Stereotaxic surgery in the treatment of multiple brain abscesses

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Controversy exists regarding the optimal treatment for patients with multiple brain abscesses. These lesions are often small and located deep in the brain and close to vital structures, making surgery difficult. With this in mind the authors review their experience in treating multiple abscesses using computerized tomography (CT)-guided stereotaxic aspiration. From 1983 to 1985, 15 patients were treated for multiple brain abscesses, of whom eight underwent stereotaxic aspiration. There were a total of 28 abscesses in these eight patients: 11 abscesses were aspirated and two excised using CT-guided techniques. Most were cortical in location, although there were 12 in the deep white matter, one in the thalamus, and two in the caudate nucleus. All patients received a total of 6 weeks of antibiotic therapy. Follow-up CT showed resolution of the abscesses in all patients. Currently, four are neurologically normal, one has a mild hemiparesis, one has a well-controlled seizure disorder, and one requires supportive care. A single death occurred 5 weeks postoperatively of unrelated causes. Location, size, and age of an abscess all have bearing upon the response to management and outcome of the patient. Stereotaxic surgery is a procedure with minimal morbidity and mortality. Stereotaxic aspiration should be considered in patients with small, multiple, or deep-seated abscesses, in those who are poor operative candidates, and in those who have failed prior therapy.

KEY WORDS • brain abscess • stereotaxic surgery • aspiration • computerized tomography

DESPITE the availability of many antimicrobial agents, the mortality rate from brain abscesses remained high through the early 1970's, with reported figures of 40% to 60%. However, in the past 10 years the prognosis has improved markedly, with some authors reporting mortality rates of zero. This decrease in mortality has been attributed to a variety of factors including: improved diagnostic modalities, earlier diagnosis, better bacteriological isolation techniques, improved antibiotics, and earlier surgery. Unfortunately, multiple abscesses continue to be difficult to treat.

The incidence of multiple brain abscesses ranged from 1% to 15% in older series of brain abscesses; however, since the advent of computerized tomography (CT) they have been reported more frequently. The mortality rate associated with multiple abscesses has been higher than with single brain abscesses: 80% to 100% compared with 0% to 60%, respectively. The higher mortality rate in patients with multiple abscesses has been attributed to various factors. Since
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TABLE 1
Clinical data and outcome in eight patients with multiple brain abscesses

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Sex, Age (yrs)</th>
<th>Symptoms</th>
<th>Signs</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M, 21</td>
<td>nausea, vomiting, seizures</td>
<td>fever, lethargy, hemiparesis, aphasia</td>
<td>normal, controlled seizures</td>
</tr>
<tr>
<td>2</td>
<td>F, 21</td>
<td>headache</td>
<td>fever, meningeismus, papilledema, normal neurological status</td>
<td>normal</td>
</tr>
<tr>
<td>3</td>
<td>M, 53</td>
<td>nausea, vomiting, headache</td>
<td>fever, meningeismus, normal neurological status</td>
<td>normal</td>
</tr>
<tr>
<td>4</td>
<td>M, 49</td>
<td>headache, weakness</td>
<td>lethargy, aphasia, hemiplegia</td>
<td>self-care, hemiparesis</td>
</tr>
<tr>
<td>5</td>
<td>F, 35</td>
<td>nausea, vomiting, sudden coma</td>
<td>fever, purposeful movement to noxious stimuli</td>
<td>blind, needs supportive care</td>
</tr>
<tr>
<td>6</td>
<td>M, 60</td>
<td>sepsis, weakness</td>
<td>fever, hemiparesis</td>
<td>normal</td>
</tr>
<tr>
<td>7</td>
<td>F, 57</td>
<td>headache, memory loss</td>
<td>ataxia</td>
<td>normal</td>
</tr>
<tr>
<td>8</td>
<td>M, 53</td>
<td>nausea, vomiting, headache, transient ischemic attack, weakness</td>
<td>lethargy, hemiparesis new murmer</td>
<td>died</td>
</tr>
</tbody>
</table>

