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Original Article

Treatment of intracranial abscess in the era of neuroimaging: An analysis of 13 consecutive cases

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We report a series of 13 consecutive patients with intracranial abscess treated at our institution since examination by computed tomography (CT) became available. After various treatments, all abscesses healed. CT has broadened the range of treatment options. Manual puncture was performed in most patients. Stereotactic aspiration through a burr hole, medical therapy alone, or complete excision, including the capsule, via craniotomy may be chosen in cases selected by CT analysis. Individualization of treatment in this disease has become increasingly valuable in effecting a cure.

Key words: brain abscess; subdural empyema; computed tomography, treatment

Introduction

With the availability of scanning by computed tomography (CT) and the development of new antibiotics, treatment outcomes in brain abscess and subdural empyema have been improved. However, treatment choice remains controversial. Some authors favor radical removal of a brain abscess including the capsule[1–3], while others puncture the abscess with or without continuing drainage[4–7]. Nonsurgical treatment limited to the use of antibiotics has also been recommended in selected patients[8–10]. Regarding patients with subdural empyema, the merits of burr hole drainage versus craniotomy are still under discussion[11–14].

Predisposing etiologic factors for intracranial abscesses include bacterial infection elsewhere in the body, including septicemia, traumatic brain injury, intradural surgery, meningitis, cyanotic congenital heart disease, and others. Intracranial abscess is relatively uncommon in Japan; the number of cases treated in a single institution is limited, except where many children with congenital heart disease are treated. Treatment strategy in patients with this disease should be carefully and individually considered.

We report here the outcome of 13 consecutive patients variously treated for brain abscess and/or subdural empyema since CT had become available and discuss bases for treatment decisions in the light of the results.

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Patients and methods

Between 1976 and 1996, 9 patients with brain abscess, 3 patients with subdural empyema, and one patient with both were treated in our hospital. They consisted of 8 males and 5 females with ages ranging from 3 months to 88 years (mean, 46 years). No patient had congenital heart disease. Clinical characteristics of the 13 patients are given in Table 1. Locations of suppuration were the frontal lobe in 4 patients, the occipital lobe in 3, the temporal lobe and the parietal lobe in 2 each, the thalamus and basal ganglia in one, and the subdural space in 4. Two patients had subdural empyema in the right temporo-occipital region and bilaterally in the frontoparietal regions.

Table 1. Clinical characteristics of 13 patients with intracranial abscess

Characteristic	No. (%)
Age range (yr)	0.25–88
mean	46
Male: female	8 : 5
Multiplicity	4 (31)
Location	
frontal lobe	4
temporal lobe	2
occipital lobe	3
parietal lobe	2
thalamus and basal ganglia	1
subdural space	4
Features on admission	
fever (>37°C) +	9
−	4
CRP 1+ to 6+	12
equivocal	1
leukocytosis >10000	6
8000–10000	3
7000–8000	4

Table 2. Neurologic signs and symptoms on admission

Signs or symptoms	No. of patients
Hemiparesis	6
Disturbance of consciousness	3
Headache only	3
Dysarthria	1
Dysphasia	1
Alexia	1
Third nerve palsy	1
Homonymous hemianopsia	1
Convulsion	1
Dementia	1

Another patient had subdural empyemas over the right frontal convexity and in the interhemispheric fissure accompanying multiple brain abscesses in the right frontal lobe. The remaining patient had subdural empyemas in the right frontal portion of the interhemispheric fissure, over the right frontoparietal convexity and over the left frontal convexity. Thus, all 4 patients with empyema had involvement at multiple sites.

Neurologic signs were evident on admission in 11 patients (Table 2). Predisposing conditions and causative organisms for each were identified in 7 patients (Table 3). Microorganisms included *α-Streptococcus hemolyticus* in 4 cases and *β-Streptococcus hemolyticus*, *Staphylococcus aureus*, and anaerobic bacteria in one case each. Seven patients with brain abscess and 3 with subdural empyema were treated by surgery, while 3 other patients with relatively small

