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Review article

Clinical outcomes of neuroendoscopic resection of brain abscess guided by electromagnetic navigation among patients presenting at Jieyang People's Hospital in China

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ABSTRACT

Background: The treatment of brain abscesses presents certain difficulties. How to enhance the surgical effect and the positive rate of bacterial culture has always been our objective.
Aim: This study explored the surgical outcome of neuroendoscopic resection of brain abscess under the guidance of electromagnetic navigation and how to increase the positive rate of bacterial culture.
Methods: From June 2018 to December 2023, a total of 5 cases of neuroendoscopic resection of brain abscess under the guidance of electromagnetic navigation were conducted in our hospital. After admission, enhanced head MR layer scans were carried out. The imaging data were imported into the neuronavigation system. After successful registration, the abscess wall was cauterized with bipolar under the guidance of electromagnetic navigation, and the abscess wall was taken for bacterial culture and drug sensitivity test. We calculated the positive rate of bacterial culture, that is, the positive rate of bacterial culture is the number of positive cases of bacterial culture divided by the total number of cases sent for culture. After the operation, sensitive antibiotics were intravenously administered according to the bacterial culture and drug sensitivity test.
Results: The headache symptoms of the 5 patients were significantly alleviated, and there was no residual limb dysfunction. Reexamination of the head MR indicated that the abscess was significantly reduced. Five cases were all subjected to bacterial culture, among which bacteria were cultured in three cases, and the positive rate of bacterial culture was 60 %. The abscess clearance rate after the operation was all greater than 80 %.
Conclusion: Neuroendoscopic resection of brain abscess under the guidance of electromagnetic navigation has a favorable effect.This surgical method increases the positive rate of bacterial culture and holds significant reference significance for the subsequent intravenous administration of antibacterial drugs.

Abbreviations: Magnetic Resonance Imaging, MRI; Computed Tomography, CT.

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1. Introduction

Brain abscess refers to suppurative encephalitis, chronic granuloma and the formation of a brain abscess capsule caused by suppurative bacterial infection. A small portion can also be caused by the invasion of fungi and protozoa into the brain tissue. According to the source of pathogen infection, it is often classified into four types: 1. Brain abscess caused by the spread of adjacent infection foci; 2. Hematogenous brain abscess; 3. Traumatic brain abscess; 4. Cryptogenic brain abscess, that is, brain abscess of unknown etiology [1–4]. For brain abscesses with a diameter of less than 2.5 cm, intravenous drug infusion therapy is generally employed, such as the third-generation cephalosporin plus metronidazole, while for brain abscesses with a diameter of more than 2.5 cm, surgery plus intravenous infusion of drugs is generally employed for treatment. The treatment of brain abscesses presents certain difficulties. How to enhance the surgical effect and the positive rate of bacterial culture has always been our objective. There are generally surgical approaches such as drilling and puncture drainage and craniotomy for brain abscesses [5]. However, puncture is blind and uncertain; while craniotomy has the drawback of significant trauma. To address these two issues of large trauma and blind puncture, since 2018, we have implemented the surgical method of endoscopic resection of brain abscess under the guidance of electromagnetic navigation. On the one hand, this surgical method can directly enter the abscess cavity under the guidance of electromagnetic navigation, and directly remove the abscess, while avoiding the trauma inflicted on the patient by craniotomy [6–8]. From June 2018 to December 2023, a total of 5 cases of neuroendoscopic resection of brain abscess under the guidance of electromagnetic navigation were conducted in our hospital. Now we analyze and summarize these 6 cases.

2. Materials and methods

This study was a retrospective study using medical records.

1. Research subjects: The research subjects were patients who underwent neuroendoscopic resection of brain abscesses under the guidance of electromagnetic navigation. The inclusion criteria for patients were: 1. The diameter of the brain abscess was greater than 2.5 cm; 2. There was no cerebral herniation; 3. The patient consented to the operation. Exclusion criteria: 1. There was cerebral herniation; 2. Those with severe cardiopulmonary dysfunction who could not tolerate the operation; 3. Those with coagulation dysfunction. According to this criterion, we collected 5 cases of neuroendoscopic resection of brain abscesses under the guidance of electromagnetic navigation from June 2018 to December 2023, including 5 males and 1 female, aged from 31 to 65 years, with an average of (51.67 ± 11.5) years.