The patients were treated at both the University of Iowa Hospitals and Clinics and the Veterans Administration Medical Center in Iowa City, Iowa. During this time a total of 43 patients were treated for brain abscesses. Fifteen of these patients had multiple abscesses, eight of whom underwent stereotaxic aspiration. Of the remaining seven patients, three were treated with non-stereotaxic surgery and antibiotics (excision of one abscess in one patient and free-hand aspiration of one abscess in two patients) and four received antibiotic therapy alone. The initial work-up consisted of routine laboratory evaluation with complete blood count, serum chemical testing, erythrocyte sedimentation rate, and urinalysis. Blood, urine, and sputum cultures were obtained when appropriate. In all cases, chest, skull, sinus, and dental films were obtained in addition to CT scans of the head.

All stereotaxic procedures utilized the Brown-Roberts-Wells (BRW) stereotaxic system* and were performed by one surgeon. On the morning of the procedure, with the localizing ring attached, an enhanced CT scan was obtained with slices 5 mm thick. Using a program provided by the BRW guidance system, the three-dimensional coordinates and trajectories of the abscesses were obtained. The patient was then transported to the operating room where, under local anesthesia, the stereotaxic procedure was performed. In all, 11 of the 28 abscesses were drained and two were excised using CT-guided techniques. In two cases a drain was left in the abscess cavity and exteriorized. Follow-up data were obtained through clinic visits and repeat CT scans.

Summary of Cases

Presentation

Most patients presented with symptoms typical for brain abscesses (Table 1). Headache was present in five (62.5%), nausea and vomiting in four (50%), and altered level of consciousness in four (50%). One patient also had meningeismus and one presented with seizure in addition to the constellation of symptoms listed above. The initial CT scans showed a total of 28 abscesses in the eight patients. Five patients had two abscesses each, two had three, and one had a total of 12 abscesses. In 13 instances the abscesses were cortical in location (at the junction of the gray and white matter), 12 were deep within the white matter, and three were within the thalamus or caudate nucleus (Table 2).

Preoperative Care

In all patients, a search was made for predisposing factors. One patient (Case 4) was an alcoholic and therefore was presumably immunocompromised. Two patients had endocarditis, resulting from calcific aortic stenosis in one (Case 8) and from an infected prosthetic aortic valve in the other (Case 6). One patient (Case 3) developed an abscess while receiving antibiotics for meningitis. No causes were identified in the remaining four.

TABLE 2
Location of abscesses and response to antibiotics prior to surgical intervention

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Abscess Location</th>
<th>Results With Antibiotics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 thalamic</td>
<td>enlargement</td>
</tr>
<tr>
<td></td>
<td>2 cortical</td>
<td>resolution (2)</td>
</tr>
<tr>
<td>2</td>
<td>1 deep white matter</td>
<td>enlargement</td>
</tr>
<tr>
<td></td>
<td>1 corpus callosal</td>
<td>enlargement</td>
</tr>
<tr>
<td></td>
<td>1 cortical</td>
<td>resolution</td>
</tr>
<tr>
<td>3</td>
<td>4 2 deep white matter</td>
<td>enlargement</td>
</tr>
<tr>
<td></td>
<td>5 1 caudate</td>
<td>enlargement</td>
</tr>
<tr>
<td></td>
<td>1 thalamic</td>
<td>resolution</td>
</tr>
<tr>
<td>4</td>
<td>6 1 deep white matter</td>
<td>resolution</td>
</tr>
<tr>
<td></td>
<td>1 cortical</td>
<td>resolution</td>
</tr>
<tr>
<td>5</td>
<td>8 3 deep white cerebritis</td>
<td>resolution</td>
</tr>
<tr>
<td></td>
<td>5 cortical</td>
<td>resolution</td>
</tr>
</tbody>
</table>

* Brown-Roberts-Wells stereotaxic system manufactured by Radionics, Inc., Burlington, Massachusetts.
At the time of admission, all patients were started on a course of intravenous dexamethasone (6 to 10 mg/6 hrs) and six had loading doses of anticonvulsants (Dilantin (phenytoin) 100 mg/6 hrs). On the basis of the presenting signs, symptoms, and CT scans, seven of the patients were started on courses of broad-spectrum antibiotics. The antibiotics chosen had good penetration of the blood-brain barrier and also gave broad-spectrum coverage for both Gram-positive and Gram-negative organisms. The length of time that each patient was treated with antibiotics prior to surgery was variable, ranging from 3 days to 6 weeks, and was entirely dependent upon the patient's response to the drugs (Table 2). The single patient who did not receive preoperative antibiotics (Case 7) was thought to have metastatic brain tumors since her presentation and laboratory evaluation did not suggest brain abscesses (Fig. 1 and Table 1).

