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Brain abscess: clinical analysis of 53 cases

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Fifty-three cases of brain abscess were treated at Mackay Memorial Hospital from January 1991 through December 2001. The ages ranged from 2 weeks to 84 years, with a peak at 40 to 50 years (11/53, 21%). The male to female ratio was 1.8:1 (34 males, 19 females). The most common presenting symptoms were fever (30/53, 57%), headache (29/53, 55%), and changed mental status (24/53, 45%). The duration of symptoms before hospitalization ranged from several hours to 2 months. A shorter duration of symptoms was associated with poor outcome. The common predisposing factors were otic infection (10/53, 19%), penetrating head trauma and neurosurgery (10/53, 19%), and bacterial endocarditis (5/53, 9%). The leading underlying diseases were diabetes mellitus (12/53, 23%) and/or liver cirrhosis (6/53, 11%), and both were independently associated with increased risk of mortality. Computed tomographic scanning and magnetic resonance imaging facilitated early diagnosis and proper management. Surgical intervention was used together with antibiotics in 33 (62%) of 53 patients in whom the average abscesses diameter was 3.75 cm (range, 2-6 cm). The remaining 20 (38%) patients whose average abscesses diameter was 2.3 cm (range, 1-3.5cm) were treated with antibiotics only. Culture of material drained from abscesses isolated 27 microorganisms from 19 (58%) of the 33 patients, 81% (22/27) of which were aerobic and 19% (5/27) anaerobic bacteria. The most common pathogen was α-hemolytic *Streptococcus* spp. (6/27, 22%). Most of the patients with *Klebsiella pneumoniae* isolated from brain abscess, cerebrospinal fluid, and blood cultures were diabetic. A high mortality rate (9/20, 45%) was found in patients with medical treatment. A high index of suspicion is needed for the early diagnosis of brain abscess, particularly in patients with predisposing factors. In this series, early diagnosis using computed tomography and/or magnetic resonance scanning, optimal timing of surgery, and appropriate use of antibiotics were associated with improved outcome.

Key words: Brain abscess, case analysis

Brain abscess is a focal, intracerebral infection which begins as a localized area of cerebritis and develops into a collection of pus surrounded by a well-vascularized capsule. It is usually caused by spreading from a contiguous focus of infection, hematogenous dissemination, or following head trauma or neurosurgery [1-3]. The spectrum of organisms cultured from brain abscesses changed in the latter part of the 20th century, and newer diagnostic and therapeutic techniques have emerged [2]. Mortality from brain abscess ranged from 30% to 60% until the late 1970s, when the availability of more effective antimicrobial regimens (eg, the addition of metronidazole), new surgical techniques, and computed tomography (CT) resulted in decreases to less than 10% [1,3]. The aim of this study was to describe the clinical characteristics, treatment, and outcome of patients with brain abscess treated during a 10-year period.

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Materials and Methods

The medical records of patients with brain abscesses treated at Mackay Memorial Hospital from January 1991 to December 2001 were reviewed. All patients had been hospitalized in the departments of Internal Medicine, Neurology, or Neurosurgery. Brain abscess was defined as one or more localized lesions with the following characteristic CT appearance: (1) hypodense center with a peripheral uniform ring enhancement following the injection of contrast material; (2) affected region surrounded by a variable hypodense area of brain edema or a nodular enhancement or an area of low attenuation without enhancement [1,4,5]. Patients with subdural and epidural abscesses were excluded from this study. The diagnosis was confirmed surgically in 33 patients, and by compatible clinical features and CT findings in 20 patients. The clinical characteristics including demographic data, presenting symptoms,

predisposing factors, number, location, and size of the lesions, laboratory data, diagnosis, treatment, use of corticosteroids, and outcome were reviewed. The clinical characteristics of surviving and deceased patients were compared. Relapse was defined as the reappearance of symptoms after cessation of treatment. Neurologic sequelae include headache, seizure, hemiparesis, and ataxia. The follow-up period for neurologic examination ranged from 1 to 12 months. Specimens obtained from brain abscess were cultured for aerobic and anaerobic bacteria, fungi, and mycobacteria. Blood, cerebrospinal fluid (CSF), and other cultures (ear discharge, cholesteatoma, tip of drainage tube, thrombophlebitis wound, and sputum) were performed. Clinical isolates from these cultures were tested for antimicrobial susceptibility.