Ethical Considerations for Brain Abscess Surgery: Before the operation, explain the necessity and risks of the operation to the patients and their families in plain language to obtain informed consent. For patients who are unconscious, seek the consent of their guardians. During the operation, maintain strict asepsis and communicate promptly when there are changes in the plan. After the operation, properly preserve the data and protect privacy. For cases used for research and teaching, obtain consent again and anonymize them.

2 Methods: For the 5 patients with brain abscesses meeting the inclusion criteria, enhanced head MR examinations, as shown in Fig. 1, were carried out after admission. Once a clear diagnosis was made, neuroendoscopic resection of brain abscesses was conducted under the guidance of electromagnetic navigation. Enhanced head MR was reexamined after the operation, as shown in

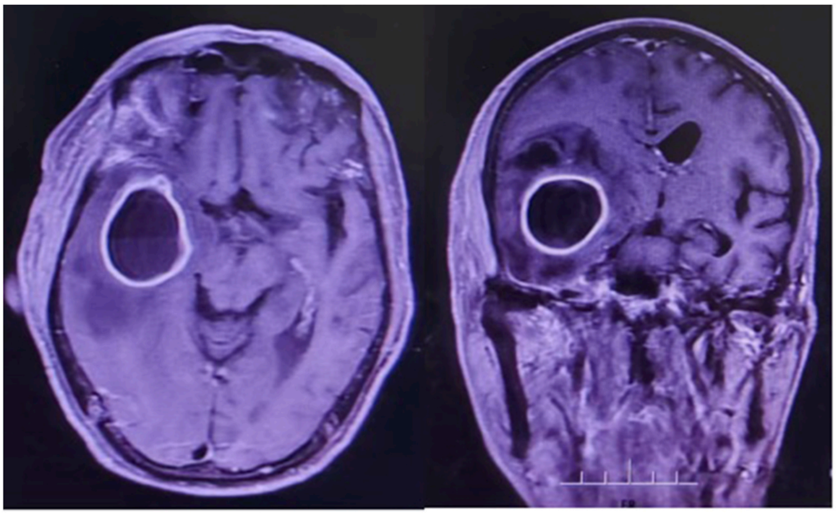

Fig. 1. Enhanced magnetic resonance imaging of the head suggests a circular enhancement in the right temporal lobe.

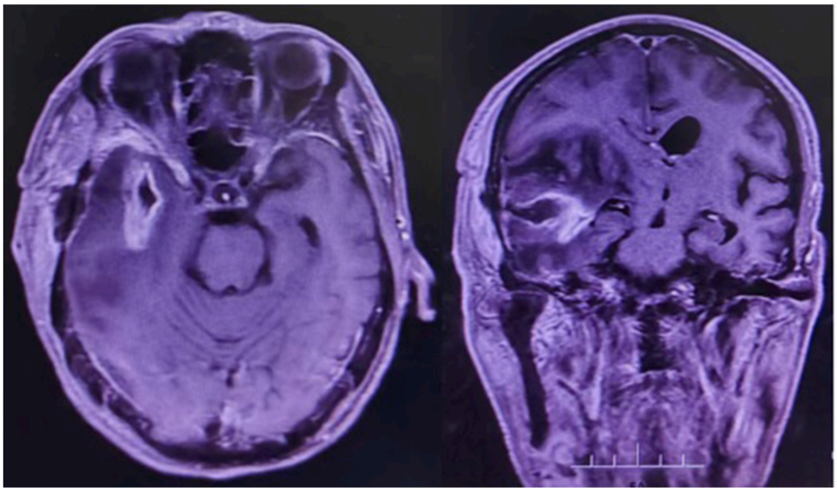

Fig. 2. After one month of postoperative follow-up, the abscess had significantly shrunk.

Fig. 2, to calculate the abscess clearance rate. The postoperative bacterial culture results of the patients were recorded, and the positive rate of bacterial culture was computed. After the surgery, antibiotics were administered intravenously based on the bacterial culture and drug sensitivity results.

