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Brain Abscess Surgery Outcome: A Comparison between Craniotomy with Membrane Excision versus Burr Hole Aspiration

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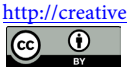

Abstract

Introduction: Brain abscess represents 8% of intracranial masses in developing countries. Despite the advances in neuro-imaging, still, the diagnosis of brain abscess is difficult and may need a biopsy in most cases to verify the diagnosis because may even lead to death. CT scan with contrast is a good tool for diagnosing and localizing brain abscesses in late stages, however, it is difficult to diagnose them in the early stages. The development of MRI helps to more accurately diagnose brain abscess. Surgical management of brain abscesses is either medical or surgical through craniotomy or burr holes. Indications of each are still a point of debate among most neurosurgeons. **Methodology:** This is a descriptive longitudinal prospective study to compare the outcomes of two surgical procedures used in The National Centre for Neurological Sciences-Khartoum-Sudan (NCNS) from 2012 to 2015, craniotomy and excision of the abscess membrane versus burr hole and aspiration of brain abscess in terms of duration of hospitalization, length of antibiotic use, recurrence rate, number of images needed for follow-up, and the final postoperative early and late outcomes. The data was collected through a designed questionnaire and was then analyzed using SPSS version 20. No significant ethical approval was required for this study. **Results:** Fifty-four patients were operated on through craniotomy (29/54) and burr hole (25/54). Their ages ranged from 1 year to 53 years with an average presentation at 13 years of age. Most patients presented with fever (23.1%), convulsions (16%), vomiting (16.7%) and headache (15.4%). The mean of illness for both groups was almost 2 months. The majority of patients in this study were having no risk factors (38.9%) while the major risk factors seen were cardiac diseases (14.8%), neurosurgical procedures (13%) and otitis media (11.1%). As most patients presented late, the diagnosis of most was made using CT brain with

contrast (83.3%). In most of the patients (85.2%) there were no organisms separated in the culture. 8/54 patients had positive cultures, 7/8 were bacterial and only one (1/8) was fungal. Most patients received antibiotics for 45 days postoperatively in both craniotomy and burr hole groups. When both groups were compared, those operated with craniotomy were found to have a relatively higher length of hospital stay, however, no significant difference was found between both groups. Also, it was found that those operated on with craniotomy had a high cure rate and less recurrence in comparison with burr hole group. Deterioration and death were significantly higher among craniotomy group. Only CT brain was used as the imaging modality of choice for follow-up in both groups for 4 months' duration and it was noted that complete evacuation was significantly higher among craniotomy group while remnants were higher among burr hole group. **Conclusion:** Brain abscess is still a challenging condition for neurosurgeons in Sudan. The limited number of Sudanese neurosurgeons, neurosurgical centers and diagnostic facilities contributed to delay in diagnosing brain abscess in most patients. It is important to design a strict protocol and precautions for any neurosurgical operation or bedside procedure to prevent infection and subsequent brain abscess development. CT brain with contrast is a good imaging tool for assessing the size, site and stage of brain abscesses. No significant difference between craniotomy or burr hole for clearance from brain abscess in terms of antibiotic used or duration of hospital stay. However, burr hole aspiration is associated with higher rates of recurrences. On the other hand, craniotomy and excision have relatively higher neurologic morbidity postoperative with expectantly higher post-operative hospitalization but no differences in the final outcome. Therefore, the selection of surgical technique should be individualized in each case based on the abscess site size source patient fitness for surgery and neurosurgeon's preference.

Keywords

Brain Abscess Surgery, Outcome, Comparison of Surgery of Brain Abscess, Craniotomy versus Burrhole

1. Introduction

A brain abscess is an intraparenchymal pus collection. The occurrence of brain abscesses is about 8% of intracranial masses in developing countries, and 1% - 2% in developed countries. [1] [2] Brain abscesses start as localized areas of cerebritis in the brain parenchyma and develop into collections of pus surrounded by a well-vascularized capsule. Despite there having been innovative advances in clinical Neuro-imaging techniques, Neurosurgical techniques, Neuroanesthesia, Microbiological isolation techniques and antibiotic therapy, brain abscesses can be fatal [3] [4] [5] [6]. A multidisciplinary approach is predominant to the successful management of brain abscesses and is a team approaches that include Neurosurgery, Neuro-medicine, Neuroradiology, and an infectious disease department.