Statistical analysis

Statistical data were analyzed using chi-square test and student *t* test. A *p* value less than 0.05 was considered significant.

Results

Demographic data

The records of 53 patients were reviewed. Of these, 33 (62%) underwent surgical treatment (Table 1), and the remaining 20 (38%) were treated medically (Table 2). There were 34 males and 19 females (male/female ratio 1.8:1), with ages ranging from 2 weeks to 84 years (mean, 41 years). Most brain abscesses occurred in adults aged 40 to 50 years (11 of 53, 21%), but 7 occurred in children younger than 10 years (Fig. 1). The criteria indicating the need for surgery depended upon the judgment of the surgeon. Surgery was recommended for abscesses larger than 2.5 cm or those situated in critical areas of the brain or causing significant mass effect. Patients with an abscess smaller than 2 cm, with multiple abscesses, with critical illness, or with an abscess at an inaccessible site were treated with antibiotics alone.

Presenting symptoms and physical findings

The duration of symptoms before diagnosis ranged from several hours to 60 days, with a mean of 6.7 days. For patients who develop posttraumatic or post-neurosurgery brain abscess, the duration of symptoms before diagnosis was considered to be the time of injury/surgery until the brain abscess was recognized. On admission, 30 (57%) of 53 patients had fever, the most common symptom (Table 3), followed by headache (29/53, 55%), changed mental status (24/53, 45%), hemiparesis (18/53, 34%), nausea and vomiting (14/53, 26%), and seizures (7/53, 13%). Neck stiffness was present in 4 (8%). Either speech or visual disturbance was observed in 3 (6%) patients. On admission, 26 (49%) of the 53 patients had normal mental status, 10 (19%) of 53 presented with confusion, 14 (26%) of 53 were stuporous, and 3 (6%) of 53 were comatose.

Predisposing factors

Table 4 shows the predisposing factors, which included otic infection in 10 (19%) of the 53 patients, penetrating head trauma and/or neurosurgery in 10 (19%), bacterial endocarditis in 5 (9%), odontogenic infection or dental procedures in 4 (8%), pulmonary infection in 3 (6%), sinus infection in 3 (6%), congenital heart disease in 2 (4%), and skin or wound infection in 1 (2%). Twelve (23%) patients had diabetes mellitus and 6 (11%) had liver cirrhosis. No predisposing factors were identified in 9 (17%) patients.

Number, location, and size of brain abscess

There were 38 (72%) patients with a single abscess and 15 (28%) with multiple abscesses (ie, ≥2). Among the 15 patients with multiple abscesses, 6 (40%) lesions were metastatic, 6 (40%) arose from parameningeal foci, and the remaining 3 were of unknown origin. Seventeen of the solitary abscesses were in the left and 19 were in the right cerebral hemisphere, and 2 were in the right cerebellum. The average diameter in the largest dimension was 3.3 cm (range, <1-6 cm). In patients treated surgically, the average diameter was 3.75 cm (range, 2-6 cm), and for those treated medically, 2.3 cm (range, <1-3.5 cm).

Laboratory findings

Peripheral white blood cell (WBC) counts on admission were >10 000 /mm^3 in 35 (66%) of 53 patients, including 14 (82%) of the 17 patients who eventually died and 21 (60%) of the 36 who survived. Cerebrospinal fluid was collected from 29 (55%) of the 53 patients. The CSF was collected by lumbar puncture in 27 and by ventricular tap in 2 of these patients. Initial CSF analysis revealed a WBC count >500 /mm^3 in 9 patients. Cerebrospinal fluid culture was performed in 28 patients and was positive in 6 (21%).