**Indications for Surgery**

The indications for stereotaxic aspiration in this series included: a progressive increase in abscess size in three patients (Cases 1, 3, and 5); progressive neurological deficit in two (Cases 4 and 6); abscess enlargement with a progressive neurological deficit in one patient (Case 2); to obtain a specimen for culture in one patient (Case 8); and to establish a diagnosis in one patient (Case 7). Three patients underwent an aspiration as an emergency procedure. The first (Case 1, Fig. 2) had undergone excision of a single cortical abscess 1 week earlier in the hope that, with culture-specific antibiotic therapy, he might show a better response. In spite of culture-specific antibiotics, he subsequently required an emergency stereotaxic procedure because of a progressive increase in the size of his thalamic abscess. Two additional patients also had emergency stereotaxic aspiration, one (Case 3) because of a progressive increase in the size of his corpus callosum abscess and the other (Case 4) because of progression from hemiparesis to hemiplegia. Surgery in the remaining five patients was performed electively.

**Microbiological Data and Management**

Each patient underwent one stereotaxic procedure. The amount of fluid aspirated ranged from 0 to 23 cc. Gram stain of the aspirate revealed the offending organism in only two of the eight cases (Table 3). Aerobic, anaerobic, mycobacterial, and fungal cultures were set

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**TABLE 3**

Management and bacteriological yield with stereotaxic drainage

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Duration of Preop Antibiotic</th>
<th>Gram Stain</th>
<th>Culture</th>
<th>Biopsy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2 wks no organism</td>
<td>no organism</td>
<td>no growth</td>
<td>no organism</td>
</tr>
<tr>
<td>2</td>
<td>2 wks no organism</td>
<td>no organism</td>
<td>no growth</td>
<td>no organism</td>
</tr>
<tr>
<td>3</td>
<td>3 wks no organism</td>
<td>Peptostreptococcus</td>
<td>Gram + coccus</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1 wk Gram + coccus</td>
<td>Peptostreptococcus</td>
<td>Gram + coccus</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>2 wks no organism</td>
<td>no organism</td>
<td>no growth</td>
<td>no organism</td>
</tr>
<tr>
<td>6</td>
<td>6 wks no organism</td>
<td>no organism</td>
<td>no growth</td>
<td>no organism</td>
</tr>
<tr>
<td>7</td>
<td>none Nocardia</td>
<td>Nocardia</td>
<td>Nocardia</td>
<td>Nocardia</td>
</tr>
<tr>
<td>8</td>
<td>2 wks no organism</td>
<td>no organism</td>
<td>no growth</td>
<td>no organism</td>
</tr>
</tbody>
</table>

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**FIG. 1.** Serial computerized tomography scans from Case 7. The initial scans obtained on January 22, 1985 (upper) show two cortical enhancing lesions with hypodense cores and surrounding edema. The irregular contour of the mesial parietal lesion raised the suspicion of metastases. Stereotaxic aspiration was performed on January 23, yielding Nocardia asteroides. Postoperative scans obtained on January 31 (center) show the decrease in abscess size after aspiration. The last scans (lower) show a residual area of calcification from the mesial parietal lesion.
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up in all cases. Cultures were positive from three stereotaxic aspirates (Table 3). One of the isolates was Nocardia asteroides and the remainder were anaerobic bacteria. In five patients a biopsy was made of the abscess wall in an effort to gain additional diagnostic information from the stereotaxic procedure (Table 3). This was helpful in two patients: in one (Case 4) a Gram-positive coccus was seen and in the other (Case 7) Nocardia was identified. Both of these patients also had positive Gram stains and cultures from the abscess aspirate. In the remaining three patients, biopsy material showed neutrophils and gliosis but no organisms.

