

# Neonatal Brain Abscess: Case Report of 12 Cases and Literature Review

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**Abstract:** *Objective:* To investigate the etiological characteristics, clinical manifestations, and early identification methods of neonatal brain abscess. *Methods:* The baseline characteristics, clinical manifestations, and laboratory results of 12 neonatal brain abscess cases were retrospectively analyzed. *Results:* The clinical manifestations were fever, convulsion, and lethargy. A small number of them had respiratory and circulatory failure. The diagnosis made was based on imaging examination. All 12 cases were confirmed by cranial enhanced computed tomography (CT) or magnetic resonance imaging (MRI). Blood cultures of 9 cases were positive, with *Escherichia coli* in 6 cases,  $\beta$ -hemolytic *Streptococcus* in 1 case, methicillin-resistant *Staphylococcus aureus* in 1 case, and *Enterococcus faecium* in 1 case. However, only 3 of them had positive cerebrospinal fluid (CSF) cultures. All the 12 neonates were treated with antibiotic therapy upon admission, with only 3 cases treated with surgery. Among them, 4 recovered and were discharged, while the remaining 8 discontinued their therapy. *Conclusion:* *Escherichia coli* is the most common pathogen of neonatal brain abscess in our study. The clinical manifestations of neonatal brain abscess are atypical, and the prognosis is poor. Respiratory and circulatory failure in children with intracranial infection may indicate the presence of brain abscess. For children with suspected brain abscess, cranial enhanced CT or MRI should be performed as soon as possible to make an early diagnosis. The prevention of brain abscess should be prioritized; neonates with sepsis or meningitis should receive prompt and strong antibiotic therapy in an effort to prevent the development of brain abscess.

**Keywords:** Brain abscess; Clinical manifestations; Enhanced CT or MRI; Antibiotic

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## 1. Introduction

Brain abscess is a focal suppurative lesion, surrounded by fibroblasts and neovascularization, in the brain parenchyma after the brain is damaged by infection, trauma, or surgery<sup>[1]</sup>. Due to the immaturity of neonatal immune and defense system, pathogenic bacteria can easily reach the brain tissue through the blood-brain barrier and cause purulent meningitis or even brain abscess. Although brain abscess is rare in newborns, once it develops, it may lead to neurological sequelae, such as epilepsy, hemiplegia, and aphasia. In recent years, with the advancements of cranial imaging technology and the widespread use of antibiotics, the mortality and morbidity rate of this disease have decreased compared with those in the past. However, brain abscess still threatens the health of neonates<sup>[2]</sup>. In this study, the clinical manifestations, laboratory and imaging findings, as well as the treatment and prognosis of 12 cases of neonatal brain abscess were

retrospectively analyzed, in order to better understand the disease, its etiological characteristics, and the early identification and diagnosis of brain abscess.

## 2. Materials and methods

### 2.1. Clinical data

Twelve neonates who were diagnosed with brain abscess in the Children's Hospital Affiliated to Chongqing Medical University from January 2015 to December 2020 were selected. The baseline characteristics of the neonates are shown in **Table 1**.

**Table 1.** Baseline characteristics

Case	Gestational age	Cesarean section	Birth weight	Asphyxia	Day of onset	EOS/LOS	Pneumonia	Cranial trauma	Congenital heart disease
1	39	-	3400	-	21	LOS	+	-	-
2	37	+	2700	-	13	LOS	+	-	-
3	40	+	2900	-	20	LOS	+	-	-
4	39	-	3200	-	30	LOS	+	-	-
5	35	+	2400	-	14	LOS	+	-	-
6	39	+	3420	-	13	LOS	+	-	-
7	40	-	3450	-	25	LOS	+	-	-
8	36	+	3150	-	30	LOS	+	-	-
9	38	+	3100	+	30	LOS	+	-	-
10	31	-	1580	-	15	LOS	+	-	-
11	39	-	3150	-	19	LOS	+	-	-
12	39	-	3100	-	30	LOS	+	-	-

Abbreviations: EOS, early-onset sepsis; LOS, late-onset sepsis

Among the 12 cases, only Case 5, Case 8, and Case 10 were preterm infants; the remaining were full-term infants. Except for Case 5 and Case 10, which were low birth weight infants, the rest had normal birth weight. The mothers of three neonates had premature rupture of membranes during pregnancy. Before the development of brain abscess, all 12 cases were diagnosed with late-onset sepsis and meningitis by etiological examination or clinical diagnosis. All the 12 neonates had pneumonia but no history of head trauma or right-to-left shunt congenital heart disease.

