Treatment of Bacterial Brain Abscess by Repeated Aspiration
—Follow up by Serial Computed Tomography—

Masaaki YAMAMOTO, Takeo FUKUSHIMA, Katsuyuki HIRAKAWA, Hideo KIMURA, and Masamichi TOMONAGA

Department of Neurosurgery, Fukuoka University School of Medicine, Fukuoka

Abstract

Bacterial brain abscess often requires repeated aspiration before the abscess finally resolves. However, there are no guidelines for treatment by aspiration; for example, when should the abscess be tapped again, or when can an abscess be treated by antibiotics alone without further aspiration. Eleven patients with bacterial brain abscess treated by aspiration were evaluated to establish treatment guidelines for brain abscess, in particular the abscess size on serial computed tomography (CT) after aspiration. CT was performed about 24 hours after aspiration to evaluate the size of the abscess, and almost weekly during follow up. The diameter of the brain abscess before and after the initial and last aspirations were reviewed. In eight of the 11 patients, abscesses were aspirated repeatedly: two to three times in most patients. The diameter of the abscesses was 2.5–4.3 cm (mean 3.5 cm) before the last aspiration, and 1.4–3.4 cm (mean 2.3 cm) after the last aspiration, or when continuous drainage was discontinued. Perifocal edema was moderately decreased within 3 weeks after the last aspiration by medical treatment alone, with a concomitant decrease in the volume of the abscess. There were no deaths, and most patients had a favorable outcome. These results suggest that after the diameter of the abscess becomes less than 2 to 3 cm and does not increase anymore on serial CT, medical treatment alone can be anticipated to give satisfactory results without further aspiration.

Key words: brain abscess, repeated aspiration, serial computed tomography, size of abscess

Introduction

The overall mortality associated with bacterial brain abscess has fallen during the past few decades as a result of the development of diagnostic modalities, improved methods for isolating and identifying infective organisms, and more appropriate antibiotic regimens for these specific pathogens. Computed tomography (CT) and magnetic resonance (MR) imaging now allow an earlier diagnosis and accurate localization of brain abscesses and associated brain edema. The infectious process can be eliminated in most brain abscesses by surgical procedures, either aspiration or excision, combined with appropriate antibiotic therapy. Aspiration or excision confirms the diagnosis of brain abscess, and the causative organism can be identified from the surgical specimens, which is useful for selecting the proper antibiotic regimen. Inadequate antimicrobial treatment has been responsible for many deaths in cases of brain abscess. Since the introduction of CT, the nonsurgical treatment of brain abscess by antibiotics alone, while still controversial, has been extended to the treatment of small or multiple brain abscesses in high-risk patients.

The choice of surgical procedures, i.e., primary excision or aspiration, for brain abscess has long remained controversial. However, technical advances with CT-guided stereotactic procedures and intraoperative ultrasound probes followed by serial CT now provide accurate and safe treatment options, and aspiration, the less invasive surgical procedure, has been applied successfully with mortality and morbidity similar to those with primary excision. When a brain abscess is treated by aspiration,
repeated aspirations are often required before the abscess finally resolves. CT is invaluable for following the progress of treatment and determining whether the abscess should be punctured again. However, there are no guidelines for treatment by aspiration; for example, when should an abscess be tapped again, or when should treatment be continued by antibiotics alone without further aspiration?

This study evaluated 11 cases of abscess treated by repeated aspirations to assess the treatment guidelines for brain abscess, in particular the size of the abscess as monitored by serial CT after aspiration.

**Clinical Materials and Methods**

A retrospective chart review was performed to identify 17 patients, 12 males and five females, aged 7 to 62 years (mean 36 years), with bacterial brain abscess who were treated at Fukuoka University Hospital from 1985 to 1996 inclusive, and who were not immunocompromised. In our institute, brain abscess has been treated by aspiration according to the following criteria. Small acute and subacute stage brain abscesses interpreted as early capsule formation without consciousness disturbance were treated by antibiotics alone. Small abscesses were defined as smaller than 2.5 cm in mean diameter. Large abscesses with consciousness disturbance were aspirated urgently, and also treated with prolonged antibiotic therapy. After aspiration, CT was performed almost weekly, or more frequently if new symptoms developed or symptoms deteriorated. To evaluate the size of abscesses after aspiration, CT was performed about 24 hours after aspiration. Antibiotic regimens were changed according to the results of a pus culture. If the size of the abscess on CT after the first aspiration was not reduced or increased despite antibiotic therapy, aspiration was repeated. Multiple abscesses were aspirated through the same burr hole or different burr holes located distant from one another, and small ones were treated conservatively. Chronic stage encapsulated abscesses as determined by CT were excised by open craniotomy. Corticosteroids were used only to decrease intracranial masses due to perifocal edema evident on CT, associated with an increasing neurological deficit or an altered level of consciousness.

