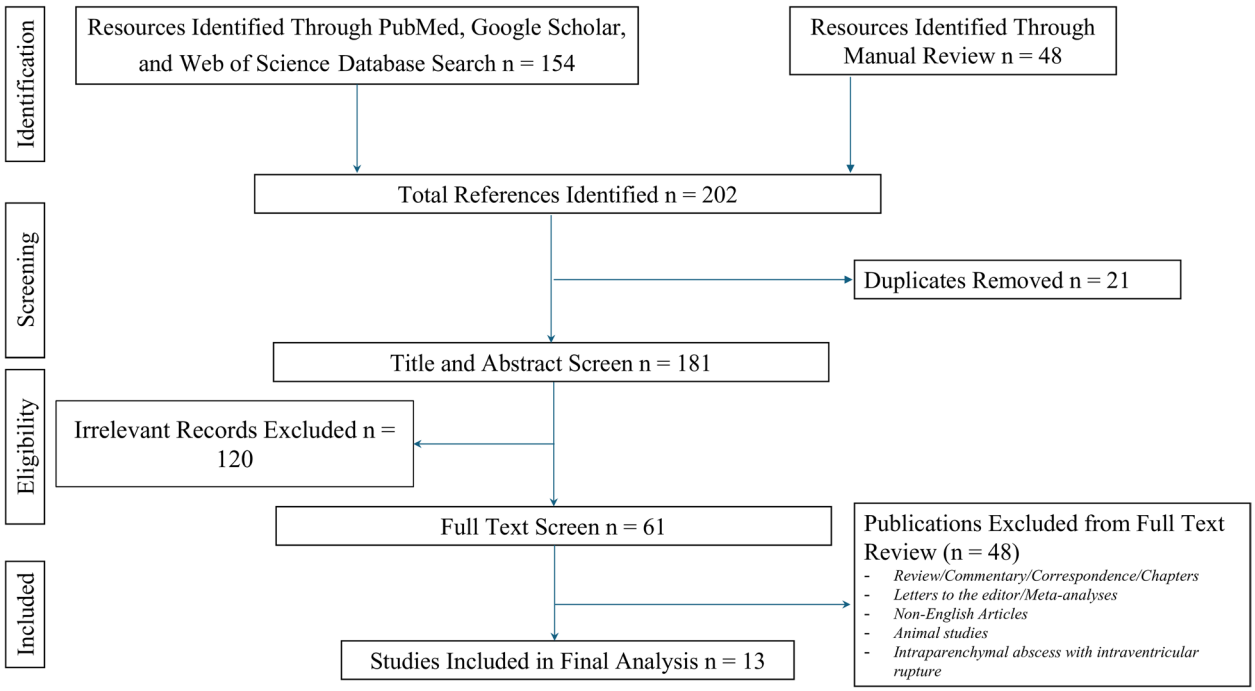


Fig. 1 PRISMA flow diagram showcasing the methodology employed in conducting the systemic review. Figure 1 was created with Microsoft PowerPoint for Mac Version 16.8

Demographics and clinical manifestations

Of the 13 patients, 46.2% (6/13) were, with a mean age of 34.5 years (SD: 24.3, range: 10–80, median: 23) (Table 1). Predisposing factors included chronic otitis media (15.4%, 2/13) [17, 21], recent dental procedures (7.7%, 1/13) [8], immunocompromised status (7.7%, 1/13) [14], and cystic ventricular dilation (7.7%, 1/13) [9]. In one case, the patient's predisposing factor was a cyanotic heart disease with pulmonary atresia [13]. Fever was the most common symptom, occurring in 9 out of 13 cases (69.2%) [9, 13–15, 17, 18, 20–22], followed by headache in 7 out of 13 cases (53.8%) [8, 13, 14, 17–20], highlighting the predominant infectious and intracranial pressure-related manifestations of primary intraventricular abscesses. Hydrocephalus was present at diagnosis in 61.5% (8/13) of cases [9, 14, 16–20, 23]. Of these, five patients had ventriculoperitoneal (VP) shunts placed [16, 17, 19, 20, 23]. Additionally, one patient had a VP shunt placed, but no associated hydrocephalus at the time of presentation [22].

