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ORIGINAL ARTICLE

Intracranial abscesses: Retrospective analysis of 32 patients and review of literature

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ABSTRACT

Background: Intracranial abscess collections, though uncommon, are dreaded complications of head trauma, neurosurgical operations, meningitis, and otogenic, mastoid, and paranasal air sinus infections. Combining surgical evacuation with the appropriate antibiotic therapy is the effective treatment for intracranial abscesses. However, literature on surgical treatment is replete with several procedures which, on their own, may not determine outcome.

Objectives: To determine the epidemiology and outcomes (of various treatment modalities) of intracranial abscesses in our institution, a major referral center for neurosurgical conditions in the midwestern region of Nigeria.

Materials and Methods: This is a retrospective analysis of demographic data as well as indications, treatment modalities, and outcomes of various surgical procedures for evacuation of intracranial abscesses between September 2006 and December 2011.

Results: We carried out 40 procedures in 32 (23 male and 9 female) patients with various intracranial abscesses. These represented approximately 5.6% of all operative neurosurgical procedures in our unit since inception. Most abscesses [16, i.e. 50%] occurred in the second decade. In the first decade, there were 7 (22%), and after the age of 30 years, there were 4 (12.5%). The most susceptible single year of life was infancy with 4 (12.5%) cases of intracranial abscesses. None of the infants had features of congenital heart disease. The predisposing factors were mostly otolaryngologic (9) or posttraumatic (6). Most abscesses (41%) were located in the frontal region, and intraparenchymal (i.e. intracerebral or intracerebellar) (50%) lesions were commoner than extradural, subdural, or intraventricular lesions. The commonest procedure performed (50%) was burr hole evacuation. Four patients (12.5% of cases) died. Prognosis appears to worsen with meningitis as the predisposing infection, ventriculitis, multiple abscesses especially in infants, and immunosuppression.

Conclusion: The relative rarity of intracranial abscesses and the frequent delays in making the diagnosis render the condition a significant challenge to the clinician. A high index of suspicion, close interaction between the neurosurgeon and infectious disease specialist, with early treatment by adequate abscess drainage and appropriate antimicrobial treatment are important in their management.

Key words: Abscesses, antibiotic therapy, intracranial, outcome, surgical evacuation

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Introduction

Between 1936 and 1950, mortality from intracranial abscesses decreased from 80% to 34%, attributed primarily to the introduction of broad-spectrum antibiotics during the Second World War.[1,2] Computerized tomography (CT) scanning, improved localization techniques, and certain fundamental changes in surgical management have reduced this further to less than 3% in some recent studies.[3,4]

This paper is a study of the pattern and outcomes of treatments of intracranial abscesses in our teaching hospital setting, as well as a review of available literature on the subject.

Materials and Methods

Demographic, clinical, and radiological data, treatment modalities, and outcomes (whether patient survived or died) were obtained from case file, and radiological and operating room records.

All patients had detailed neurological and systemic examination to find sources of infection and any other underlying/predisposing conditions such as chest infections, malignancy, sinusitis, etc.

CT scan was carried out on all patients on the finding of clinical features referable to the nervous system or focal neurological deficits and/or features of raised intracranial pressure, i.e. headaches, hemiparesis, seizures, vomiting, papilledema, etc.

A hypodense mass with an encircling ring of contrast enhancement - usually associated with perilesional edema and mass effect - on brain CT confirms the diagnosis of abscess and precludes likely differential diagnoses. The patients were thereafter prepared for emergency evacuation.

Laboratory investigations

Full blood count (with total and differential white cell counts), erythrocyte sedimentation rate, serum electrolytes, urea and creatinine, blood sugar, Mantoux test, and retroviral screening were requested, if indicated, especially in recurrent abscesses and very ill patients.

Chest radiographs were requested for all patients and children below 2 years, who were further examined with echocardiography.

Otorhinolaryngologic assessment was carried out on patients with history of or ongoing sinus and ear infections.

Five patients were excluded from the study - three had abscesses ≤2 cm and two died before evacuation.