Table 3. Predisposing condition and causative organisms

Predisposing condition	No. of patients
Subcutaneous abscess	1
Meningitis	1
Epipharyngeal cancer	1
Interstitial pneumonia	1
Cholangitis with sepsis	1
Paranasal sinusitis	1
Subdural fluid collection	1
None	6
Organisms	**No. of patients**
α-streptococcus	4
β-streptococcus	1
Staphylococcus aureus	1
Anaerobic bacteria	1
Negative cultures	3
Unknown	3

lesions were treated with antibiotics only. One patient with a large abscess that penetrated the lateral ventricle underwent abscess removal, irrigation of the lateral ventricle, and external ventricular drainage. Puncture and aspiration of the brain abscess was performed in 6 other patients, including one patient with a thalamic abscess treated by stereotactic aspiration. In 3 patients with subdural empyema, aspiration of pus through a burr hole was performed with external drainage. One of these had a recurrence of the empyema, which was evacuated by craniotomy. All patients were given various combinations of intravenous antibiotics for periods ranging from 40 to 86 days (mean, 55). Penicillin G and chloramphenicol were used in 4 patients each.

Results

All abscesses healed (Table 4). Seven adult patients fully regained their former level of activity. Two children also showed good recovery. One 88-year-old patient who had been treated medically died from pneumonia that developed shortly after ultrasonic cholelithotripsy, although the brain abscess had healed. The underlying cause of her brain abscess was suspected to be sepsis following cholecystitis. An elderly patient (Case 3, below) had mild residual dementia. Brain abscess in another patient is suspected to have resulted from destruction of the skull base by epipharyngeal cancer, and a different patient had interstitial pulmonary fibrosis. Each abscess healed, but these patients were

Table 4. Treatment and outcome

Surgical procedure	No. of patients
Brain abscess (10 cases)	
puncture and aspiration	4
puncture and drainage	2
removal of capsule	1
none (antibiotics only)	3
Subdural empyema (4 cases)	
drainage	3
craniotomy	1
none (antibiotics only)	1
Period of chemotherapy (days)	40–86
average	55
Outcome (by GOS) at discharge	**No. of patients**
Good	10
Moderate disability	2
Died (of pneumonia)	1

GOS, Glasgow outcome scale.

rendered moderately disabled by their primary diseases.

Illustrative cases

Case 1. A 51-year-old male complaining a moderate headache was referred to our hospital because of a ring-enhancing lesion in the right frontal lobe demonstrated by CT and magnetic resonance imaging (MRI); (Fig. 1). He had a history of chronic paranasal sinusitis. His temperature on admission was 37.5°C. Neurologic examination demonstrated a left mild hemiparesis. Laboratory examination revealed a white blood cell count (WBC) of 7600/mm^3 and equivocally positive C-reactive protein. Diagnosed with brain abscess, the patient was treated with intravenous antibiotics alone, including a third-generation cephalosporin, penicillin and aminoglicoside for 50 days. Subsequently antibiotics were given orally for 2 weeks. Surgery had been deferred because the lesion was small and deeply seated. At completion of treatment a small enhancing focus was still seen on CT. However, the patient became well and the abscess has not relapsed, so far.

Case 2. A 55-year-old male was referred to our hospital with two cystic, ring-enhancing lesions demonstrated on CT and MRI (Fig. 2). The patient had developed a left hemiparesis 10 days before admission. His past history was uneventful. His temperature was 36.4°C. Neurologic examination on admission revealed that he was alert but had left facial palsy and a left hemiparesis. The erythrocyte sedimentation rate was 17 mm/h. Other laboratory findings included 6+ C-reactive protein and 14800/mm^3 WBC. After admission, the patient's neurologic condition deteriorated in association with enlargement of the two lesions, which were diagnosed as brain abscesses. Because of their multiplicity and rapid growth, the patient underwent puncture and aspiration of the two lesions 3 days after admission. The causative organism was identified as α-streptococcus. After a third-generation cephalosporin, penicillin, and aminoglicoside had been given intravenously for 9 days, penicillin G was administered for 51 days, because the coccus was reported to be sensitive to the drug at this moment. The patient took oral penicillin for an additional week and underwent rehabilitation for the left hemiparesis. The patient was discharged with no neurologic deficit after 117 days, when a postcontrast CT still revealed slight enhancing spots.