Anatomical location and microbiological profile

The most common abscess location was the lateral ventricles [8, 9, 13–16, 18–23] reported in 12 out of 13 cases (92.3%) with left ventricle being the most common at 38.5% (Fig. 2). Some cases (23.1%) involved bilateral ventricles [19, 21, 23]. Additionally, one case (7.7%) was in the fourth ventricle, representing a rare anatomical presentation [17]. The identified pathogens varied, with bacterial infections accounting for 77% (10/13) of cases including *Staphylococcus aureus* [8, 18], *Mycobacterium tuberculosis* [14, 20], *Nocardia asteroides* [15], *Streptococcus spp.* [8, 9, 19], and *Klebsiella oxytoca* [17]. One case involved mixed infection with *Staphylococcus* and *Streptococcus mitis* [8]. In one case, *Cladophialophora bantiana* (a rare fungal pathogen) was identified [16].

Management and outcome

Treatment approaches included stereotactic aspiration [9, 13, 18, 19], excision [8, 15, 17, 20], and ventricular irrigation and ventricular drain placement [14, 21, 23] (Fig. 3). These were often combined with targeted intravenous antimicrobial therapy (Table 2). In all cases, the definitive choice of antimicrobials was tailored to the susceptibility profile. The duration of therapy varied, with typical courses lasting three weeks to several months. The majority of cases (11/13, 84.5%) resulted in resolution, though one patient [9] experienced a relapse before eventual recovery, while two patients (15.4%) succumbed to the infection [16, 21].

Table 1 Demographics and clinical profile of patients

Author, Year	Age (years)/Sex	Predisposing Factors	Signs and Symptoms	Location	Hydrocephalus at Presentation and Shunting Procedures
Robinson et al.[18], 1993	40/M	–	Headache, Fever	Left LV	Hydrocephalus
Vajramani et al. [20], 1999	26/F	–	Headache, Fever, Cough	Right LV	Unilateral hydrocephalus VP Shunt
Mogilner et al. [15], 1998	56/M	–	Fever, Nuchal rigidity, Diplopia, Bilateral CN 6 palsy	Left LV	–
Lambo et al. [9], 2003	13/M	Cystic dilatation Left V	Fever, Vomiting, Abdominal pain, Nuchal rigidity	Left LV	Unilateral hydrocephalus
Pruthi et al. [17], 2007	23/M	Otitis Media	Headaches, Fever, Vomiting, Imbalance, Papilloedema	Fourth V	Obstructive hydrocephalus VP Shunt
Farook et al. [22], 2009	14/F	Cerebral palsy with VP shunt for Multiloculated hydrocephalus Revision for infection 2 years prior to presentation	Nausea and Fever	Left LV	VP Shunt
Gadgil et al. [8], 2012	62/F	Dental Procedure	Headache, Nausea, Vomiting, Altered mental status	Right LV	–
Fernández et al. [13], 2015	10/F	Cyanotic heart disease with pulmonary atresia	Headache, nausea, vomiting, nuchal rigidity and fever	Left LV	–
Bajracharya et al. [21], 2015	11/F	Otitis Media	Neck pain, fever, otorrhea	Bilateral LV	–
Kobayashi et al. [23], 2016	80/F	Bisphosphonate-related osteonecrosis of the jaw Rheumatoid arthritis – on steroid	Septic Shock	Bilateral LV	Hydrocephalus VP Shunt
Tingate et al. [19], 2019	22/M	–	Headache, Vomiting, Imbalance, Diplopia, Tinnitus, Dysphasia	Bilateral LV and V4	Hydrocephalus VP Shunt
Offerman et al. [16], 2020	75/M	Non-small cell lung cancer	left-sided weakness and facial droop	Right LV	Non-obstructive hydrocephalus VP Shunt
Hanafiah et al. [14], 2021	17/M	Immunocompromised	Headache, Fever, Vomiting	Right LV	Obstructive hydrocephalus

F: Female, LV: Lateral ventricle, M: Male, V: Ventricle, V4: Fourth ventricle, VP: Ventriculoperitoneal

