ELSEVIER

Infection

STEREOTACTIC SURGERY IN THE MANAGEMENT OF BRAIN ABSCESS

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BACKGROUND

Bacterial brain abscesses can be diagnosed and treated with stereotactic aspiration.

METHODS

From 1991 to 1997 we have used computed tomography-guided stereotactic aspiration to diagnose and treat 21 patients with a total of 58 bacterial brain abscesses. The ages of the patients ranged from 4 to 72 years (median 25 years); 11 of these 21 patients had multiple abscesses. The number of abscesses per patient with multiple abscesses ranged from 2 to 9, all located deep in subcortical white matter.

RESULTS

All patients underwent stereotactic surgical drainage and an 8-week intravenous antibiotic medical treatment. Of the 58 abscesses, 23 were aspirated. Of these 23 abscesses, 19 were radiologically stage III or IV and four were stage I or II. Pathological examination confirmed radiological staging in 19 patients (83%). Except for the three patients who have mild residual hemiparesis and one patient recovering from ataxia, all patients had complete neurological recovery.

CONCLUSIONS

Computed tomography-guided stereotaxy achieved all the objectives of management; namely, ascertaining the diagnosis, draining the content of the mass, and obtaining pus for accurate bacteriological diagnosis without morbidity. Stereotactic aspiration combined with an 8-week intravenous antibiotic regimen has yielded an effective therapeutic result in all of our abscesses, small or large, solitary or multiple, superficial or deep-seated. A high radiological-pathological correlation was also deduced from this study.

KEY WORDS

Bacterial brain abscesses, computed tomography, multiple brain abscesses, stereotactic surgery.

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The introduction of computed tomography (CT)-guided stereotactic techniques has had a dramatic effect on the management of brain abscess [2,12,15,16,18,20,23]. Between 1971 and 1997, 204 cases of pyogenic brain abscesses have been treated in our institution. Before the introduction of CT in 1981, the mortality rate was 18%; it was reduced to 9% between 1981 and 1991, when CT was available [8]. The advent of stereotactic surgery has enabled us to attain zero mortality with very little morbidity. We present this series of 21 cases of bacterial brain abscess in non-AIDS patients diagnosed and treated stereotactically.

PATIENTS AND METHODS

During the period between March 1991 and September 1997, 21 of 679 consecutive patients with mass lesions who underwent stereotactic diagnostic and therapeutic procedures in our institution were diagnosed to have brain abscesses.

Tables 1 and 2 summarize the signs and symptoms at the time of admission, none of which had lasted more than 3 weeks. Headache and altered level of consciousness, ranging from mild confusion to drowsiness, was prominent. Eleven patients presented with focal deficits: hemiparesis in eight, dysphasia in two, and a visual field defect in one. Seizures occurred in six patients.

Complete blood counts, erythrocyte sedimentation rates (ESR), coagulation profile, serologic tests, urinalysis, and X-rays of skull, paranasal sinuses, and chest were performed preoperatively in all patients. Blood, urine, and sputum cultures were obtained when appropriate. Routine laboratory studies were not of particular value; mild elevation of leukocyte counts and ESR was found in all patients. None had human immunodeficiency virus infection.

Table 3 summarizes the clinical and radiological

1 Presenting Symptoms of our Patients at Admission

Presenting Symptoms	No. of Patients (%)
Headache	17 (81)
Nausea	11 (52)
Vomiting	11 (52)
Seizures	6 (30)
Fever	3 (14)

features of the series. There were 14 male and seven female patients. Their ages ranged between 4 and 72 years, with a mean of 28 years. Six patients had various predisposing infections. Five were immunocompromised, three of them receiving cytotoxic chemotherapy for non-Hodgkin's lymphoma, one for renal transplantation, and one child who was being followed up for major vessel transposition.