Microbiological findings

Of 33 patients treated surgically, abscess cultures were positive in 19 (58%). A total of 27 microorganisms were isolated from these 19 patients, 81% (22/27) of which were aerobic and 19% (5/27) anaerobic bacteria (Table 5). The most frequently isolated aerobic organism was

Table 1. Characteristics of 33 patients with brain abscesses who received surgical treatment

No.	Age/sex	Symptom/sign	Predisposing factor	No. of abscess, site	Culture finding	Other cultures	Outcome
1	32/F	H, Left HP	PNS	1, PL	*H. parainfluenzae* *Peptostreptococcus* sp.	–	Survived
2	51/M	Changed mental status	TA, Skull fracture, Mastoiditis	1, TL	No growth	–	Survived
3	31/M	Changed mental status, Aphasia	TA, Facial fracture	1, FL	No growth	–	Survived
4	49/F	Changed mental status	TA, SDH with OP	1, FL	*K. pneumoniae*	CSF: *K. pneumoniae*	Died
5	22/M	F, H, V	Unknown	1, TL	α-hemolytic *Streptococcus* sp.	–	Survived
6	22/F	H, Right HP	Unknown	1, FL	γ- hemolytic *Streptococcus* sp.	–	Survived
7	60/M	Left HP	TA	1, PL	No growth	Drained tube tip: CoNS	Survived
8	46/M	F, H, V, Left HP	COM	1, TL	*P. mirabilis*	Ear discharge: *P. mirabilis*	Survived
9	43/M	Changed mental status, Speech disturbance, Right HP	Dental caries	1, FL	α-hemolytic *Streptococcus* sp.	–	Survived
10	12/M	F, H, V, NR	VSD	1, TL	α-hemolytic *Streptococcus* sp.	–	Survived
11	7/F	F, H, V, S, Changed mental status	Unknown	1, FL	GPC	–	Survived
12	38/M	F, H	LC	1, FL	GPC	BC: *Aeromonas*	Died
13	64/M	Changed mental status	TA, ICH, SAH, V-P shunt, COM	1, FL	No growth	–	Survived
14	23/F	F, H	Right COM	1, C	GPC	Cholesteatoma: *Providentia* spp.	Survived
15	19/F	F, H, NR	Mastoiditis	M, TL	*P. mirabilis*	Ear discharge: *P. mirabilis*	Survived
16	55/F	F, H, V, Left HP	DM, MR	M, FL	No growth	BC: *K. pneumoniae*	Survived
17	67/M	Changed mental status, H	SAH with OP	1, FL	No growth	CSF: *Clostridium* spp.	Died
18	43/M	Changed mental status	TA, Craniectomy, V-P shunt	M, PL	*Serratia* spp.	–	Died
19	79/F	Changed mental status, Right HP	COM	1, TL	*P. P.mirabilis,P. vulgaris*, *Enterococcus*, *K. oxytoca*, *B. fragilis*	Drained tube tip: *Proteus mirabilis*, *K. oxytoca*, *Enterococcus*	Died
20	75/F	F, visual disturbance, Changed mental status	LC, DM, MRSA pneumonia	1, OL	MRSA	–	Died
21	0.1/F	F, H, V	Meningitis	1, PL	*B. fragilis*	CSF: α-hemolytic *Streptococcus* spp.	Survived
22	45/M	F, H, Changed mental status	TA, Right T-P Craniectomy, VSD, IE	1, T-P	α-hemolytic *Streptococcus* sp.	BC: α- hemolytic *Streptococcus* spp.	Died
23	70/M	F, H, Left HP, Changed mental status	COM	1, FL	No growth	–	Survived
24	35/F	H, S	Sinusitis (Sphenoid)	1, TL	GPC	–	Survived
25	36/M	H, Changed mental status	COM (Left)	1, PL	*F. nucleatum*	–	Survived
26	1/M	F, S	Thrombophlebitis wound, IE	1, FL	No growth	BC and thrombophlebitis wound: *S. aureus*	Survived
27	83/M	Right HP, Changed mental status	DM, Meningioma OP	1, TL	MRSA	–	Survived
28	54/M	H, V, S, Right HP	Brain tumor, Left F-P craniotomy	2, F-P	*E. corrodens*, α-hemolytic *Streptococcus* sp, *Peptostreptococcus* sp.	–	Survived
29	61/M	Left HP	Unknown	1, FL	–	–	Survived
30	61/M	Left HP	Tooth extraction	1, F-T	*Haemophilus aphrophilus*, *Gemella morbillorum*	–	Relapse
31	72/M	Right HP	DM	1, TL	No growth	–	Survived
32	49/M	F, Left HP	DM	1, FL	*K. pneumoniae*	–	Survived
33	47/F	F, H, V	MVP, tooth extraction	1, FL	α-hemolytic *Streptococcus* sp.	BC: α-hemolytic *Streptococcus* sp.	Died