Discussion

This systematic review highlights the rare occurrence of PIAs and the complexities in their management. With a mean age of 34.5 years, predisposing factors such as chronic otitis media, recent dental procedures, and immunocompromised status were identified, suggesting important risk factors that could aid in early recognition. Fever and headache were the most common symptoms, with hydrocephalus present in over 60% of cases. Most abscesses were located in the lateral ventricles, and bacterial pathogens like *Staphylococcus aureus, Mycobacterium tuberculosis*, and *Klebsiella oxytoca* were identified as causative agents. Surgical management, including stereotactic aspiration or excision combined with targeted antimicrobial therapy, led to resolution in 84.5% of cases, emphasizing the importance of prompt and tailored interventions. These findings highlight the critical role of early diagnosis, timely surgical intervention, and appropriate antimicrobial therapy in improving patient outcomes.

Epidemiology and clinical presentation

Intraventricular brain abscesses, though rare, represent a severe complication often occurring secondary to congenital heart disease or immunosuppression which increase abscess formation risk [13, 14]. Several pathophysiological mechanisms have been suggested distinct from parenchymal abscesses. One possible key factor is the ventricular choroid plexus, which serves as the interface between systemic circulation and cerebrospinal fluid (CSF), regulating immune responses. Unlike the tight blood–brain barrier (BBB) of the parenchyma, the blood–CSF barrier is more permeable, allowing selective

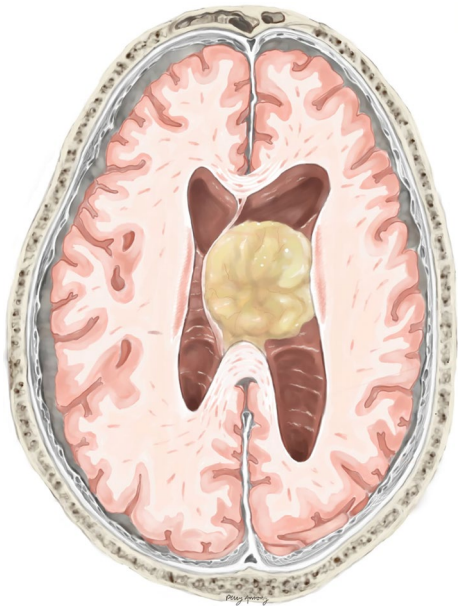


Fig. 2 Axial cross-sectional illustration showing primary intraventricular abscess in the lateral ventricle, the most common location identified in this review, leading to obstructive ventriculomegaly

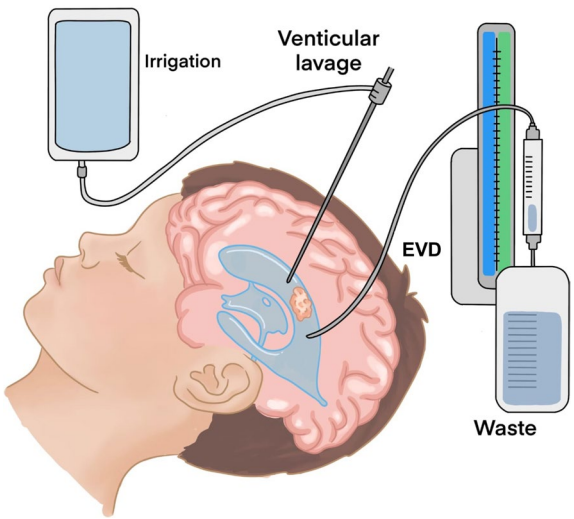


Fig. 3 Illustration shows standard procedure of ventricular lavage and external ventricular drainage for intraventricular abscess management

pathogen entry [15]. This may explain why certain infections, such as Mycobacterium tuberculosis and fungal abscesses, preferentially involve the ventricles rather than the parenchyma. *Mycobacterium tuberculosis* and certain fungi have properties that allow them to survive and proliferate in the relatively immunoprivileged environment of the ventricles [24, 25]. For example, *Mycobacterium tuberculosis* can survive in macrophages [24], which are present in the choroid plexus [26]. Fungi, including *Cladophialophora bantiana*, are known to have a tropism for CNS tissues, especially in immunocompromised individuals [27, 28].