Thirty-two patients underwent various surgical evacuation procedures, viz. burr hole evacuation, limited craniectomy procedures with abscess evacuation in patients with associated osteomyelitis of the skull, transfontanelle or transcranial defect ultrasound (TFUSS or TCDUSS)-guided aspiration, bedside needle aspiration via previous burr hole or cranial defect, craniotomy with decortication, and ventriculostomy with external ventricular drainage.

The patients were commenced on broad-spectrum antibiotics: Intravenous ceftriazone and gentamycin and, in patients with otogenic infections, metronidazole for 6-8 weeks.

Results

Thirty-two patients underwent 40 surgical procedures for evacuation of intracranial abscesses. This formed 5.6% of all neurosurgical operations during the 66-month period.

The ages of patients ranged from 2 months to 71 years (mean 18.5 years; median 14.5 years). There were 23 males and 9 females (M:F = 2.5:1). Most intracranial abscesses occurred in the second decade of life, accounting for 16, i.e. 50%. In the first decade, there were 7 (22%), and after the age of 30 years, there were 4 (12.5%) [Table 1].

The most susceptible age, in a single year of life, for brain abscesses is the first year, i.e. in infancy. Infants in this study aged from 2 to 10 months accounted for four cases, i.e. 12.5%. They were all females [Table 1]. None of them had evidence of congenital heart disease.

Predisposing factors

The source of the abscess was unknown in six patients. The others were: Post-meningitic (3), otogenic (1), mastoiditis (2), sinusitis (6), posttraumatic (6), tuberculosis (1), shunt sepsis (2), cancer chemotherapy (2), septicemia (2), and cannabis abuse (1) [Table 2].

Location and type

Thirteen (41%) intracranial abscess were frontal in location. The other locations were: Parietal (4), fronto-parietal (3), temporo-parietal (1), parieto-occipital (1), cerebellar (2), bifrontal (2), biparietal (1), bilateral fronto-parietal (1), multiple (3), and intraventricular (1).

Most abscesses (16 of 32, i.e. 50%) were intraparenchymal - 14 involving the cerebral and 2 the cerebellar hemispheres. The others were: Extradural [7 (22%)], subdural [8 (25%)], and intraventricular [1 (3%)] [Table 3 and Figures 1-6].

Hemispheric distribution

Fourteen were located in the right hemisphere, 10 in the left, 4 bilateral and 3 multiple; 1 was intraventricular [Figures 1-6].

Surgical treatment

Burr hole evacuation was carried out in 20 patients - frontal (8), parietal (3), temporal (1), frontal and parietal (2), biparietal (1),

Table 1: Age and sex distribution of intracranial abscesses

Age years	Male	Female	Total
0-1	-	4	4
2-3	-	-	0
4-6	-	-	0
7-10	1	2	3
11-16	8	3	11
17-20	5	-	5
21-30	5	-	5
31-40	1	-	1
41-50	2	-	2
51-60	-	-	-
>60	1	-	1
Total	23	9	32

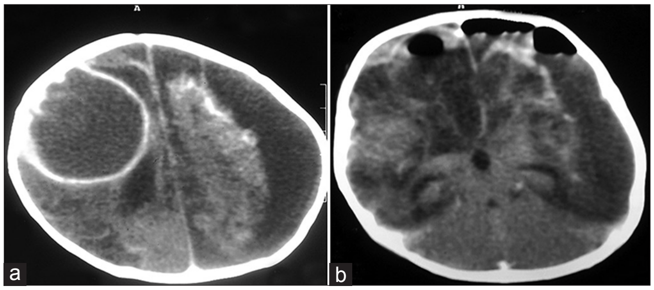

Figure 1: (a) Computed tomography scan showing multiple intracranial abscesses in a two-month old female infant. Note the right fronto-parietal intracerebral abscesses and left-sided subdural empyema. (b) CT showing pneumocephalus after burr hole evacuation of right frontoparietal abscesses. The residual subdural collection was drained under ultrasound guidance