Our subject group included 58 abscesses in 21 patients; single lesions in 10 cases, and multiple ones in the remaining. In the solitary abscess group, two lesions were located in the thalamus, two in the basal ganglia, one in the mesencephalon, one in deep white matter, and four in the cortex. In the multiple abscess group, four patients had only deep-seated lesions, whereas six patients had both cortical and deep seated lesions (Figures 1**A** and 1**B**).

Radiological staging of the abscesses was based on CT features in all patients and reinforced by magnetic resonance imaging (MRI) in eight [17]. Among the 23 abscesses that were aspirated stereotactically, CT disclosed early and late capsule period (stage III and IV) in nineteen and early or late cerebritis (stage I and II) in four lesions (Table 4). MR imaging, available in eight cases, agreed with previous CT staging, with delineation of the bilobulated form of a single thalamic lesion in one case (Figure 1**A**) and the very thick irregular wall and heterogenous centre of the lesion in another single abscess. Hydrocephalus was noted in one case with multiple lesions around the third ventricle.

2 Presenting Signs of our Patients at Admission

Presenting Signs	No. of Patients (%)
Mental status:	
Alert	8 (38)
Drowsy	11 (52)
Responsive to painful stimuli only	2 (10)
Comatose	0
Papilloedema	10 (48)
Meningismus	3 (14)
Cranial nerve involvement	4 (19)
Pyramidal signs	10 (48)

Three patients had been started on antibiotics before referral to our institution. At the time of admission, all patients were started on dexamethasone and phenytoin.

CT-guided stereotactic biopsy procedures were performed using a Leksell stereotactic instrument (Elekta SA, Stockholm) under local anesthesia in adults and general anesthesia in children. The target points were determined to ensure sampling of hypodense, isodense, hyperdense, and enhancing regions. The spiral needle was used to penetrate and obtain samples of the wall and the center. Imprints of each piece of obtained tissue were stained (hematoxylin and eosin, and gram stains) and examined immediately in the operating room. Liquefied content of the cavity was then gently aspirated through an aspiration needle placed posterior to the geometric center of the lesion; 23 of the 58 abscesses were sampled and drained. Specimens were cultured for aerobic and anaerobic bacteria. Immediate postoperative CT scans were obtained to assess adequacy of aspiration and to detect possible complications.

Postoperatively, empiric therapy with two agents was started. In earlier cases, a combination of penicillin G and chloramphenicol were used. More recently, the combination of a nitroimidazole (metronidazole or ornidazole, 2 g/d) plus ampicillin-sulbactam (8 g/d) was usually preferred. Therapy was modified as soon as culture results became available. Appropriate antibiotics were administered intravenously for 6 to 8 weeks.