Abbreviations: H = headache; HP = hemiparesis; PNS = paranasal sinusitis; PL = parietal lobe; TA = traffic accident; TL = temporal lobe; FL = frontal lobe; SDH = subdural hemorrhage; OP = operation; CSF = cerebrospinal fluid; F = fever; V = vomiting; CoNS = coagulase-negative *Staphylococcus*; COM = chronic otitis media; NR = neck rigidity; VSD = ventricular septal defect; GPC = gram-positive cocci; LC = liver cirrhosis; BC = blood culture; ICH = intracerebral hemorrhage; SAH = subarachnoid hemorrhage; V-P = ventriculoperitoneal; M = multiple; DM = diabetes mellitus; MR = mitral regurgitation; OL = occipital lobe; MRSA = methicillin-resistant *Staphylococcus aureus*; T-P = temporoparietal; IE = infective endocarditis; S = seizure; F-P = frontoparietal; F-T = frontotemporal; MVP = mitral valve prolapse;

Table 2. Characteristics of 20 medically treated patients with brain abscesses

No.	Age/sex	Symptom/sign	Predisposing factor	No. of abscess, site	Culture finding	Outcome
1	42/M	Right HP, Speech disturbance	LC, Hepatoma	1, PL	–	Died
2	38/M	H, Changed mental status	LC, EV, splenectomy	1, FL	–	Died
3	66/F	F, Left HP	DM, CRI	1, FL	–	Survived
4	32/M	F	IE, MR	2, F-T	BC: α-hemolytic *Streptococcus* group D	Survived
5	31/F	F, H, NR, Visual disturbance	TA, HI	1, OL	–	Survived
6	67/F	H, Left HP, Changed mental status	Cholelithiasis, DM	M, TL	BC and CSF: *K. pneumoniae*	Died
7	0.6/M	F, Visual disturbance, Changed mental status	SD empyema, Hydrocephalus	M	CSF: *H. influenzae*	Survived
8	69/M	H, V, NR	DM	M	–	Died
9	29/M	H, V, S	TA	2, FL	–	Died
10	10/F	F, H, V, Changed mental status	Bronchopneumonia	1, FL	–	Died
11	2/F	F, H, V	Bronchiolitis, HI	1, C	–	Survived
12	84/F	F, Left HP, Changed mental status	DM	1, FL	–	Survived
13	42/M	F, Left HP	LC, EV, DM, CRI	1, F-P	BC: *K. pneumoniae*	Died
14	15/F	F, H, V, Changed mental status	IE, MVP	M, F-P	BC: *S. aureus*	Survived
15	49/M	F, H, Changed mental status	Chronic alcoholism	M, BS	Sputum: *M. tuberculosis*	Survived
16	3/M	F, Changed mental status	Not identified	M	–	Died
17	39/M	F, Changed mental status	LC, EV, IHD stone, DM	M, PL	BC: *K. pneumoniae*	Died
18	53/M	F, Changed mental status	DM, CRI, IE, MR	M, PL	BC: *S. aureus*	Survived
19	44/M	F, H, S	Right COM, Right upper incisor extraction	1, TL	BC: γ-hemolytic *Sreptococcus* spp.	Survived
20	11/F	F, H, V, S	TA, craniotomy	M, F-T	CSF: *S. pneumoniae*	Survived