2.1. Surgical procedure

The operation method of electromagnetic navigation: After admission, the patient undergoes an enhanced head MR scan [9]. All enhanced head MR scans are thin-layer 2 mm scans. Select Electromagnetic Navigation Catheter Placement (EM) on the interface of the neuronavigation system. Scan the enhanced data of the patient's cranial MR through a U disk and import it into the neuronavigation system. Paste the electromagnetic reference frame closely on the tight skin area such as the forehead of the patient, and stick it firmly with 3M film. Place the electromagnetic plate at the head of the operating bed, and the patient's head rests on the center above the plate. Connect the electromagnetic reference frame and the electromagnetic plate connector respectively. Register on the patient's head with the navigation stick according to the system prompt. After successful registration, each anatomical position of the patient's head can be verified.

The operation method of neuroendoscopy: Make an incision of approximately 4 cm on the scalp near the lesion, and employ a mastoid distractor to open the scalp. Drill a bone hole with a grinding drill, and mill the skull with a milling cutter to form a small bone flap of about 3 cm $\times$ 3 cm, and turn over the small bone flap. At this point, we need to remove the mastoid distractor as it will interfere with electromagnetic navigation. Fix the scalp on both sides with sutures respectively, then cut the dura mater, and suture and retract the dura mater with sutures to expose the cerebral cortex. Separate the veins of the cerebral cortex, cut the cerebral cortex along the

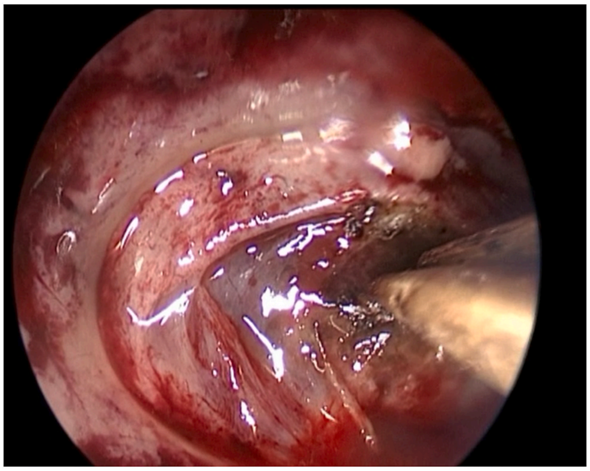

Fig. 3. We employed bipolar cauterization to burn the abscess wall and took the abscess wall for bacterial culture and drug sensitivity testing.

cerebral sulcus, and insert the neuroendoscopic sleeve. Insert the intraoperative navigation probe and place it in the sleeve. According to the guidance of electromagnetic navigation, direct the sleeve direction to the center of the brain abscess. Under the guidance of electromagnetic navigation, the sleeve fistulates in the brain tissue until reaching the abscess wall of the brain abscess. Connect the neuroendoscope, and cauterize the abscess wall with bipolar (Figs. 3 and 4) under direct vision. Take the abscess wall and preserve it in the specimen bottle used for blood culture in normal times for bacterial culture and drug sensitivity test. Some patients undergo genetic testing. After entering the abscess cavity, insert the drainage tube to aspirate the pus. The pus was also preserved in the specimen bottle for blood culture and sent for bacterial culture and drug sensitivity test and genetic testing. Completely remove the pus in the abscess cavity under the neuroendoscope. Rinse the abscess cavity repeatedly with gentamicin, metronidazole and normal saline as shown in Fig. 5. Finally, place a drainage tube in the abscess cavity and fix it, suture the dura mater, fix and restore the small bone flap with a bone plate, and suture the skin. After the operation, sensitive antibiotics were intravenously administered according to the bacterial culture and drug sensitivity test.

Bacterial culture and susceptibility test methods:Bacteria were identified and tested for drug sensitivity using the VITEK2 Compact fully automatic microbial identification and drug susceptibility analyzer, Gram-negative bacteria identification cards, and *Gram-negative bacteria* drug susceptibility cards. *Escherichia coli* ATCC25922 and *Pseudomonas aeruginosa* ATCC27853 were used as quality controls for drug susceptibility. The drug susceptibility results were referred to the Clinical and Laboratory Standards Institute (CLSI) in 2019. Bacterial culture and susceptibility test were completed in the bacteriological laboratory of our hospital.