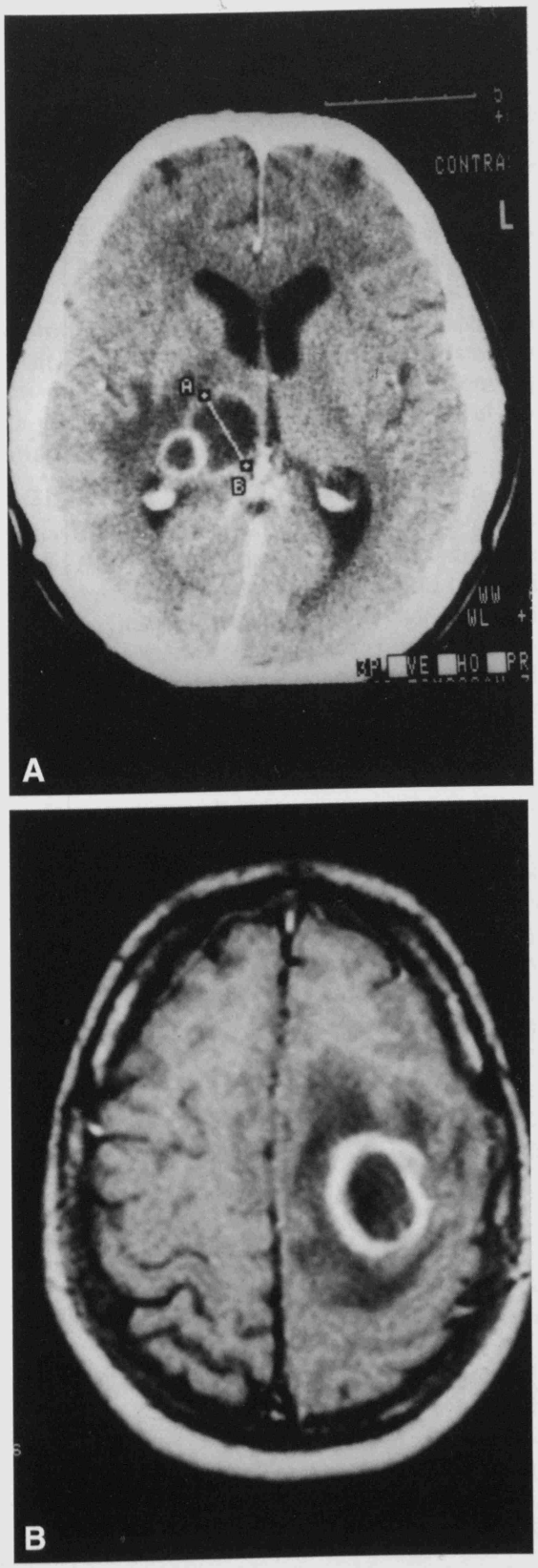
Dexamethasone and phenytoin were continued in all patients postoperatively. The steroid dose was tapered depending on the extent of mass effect and edema seen on CT scans, obtained weekly during the course of the therapy, and monthly after discontinuation of the treatment for the next 6 months. Anticonvulsants were continued for 2 years, after which they were tapered off.

The follow up period ranged from 11 to 84 months, with an average of 3.1 years.

Results

Surgical Intervention

There was no mortality. An iatrogenic intracerebral hematoma associated with the procedure represented the only morbidity and was evacuated



1 (**A**) A bilobulated rim enhancing right thalamic lesion is shown. (**B**) Post-contrast T1-weighted MR scan shows a superficial rim enhancing lesion with peripheral edema.

through a craniotomy. Three patients required a repeat aspiration.

BACTERIOLOGY

Cultures of the specimens revealed the offending organism in 12 of the cases. Two bacteria were isolated in one patient. *Peptostreptococci* were isolated in five, *staphylococcus aureus* in four, and *viridans streptococci* in three. In one immunocompromised patient, *N. asteroides* was identified as the offending agent. Preoperative use of antibiotics in three patients correlated with sterile cultures despite the presence of an organism on Gram stains. Ampicillin-sulbactam started empirically were changed to vancomycin (2g/d) in one instance, in which a methicillin-resistant *S. aureus* was isolated. Trimethoprim-sulromethoxazole therapy was used for the *Nocardia* abscess. Initial antimicrobial chemotherapy was continued in the remaining patients for 8 weeks without any modification.

PATHOLOGY

An intraoperative pathological diagnosis of the abscess could be made in all of the cases on imprint smear examinations of the surgical specimens. Examination revealed typical features associated with the zone of the abscess the specimen represented, varying with ages of the lesions. Hypodense centers showed necrosis, liquefaction, and polymorphonuclear leukocytes in mature abscess, but hyperemia and a neutrophilic infiltration in the early stages. Regions surrounding the abscess showed gliosis, which could be very severe (Figure 2).

RADIOLOGY AND PATHOLOGICAL CORRELATION

In our series, according to the CT criteria presented in the discussion, 19 of 23 lesions were assessed as radiological stage III or IV (early and late capsule). Of these, 17 were pathologically diagnosed as "abscess" or "encapsulation." In two specimens, pathological diagnosis was cerebritis. Of the remaining four lesions, which were radiologically stage I or II (early and late cerebritis), two were assessed as cerebritis histopathologically and two were frank abscesses. In summary, 19 of the 23 aspirated lesions showed absolute pathological-radiological correlation. In four lesions, the radiological stage and pathological results did not correlate (Table 4).