Intracranial abscess formation is a direct interaction between the virulence of

the affront microorganism and the immune response of the host. It is still a severe, life-threatening disease and remains a conceivably fatal entity. [3] [7] It may lead to severe disability, or even death if misdiagnosed or managed inappropriately. However, the approach of current neurosurgical techniques including burr hole and aspiration or craniotomy and membrane excision with culture techniques, new generation antibiotics, and modern non-invasive neuroradiological imaging procedures have revolutionized the treatment and outcome of brain abscess. Eradication of the primary foci of infection is a chief. [3] [8] [9] The success of treatment is best when the etiologic agent is identified and antimicrobial therapy is targeted. The causative pathogens of brain abscesses vary according to geographic location, age, underlying medical and/or surgical condition, and mode of infection. [5] [8] [10] [11] [12]

Over the period of the last two decades, the incidence of the otogenic abscess has reduced while the post-traumatic or postoperative brain abscess has increased. [13] [14] [15]

2. Methodology

This is a descriptive longitudinal prospective study to compare the outcomes of two surgical procedures used for the treatment of brain abscess either via craniotomy with excision of membrane or via burr hole with an aspiration of the abscess. The study is conducted at The National Center for Neurological Sciences-Khartoum-Sudan (NCNS) including all patients who presented and were diagnosed with brain abscess and underwent surgery either craniotomy or burr hole with aspiration during the period from 2012 to 2015. The inclusion criteria represent all patients diagnosed with brain abscess in the (NCNS) during the mentioned period who underwent intervention either by craniotomy or burr hole. Exclusion criteria were patients without a confirmed diagnosis of brain abscess; those who were diagnosed with brain abscess and not treated surgically or operated on in other hospitals other than (NCNS). Data is collected by structured questionnaire sheet. The comparison was about the duration of hospitalization, length of antibiotic use, recurrence rate, number of images needed for follow-up and the final outcome. No significant ethical approval was required for this study because it is just an observational descriptive study for that outcome of two surgical procedures that are already used in this discipline and no new intervention was done to the selected participants by the researcher and no break to the patient's confidentiality and privacy

3. Results

3.1. Age Distribution

The youngest patient was 1-year-old and the oldest was 53 years old and the average age at presentation was approximately 12 years old (**Table 1(a)**) while the most affected age group was from 1 - 10 years (55.6%) (**Table 1(b)**).

Table 1. (a) The statistical values of age distribution among this series; (b) The age distribution in groups.

(a)

Mean	12.72
Median	7.50
Range	52
Minimum	1
Maximum	53

(b)

Age in Groups	Frequency	Percent %
1 - 10 years	30	55.6%
11 - 20 years	12	22.2%
21 - 30 years	4	7.4%
More than 30 years	8	14.8%
Total	**54**	**100.0%**

3.2. Sex Distribution

Most of the patients were males (63%) and one-third were females (37%), (Table 2).

3.3. Geographic Distribution

For ease of description, the patients were divided among 5 main regions according to their region of origin. The majority of them were found in Khartoum and the central area (72.2%) (Table 3).

3.4. Diagnosis

All of the patients were diagnosed with brain abscess pre-operatively.

3.5. Period between Diagnosis and Surgery

Most patients spent approximately 25 days between diagnosis and brain abscess surgery. Two patients were operated on the same day of diagnosis, while 2 patients spent approximately one year (Table 4(a)). The average duration was found to be ranging between 0 - 20 days (79.6%) (Table 4(b)).

3.6. Main Complaint

Most patients presented with fever, convulsions, vomiting and headache while only a few of them presented with motor weakness. (Table 5(a)) Those who had other symptoms most of them presented with aphasia and ear discharge (Table 5(b)).

Table 2. The gender distribution.

Gender	Frequency	Percent %
Male	34	63.0%
Female	20	37.0%
Total	**54**	**100.0%**

Table 3. The geographical distribution of the patients according to the area of origin.

Residence	Frequency	Percent %
Khartoum	19	35.2%
Central Area	20	37.0%
North	3	5.6%
South	1	1.9%
West	11	20.4%
Total	**54**	**100.0%**

Table 4. (a) The statistical values of the duration in days between the diagnosis and surgical intervention; (b) The duration between diagnosis and surgical intervention in groups.