2.2. Observation indicators

Abscess clearance rate: The volume of the cleared brain abscess divided by the total volume of the brain abscess.

Bacterial culture positive rate: The number of positive bacterial cultures divided by the total number of bacterial cultures.

2.3. Statistical methods

The sample size of this study was 5 patients with brain abscess. For the two categorical variable indicators, namely the brain abscess clearance rate and the positive rate of bacterial culture, descriptive statistical analysis approaches were employed. The distribution of each observation indicator was presented by frequency and percentage.

3. Results

The symptoms of the patients at admission are shown in Table 1, including headache and fever, and some patients were accompanied by limb dysfunction. There were 2 cases with suspected sources of bacteria before the operation.

As shown in Table 2, during the operation, we took the abscess wall and pus for bacterial culture and drug sensitivity testing. A total of 5 cases were cultured with bacteria, and the positive rate of bacterial culture was 60 %. The abscess clearance rate after the operation was all greater than 80 %. At discharge, the patient's headache symptoms were significantly alleviated and there was no residual limb dysfunction.

4. Discussion

Brain abscess is an acutely deteriorating disorder in the field of neurosurgery. Especially in the early stage of the disease, emergency surgical treatment may be necessary due to the acute exacerbation of inflammation causing a sharp increase in intracranial pressure.

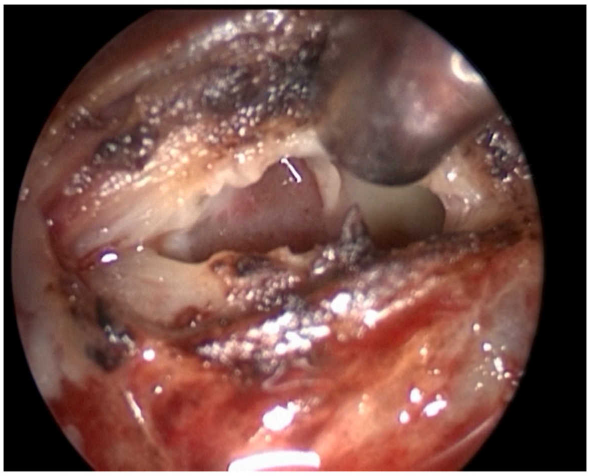

Fig. 4. After the abscess wall was opened, we could see the abscess cavity inside.

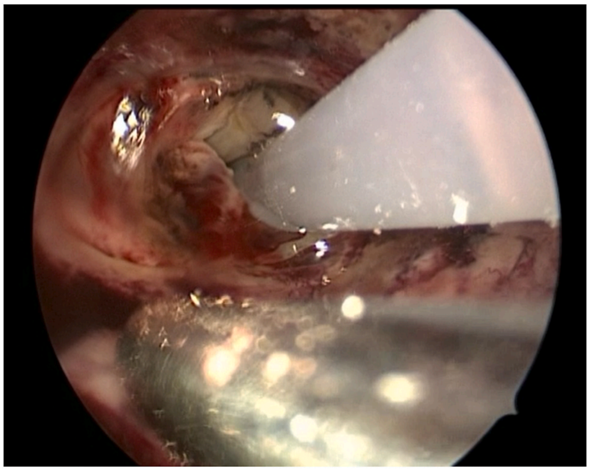

Fig. 5. The pus cavity was rinsed using gentamicin, metronidazole, and physiological saline.

Table 1
Clinical data of patients with brain abscess.

Case	Gender	Age	Underlying disease	Smoking	Drug or substance abuse	COVID-19	Symptoms and signs	Suspected bacterial source	Maximum diameter of brain abscess (cm)	The location of brain abscess
1	Male	65	No	Yes	No	No	Headache, fever	Not found	4.10	Right temporal lobe
2	Male	31	No	No	No	No	Headache, convulsions	Congenital heart disease	4.72	Left frontal lobe
3	Male	52	No	Yes	No	No	Dizziness, headache, and limb fatigue	Not found	3.65	Right basal ganglia area
4	Female	59	No	No	No	No	Left limb weakness	Not found	3.21	Right occipital parietal lobe
5	Male	51	No	Yes	No	No	Headache and fever, right limb muscle strength level 4	Inflammation in the left ear	4.18	Left temporal lobe