Each patient received a total of 6 weeks of intravenous antibiotic therapy. This 6-week course included both pre- and postoperative treatment. In addition to this intravenous treatment, the patient with the Nocardia abscess received an additional 10½ months of oral trimethoprim/sulfamethoxazole for a total of 12 months of coverage. All patients received dexamethasone after surgery. The steroid was tapered on an individual basis depending on the extent of mass effect and edema seen on follow-up CT scans. Postoperative CT scans were obtained every 7 to 10 days until the time of discharge. All patients who were given anticonvulsant drugs prior to surgery continued to receive them after discharge.

**Outcome**

The results in this series demonstrate the success that is possible with stereotaxy in the treatment of multiple brain abscesses (Table 1). Six patients had a good outcome: four are without sequelae (Cases 2, 3, 6, and 7), one is normal except for a well-controlled seizure disorder (Case 1), and one has a mild residual hemiparesis but is capable of self-care (Case 4). One patient (Case 5) is blind secondary to cortical infarcts; she requires supportive care, and developed a seizure disorder 12 months postoperatively. She lives at home with her family and has shown some signs of improvement. The single death occurred 35 days postoperatively in Case 8. Although no conclusive cause of death was found, because of his underlying cardiac dysrhythmia and heart failure it seems likely that he suffered a fatal arrhythmia or myocardial infarction.

Follow-up CT scans have shown resolution of all abscesses in the seven survivors. There were no complications associated with the stereotaxic procedure in spite of the fact that it was performed as an emergency in three cases and that these patients were at times debilitated. Follow-up monitoring has failed to show recurrence of abscesses in any of the seven survivors after an average follow-up period of 29 months.

**Discussion**

Among 43 patients treated for brain abscesses, the incidence of multiple lesions was 35%, with no mortality directly related to the brain abscesses in those cases.

This is comparable to other series treated since the introduction of the CT scanner. In these series, multiple abscesses were found in 11% to 50% of the patients, with mortality rates ranging...
from 0% to 8%. Prior to the advent of CT, multiple abscesses had a reported incidence of between 1% and 15%. In these same series, the mortality rate for multiple abscesses was 80% to 100% versus 23% to 60% for patients with single abscesses. Reasons offered for the high mortality associated with multiple lesions included delays in diagnosis and difficulties in localizing the abscesses. In fact, these patients often died before receiving any treatment. Thus, it seems clear that the increased incidence and decreased mortality from multiple abscesses is primarily related to the CT and its ability to give an earlier diagnosis, accurate location and size, and important follow-up data during the subsequent treatment.

The treatment for patients with multiple brain abscesses has received little attention in spite of the increased frequency with which the abscesses have been diagnosed. Previous publications have had proponents of both medical and surgical modalities. We believe that stereotaxic surgery is ideally suited to the management of multiple brain abscesses. The use of stereotaxic aspiration in the treatment of brain abscesses has been reported previously. The use of stereotaxy enables the surgeon to treat small and deep lesions within eloquent regions of the brain without harming surrounding structures. Multiple lesions can easily be treated in a single setting utilizing local anesthesia, which is important since these patients are often too debilitated to undergo general anesthesia.

Once a diagnosis of multiple brain abscesses is made, the patient is often started on a course of broad-spectrum antibiotics and followed clinically and by sequential CT scans. There have been many reports of successful treatment of abscesses with antibiotics alone. Because the CT scanner offers early diagnosis and allows monitoring of the response of abscesses to treatment, many investigators have used this modality alone. However, there are several potential problems that can arise when antibiotics are used without surgery. If treated nonoperatively, the presumed organism is often cultured from blood, sputum, and/or cerebrospinal fluid and antibiotic treatment for the abscess is based on these results. However, the offending organism in the brain abscess may not be the cause of the infection elsewhere. Empiric broad-spectrum antibiotics will not cover organisms such as Nocardia, Mycobacteria, certain fungi, or parasites. Finally, several papers have shown that, in spite of adequate penetration of antibiotics into an abscess, treatment may still fail.