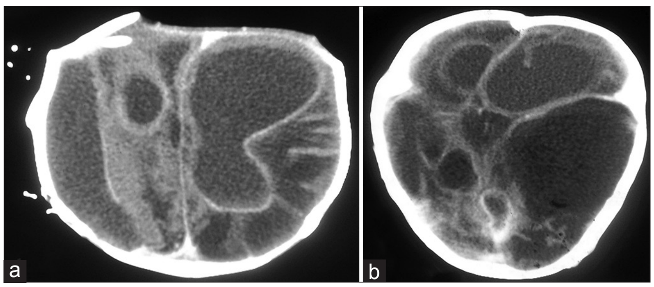

Figure 3: (a) CT showing multiple abscesses in a female infant. Note right subdural and intracerebral abscesses with associated ventriculitis. (b) Note multiple ring-enhancing collections with widespread distortion of parenchymal architecture in the patient

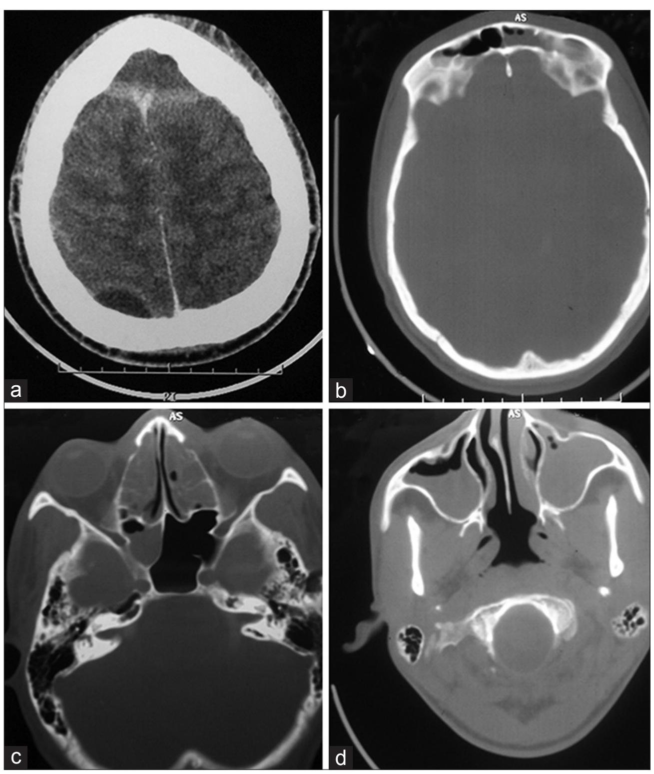

Figure 5: (a) Computed tomography showing post-sinusitic frontal and right occipital extradural abscesses. (b) Abscess collection within the frontal air sinus. (c) Abscess within the ethmoidal sinuses. (d) Abscesses within the maxillary sinuses

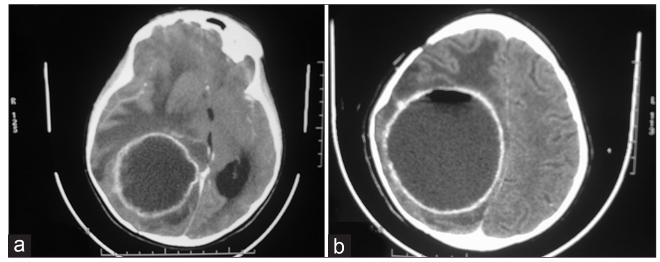

Figure 2: (a) Right parietal intracerebral abscess in an 11-year-old boy. (b) Recurrence after burr hole drainage. Note air within the abscess cavity

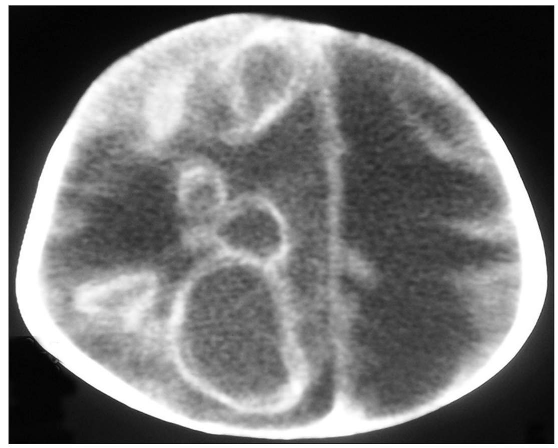

Figure 4: Computed tomography showing multiple intracerebral abscesses in a female infant