Case 3. A 70-year-old female developed mild but persistent headache and became disoriented. CT imaging obtained at a nearby hospital demonstrated a mass with ring enhancement in the left thalamus. A week after onset of the symptoms she was transferred to our hospital. Her temperature on admission was 37.0°C. Neurologic examination demonstrated evidence of dementia and a mild right hemiparesis. Laboratory examination revealed 1+ C-reactive protein and 12900/mm^3 WBC. The lesion increased in size despite intravenous administration of antibiotics after the diagnosis of brain abscess (Fig. 3). CT-guided stereotactic puncture and aspiration of the lesion was done 8 days after admission. The causative organism was β-streptococcus. Only small areas of apparent scarring could be visualized after treatment for 47 days with antibiotics, which were selected according to in vitro sensitivities. The patient was transferred back to her community hospital with mild dementia.

Case 4. A 32-year-old dentist developed a left parietal headache one week before admission and gradually became unable to work over the next few days. CT imaging demonstrated a large ring-enhancing mass in the left frontal lobe with pronounced edema surrounding it (Fig. 4, A). The patient had a temperature of 37.4°C and was alert. He manifested motor and sensory dysphasia and complained of headache on admission. C-reactive protein was 6+ and WBC was 12100/mm^3. After admission his fever worsened in association with clinical deterioration. MRI demonstrated contact between the mass and the lateral ventricle (Fig. 4, B), and rupture of the abscess into the