### 2.2. Clinical manifestations

Among the 12 neonates, 11 (91.7%) had fever, with an average duration of 6.27 days. Convulsions occurred in 8 neonates (66.7%). Nine (75%) had poor feeding or vomiting, 7 (58%) had lethargy, and 6 (50%) had cyanosis. Jaundice occurred in only 4 cases (33.3%), while cranial hypertension occurred in only 3 cases (25%). In addition, 5 cases (41.7%) had respiratory failure, while 4 cases (33.3%) had circulatory failure. The clinical manifestations are shown in **Table 2**.

**Table 2.** Clinical manifestations

Case	Fever	Convulsion	Lethargy	Jaundice	Vomiting	Cyanosis	Respiratory failure	Circulatory failure	Bulging fontanelle
1	+	+	-	-	+	+	+	-	+
2	+	+	+	+	+	+	-	-	-
3	+	-	-	-	-	+	-	-	-
4	+	+	+	+	-	-	-	-	+
5	+	+	+	+	+	-	-	+	-
6	+	+	+	+	-	+	-	-	-
7	+	-	+	-	+	-	+	+	+
8	+	-	+	-	+	-	+	+	-
9	+	+	+	-	+	+	+	+	-
10	-	+	-	-	+	+	+	-	-
11	+	-	-	-	+	-	-	-	-
12	+	+	-	-	+	-	-	-	-

### 2.3. Laboratory tests

#### 2.3.1. Blood analysis and inflammatory indicators

Blood analysis and tests for inflammatory indicators were performed on all 12 neonates. The results of the first routine blood examination upon admission were analyzed: white blood cell count increased in 7 cases and decreased in 2 cases; 11 of them had significantly elevated C-reactive protein (CRP) values.

#### 2.3.2. Cerebrospinal fluid (CSF) examination

Lumber puncture was performed in all 12 patients with brain abscess. White blood cells were higher than  $25 \times 10^6/L$  in 10 patients, protein content was higher than 1 g/L in 10 patients, and glucose content decreased in all patients.

#### 2.3.3. Etiological study

In this study, blood culture and CSF culture were performed for all 12 cases, wherein 8 cases showed positive culture. There were 5 cases of *Escherichia coli*, 1 case of  $\beta$ -hemolytic *Streptococcus*, 1 case of methicillin-resistant *Staphylococcus aureus*, and 1 case of *Enterococcus faecium*. Only 3 cases had positive CSF culture, with 1 case of *Escherichia coli* and another case of *Enterococcus faecium*, which was the same as the blood culture results. All those with positive pathogen tests showed multidrug-resistant bacteria.

**Table 3.** Pathogen

Case	Blood culture	Cerebrospinal fluid culture
1	<i>Escherichia coli</i>	<i>Escherichia coli</i>
2	<i>Escherichia coli</i>	-
3	-	-
4	<i>Escherichia coli</i>	-
5	<i>Escherichia coli</i>	-
6	-	-
7	Methicillin-resistant <i>Staphylococcus aureus</i>	-

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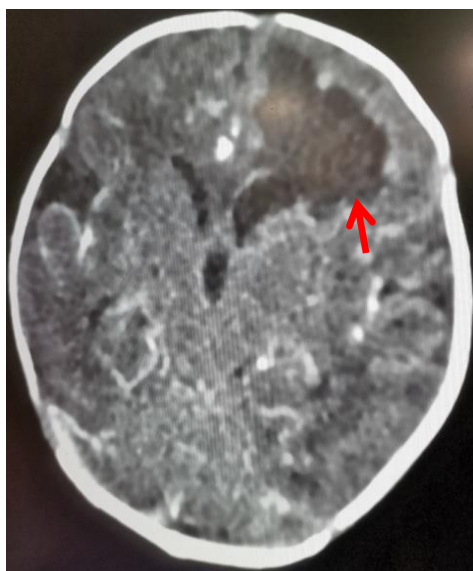
Case	Blood culture	Cerebrospinal fluid culture
8	<i>Enterococcus faecium</i>	<i>Enterococcus faecium</i>
9	-	-
10	-	-
11	$\beta$ -hemolytic <i>Streptococcus</i>	-
12	<i>Escherichia coli</i>	-

## 2.4. Imaging examination

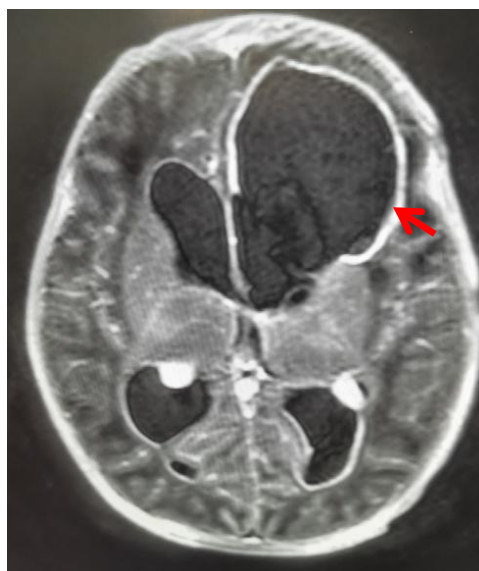
### 2.4.1. Computed tomography (CT) examination of the head

All 12 cases underwent head CT examination, with 10 cases reported having low-density shadow on plain CT scan. Only 3 cases underwent enhanced CT scan, with 1 case showing circular enhancement, and 2 cases without clear circular enhancement.