Abbreviations: HP = hemiparesis; LC = liver cirrhosis; PL = parietal lobe; H = headache; EV = esophageal varices; FL= frontal lobe; F = fever; DM = diabetes mellitus; CRI = chronic renal deficiency; IE = infective endocarditis; MR = mitral regurgitation; F-T = frontotemporal; BC = blood culture; NR = neck rigidity; TA = traffic accident; HI = head injury; OL = occipital lobe; M = multiple; TL = temporal lobe; CSF = cerebrospinal fluid; SD = subdural; C = cerebellum; V = vomiting; S = seizure; CRI = chronic renal deficiency; F-P = frontoparietal; MVP = mitral valve prolapse; BS = brain stem; IHD = intrahepatic duct; COM = chronic otitis media

α-hemolytic *Streptococcus* spp. (6/27, 21%), followed by *Proteus mirabilis* (3/27, 11%), *Klebsiella pneumoniae* (2/27, 7%), and *Staphylococcus aureus* (2/27, 7%). The most commonly isolated anaerobes were *Peptostreptococcus* spp. (2/27, 7%) and *Bacteroides fragilis* (2/27, 7%). A single organism was isolated in 15 (79%) of the 19 patients, and was an aerobe in 13 and an anaerobe in 2. Two organisms were identified in 2 patients, and multiple organisms in 2. The gram stain of the abscess material was positive for gram-positive cocci in 4 (12%) of 33 patients, all of whom had no growth in abscess cultures. Cultures of intracerebral material were sterile in the remaining 33 (30%) patients, but histopathologic study of the excised specimens in these patients revealed acute inflammatory cells and necrotic tissue compatible with an acute abscess.

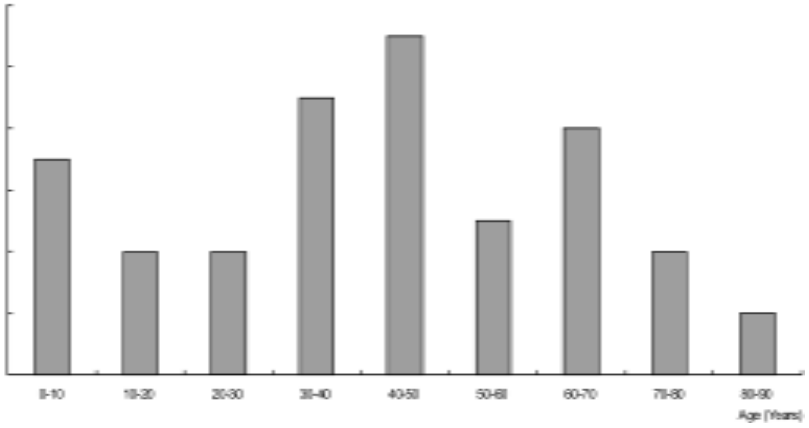

Fig. 1. Age distribution of brain abscess in 53 patients.

Table 3. Clinical symptoms and signs of patients with brain abscess (n = 53)

Symptom/sign	No. of cases (%)
Fever	30 (57)
Headache	29 (55)
Mental status changes	24 (45)
Hemiparesis	18 (34)
Nausea/vomiting	14 (26)
Seizure	7 (13)
Neck stiffness	4 (8)
Speech disturbance	3 (6)
Visual disturbance	3 (6)

Blood cultures were performed on admission in 40 patients and were positive in 14 (35%). Three of the positive blood cultures identified the same organisms as the abscess cultures (2 α-hemolytic Streptococcus spp. and 1 methicillin-resistant *S. aureus* [MRSA]). Cerebrospinal fluid cultures were performed in 28 patients and were positive in 6 (21%). One of the positive CSF cultures grew the same organism as in the patient's blood culture and abscess culture (*K. pneumoniae*). One patient with thrombophlebitis had an MSRA culture from a wound site , and the same organism was isolated from this patient's blood.

Diagnosis

Brain abscess was diagnosed by CT scan within 24 h of hospitalization in 23 (43%) of the 53 patients and within 72 h in another 5 (9%) patients. The diagnosis was delayed beyond 72 h in the remaining 25 (47%) patients. The infections in 7 of these patients with delayed diagnosis were attributed to recent neurosurgery. In 18 patients with a diagnosis made on admission, the brain abscess was identified on CT as a ring-enhanced lesion with perifocal edema. All initial scans were screened for evidence of sinusitis and mastoiditis. In 14 of 25 surgically treated patients who survived, improvement on CT was noted within 8 to 40 days. Electroencephalography was abnormal in 10 of the 18 patients who received this type of examination. Most neurologic abnormalities were due to focal destructive lesions and/or increased intracranial pressure.