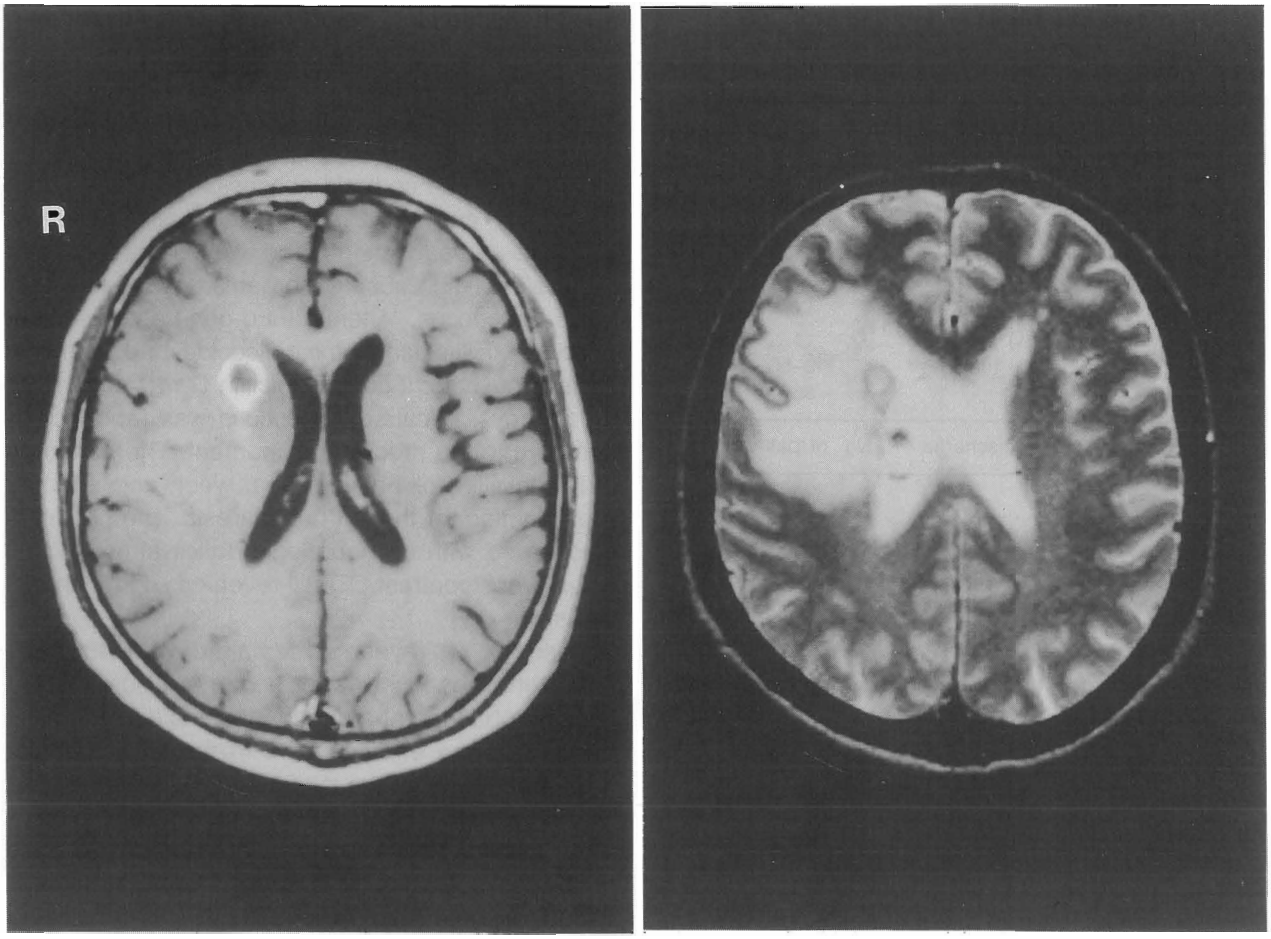

Fig 1. Case 1. T1-weighted contrast (left) and T2-weighted (right) magnetic resonance images (MRI) showing a small, deep area of ring enhancement in the right frontal lobe and an extensive area of high signal intensity around the lesion, indicating edema. This lesion was cured by intravenous administration of antibiotics for 50 days.

lateral ventricle was suspected. The patient underwent removal of the abscess and ventricular irrigation with saline containing gentamicin. External ventricular drainage was effected (Fig. 4, C). The causative organism was α-streptococcus. Various antibiotics were given, according to sensitivity studies, including chloramphenicol, aminoglycoside, penicillin G, and other penicillins in two- to three-drug combinations over 54 days. The patient's level of consciousness decreased transiently after the operation but later recovered completely. Though he developed generalized convulsions for a limited interval after discharge despite anticonvulsant medication, he now is working at his full capacity.

Discussion

Despite a reduction in mortality among patients treated for brain abscess or subdural empyema with the availability of CT imaging, controversy as to treatment has increased. Before the introduction of CT, radical abscess removal, including the capsule, via craniotomy had been the treatment of choice. CT has facilitated both diagnosis and treatment assessment of intracranial abscess, as well as the disclosure of smaller abscesses. Therefore, choices of treatment have increased to include puncture and aspiration, with or without external drainage, and strictly medical therapy with antibiotics. Leys et al. recently reported the outcomes of 56 patients with brain abscess or subdural empyema, finding no differences among

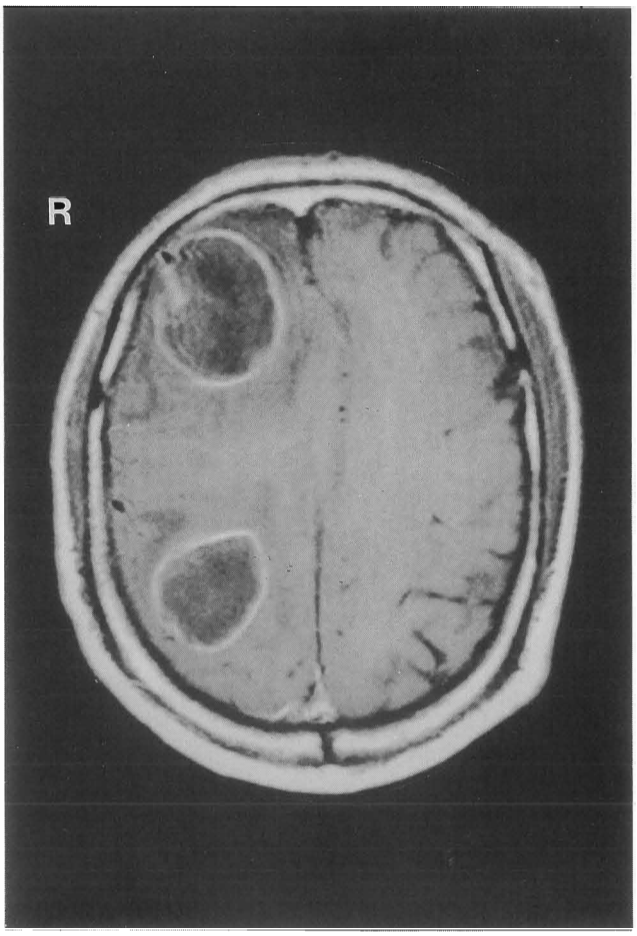

Fig 2. Case 2. T1-weighted contrast MRI showing two ring-enhancing lesions in the right frontal and parietal lobes. These lesions were cured by puncture and aspiration with intravenous administration of antibiotics for 60 days.