Four patients underwent craniotomy and excision, since CT showed chronic encapsulated brain abscesses. Thirteen patients underwent aspiration and drainage by freehand methods in the early 1980s, and under intraoperative ultrasound imaging-guided and/or CT-guided stereotactic aspiration in the late 1980s and 1990s. Serial CT scans before and after aspiration were available for evaluation in 11 of these 13 patients. By referring to their clinical records and serial CT scans, the following information was documented for each of these 11 patients: sex, age, clinical status on admission, duration of history, abscess site and predisposing factors, organism culture, antibiotic therapy, and mean diameter of brain abscess on CT before and after the initial and last aspirations. The diameter of the abscess was defined as mean maximum diameter in length, width, and height on CT scan. Clinical status on admission was evaluated using the Glasgow Coma Scale. The neurological outcome based on the Glasgow Outcome Scale was determined at discharge.

**Results**

Table 1 summarizes the clinical characteristics of the 11 patients, eight males and three females aged 7 to 62 years (mean 31.4 years). Headache was the most common initial complaint in eight patients. Initial neurological examination detected localizing signs in eight patients. Four patients were alert, and seven were somnolent or confused at admission. Nine patients had solitary brain abscesses. Three patients had adjacent localized cranial infection, paranasal sinusitis, as a predisposing factor. Four patients had pulmonary or congenital heart disease. Four patients had no identifiable predisposing cause. Single organisms were identified in six patients and multiple organisms in three; no organisms were identified in two. The most common antibiotic regimen was the combination of penicillin and cephalosporin, and the antibiotics were changed to more appropriate ones as soon as the results of sensitivity tests were available. Antibiotic therapy was continued for at least 4 weeks.

Table 2 summarizes abscess localization and the clinical course. CT or MR imaging demonstrated late cerebritis in two patients and early or late capsule formation in nine. The diameter of the abscesses on CT scan was 3.5–6.6 cm (mean 4.8 cm) before the first aspiration. Two patients had multiple brain abscesses, and the smallest abscesses were medically treated (Cases 1 and 6). Four patients had abscesses remote from ventricles, so continuous drainage of abscesses was combined with simple aspiration. Eight patients underwent repeated aspiration for two to five times. CT showed the abscess size was decreased in most patients 24 hours after the first operation. Repeated aspiration was performed because of abscess enlargement (Case 2), or failure to reduce the abscess despite antibiotic ther-
Table 1  Summary of neurological evaluations, presumed predisposing factors, causative organisms, and antibiotic therapy

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age</th>
<th>Sex</th>
<th>Number of abscesses</th>
<th>Neurological grade on admission</th>
<th>Predisposing factors</th>
<th>Causative organisms</th>
<th>Antibiotic therapy</th>
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<td>26</td>
<td>M</td>
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<td>13</td>
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<td>14</td>
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<td>M</td>
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<td>14</td>
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<td>negative</td>
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</tr>
<tr>
<td>6</td>
<td>43</td>
<td>M</td>
<td>3</td>
<td>15</td>
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<td>8</td>
<td>62</td>
<td>F</td>
<td>1</td>
<td>14</td>
<td>pulmonary AVF</td>
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<tr>
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<td>8</td>
<td>F</td>
<td>1</td>
<td>14</td>
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<td><em>Streptococcus anginosus</em></td>
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<tr>
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<td>M</td>
<td>1</td>
<td>14</td>
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<td>11</td>
<td>52</td>
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<td>1</td>
<td>15</td>
<td>unknown</td>
<td><em>Streptococcus intermedius</em></td>
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Table 2  Summary of abscess location, diameter of abscess, and chronology of clinical course

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Location</th>
<th>Diameter of abscess at first aspiration (cm)</th>
<th>Number of aspirations</th>
<th>Combined with continuous drainage</th>
<th>Diameter of abscess at last aspiration (cm)</th>
<th>Interval or duration (days)</th>
<th>GOS</th>
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<tr>
<td></td>
<td></td>
<td>Before</td>
<td>After</td>
<td>Before</td>
<td>After or at removal of drainage</td>
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<td>5.5*</td>
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<td>4.1</td>
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<td>3.4</td>
<td>3</td>
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<td>2.6</td>
<td>1</td>
<td>+</td>
<td>1.4</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>frontal</td>
<td>3.8</td>
<td>2.5</td>
<td>1</td>
<td>+</td>
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<td>10</td>
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</table>