Table 4. Predisposing factors for brain abscess (n = 53)

Predisposing factor	No. of cases (%)
Otic infection	10 (19)
Otitis media	7
Mastoiditis	3
Penetrating trauma/neurosurgery	10 (19)
Bacterial endocarditis	5 (9)
Odontogenic	4 (8)
Caries	1
Extraction	3
Pulmonary infection	3 (6)
Pulmonary tuberculosis	1
Pneumonia	2
Sinusitis	3 (6)
Sphenoid	1
Maxillary	1
Unspecified	1
Congenital heart disease	2 (4)
Wound and skin infection	1 (2)
Unknown	9 (17)

Table 5. Pathogens isolated from brain abscess (n = 27)

Microorganism	No. of isolates (%)
Aerobic organisms	22 (81)
α- hemolytic *Streptococcus* spp.	6 (22)
Proteus mirabilis	3 (11)
Staphylococcus aureus (Methicillin-resistant)	2 (7)
Klebsiella pneumoniae	2 (7)
γ- hemolytic *Streptococcus* sp.	1 (4)
Enterococcus sp.	1 (4)
Gemella morbillorum[a]	1 (4)
Klebsiella oxytoca[a]	1 (4)
Proteus vulgaris[a]	1 (4)
Serratia sp.	1 (4)
Haemophilus parainfluenzae	1 (4)
Haemophilus aphrophilus[a]	1 (4)
Eikenella corrodens[a]	1 (4)
Anaerobic organisms	5 (19)
Peptostreptococcus spp.[a]	2 (7)
Bacteroides fragilis[a]	2 (7)
Fusobacterium nucleatum	1 (4)

[a]Organisms isolated in mixed infection.

Surgical treatment

Surgery was performed on 33 (62%) patients. The median duration between hospital admission and surgical intervention was 12.2 days (range, 1-60 days). A duration of hospitalization before surgery exceeding 1 week occurred in 14 patients and was related to previous neurosurgical complications and intercurrent medical problems. The lesions were partially or totally excised in 8 (24 %) patients, and drained or aspirated in 25 (76%).

Medical treatment

The mean duration of antibiotics therapy for surviving patients was 54 days (range, 28-88 days) in medically treated and 46 days (range, 28-77 days) in surgically treated patients. In 8 of 33 surgically treated patients, antibiotic therapy was started before surgery, resulting in sterile culture. All of the aerobic gram-positive

Table 6. Clinical characteristics and outcome in 53 patients with brain abscess

Factors	Outcome		
	Survived (n = 36)	Died (n = 17)	*p* value
Age (mean, years)	38.01	47.65	NS
Sex			NS
Female	12	7	
Male	24	10	
Mental status on admission			NS
Fully alert	19	7	
Confusion	7	3	
Stupor or Coma	10	7	
Interval between symptom onset and surgery (mean, days)	8	20	0.0.14
Duration of symptoms (mean, days)	7.6	4.94	NS
Number of abscesses			NS
Single	26	12	
Multiple	10	5	
Corticosteroid therapy	12	5	NS

Abbreviation: NS = nonsignificant

isolates except MRSA were susceptible to penicillin and ampicillin. All anaerobic isolates were susceptible to chloramphenicol and metronidazole. About half of the patients were treated with a combination of penicillin and chloramphenicol and/or metronidazole. Corticosteroids were administered to 17 (32%) of the 53 patients. In 9 of these patients, corticosteroids were given perioperatively to reduce intracranial pressure.

Outcome

The overall mortality was 32% (17/53, 10 males and 7 females). The mean age of the patients who died was 48 years (range, 7 months-79 years). The mortality among patients treated with surgery and antibiotics was 24% (8/33), and in patients with conservative treatment was 45% (9/20).