Table 2
Bacterial culture results, abscess clearance rate, and antibiotic use in patients with brain abscess.

case	Bacterial culture results	Percentage (%)Antibiotics clearance of abscess	Antibiotics
1	No bacteria	90	Meropenem plus vancomycin
2	No bacteria	85	Ceftriaxone sodium combined with vancomycin
3	*Grass green hemolytic streptococcus*	85	vancomycin
4	*Anaerobic bacteria, chain arranged Gram positive cocci*	90	vancomycin
5	*Pseudomonas aeruginosa, Actinobacteria Zurich, Grass green hemolytic streptococcus*	80	Linazolam plus meropenem

Therefore, the early stabilization, diagnosis and management of this disease are extremely important for reducing morbidity and mortality [10].The most common intracranial locations of brain abscesses are: frontotemporal lobe, frontoparietal lobe, parietal lobe, cerebellar lobe and occipital lobe. Brain abscesses are mostly formed by infection foci in adjacent areas, trauma or hematogenous dissemination of distant infection foci. Among them, brain abscess after brain surgery is a rare complication, mainly occurring in tumor patients and those undergoing emergency surgery [11].Therefore, its microbial etiology depends on the location of the primary infection. The most commonly isolated organisms are *anaerobic bacteria, aerobic* and *microaerophilic streptococci, Enterobacteriaceae* and *Staphylococcus aureus*, and less commonly viruses, fungi, amoebas, etc [4,12,13]. Therefore, surgical specimens should be sent for aerobic, anaerobic, mycobacterial and fungal cultures, and protozoan cultures when necessary [14,15]. Despite advancements in the diagnosis and treatment of brain abscesses, it remains a serious and life-threatening disease in children. The most important infection causing brain abscess in children is still upper respiratory tract infection. Clinicians can treat upper respiratory tract infections in children through appropriate selection and duration of antibiotics [16].

The most common manifestations of brain abscess are headache and vomiting caused by increased intracranial pressure. Patients may have fever, limb dysfunction, seizures, and even disturbance of consciousness. It has been reported that up to 50 % of cases have seizures [17]. Patients suspected of having brain abscess should undergo timely cranial CT or MR examinations, and it is preferable to perform enhanced scans of the cranial MR. At different stages of the disease, differential diagnosis from various diseases is required. In the early stage, it is necessary to differentiate from other infectious diseases, and in the mature stage of the abscess, it is necessary to differentiate from gliomas or metastases.

Before the abscess has formed, we need to employ large doses of antibacterial drugs that can pass through the blood-brain barrier and measures to reduce increased intracranial pressure. Once the abscess has formed, the need for surgery depends on the diameter of the abscess [18,19]. For brain abscesses with a diameter of less than 2.5 cm, intravenous antibiotic treatment alone is generally chosen. If the diameter of the brain abscess is greater than 2.5 cm, surgical intervention is generally required. Studies have pointed out that in the treatment of brain abscesses, patients who only receive drug treatment have a higher mortality rate compared to those who receive combined treatment [20]. It is estimated that patients with simple drug treatment are prone to a sharp increase in intracranial pressure and miss the rescue opportunity.

Since brain abscesses are usually polymicrobial. Therefore, when we choose antibiotics, before the bacterial culture results come out, we generally need to cover Gram-negative and Gram-positive bacteria. Some experts also advocate covering anaerobic bacteria. It may be considered that many are derived from paranasal sinus infections [21]. Once the bacterial culture results come out, we must choose sensitive antibiotics and use them intravenously continuously for 4–8 weeks, and change to oral administration depending on the situation.

The surgery for brain abscess can remove the pus, rapidly reduce the intracranial pressure, alleviate the toxin reaction, and can also conduct bacterial culture to identify the pathogenic bacteria, providing sensitive antibiotics for the subsequent intravenous treatment, which is conducive to the standardized treatment of patients. The surgical treatment of brain abscess is traditionally divided into puncture and drainage and craniotomy [22,23]. Aspiration may be the preferred surgical method for patients with supratentorial parenchymal brain abscess [24]. There is no significant difference in the mortality rate among surgical treatment options, but stereotactic guided aspiration has fewer complications [25]. Puncture and drainage is a minimally invasive surgery, which causes less trauma to the patient, but has the disadvantages of incomplete drainage and easy recurrence. Craniotomy can completely remove the abscess, but it has a large trauma and is prone to complications of infection spread.