**Figure 1** shows low-density shadow (red arrow) on plain CT scan, while **Figure 2** shows annular enhancement (red arrow) on enhanced CT scan.



**Figure 1.** CT plain scan



**Figure 2.** Enhanced CT scan

### 2.4.2. Magnetic resonance imaging (MRI)

All 12 cases underwent head MRI examination, with 9 cases showing abnormal signals on plain scan. Seven of them underwent enhanced scan, with 6 cases showing circular enhancement, and 1 case showing nodular enhancement. Diffusion-weighted imaging (DWI) was performed in 3 cases, with 2 cases showing obvious restricted diffusion and pus cavity with high signal, and 1 case showing normal signal. The lesions (red arrows) are shown in **Figure 3** and **4**, and the annular enhancement is shown by the red arrow in **Figure 5**.

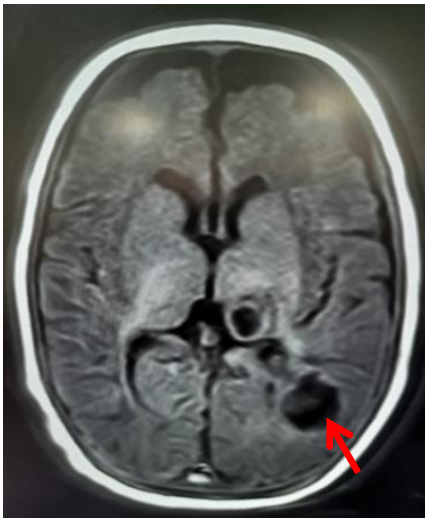


Figure 3. T1-weighted imaging



Figure 4. T2-weighted imaging

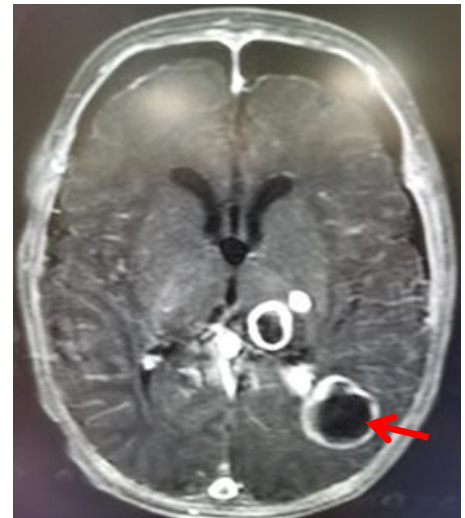


Figure 5. Contrast-enhanced MRI scan

## 2.5. Treatment and outcome

### 2.5.1. Treatment

In this study, 12 neonates with brain abscess were treated with antibiotic therapy, with only 3 of them treated with surgery. Some of them also received symptomatic treatment, such as barbiturates for sedation, mannitol to reduce intracranial pressure, and prophylactic antiepileptic drugs. Glucocorticoids were used in 2 neonates to reduce inflammation. The medications were adjusted according to their clinical symptoms and CT or MRI results. Initially, all 12 cases were empirically treated with third-generation cephalosporins, but due to the ineffectiveness of this treatment and based on antibiotic sensitivity analysis, vancomycin or meropenem was prescribed accordingly.

### 2.5.2. Outcome

Given their condition at discharge, only 4 neonates recovered. The other 8 neonates were discharged from hospital without completing their antibiotic course; in addition, symptoms such as absence of spontaneous breathing, coma with eye-opening, and poor response and natural reflexes remained persistent; their CSF and imaging examinations also showed no significant improvement. Although surgery or antibiotic therapy was required, the treatment was stopped upon the parents' request.

## 3. Literature review

Using “newborn” and “brain abscess” as keywords, Chinese literatures in China National Knowledge Infrastructure (CNKI), Wanfang Database, and China Biomedical Literature Database were searched. The keywords “medical” and “brain abscess” were used in the search of PubMed database. According to literature reports, brain abscesses commonly present with fever, headache, and focal neurological deficits. However, brain abscesses in neonates do not present with these typical symptoms. The clinical symptoms of brain abscess vary due to different virulence of pathogenic bacteria and the body's response to different conditions, which may easily lead to misdiagnosis, thus resulting in poor prognosis and an increased risk of mortality in children. Even if they survive, there will be permanent neurological impairment [3-11]. Therefore, in addition to the prevention of brain abscess, diagnosing and treating it early are essential.