Symptoms in cases of intraventricular brain abscesses are often non-specific, typically including fever, headache, vomiting, and signs of meningeal irritation, such as positive Kernig's and Brudzinski's signs [9, 16, 20]. According to the reviewed literature, headache and fever are the most frequently reported symptoms, making the diagnosis challenging, especially for non-specialists and in the absence of focal neurological deficits; our review supports this, with fever (69.2%) being the most common symptom, followed by headache (53.8%), reinforcing the difficulty in early recognition. However, a sudden worsening of headaches, accompanied by new-onset meningismus, may indicate rupture of the abscess into the ventricular space, making the diagnosis more apparent. This, however, presents a diagnostic challenge in differentiating between abscess rupture with subsequent ventriculitis or meningitis and primary meningitis, the latter of which does not require surgical intervention.

Diagnosis and neuroimaging

Blood tests are often non-specific showing elevated inflammatory markers, and blood cultures are usually negative. Performing a lumbar puncture in cases of raised intracranial pressure is potentially dangerous as it can create a pressure gradient that leads to brain herniation, resulting in rapid neurological deterioration or death. When CSF is obtained from a patient with intraventricular brain abscess, it typically shows increased white blood cells and protein levels, though positive cultures are generally only found after the abscess ruptures into the CSF spaces [13]. Regarding neuroimaging, MRI is the diagnostic modality of choice for intraventricular abscesses, offering superior soft tissue contrast and the ability to detect associated complications, such as periventricular edema and hydrocephalus [15, 29]. In cases, MRI reveals an enhancing lesion in the ventricles, accompanied by periventricular hyperintensities, consistent with previous reports where ventricular abscesses often mimic tumors or hemorrhages [13, 15, 16], complicating diagnosis. For example, intraventricular tuberculous abscesses can resemble tumors in both appearance and location, further challenging accurate identification [14, 20].

Microbiology

Neuroimaging plays a crucial role in guiding early diagnosis, but definitive confirmation often relies on microbiological analysis of the drained pus. Bacteria from the oral cavity are a common cause of brain abscesses. *Roy* et

Table 2 Microbiology, management, and outcome of patients

Author, year	Microorganism identified (gram stain)	Surgical management	Choice and route of antimicrobial therapy	Duration of antimicrobial therapy	Outcome
Robinson et al. [18], 1993	*Staphylococcus aureus* (+)	Stereotactic aspiration	Vancomycin (IV), rifampin (Oral)	21 Days	Resolution
Vajramani et al. [20], 1999	Acid-fast bacilli	Craniotomy with excision	Tuberculostatic Medication (Oral)	14 Months	Resolution
Mogilner et al. [15], 1998	*Nocardia asteroids* (+)	Craniotomy with excision	Trimethoprim/Sulfamethoxazole (Oral), Ceftriaxone (IV), Amikacin (IV)	18 Days	Resolution with persistent homonymous hemianopsia
Lambo et al. [9], 2003	*Streptococcus pneumoniae* (+)	Stereotactic aspiration	Cefotaxime (IV)	NA	Relapse, Resolution
Pruthi et al. [17], 2007	*Klebsiella oxytoca* (–)	Craniectomy with excision	NA	NA	Resolution
Farook et al. [22], 2009	*Escherichia coli* (–)	VP shunt removal; craniotomy with excision	NA	NA	Discharged with no new neurological deficit
Gadgil et al. [8], 2012	Coagulase-negative *Staphylococcus* (+), *Streptococcus mitis* (+)	Craniectomy with excision	NA	NA	Resolution
Fernández et al. [13], 2015	*Eikenella Corrodens* (–)	Stereotactic aspiration	Non-specified IV Antibiotics then Cefuroxime (Oral)	IV: 3 Weeks Oral: 8 Weeks	Resolution
Bajracharya et al. [21], 2015	NA	Ventriculostomy and irrigation	Non-specified IV Antibiotics and Daily irrigation of ventricular space with Injectable gentamycin and hydrocortisone	NA	Gradual improvement on admission until sudden cardiac arrest and death on day 13
Kobayashi et al. [23], 2016	*Bacteroides pyogenes* (–)	Intraventricular irrigation and ventricular drainage (endoscopic); placement of Bilateral EVDs	Vancomycin and Meropenem (IV)	NA	Discharged to nursing home, bedridden
Tingate et al. [19], 2019	*Streptococcus intermedius* (+)	Stereotactic EVD placement	Vancomycin and Meropenem (IV)	NA	Resolution
Offerman et al. [16], 2020	*Cladophialophora (Xylohypha) bantiana*	None	Posaconazole and Micafungin	NA	Death
Hanafiah et al. [14], 2021	*Mycobacterium Tuberculosis*	EVD; Intraoperative abscess drainage	Antituberculous Medication (Oral)	12 Months	Resolution