Resection of the abscess under neuroendoscopy is a novel surgical method [26]. It can completely remove the abscess, stop bleeding during the operation, rinse the abscess cavity, and it causes less trauma to the patient and is conducive to the patient's recovery. Endoscopic techniques have proven to be a safe and effective option for the treatment of intracranial abscesses. For larger superficial lesions, the surgical risk is similar to that of simple drainage through a catheter, but the recurrence rate may be reduced by 20 % [7]. The neuroendoscope can incise the abscess wall under direct vision, and the abscess wall can undergo bacterial culture and drug sensitivity tests, which greatly enhances the positive rate of bacterial culture and provides an important reference for the subsequent intravenous use of sensitive antibiotics for patients. The positive rate of bacterial culture of brain abscess pus in many hospitals is typically relatively low, generally approximately 12 % [27]. Our research finding is that the positive rate of bacterial culture is 60 %. Our positive rate of bacterial culture is significantly higher. We find that the positive rate of culture with only pus is very low, while bacterial culture of the abscess wall can greatly increase the positive rate of bacterial culture, which cannot be achieved by puncture and drainage surgery. The postoperative abscess clearance rate in this study was all greater than 80 %, while that of brain abscess puncture and drainage is generally 30 %–40 %. This represents a significant improvement [28,29]. Compared with microscopic abscess resection techniques, one aspect is that the bone window of the endoscope is much smaller than that of the microscope, and the other aspect is that the endoscope can have a broader field of view than the microscope when it is deep in the abscess cavity.

Neuronavigation can play an important guiding role in the surgery of brain abscesses [30,31]. Since most brain abscesses are located in the deep part of the brain, without good direction guidance, it is prone to deviation, resulting in puncture failure or even infection spread, leading to severe encephalitis [32].Previously, stereotactic technology was mostly utilized for the localization of brain abscesses. However, the operation steps of stereotactic positioning technology are more cumbersome, take more time, and the key point is that puncture positioning in any direction cannot be performed. The electromagnetic navigation system we employ is very straightforward to operate. Whether it is preoperative registration or intraoperative navigation guidance, the operator can master it with a little learning and can perform positioning guidance in any direction. Compared with traditional navigation, electromagnetic navigation has the following advantages: It is not necessary to fix the head with a head frame, and even if the head moves during the operation, it will not cause deviation; the accuracy is improved to the millimeter level. Therefore, the neuroendoscopic resection of brain abscesses we carried out was conducted under the precise guidance of electromagnetic navigation. This ensures the safety of the operation and avoids unexpected occurrences [33].

The limitation of this study is that the sample size is relatively small, so we still need to collect more samples.

5. Conclusion

Neuroendoscopic resection of brain abscess under the guidance of electromagnetic navigation has a favorable effect.This surgical method increases the positive rate of bacterial culture and holds significant reference significance for the subsequent intravenous administration of antibacterial drugs.

CRediT authorship contribution statement

Mindong Huang: Formal analysis, Data curation, Conceptualization. **Jiandan Zou:** Data curation.

Ethics approval and consent to participate

The Ethics Committee of Jieyang People's Hospital approved my research, which pertains to Jieyang People's Hospital. As this is a retrospective analysis of existing anonymous data and does not involve any direct interaction with patients or interference in their treatment, the hospital ethics committee has waived the requirement for individual informed consent. Nevertheless, all methods are carried out in accordance with relevant guidelines and regulations to ensure the protection of patient privacy and data integrity. The data used in this study originates from the hospital's electronic medical record system and is strictly managed and analyzed in accordance with the hospital's data protection and security protocols.

Consent for publication

Not applicable.

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Declaration of competing interest

I Iam employed by the Jieyang People's Hospital and hereby declare the following statement regarding conflicts of interest: I promise to avoid conflicts of interest with the hospital, shareholders, and clients. I promise to ensure that my personal behavior complies with the guidelines. My conflict of interest is not related to my immediate family members, other family members, or interests. This is my personal research, without funding support.

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