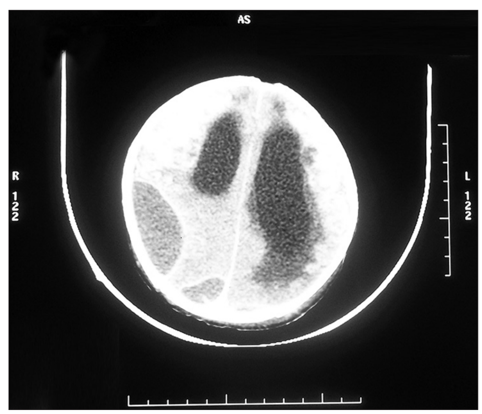

Figure 6: Computed tomography showing extradural abscesses in a female infant with hydrocephalus

bifrontal with fronto-ethmoidectomy and bilateral intranasal antrostomy (BINA) (1), unilateral frontal with elevation of depressed skull fracture and fronto-ethmoidectomy (1), suboccipital (1), and multiple in 2 infants [Table 4].

Limited (3-6 cm diameter) craniectomy procedures with abscess evacuation were carried out in patients with associated osteomyelitis of the skull with or without depressed skull fracture: suboccipital craniectomy evacuation with maistoidectomy (1), frontal craniectomy evacuation with elevation of depressed fracture (1), frontal craniectomy evacuation (1), parietal craniectomy evacuation (1), parietal craniectomy evacuation with elevation of depressed fracture

Table 2: Treatment modalities (40 procedures in 32 patients)

Age (years)	Diagnosis/location	Procedure/operations							Outcome
		Burr holes	Ventriculostomy	TFUSS	TDUSS	Craniectomy	Decortication	Bedside aspiration	
0-1	8 mo, F, multiple huge intracerebral abscesses	Multiple							Died
	2 mo, F, multiple intracerebral abscesses			TFUSS					
	Residual			TFUSS					
	10 mo, F, bilateral subdural empyema fronto-parietal	Multiple							
	Recurrence			TFUSS					
	6 mo, F, multiple intracerebral abscesses			TFUSS					
	Recurrence			TFUSS					
2-6	None								
7-10	7, M, third ventricular abscess (post-meningitic)		Frontal						
	10, F, Lt temporo-parietal intracerebral abscess (otogenic)	Temporal							Died
	9, F, Rt cerebellar abscess 2° to chronic mastoiditis					+Mastoidectomy			
11-16	12, M, Rt frontoparietal subdural empyema (sinusitis)	Frontal+parietal							
	15, F, bifrontal extradural empyema, Potts puffy tumor, frontal osteomyelitis	Bifrontal+fronto-ethmoidectomy							
	14, M, Rt frontal intracerebral abscess	Frontal							
	Recurrence				TDUSS				
	11, F, frontal intracerebral abscess 2° to open depressed skull fracture					Frontal elevation			
	13, M, Rt frontal extradural empyema	Frontal							
	12, F, Rt parietal intracerebral abscess	Parietal							
	11, M, Rt parieto-occipital intracerebral abscess					Parietal			
	11, M, recurrence							Needle aspiration	
	11, M, recurrence							Needle aspiration	
	11, M, recurrence							Needle aspiration	
	11, M, recurrence						Craniotomy		
	13, M, right frontal extradural empyema with sinusitis					+Fronto-ethmoidectomy			
	14, M, Rt parietal subdural empyema	Parietal							Died
	14, M, Rt frontal Pott's puffy+subdural empyema	Frontal+fronto-ethmoidectomy							
	16, M, Rt frontal extradural abscess	Frontal							
17-20	20, M, huge left frontal intracerebral abscess secondary to post-traumatic cerebrospinal fluid rhinorrhoea	Frontal							

Contd...