The time course of abscess resolution on CT scans varied. A decrease in size was noticeable in the first week after surgery (Figure 3), whereas complete resolution of the abscess cavity and contrast enhancement occurred in 2 to 6 months (Figures 4**A** and 4**B**). In one patient, CT scans up to 5 years after

3 Summary of Clinical, Radiological, and Bacteriological Features of our Data

Case No.	Age/ Sex	Predisposing Factors	No. of Lesions	Location of Lesion	Mean Diameter	Culture	Functional Outcome	Duration of Follow-up (mo.)
1	37 M	Unknown	Multiple (3)	Cortical, deep white matter, bilateral	0.8 cm	*Peptostreptococcus*	Excellent	84
2	33 M	Unknown	Multiple (2)	Deep white matter, bilateral	0.75 cm	No growth	Excellent	65
3	30 F	Unknown	Multiple (5)	Deep white matter, bilateral	1 cm	No growth	Excellent	54
4***	9 F	Unknown	Multiple (8)	Cortical, deep white matter	1.8 cm	No growth	Excellent	56
5	16 F	Dental abscess	Multiple (5)	Cortical, deep white matter, bilateral	0.8 cm	No growth	Mild left hemiparesis	51
6	32 F	Unknown	Single	Thalamic (R)	2.5 cm	*Viridans strep.*	Mild left hemiparesis	48
7**	11 M	Immunocompromised	Single	Deep parietal	1.3 cm	No growth	Excellent	48
8**	48 M	Chronic otitis media	Single	Thalamic (R)	3.6 cm	No growth	Excellent	44
9	30 M	Unknown	Multiple (4)	Cortical, deep white matter	1.5 cm	*Peptostreptococcus*	Excellent	44
10***	24 M	Pulmonary	Single	Parietal (L)	3.5 cm	*Viridans strep.*	Excellent	34
11	20 F	Unknown	Multiple (5)	Deep white matter	1.2 cm	No growth	Excellent	42
12***	72 M	Infective endocarditis	Single	Parietal (L)	4.5 cm	*S. aureus*	Excellent	19
13	43 M	Immunocompromised	Multiple (2)	IIIrd vent. + L. thalamic	3.0 cm	*Viridans strep.*	Mild right hemiparesis	24
14	4 F	Immunocompromised	Multiple (9)	Cortical and deep white matter, bilateral	1.5 cm	*S. aureus*	Excellent	32
15	25 M	Pulmonary infection	Single	Parietal (L)	3.5 cm	*Peptostreptococcus*	Excellent	22
16	15 M	Nasopharyngeal infection	Multiple (3)	Cortical and deep white matter	2.5 cm	*Peptostr., viridans strep.*	Excellent	16
17	27 M	Unknown	Single	Frontal (L)	1.5 cm	*S. aureus*	Excellent	19
18	49 F	Unknown	Single	Caudate nucleus	2.0 cm	*S. aureus*	Excellent	48
19	22 M	Unknown	Single	Mesencephalon (R)	1.6 cm	No growth	Excellent	12
20***	31 M	Immunocompromised	Multiple (2)	Frontal (R) and cerebellar (R)	2.5 cm	*N. asteroides*	Excellent	14
21	10 M	Immunocompromised	Single	Thalamic (R)	2.2 cm	No growth	Severely disabled	11

*Two aspirations from the right frontal and parietal regions of 2.5 and 3 mL, respectively, were carried out during the same session.

**Combined treatment with ceftriaxone and ornidazole was used preoperatively before admission to our clinic.

***Repeated aspiration.

4 Radiological-Pathological Correlation

Pathological Staging	Radiological Staging			
	Cerebritis Early	Cerebritis Late	Encapsulation Early	Encapsulation Late
Cerebritis	1	1	2	0
Encapsulation	1	1	15	2

the aspiration still showed persisting enhancement at the site of prior abscesses, considerably smaller in size and without mass effect or surrounding edema. This patient is still under close clinical observation and radiological follow-up.