+: Gram Positive, –: Gram Positive, EVD: External Ventricular Drain, IV: Intravenous, NA: Not Available, VP: Ventriculoperitoneal

al. [30] conducted a chart review of 87 patients and found that when no clear cause for the abscess was identified, patients were nearly three times more likely to have oral bacteria present in their samples. These patients also exhibited significantly higher counts of *Streptococcus anginosus*, a bacterium associated with pharyngitis, bacteremia, and infections of internal organs, including the brain, lungs, and liver. This bacterium is frequently isolated from dental abscesses [30]. In a separate retrospective study of 46 patients with brain abscesses, *Dakurah* et al. [31] identified *Streptococcus milleri* and gram-negative bacilli as the most commonly isolated pathogens (13.5%). This was followed by methicillin-resistant *Staphylococcus aureus* (MRSA) at 10.2%, *Nocardia* and anaerobes at 8.5%, while 13.5% of specimens showed no microbial growth on culture.

Treatment

Generally, brain abscesses are managed surgically by aspirating the encapsulated abscess, culturing the material, and administering appropriate antimicrobial therapy. However, ventricular abscesses pose a heightened natural and operative risk for the spread of infection within the CSF spaces, leading to potential neurological deterioration. As such, the initial approach should be limited, focusing on securing a diagnosis with minimal intervention. Nonetheless, in four reported cases, complete excision of the abscess was performed during the primary

surgery [8, 15, 17, 20]. Additionally, some studies suggest that intrathecal antibiotic administration can aid in managing ventriculitis or meningitis and help prevent complications such as ventricular septations that impair CSF drainage, potentially necessitating VP shunting [32]. Although patients receiving intrathecal antibiotics showed a lower rate of relapse and clinical improvement, current literature does not strongly support the routine use of this method [33] as mirrored by the included articles.

In the present analysis, patients' favorable outcome, marked by minimal neurological deficits at follow-up, highlights the effectiveness of combining surgical drainage with medical management, emphasizing that early surgical drainage, when feasible, combined with appropriate antimicrobial therapy, leads to positive recovery outcomes [9, 16, 20].

Limitations

This study has several limitations. First, the few reported cases of PIAs limit the availability of comprehensive data, as the analysis was based on only 13 reported cases, restricting the generalizability of findings. Second, the reliance on case reports and small case series introduces potential publication bias, as cases with poor outcomes may be underreported. Furthermore, long-term follow-up data were inconsistently reported in the included cases, preventing a thorough assessment of long-term outcomes. Regardless, the rarity of this condition means that even with concerted efforts, it may not be possible to accumulate a sufficiently large cohort to establish definitive treatment protocols or prognostic models, shedding light on the need for continued case reporting.

Conclusion

This study provides a comprehensive review of microbiology, clinical presentation, and management of PIAs. Our findings emphasize that PIAs necessitate both surgical consideration and antimicrobial therapy resulting in favorable recovery. Effective management strategies should account for the diverse microbiological profiles of these infections and prioritize susceptibility testing to guide targeted antimicrobial treatment.

Abbreviations

BBB	Blood–brain barrier
CSF	Cerebrospinal fluid
MRI	Magnetic resonance imaging
MRSA	Methicillin-resistant Staphylococcus aureus
PIA	Primary intraventricular abscess
VP	Ventriculoperitoneal

Author contributions

Conceptualization, methodology, resources, data curation, writing—original draft, and writing—review and editing were done by all authors. Formal analysis and supervision were performed by KD. Visualizations were done by KD and PA.

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Availability of data and materials

All data reported from this study are available in the primary articles from PubMed.

Declarations

Competing interests

The authors have no personal or institutional interest with regards to the authorship and/or publication of this manuscript.

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