Table 2: Contd...

Age (years)	Diagnosis/location	Procedure/operations							Outcome
		Burr holes	Ventriculostomy	TFUSS	TDUSS	Craniectomy	Decortication	Bedside aspiration	
	19, M, Rt frontal extradural abscesses 2° to open depressed skull fracture	Frontal+fronto-ethmoidectomy							
	17, M, Lt fronto-parietal subdural empyema 2° to EVD for shunt sepsis	Frontal							
	17, M, Lt parietal intracerebral abscess 2° to open depressed skull fracture					Parietal+elevation			
	17, M, Lt frontal extradural empyema+sinusitis					Frontal+fronto-ethmoidectomy			
21-30	28, M, Rt cerebellar abscess 2° to mastoiditis					sub occipital craniectomy			
	28, M, Rt frontal extradural empyema					frontal			
	27, M, Lt frontoparietal subdural (+interhemispheric) empyema	Frontal+parietal							
	30, M, Lt frontal intracerebral abscess 2° to open depressed skull fracture					Frontal			
	22, M, bifrontal extradural abscess 2° to posttraumatic orbital cellulitis	Frontal							
31-40	36, M, biparietal subdural empyema 2° to VP shunted hydrocephalus	Biparietal							
41-50	44, M, chronic Rt fronto-orbital discharging sinus' frontal osteomyelitis and frontal cerebral abscess					Frontal+fronto-ethmoidectomy			
	45, F, Lt frontal intracerebral abscess 2° cytotoxic therapy for breast cancer	Frontal							
51-60	None								
>60	71, M, Rt parietal extradural empyema with cancer of larynx	Parietal							Died
Total	40 procedures								

(1), frontal craniectomy with elevation of depressed fracture and exenteration of the frontal sinus (1), frontal craniectomy with exenteration, fronto-ethmoidectomy, and BINA (3) [Table 5].

Other procedures were: TFUSS- or TCDUSS-guided aspiration: TFUSS-guided aspiration (4), TCDUSS (1), bedside needle aspiration via a previous burr hole or cranial defect (3), and ventriculostomy with external ventricular drainage (1). One patient had craniotomy with decortication for a recurrent tuberculous abscess [Tables 6 and 7].

Discussion

A brain abscess is a collection of immune cells, pus, and other materials in the brain, usually from a bacterial, fungal, or protozoan infection.[4-7] Notable contributions have been made recently in the diagnosis and management of intracranial abscesses, including a profound decrease in mortality with CT, early recognition and treatment.[2,3,8,9] Although brain abscess is a well-recognized lesion, it is relatively rare, being reported in 3-5 cases/500,000 population/year; it can occur at any age (average ranges from 40 to 45 years), with a male to female ratio of 2:1 in most studies.[3,10-17]

Our study showed a marked female predominance in children and the reverse in adults; significantly, there are more pediatric patients with intracranial abscess in our setting, probably highlighting the factors such as low socioeconomic conditions and pediatric meningitis, among others.

Table 3: Location and type of abscess

Location	Extradural	Subdural	Intraparenchymal	Intraventricular	Total
Frontal	4	2	7		13
Parietal	1	1	2		4
Temporal					0
Frontoparietal		3			3
Temporo-parietal			1		1
Parieto-occipital			1		1
Cerebellar			2		2
Bifrontal	2				2
Biparietal		1			1
Multiple			3		3
Bilateral fronto-parietal		1			1
Intraventricular				1	1
Total	7	8	16	1	32

Table 4: Burr hole evacuation and location

Location of burr hole	Number %
Frontal	8
Parietal	3
Temporal	1
Frontal and parietal	2
Biparietal	1
Bifrontal with fronto-ethmoidectomy and bilateral intranasal antrostomy	1
Unilateral frontal with elevation of depressed skull fracture and fronto-ethmoidectomy	1
Suboccipital	1
Multiple	2
Total	20