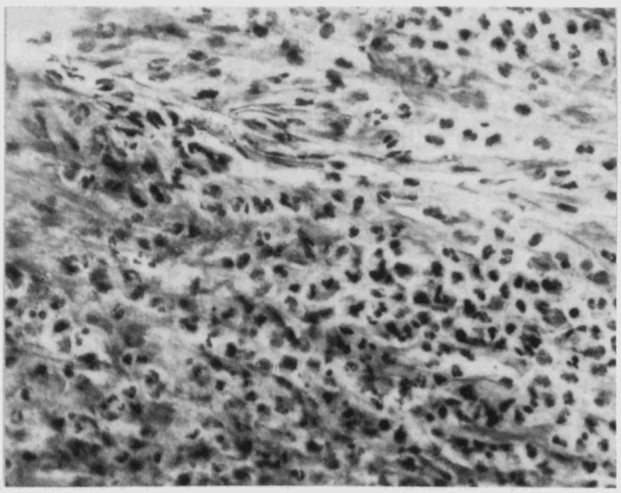
PROGNOSIS

There have been no recurrences; 20 of the 21 patients had excellent functional recovery: seventeen are neurologically normal, three have mild residual hemiparesis. Only one patient (the 10-year-old child who had major vessel transposition) who was operated on for an intracerebral haematoma remained ataxic. In one patient seizures occurred after the discontinuation of anticonvulsant therapy.

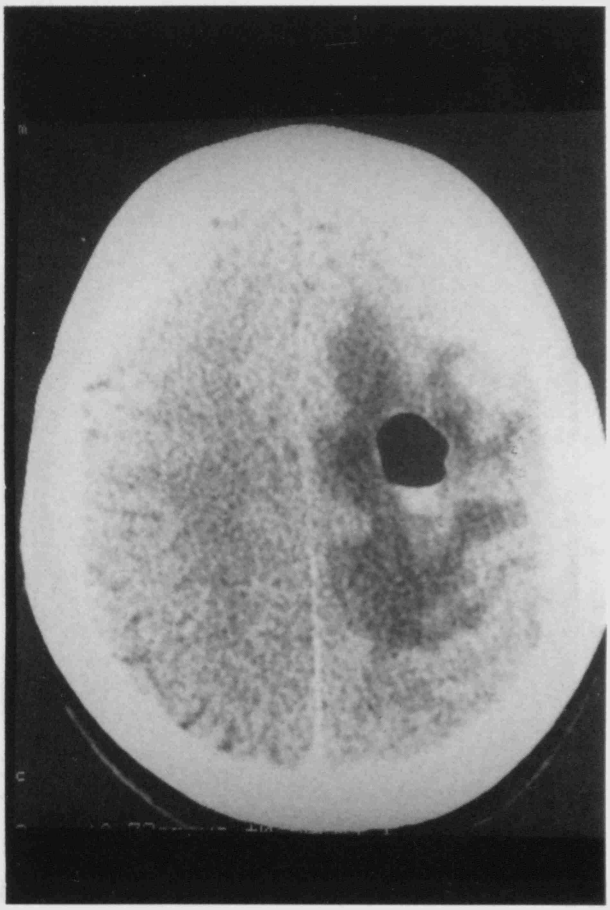
DISCUSSION

Throughout the history of neurosurgery, treatment of brain abscess has been a challenge. Various types of operative procedures have been used. Choice of procedure has been the subject of many debates [15,20,22]. Craniotomy, much advocated in the earlier era, when neither antibiotics nor CT was available, is now rarely resorted to. Aspiration, repeated as necessary or with drainage, has widely replaced attempts at complete excision.