## 4. Discussion

### 4.1. Etiology of brain abscess

*Staphylococcus aureus* used to be the most common pathogenic bacteria of neonatal brain abscess, but in

recent years, the number of neonatal brain abscess caused by anaerobic bacteria and Gram-negative bacteria has increased [12,13]. In most of the reports published, *Citrobacter cruzi* and *Proteus* are the most common microorganisms that cause brain abscess in neonates [14]. However, considering the cases in this study, *Escherichia coli* is the most common pathogenic bacteria. A possible explanation is that all the neonatal brain abscesses in this study originated from pneumonia, and *Escherichia coli* is known to be the most common Gram-negative bacteria of neonatal community-acquired pneumonia [15].

#### **4.2. Clinical manifestations of brain abscess**

The signs and symptoms of neonatal brain abscess vary and are non-specific. There are very few localized signs of the nervous system and typical symptoms of meningeal irritation, which might lead to delayed diagnosis and treatment. The most common clinical manifestations of neonatal brain abscess include bulging fontanelle, convulsion, and vomiting. The majority of patients in this study presented with fever, convulsion, lethargy, food refusal, and vomiting, and half of them presented with intracranial hypertension, which is consistent with literature reports.

It is worth noting that among the 12 children in our hospital, 5 children had respiratory failure, while 4 children had circulatory failure. According to Masand *et al.*, patients with brain abscess may present with non-specific signs, such as oxygen saturation failure, cyanosis, and bradycardia [16]. Therefore, when considering the manifestations of respiratory and circulatory failure in children with intracranial infection, the presence of brain abscess should be warned.

#### **4.3. Diagnosis of brain abscess**

As CSF examination can only indicate intracranial infection and has a low positive rate, it cannot be used as the main diagnostic method for brain abscess. The diagnosis of brain abscess mainly relies on imaging examination, such as CT and MRI.

On plain CT, an abscess would show a low-density shadow with a slightly higher density ring shadow within the low-density shadow. With contrast enhancement, a density enhancement zone, also known as “ring enhancement shadow,” which is typical of a brain abscess, can be seen surrounding the abscess. However, CT abnormalities often appear later than the clinical manifestations. Hence, the presence of brain abscess cannot be ruled out by a normal CT at the onset of the disease; otherwise, the diagnosis and subsequent treatment might be delayed. Compared with CT, brain MRI has a higher sensitivity to multiple small lesions. MRI examination of an abscess cavity would show low signal on T1WI and high signal on T2WI, with annular enhancement observed following enhancement. The abscess capsule is generally not well-demarcated on T1WI, but it is characterized as a smooth, thin-walled, low-signal “dark band” on T2WI [17,18].

In this study, CT or MRI was performed on all the neonates. Plain CT or MRI scans were not able to confirm the diagnosis of brain abscess, but a typical ring enhancement shadow was observed after enhancement. Therefore, for children with suspected brain abscess, cranial enhanced CT or MRI should be performed as soon as possible.

#### **4.4. Treatment of brain abscess**

For children with brain abscess, strong bactericidal drugs, such as third-generation cephalosporins and carbapenems like meropenem, can be used as antibiotics, as they can easily penetrate the blood-brain barrier. If an abscess continues to expand even with the administration of antibiotics, the treatment should be switched to surgical methods, such as puncture, drainage, or excision of the abscess. If the volume of the abscess cavity is larger than 10 mL or the pus is thick and difficult to be removed completely, a drainage catheter should be placed. The catheter should then be removed after daily irrigation with antibiotic saline

until clear.

All 12 neonates in this study received antibiotic treatment, but in 10 of them, the intracranial infection was not controlled effectively. Even with the use of meropenem or vancomycin, the effect was still poor. Among the three patients who received surgical treatment, two of them showed significant improvement after timely completion of abscess aspiration. Therefore, surgery should be performed as early as possible to improve the prognosis of neonates who are indicated for surgery.

## 5. Conclusion

Neonates with brain abscess tend to present with atypical clinical manifestations. For children with intracranial infection, brain abscess should be suspected when respiratory and circulatory failure occur. For children with suspected brain abscess, enhanced CT or MRI examination of the brain should be performed as soon as possible. This would be helpful for early diagnosis.

*Escherichia coli* is a common pathogen that causes brain abscess in neonates. For children with surgical indications, surgery should be performed as soon as possible to improve their prognosis. The treatment of neonatal brain abscess takes a long time, is expensive, and may still lead to poor prognosis even with antibiotics and surgery. Therefore, the prevention of brain abscess should be given priority in addition to administering strong antibiotics for sepsis or meningitis as soon as possible to prevent the development of brain abscess.

## Disclosure statement

The authors declare no conflict of interest.

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