Table 5: Limited (3-6 mm diameter) craniectomy and abscess evacuation

Location	Number %
Suboccipital with mastoidectomy	1
Frontal craniectomy with elevation of depressed skull fracture	1
Frontal craniectomy	1
Parietal craniectomy	1
Parietal craniectomy with elevation of depresses skull fracture	1
Frontal craniectomy, elevation of depresses skull fracture, exenteration of the frontal sinus	1
Frontal craniectomy, exenteration of the frontal sinus, fronto-ethmoidectomy, and BINA	3
Total	9

Table 6: Transfontanelle or transcranial defect ultrasound-guided drainage

Procedure	Number %
Follow-up TFUSS for residual/recurrence after multiple burr holes	1
TFUSS for multiple abscesses and follow-up evacuation of residual/recurrence	4
TCDUSS in a 14-year-old with recurrent abscess after initial burr hole evacuation	1
Total	6

TFUSS or TCDUSS - Transfontanelle or transcranial defect ultrasound

Table 7: Procedures less performed

Procedure	Number
Craniotomy with decortications (for tuberculous abscess)	1
Bedside needle aspiration	3
Ventriculostomy	1
Total	5

The clinical features in patients with intracranial abscesses evolve with time as a result of the size and location of lesion, and depend upon interactions between the virulence of the pathogen and host immune response.[3,12,14,18] The common findings result from raised intracranial pressure, and focal neurological deficits due to compression and seizures. These include headaches, found in up to 85% of cases, nausea and vomiting, papilledema, and altered mental status.[3,12,13] The triad of fever, focal neurological deficit, and headaches is found in less than half of the patients.[12]

The neuropathological progression of brain abscess formation correlates with the appearance on CT brain scans. The evolution of a brain abscess includes four stages based on histological criteria: The acute inflammatory stages, early cerebritis (days 1-3) and late cerebritis (days 4-9), early encapsulation (days 10-13), and late encapsulation (day 14 and later).[3,6,7] In lesions that were well encapsulated (14 days and older), five distinct histological zones were apparent: A well-formed necrotic center; a peripheral zone of inflammatory cells, macrophages, and fibroblasts; the dense collagenous capsule; a layer of neovascularity associated with continuing cerebritis; and reactive astrocytes, gliosis, and cerebral edema external to the capsule.[6] The CT appearance of well-encapsulated abscesses showed a typical ring-shaped contrast-enhancing lesion. The diameter of the ring correlated best with the presence of cerebritis (perivascular infiltrates in the adventitial sheaths of vessels surrounding the abscess).[6,7] Necrotic liquefaction and inflammatory exudates accumulate in the abscess cavity; during expansion, the medial wall is thinner and less resistant and may result in ventriculitis. This is a poor prognostic indicator.[3]

CT and magnetic resonance imaging (MRI) play an important role in the diagnosis of intracranial abscess, and in elucidating the neuropathological stages and clinical as well as prognostic correlations.[6,14,19-22] Though the current diagnostic studies highlight the superiority of MRI to CT in the detection of subdural empyema, CT provides sufficient diagnostic information in all cases of intracranial abscess.[8,14,23]

The classic appearance of a ring-enhancing lesion on CT may be mimicked by several other entities such as a necrotic tumor or a cystic tumor.[17,19] Other common differentials, especially of multiple small ring-enhancing lesions, include cerebral candidiasis, *Staphylococcus aureus*, tuberculosis, metastases, and multiple sclerosis.[3,24,25]

The predisposing condition or primary focus of infection which determines the causative organism includes sinus and dental infections, ear infections, pulmonary infections, endocarditis, congenital heart disease, neurosurgical procedures, head trauma and immunosuppression.[3,12,13,23,26-29]

The etiology or causative organism depends on the patient's age, site of primary infection, and the patient's immune status; the common isolates include anaerobic cocci, microaerophilic cocci, and gram-negative and gram-positive bacilli, though 12-40% of most abscesses are polymicrobic.[12,27-31] Though many centers consistently demonstrate the predominance of staphylococci and streptococci, the sterile "cultures" in brain abscess may indeed be in part due to failures of recovering anaerobes which survive only in oxygen-free environment and require careful isolation techniques.[28]