*Three days after first aspiration.  **Twenty-five days interval from first aspiration to last aspiration, and continuous drainage for 5 days initiated at the fifth aspiration.  G: good recovery; GOS: Glasgow Outcome Scale; Interval or duration: interval from first aspiration to last aspiration, or duration of continuous drainage; M: moderately disabled.
apy after the first operation. The diameter of the abscesses was 2.5 to 4.5 cm (mean 3.5 cm) on CT before the last aspiration, and was reduced to 1.4 to 3.4 cm (mean 2.3 cm) after the last aspiration or at the time of discontinuing continuous drainage of the abscesses. The interval from the first aspiration to the last aspiration was 7 to 25 days, and the duration of continuous drainage was 5 to 8 days. In Case 9, continuous drainage was initiated at the time of the fifth aspiration, and was maintained for 5 days. The neurological condition of all patients except Case 11 improved as the size of the abscess decreased. Case 11 deteriorated progressively, and CT showed that cerebral edema had significantly increased around the abscess, though the size of the abscess had decreased after aspiration. The patient was treated with corticosteroids (betamethasone), and his symptoms subsequently resolved completely.

Perifocal edema was also evaluated by CT. Perifocal edema in six patients moderately decreased within 2 weeks after the last aspiration or after discontinuing continuous drainage, concurrent with a decrease in the volume of the abscess, but in five patients (Cases 1, 5, 7, 8, and 11) persisted for 3 weeks before moderate decrease. Perifocal edema did not change remarkably within 1 week after the last aspiration in all patients.

Nine of the 11 patients had no or minimal disability at discharge. Case 1 had persistent sensory aphasia and homonymous hemianopsia. Case 9 had left hemiparesis. In the follow-up period of 1.5 to 12 years, none of the patients showed clinical or radiological signs of recurrence.

**Representative Case**

A 13-year-old male (Case 10) with chronic sinusitis was admitted to our institution. Initial examination revealed decreased level of consciousness manifesting as somnolence (Glasgow Coma Scale 14) and bilateral papilledema. T1-weighted MR imaging showed a well-defined, homogeneous hypointense mass lesion with ring enhancement in the right frontal lobe after the administration of gadolinium-diethylenetriaminepenta-acetic acid (Fig. 1A). About 40 ml of purulent material was aspirated and drained from the abscess cavity through a right frontal burr hole under ultrasound guidance on the first day of admission. The patient became alert and neurologically stable. Piperacillin sodium (70 mg/kg/day) and cefmetazole sodium (70 mg/kg/day), as well as phenytoin for seizure prophylaxis, were administered. The size of the abscess was decreased to 3.4 cm on CT 24 hours after the first operation (Fig. 1B). A second aspiration was performed on 7th hospital day because CT demonstrated enlargement of the abscess to 3.8 cm (Fig. 1C). The size of the abscess was decreased to 2.8 cm on CT 24 hours after the second operation (Fig. 1D). CT on the 12th hospital day showed that the brain abscess was still 3.0 cm in diameter, so a third aspiration of purulent material was performed (Fig. 1E). The size of the abscess was decreased to 1.5 cm on CT 24 hours after the third operation (Fig. 1F). By the end of the 4th hospital week, antibiotics were discontinued because serial CT showed almost complete resolution of the perilesional brain edema and decreased enhancement of the abscess wall. The patient was discharged on the 34th hospital day without neurological abnormalities.

**Discussion**

Most patients in our series were treated by aspiration with or without continuous drainage of the abscesses and had a favorable outcome. Most patients were treated with penicillin and cephalosporin while awaiting the bacteriological results, and the regimens were promptly changed to a more suitable choice based on the results of culture and antibiotic sensitivity testing. Many series have shown that the initial neurological condition is strongly correlated with the mortality.14-17 In our series, none of the patients were comatose preoperatively, and there were no deaths. Earlier detection and diagnosis by CT and MR imaging, and correct antibiotic therapy may have contributed to the favorable outcome in our series.