There are several CT features that can be evaluated to predict the outcome when antibiotics are used as the initial modality. These include the time at which antibiotics are started, the abscess size, and the location of the abscess. Success with medical therapy alone may be dependent on the time that antibiotic therapy is initiated. If therapy is started prior to formation of the necrotic center, abscess formation may be aborted.
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size of the deep white matter abscesses was 2.0 cm, of
the deep caudate nucleus abscesses was 2.2 cm, and of
the cortical abscesses was 1.5 cm. These values are not
significantly different from each other. Difficulty in the
treatment of deep abscesses has also been demonstrated
by Whelan and Hilal.27 In their series, a postoperative
residual focus of enhancement in the periventricular
area led to a recurrence in two of the three cases in
which it was seen. In contrast, in the seven cases where
there was residual enhancement in a cortical location,
there were no recurrences. They considered that a resi-
dual focus of infection in the cortical gray matter could
more easily be eradicated because of its increased vas-
cular supply relative to the periventricular white matter,
where leptomeningeal collateral vessels are not present.

Historically, the technique of aspiration was associated
with a slightly higher mortality rate than that for excision1,13,19,31,33,36,59 and, because of this, excision was the
preferred surgical modality for treatment of brain
abscesses. However, series published during the CT era
have shown an 11% mortality rate for aspiration com-
pared with 8% for excision.1,12,25,27,37,39,41,46,49 In spite of
the improved survival rate, the use of excision is not
well suited to the treatment of multiple or deep ab-
sscesses. Because these abscesses are often small and
deply located, free-hand aspiration may require mul-
tiple passes before contact with the lesion is made. In
contrast, CT-guided stereotaxic aspiration can accu-
rately localize and treat small and deep lesions within
eloquent regions of the brain. Multiple lesions can be
drained at a single procedure and one pass per lesion
may be all that is necessary.

Comparing the results of patients treated stereotaxi-
cally with those of patients treated nonstereotaxically
reveals several interesting points. First, there was no
difference between the groups in terms of the duration
of hospitalization, microbiological yield, or incidence
of seizures. In addition, in both groups the overall
results were good, with improvement in the neurologi-
cal deficits after treatment. As has been reported before,
the best predictor of outcome is the preoperative neu-
rological condition of the patient.1,15,19,20,33,34,57 How-
ever, both the location and size of the abscesses was
different between the two groups. In the nonstereotaxic
group there was only one deep (periventricular) abscess;
all of the remaining 24 abscesses were cortical in loca-
tion. The abscesses also tended to be smaller in the
nonstereotaxic group, with an average size of 1.1 cm
compared with 1.75 cm in the stereotaxic group. Both
the cortical location and the smaller size help to explain
the better response to antibiotics shown by the nonstere-
otaxic group. One patient died in each treatment
group; both patients had overwhelming sepsis and en-
docarditis in addition to their multiple brain abscesses
and eventually died of cardiopulmonary arrest. The
most important difference between the two groups was
in the ease of abscess aspiration. In both of the non-
stereotaxic aspirations, multiple passes were required
before the abscesses were successfully punctured. In the

first patient, attempts at aspirating a 2-cm cortical
abscess were eventually aborted after multiple attempts.
A second 2.5-cm cortical abscess was approached from
a second burr hole and eventually drained, but again
only after multiple attempts. In the second patient,
intraoperative ultrasonography was used to help target
a 2-cm periventricular abscess. In spite of this, multiple
passes were again required before contact with the lesion
was made. This difficulty in targeting abscesses was
never encountered in the patients with stereotaxic as-
piration where only one pass was made for each abscess.

This series represents the largest reported group of
brain abscess patients treated with stereotaxic surgery.
Our results are similar to those in recent series where a
variety of modalities were used. Because of the multiple
abscesses, each patient presented a challenging ther-
apeutic problem, emphasizing the potential role of
stereotaxic aspiration. The functional outcome in our
series is similar to the results that have been reported
for single abscesses, which again stresses the role of CT-
guided aspiration and biopsy.

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