Two patients had rupture of the abscess into the ventricles and eventually died. Clinical characteristics were analyzed to determine their influence on mortality (Table 6). Age, sex, mental status on admission, duration of symptoms, numbers of abscess, and corticosteroid therapy were not significantly associated with mortality. The interval between onset of symptoms and surgery was correlated with outcome ($p<0.05$).

Relapse

Relapse occurred in one patient after surgical intervention and 4 weeks of treatments with antibiotics. He responded well to further aspiration and antibiotics treatment.

Neurological sequelae

Neurological sequelae including headache, seizures, hemiparesis, and ataxia were observed in 20 patients at the time of discharge from the hospital. Of the 36 survivors, follow-up neurological examination was performed in 26 over a period ranging from 1 to 12 months after discharge. No severe neurological sequelae were noted. Nine of the 36 survivors were lost to follow-up and the tenth patient had relapse.

Discussion

Brain abscess is a serious, life threatening infection. It is an uncommon condition with a poor prognosis. The overall mortality of 32% in this study was similar to the value of 31.5% reported by Schliamser *et al* [6] in 1988. Chun *et al* [4] reported an overall mortality of 40% which was significantly associated with older age, male sex, altered sensorium on admission and a pulmonary source. Other studies found that the mortality among treated patients correlated significantly with the initial neurological grade [7,8]. Seydoux and Francioli [5] found that death and severe sequelae were related to the severity of neurological impairment on admission and a shorter duration from the onset of symptoms to admission. Mental status on admission, and duration of symptoms before hospitalization were not significantly associated with mortality in this study.

A short duration of symptoms before hospitalization was associated with poor outcome in this series. Not all patients presented with symptoms suggesting central nervous system (CNS) involvement, and only 34% of our patients had the triad of headache, fever and focal neurological deficits. The presence of fever was not a diagnostic clue. Neck stiffness occurred only in patients with abscess located in the cerebellum or temporal lobe. Speech disturbance was associated with frontal lobe and visual disturbance with occipital lobe lesions. These

findings highlight the diagnostic difficulties in patients presenting with nonspecific symptoms.

Predisposing factors were present in 83% patients but these patients were not equally distributed in the different age groups, in contrast with previous studies [1,6,8,9]. Direct spread from an otic infection was more common in adults than in children, which contrasted with findings in other reports [8,9]. One patient who had previously been hospitalized for MRSA pneumonia and had not received effective antibiotics therapy had an abscess culture positive for MRSA. One patient who developed *S. aureus* infection of the skin due to thrombophlebitis subsequently developed infective endocarditis and a metastatic brain abscess. Underlying liver cirrhosis and diabetes mellitus were associated with high mortality. Patients with these underlying diseases presented with nonspecific symptoms. This finding highlights the importance of a high index of suspicion for brain abscess in these patient groups.

The location of abscess and the organisms isolated were usually consistent with the original source of infection [2,3,6,10-12].

S. aureus and Enterobacteriaceae are commonly isolated from brain abscess following head injury and postoperative infection [2,3,10-12]. In this study, cultures from abscess due to penetrating head trauma and neurosurgery yielded gram-positive cocci in three cases (α-hemolytic *Streptococcus* spp. in 2 and MRSA in 1) and gram-negative bacilli in 2 cases (*K. pneumoniae* in 1, *Serratia* sp. in 1). In a review of otogenic brain abscesses, the most common organism was *Proteus* spp. [9]. In this study, 3 isolates of *P. mirabilis* were cultured from abscesses caused by otic infection. In neonatal brain abscesses, the most common pathogen was *Proteus* spp. [13]. In this study, abscess culture from a 2 week-old neonate who developed meningitis with subsequent brain abscess yielded *B. fragilis*, and the CSF grew α-hemolytic *Streptococcus* spp. All patients whose abscesses, CSF, or blood culture isolated *K. pneumoniae* were diabetic, except for one patient who had head injury and a craniotomy. Gram-positive cocci (α-hemolytic *Streptococcus* spp. in 2 and *S. aureus* in 3) were isolated from blood cultures of patients with infective endocarditis, which is similar to findings reported in other study [14]. Similar to a previous study [7], aerobic bacteria in this study were 4 times as common as anaerobic bacteria. The only means for establishing definitive antibiotic treatment is determination of the pathogens involved [5]. In this study, blood cultures, CSF cultures, sputum cultures and cultures from abscess materials lead to a bacteriological diagnosis in most of the cases. Cases with sterile abscess culture were probably due to prior treatment with antibiotics. Most abscesses caused by otic infections were located in the temporal and parietal lobes or in the cerebellum. Abscesses of odontogenic origin were located in the frontal lobes.