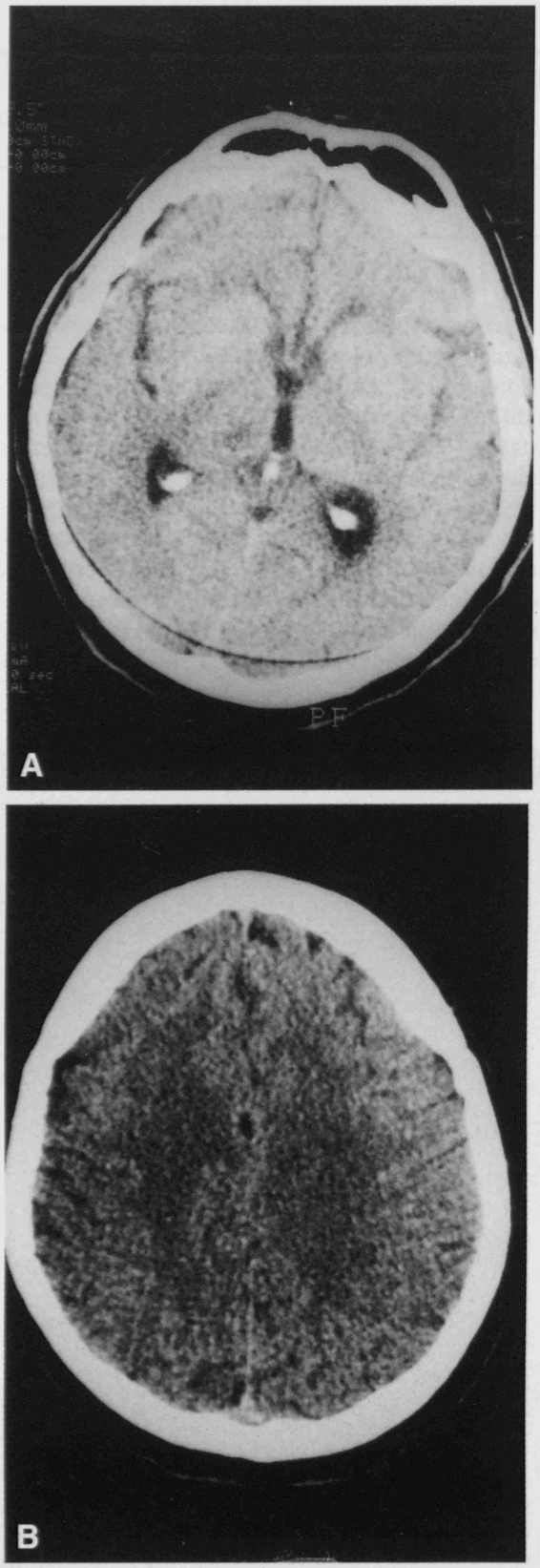
Nonsurgical empiric treatment of suspected small brain abscesses with antibiotics has been advocated [3,7]. Rational management of intracranial mass lesions requires possession of a positive diagnosis before implementation of therapeutic measures. As diagnosis based only on clinical and neuroradiological findings can be erroneous, nonsurgical therapeutic decisions should not be taken without positive pathological diagnosis. Stereotactic management of brain abscess, allowing



2 Cerebritis: polymorphonuclear leukocyte infiltration in central focus. HE. × 100.



3 Same patient as Fig 1**B**. Abscess has totally disappeared after the first aspiration.



4 (**A**) Same patient as Fig 1**A**. Control CT scan after 6 months shows total resolution. (**B**) Same patient as Fig 1**B** and 3. No recognizable lesion is present at the previous abscess site on the follow-up CT scan.

both confirmation of the diagnosis and institution of therapy by aspiration of its contents and identification of the offending organism, has become widespread with the introduction of CT-guided stereotaxy [4–6,9,13,14,19,22]. A review of the recent literature shows several series of brain abscesses primarily treated with stereotactic techniques. Shahzadi et al have reported their results of stereotactic management in 20 consecutive patients with 28 brain abscesses with zero mortality and 15% morbidity [19]. Stapleton et al, reviewing their series of 11 patients, concluded that stereotactic aspiration should be considered the treatment of choice in all but the most superficial and the largest cerebral abscesses [21]. Kondziolka et al related the failure of stereotactic treatment of brain abscesses in a series of 29 cases, because of either inadequate aspiration, lack of catheter drainage, chronic immunosuppression, or insufficient antibiotic therapy [11].