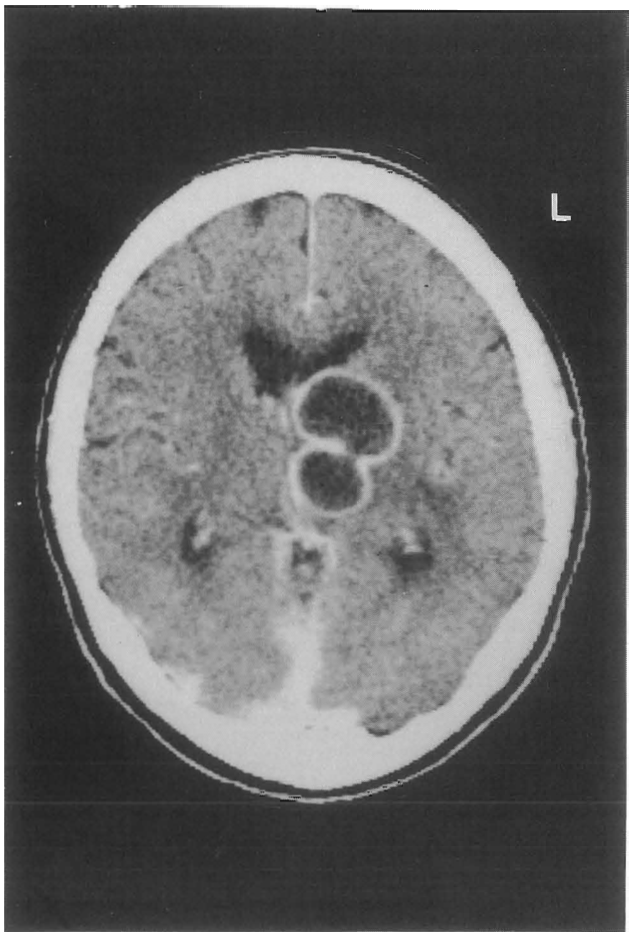

Fig 3. Case 3. Contrast computed tomography (CT) showing a dumbbell-shaped ring enhancement in the left basal ganglia and thalamus. This lesion was cured by stereotactic puncture with intravenous administration of antibiotics over 47 days.

survival by medical treatment alone, puncture and aspiration, and excision of abscess; indeed, medical treatment gave better results for long-term sequelae[8]. In addition, stereotactic puncture and aspiration have also been adopted in patients with deep-seated brain abscesses[15,16].

In the present series, two patients with small abscesses at deep sites and one patient with a small subdural empyema were healed with medication alone. Except for one patient who undergwent craniotomy for ventricular rupture, we treated the others with puncture and aspiration in addition to antibiotics. We closely followed changes in abscess size by CT. Results using this strategy were satisfactory, and we consider puncture and aspiration to be the first choice for most patients with an encapsulated brain abscess or subdural empyema exceeding 2 cm in diameter; lesion puncture can be performed safely, and neurological deficits become apparent due to its mass effect in such cases. When CT shows that an abscess has failed to respond to this approach including antibiotics, repeat aspiration, changes of antibiotics guided by sensitivity testing, abscess removal by craniotomy may be considered. How long antibiotic therapy should be continued to treat brain abscess and subdural empyema remains a difficult question, because enhancing lesions do not always completely disappear with long-term antibiotic administration. Intravenous administration in our series ranged from 40 to 86 days (mean, 55), with no recurrences. As medication timing is clinically not an easy decision, the appropriate duration of medication should be determined individually with subsequent close CT follow-up.