Laboratory tests are of limited value for the diagnosis of brain abscess. Peripheral WBC has not been shown to be an indicator. Lumbar puncture provides the little diagnostic assistance in this series, and it is potentially very dangerous in patients with an intracranial mass lesion. It should be reserved for patients with clear signs of meningitis who have no findings suggestive of increased intracranial pressure or focal neurologic deficits. CT scan is the diagnostic procedure of choice for diagnosis, localization and follow-up of intracranial abscesses [6]. Although resolution of soft tissue is better with MRI than with CT, MRI it does not add significant information in guiding management [2]. Radionuclide brain scans have been largely replaced by CT and MRI scans in the diagnosis of brain abscess [3].

Treatment of brain abscess requires a combination of antimicrobials, surgical intervention, and eradication of primary infected foci [4,15]. Surgical intervention is the only procedure for definitive microbiological proof and should be done as early as possible [2,5]. In this series, patients treated surgically had an average abscess diameter of 3.75 cm (range, 2-6 cm). The surgical technique used depended on the depth rather than the location of the lesion. Excision was attempted only for superficial and encapsulated abscesses. A formal stereotactic biopsy and drainage procedure should be performed for abscesses located in deeper critical regions (eg, the brain stem, cerebellum, or diencephalic structures adjacent to the ventricle) [1,3].

Several studies have recommended medical therapy for patients with abscesses of size <2 cm in diameter, high-density lesions, multiple abscesses, clinically stable patients who are poor candidates for surgery, and for patients with surgically inaccessible lesions [3,5, 16-18]. The microbial spectrum of brain abscess varies with the primary site of infection, and the initial choice of antibiotics can be directed to the most likely organisms [2,3]. Antibiotics should not only be active against possible causative pathogens, but also be capable of penetrating infected brain tissue and the abscesses [3,6,19,20]. The high incidence of *S. aureus* in brain abscesses after trauma and neurosurgery suggests the need for a brief course of prophylactic antibiotics at the time of the initial surgery. Vancomycin therapy should be part of the initial regimen in such cases until culture results are available [3,20,21].

Combination of a β-lactam agent with chloramphenicol and/or metronidazole is recommended as treatment of brain abscess [3,16,17,22]. This combination was given to about half of our patients.

The appropriate duration of antimicrobial therapy for brain abscess remains unclear. A 6 to 8 week course of parenteral treatment has traditionally been recommended, provided that the etiologic organisms are susceptible and adequate surgical drainage can be established [3,16]. In this series, a shorter course of antibiotics treatment was given in patients whose abscesses were excised. The duration of antibiotics therapy in medically treated patients was longer. Relapse occurred in one patient who had been treated with surgical drainage and 4 weeks of antibiotics selected based on culture results. We suspect that this relapse occurred either because of inadequate antibiotic treatment or the large size of the abscess, rather than due to a particularly virulent nature of the offending organism. A short interval between the onset of symptoms and surgery was significantly associated with a favorable outcome. In this study, 32% of patients received corticosteroids. No significant difference in outcome was observed between patients with and without steroid treatment. Steroids are indicated only for reducing cerebral edema in patients with brain abscess.

Early diagnosis of brain abscess depends on a high index of suspicion, particularly in patients with nonspecific symptoms and predisposing factors. Early diagnosis, optimal timing of surgical intervention, and adequate antibiotics therapy are essential to good outcome. Improvements in imaging techniques, antimicrobial agents, and increasingly refined surgical procedures offer the possibility of reducing morbidity and mortality of brain abscess in the future.

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