Bacterial brain abscess often requires repeated aspiration before the abscess finally resolves.5 Most series found that two or three aspiration procedures were generally sufficient.5,20-27 In our series, repeated surgical drainage was undertaken either when the size and mass effect of the abscess were not decreased on serial CT after the first operation, or when there was enlargement of the abscess despite antibiotic therapy. Eight of the 11 patients required repeated aspiration of abscesses: two to three times in most patients. We employed intraoperative ultrasound imaging-guided or CT-guided stereotactic aspiration in the last five patients in our series to achieve precise localization and decompression of abscess cavities with minimal tissue damage, especially to avoid ventricular rupture of the abscess. The abscess can be almost completely drained by stereotactic aspiration using intraoperative monitoring with CT, resulting in reduced number of aspirations.14

The size of the brain abscess is an important factor when planning initial therapy. Large abscesses may

*Neurol Med Chir (Tokyo) 40, February, 2000*
be refractory to antibiotic treatment alone.\textsuperscript{19} Medical treatment has been successful with abscesses smaller than 2.0 cm,\textsuperscript{16} 2.5 cm,\textsuperscript{17,19} or 2.0–3.0\,cm\textsuperscript{10} in diameter in a few highly selected patients. However, the guidelines for treatment by aspiration are unclear; for example, when should an abscess be tapped again, and when can an abscess be treated by antibiotics alone without further aspiration. An algorithm for the treatment of brain abscess has indicated that antibiotics can be used as the sole treatment for lesions smaller than 1.5 cm in a neurologically intact patient with a clear source of infection in a solitary brain abscess, or smaller than 2.5 cm if initial treatment of multiple abscesses has identified the causative organism.\textsuperscript{12} The abscess should be repeatedly aspirated when the size is not changed or has enlarged from the initial postoperative CT scan.

We sought to determine the size of the brain abscess which can be safely treated by antibiotics alone without further aspiration. In our series, abscesses could be successfully treated by antibiotics alone without further aspiration after the diameter was reduced to 1.4 to 3.4 cm (mean 2.3 cm). Organisms possibly remain viable in the pus material in abscesses of certain sizes despite lethal levels of antibiotics, and surgical drainage is required.\textsuperscript{14,18} Based on our limited experience, we propose the following guidelines. The size of the abscess should be closely monitored after aspiration by weekly CT.
Medical treatment is likely to give satisfactory results when the diameter of the abscess becomes less than 2 to 3 cm and the size does not increase on serial CT. Medical treatment will also reduce perifocal edema within 3 weeks of the last aspiration, with a concomitant decrease in the volume of the abscess. When the abscess is not close to a ventricle, continuous drainage can be combined with aspiration. Care must be taken not to penetrate an abscess in a ventricle, which might cause death. Any evidence of neurological deterioration requires immediate CT to evaluate whether the lesion has enlarged again, which would require surgical aspiration. It is important to follow the patient carefully by CT until the abscess has completely resolved.

References

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scess is to halt the vicious circle that disturbs the healing of infection, it is usually performed only once. The interval between repeated aspirations in this series may be considered too short. In the treatment of brain abscess, it is also essential to help patients recover their resistance to infection. Therefore, the authors' guidelines should have included details of medical therapy, including the timing and dose of corticosteroids and γ-globulin.

The authors report on a series of 17 brain abscesses that were treated over 11 years. Among these, 4 underwent excision of the entire abscess and 13 underwent aspiration through a burr hole at one or more occasions. The mainstay of the treatment was parenteral antibiotics. The patients requiring multiple aspiration had enlargement of the abscess despite previous aspiration and antibiotics. Although this is not a controlled study, they have concluded that once the abscess is reduced to a size of less than 3.4 cm, it does not need to be re-aspirated. In addition, abscesses less than this size can be treated solely by antibiotics, if the organism is known. I intuitively agree with the treatment algorithm for intracranial brain abscesses that they have suggested. However, it is difficult to fully substantiate this based on the information available in this report. In order to substantiate this, a prospective controlled study would have to be undertaken. Given the rarity of brain abscesses in these days in the immunocompetent patient, this would be difficult to perform at a single center.

Chandranath Sen, M.D.
Department of Neurosurgery
The Mount Sinai Medical Center
New York, New York, U.S.A.

Adequate abscess drainage and effective antibiotic therapy remain the cornerstones of treatment of a brain abscess. The advantages of aspiration are that it is simple, can be used in the early stages, and may give swift relief of ICP. It provides essential information, that an abscess is present, what the organisms are and which antibiotic they are sensitive to, and whether a capsule has formed. The authors give us the guidelines for treatment of brain abscess by aspiration. I do think that these guidelines are useful for neurosurgeons. Based on the small group of patients, the experience is limited, so more patients must be treated to confirm that these guidelines are correct and useful.
References


Shu-yuan Yang, M.D.
Department of Neurosurgery
Tianjin Medical University
General Hospital
Tianjin, People’s Republic of China

Neurol Med Chir (Tokyo) 40, February, 2000