Successful stereotactic aspiration of brain abscesses has been reported[15–18]. Stapleton et al. have argued that this procedure should be considered the

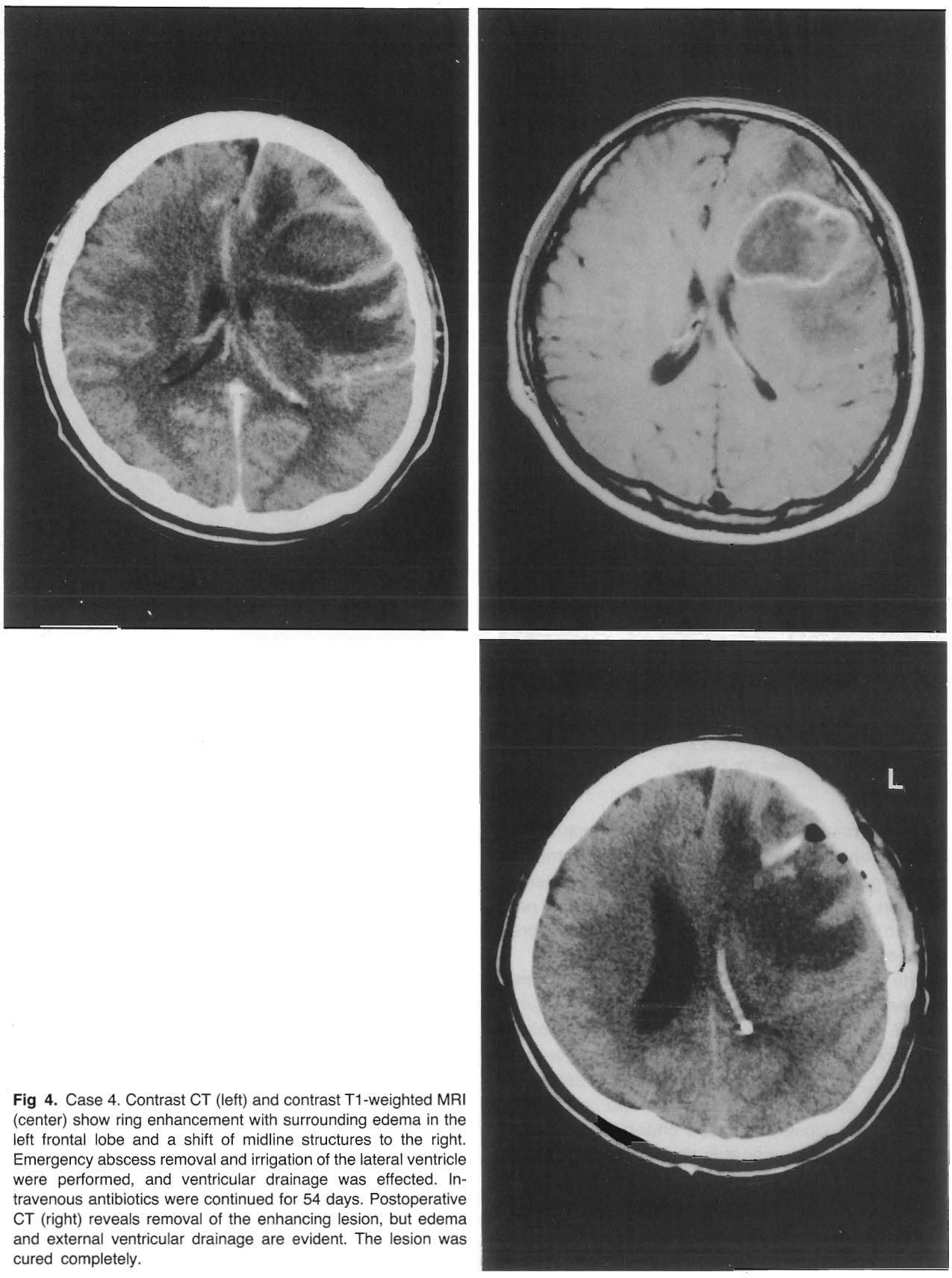

Fig 4. Case 4. Contrast CT (left) and contrast T1-weighted MRI (center) show ring enhancement with surrounding edema in the left frontal lobe and a shift of midline structures to the right. Emergency abscess removal and irrigation of the lateral ventricle were performed, and ventricular drainage was effected. Intravenous antibiotics were continued for 54 days. Postoperative CT (right) reveals removal of the enhancing lesion, but edema and external ventricular drainage are evident. The lesion was cured completely.

treatment of choice in all but the most superficial and large brain abscesses, though they found that mortality remained high in severely ill patients[17]. Other authors propose that this minimally invasive procedure should be used in patients with small, multiple, or deep-seated abscesses, in poor operative candidates, and in those with failure of prior therapy[15,19,20]; we agree with that view. Since the introduction of CT, the reported incidence of multiplicity in brain abscesses has ranged from 11% to 50% of cases[15]. Before the CT era, mortality for multiple abscesses was higher than for solitary ones because of difficulty in their treatment. Radical removal of deep-seated brain abscesses is also difficult. Thus, stereotactic aspiration is a suitable procedure in patients with deeply located brain abscesses, as shown by our Case 3.