Intraoperative imprint-smear diagnosis of brain abscess is fraught with pitfalls. First, abscess-related necrosis must be differentiated from tumor necrosis. Small or large areas of coagulation necrosis are frequently seen in glioblastomas. Sometimes, the necrotic area of a tumor is taken over by a massive infiltration of polymorphonuclear leukocytes that change the necrotic area into a liquefactive one, leading to the erroneous diagnosis of a brain abscess. On the other hand, perilesional gliosis of an abscess may be so marked as to mimic a low-grade astrocytoma. Although in a nonneoplastic proliferation of reactive astrocytes the cellularity is usually lower and individual cells very regular, it is not uncommon to have predominantly cellular areas of proliferating astrocytes with pleomorphic and hyperchromatic nuclei [10]. In this study, for a better and simplified understanding of the pathological features and more effective pathological-radiological correlation, we have categorised brain abscesses as cerebritis (stage I) when scarce polymorphonuclear leukocytes (PNL) and perivascular erythrocytes were detected, and encapsulation (stage II) when frank pus, PNL crowding, necrosis, granulation tissue, and dense reactive gliosis were noted.

Widespread use of CT and MRI has made it possible to detect abscesses in early stages. This may be in the form of multiple small lesions in patients without AIDS, or nonenhancing hypodense lesions in the stage of acute cerebritis [17].

The course of brain abscess evolution is as follows. Nonenhanced CT scans may be normal or show a vague hypodense lesion in early cerebritis (radiological stage I). Enhancement pattern, when

present, is variable. Lesion demarcation and mass effect will be more pronounced in late cerebritis (stage II) with more distinct rim-like contrast enhancement. During the early capsule period (stage III), a delicate and heavily enhancing collagen capsule surrounding the necrotic center will be present. The cortical side of the capsule will be thicker than the ependymal side, a detail quite suggestive of abscess. Abscess shrinkage and regression of edema will ensue during late capsule stage (radiological stage IV). Ring enhancement may persist even after clinical resolution. We think that residual contrast enhancement itself should not dictate the need for additional therapy. During all stages, MRI is more sensitive than CT to edema and contrast enhancement [17]. In this series cytological diagnosis concurred with radiological stage in 19 of 24 patients (83%).

The antimicrobial regimens commonly recommended for the therapy of brain abscess are empiric, as no controlled trials on the relative efficacy of various regimens have been performed. Ampicillin-sulbactam is active against many β-lactamase-producing Gram-negative and Gram-positive organisms, including anaerobic ones. An open prospective study evaluated the efficacy of ampicillin-sulbactam alone in the treatment of 21 patients with brain abscess [1]. Seventeen patients were cured, including all five treated without surgery, suggesting the potential utility of this agent in the treatment of brain abscess. In this study, a combined regimen containing both nitroimidazole, metronidazole or ornidazole, and ampicillin-sulbactam, was not changed unless any pathogen resistant to initial agents was isolated in pus obtained by aspiration. Isolated organisms were Gram-positive pathogens in all instances except for one immunocompromised patient in whom *N. asteroides* abscess was diagnosed and trimethoprim-sulfomethoxasole treatment was given.

We conclude that stereotactic surgery is the treatment of choice in the management of brain abscess.

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COMMENTARY

The management of brain abscess remains controversial despite recently developed techniques and reported studies. I am sure that there are many neurosurgical clinics worldwide where the treatment of choice for brain abscess is surgical resection via craniotomy. Therefore, further studies should be published that emphasize that brain abscesses can be treated by puncturing them, preferably using stereotactic techniques. This seems to be the safest method, with minimal risk to brain tissue, and it is a very effective treatment. However, free-hand puncturing of abscesses may be an alternative for clinics with no access to a stereotactic system, especially in developing countries. Total removal of an abscess via craniotomy should be reserved as a last option if all others fail.

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