Due to widespread use of parenteral hyperalimentation, aggressive chemotherapy, corticosteroids, and other immunosuppressive therapies, as well as in intravenous drug abusers and transplant patients, the risk of fungal infection such as *Candida albicans*, *Aspergillus* species, etc., is increasing.[25,26,32-34]

Recent advances in the diagnosis of intracranial abscesses include 99m Tc-hexamethylpropyleneamine oxime leukocyte scintigraphy, CT perfusion, and new MR sequences such as diffusion-weighted imaging (DWI) sequence, apparent diffusion coefficient (ADC) map, MR spectroscopy, fluid attenuated inversion recovery (FLAIR) sequence, and post-enhanced T1 images.[8,17,19] This also includes the potential value of positron emission tomography (PET) and the value of C-reactive protein.[8] Despite the reduction in mortality which followed recent advances in diagnosis and treatment, from 40% to about 5-10% in the post-CT era, mortality ranges from 30% to 90% in fungal infections and immunosuppression.[10,12,13,33,35,36] This is because the signs and symptoms of CNS fungal invasion are vague and fleeting; thus, most cases are diagnosed just before death or at autopsy.[35-37]

The predominant location of intracranial abscess in this study, as in many others was, frontal.[13,14]

Surgical aspiration and/or drainage of brain abscesses is the first-line treatment for abscesses larger than 25 mm.[2,3,38] Surgery is required to obtain pus from a solitary abscess, but sometimes this is non-diagnostic, particularly if antibiotics have been administered.[3] It, however, reduces bulk of the abscess, provides symptomatic relief, and minimizes the risks of abscess growth, intraventricular rupture, herniation, and venous sinus thrombosis.[3] Literature on surgical management of intracranial abscess is replete with techniques.[1-4,29,39-42] The earlier techniques which include wide open drainage, tapping, and/or repeated aspiration with a needle through a burr hole carry the risks of collapse of the abscess cavity, subarachnoid and subdural contamination, and multilocation with their attendant high mortality rates; frequently, surgical techniques were developed in an effort to reduce the mortality rate.[2] Thus, other factors influence mortality to a greater extent than specific surgical techniques in which case the simplest and less traumatic one should be the method of choice.[2,8] With progress in the development of neuronavigational systems, the acceptance of image-guided neurosurgery has increased dramatically refining surgical access, improving accuracy, and reducing the morbidity.[3,43-46] Image-guided (CT or MRI) frameless stereotactic aspiration techniques have become valid alternatives to traditional methods, namely, conservative medical treatment, craniotomy, and open surgical excision, especially for small and deep (<2 cm) abscesses.[3,43-46] However, craniotomy excision or marsupialization is still performed for as much as 72% of the intracranial abscesses in many centers.[2,3,13,29] To avoid recurrence, attention should be given to the predisposing condition, and as many as 40% may require sinus surgery, stressing multispecialty approach to complete treatment.[9,29]

Untreated cases of brain abscess are lethal.[2] The most significant predictors of poor outcome are the patient's preoperative level of consciousness and the rapidity of disease progression prior to initiation of treatment.[3,4,8] Good outcome may correlate with being male, initial Glasgow coma score >12, absence of other septic foci, and Gram-positive cocci.[11] There is no association between outcome and age, focal deficits, seizures, laboratory findings, abscess characteristics, associated factors, or treatment modalities including surgical technique.[2,11] Risk factors for worse outcomes include a poor initial neurological status, underlying medical conditions, a deep-seated location, and intraventricular abscess rupture causing ventriculitis.[3] The mortality ranges from 0% to 21% in alert patients to 60% in those with signs of herniation, and to 89% in those with coma.[4] But recently, with the introduction of CT scan, improved bacteriological techniques, more versatile antibiotics, and stereotactic surgery, most major centers report a mortality of less than 10%.[3,4] The morbidities are mainly focal neurologic deficit, cognitive impairment, and seizures. These are also on the decline because of the above-mentioned factors.

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