Mortality in patients with intraventricular rupture of a brain abscess may approach 85%, according to the literature review of Zeidman et al[21]. Even in the CT era, Shibayama et al. reported in a literature review that 38% of 16 cases with intraventricular rupture had died[22]. Zeidman et al. presented a treatment plan for such patients based on their experience with good outcome following open craniotomy, accompanied by debridement of the abscess cavity, lavage of the ventricular system, 6 weeks of intravenous antibiotics, intraventricular gentamicin given twice daily for 6 weeks, and ventricular drainage for 6 weeks. Our patient with intraventricular rupture of abscess underwent similar therapeutic procedures and recovered fully. Other authors recommend intraventricular irrigation with effective concentrations of antibiotics and rapid drainage of pus to treat severe ventriculitis following rupture[23,24]. Conservative therapies, such as ventricular drainage and intravenous administration of antibiotics, have resulted in disastrous outcomes in this situation[22,25]. Rupture into the ventricle requires prompt diagnosis and a combination of aggressive procedures for control of intracranial pressure and eradicating ventriculitis[22,23].

Controversy also has existed as to the treatment of subdural empyema. Most authors have preferred craniotomy. However, paralleling experience with brain abscess, recent studies on the treatment of subdural empyema have shown that CT permits a choice among several treatment modalities with a potential for good results[11–13,26]. One may even treat patients in good neurologic condition with small empyema by antibiotics alone[12]. When a patient is in critical condition neurologically, because of a large empyema, a combination of burr hole aspiration and antibiotics may be chosen[11,13,26], reserving craniotomy for treatment failure. Close CT monitoring of lesion size is essential for timely changes of approach. Postoperative subdural empyema remains difficult to treat by any procedure described above, and its mortality rate is high[26]. Particular care is necessary in making treatment decisions for postoperative subdural empyema.

Epilepsy complicating brain abscess has been reported to occur in 15 to 55% of cases[27–30]. Whether choice of treatment can influence the development of epilepsy remains to be elucidated. Koszewski analyzed possible risk factors for epilepsy in following up 108 patients, concluding that risk factors for epilepsy included male sex, age between 15 and 45, abscess size greater than 4 cm, location in the frontal or temporal lobe, and certain abscess etiologies[31]. However, no difference among methods of treatment was found with regard to late seizure occurrence. This report and other data fail to support assertions that radical removal of the abscess is superior to other treatment methods for prevention of epilepsy[5,29,32]. In the present series, all patients were given prophylactic anticonvulsant therapy. Only two patients, one with subdural empyema and another with brain abscess treated by craniotomy, developed late epileptic attacks.

Conclusion

Important factors for determining which reatment method to select for brain abscess include neurologic condition, lesion size, location, and multiplicity. From the experiences presented here, our principle of treatment is as follows: If an abscess is small, and the neurologic condition is good, administration of antibiotics with close follow-up with CT can be chosen. When an abscess is large with a discrete capsule, manual puncture and aspiration of pus with or without drainage should be selected. Multiple brain abscesses also are treated best by puncture and aspiration. When an abscess is deeply seated in the brain, stereotactic aspiration should be adopted. Once an abscess ruptures into the ventricle, the patient's condition becomes critical, resulting in a high mortality rate with conservative therapy including ventricular drainage. Reported experience and ours would prompt aggressive surgical treatment in such cases. Although treatment choice still remains controversial, we believe the above principle has ratified commonly acceptable treatment strategy for brain absess. Treatment of subdural empyema is not basically different from that

of brain abscess. With such an individualized, imaging-based treatment strategy, satisfactory treatment outcomes in localized intracranial suppuration are expected.

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