(a)

Mean	25.74
Median	9.00
Range	374
Minimum	0
Maximum	374

(b)

Period between Diagnosis and Surgery	Frequency	Percent %
0 - 20 days	43	79.6%
21 - 40 days	6	11.1%
41 - 60 days	1	1.9%
More than 60	4	7.4%
Total	**54**	**100.0**

3.7. Duration of Illness in Days

The minimum duration of illness among this series was 2 weeks while the maximum duration was 13 months. The majority of patients presented in 2 months' duration (Table 6(a)). When the duration was put in groups, the majority of cases were lying in periods ranging from 21 - 60 days (61.1%) (Table 6(b)).

Table 5. (a) The distribution of the main presenting complaint; (b) Other presenting complaints; the distribution of the other complaints among the affected groups.

(a)

Main Complain	Frequency	Percent %
Headache	24	15.4%
Vomiting	26	16.7%
Fever	36	23.1%
Motor Weaknesses	17	10.9%
Convulsion	25	16%
Others	28	17.9%
Total	**156**	**100%**

(b)

Other Complains	Frequency	Percent %
Aphasia	6	21.4%
Squint and Eye Swelling	1	3.6%
Complete Blindness	1	3.6%
Blurring of Vision	1	3.6%
Confusion	1	3.6%
Decreased Level of Consciousness	3	10.7%
Impaired Vision	1	3.6%
Ear Discharge	5	17.8%
Ear Pain	1	3.6%
Exposed V. P. Shunt	1	3.6%
Increased Head Size	4	14.3%
Facial Palsy	1	3.6%
Refusal of Feeding	1	3.6%
Unsteady Gait, Dizziness & Decreased Hearing	1	3.6%
Total	**28**	**100%**

Table 6. (a) The statistical values of the duration of patient illness in days; (b) The distribution of the duration of patient illness in groups.

(a)

Mean	62.83
Median	44.50
Range	386

Continued

Minimum	14
Maximum	400

(b)

Duration in Groups	Frequency	Percent %
1 - 20 days	8	14.8%
21 - 40 days	18	33.3%
41 - 60 days	15	27.8%
61 - 80 days	1	1.9%
More than 80 days	12	22.2%
Total	**54**	**100.0%**

3.8. Risk Factors

Although the majority of the cases were having no risk factors (38.9%), but many risk factors were detected. Of these, cardiac disease and previous neurosurgical procedures were the dominant risk factors (27.8%) (Table 7(a)).

The patient with pulmonary infection had tuberculosis. One of the patients with head trauma had Mycetoma, (6/7) patients with neurosurgical procedures were found to have infected V. P. shunt and (1/7) had EVD. (3/8) of the patients with cardiac disease had VSD, (2/8) had Fallot's tetralogy, (1/8) had patent truncus arteriosus.

Other risk factors were detected in seven patients apart from those listed above and are distributed as follows (Table 7(b)).

3.9. Diagnostic Tools

Both CT brain and MRI with contrast were used to diagnose brain abscess in this series however the majority of them were diagnosed with brain CT scan (83.3%) (Table 8).

3.10. The Location of Brain Abscess

The brain abscesses were distributed in both cerebral hemispheres equally (Table 9(a)).

Most of the abscesses were detected in the frontal and parietal lobes (61.1%) (Table 9(b)). In 20% of the cases (11 cases) abscess was detected in other brain regions, half of them were in the fronto-parietal area.

3.11. Type of Surgical Procedures

Two types of surgical procedures were used; craniotomy and burr hole with an almost equal distribution (Table 10). The selection of either procedure depends on the size and location of brain abscess besides the surgeon preference.

Table 7. (a) The distribution of risk factors among the affected groups; (b) Other risk factors detected in little number of cases.

(a)

Risk Factors	Frequency	Percent %
Otitis Media	6	11.1%
Mastoiditis	2	3.7%
Head Trauma	2	3.7%
Neurosurgical Procedure	7	13.0%
Pulmonary Infection	1	1.9%
Cardiac Disease	8	14.8%
Other	7	13.0%
No Risk Factor	21	38.9%
Total	**54**	**100.0%**

(b)

Risk Factors	Frequency	Percent %
Diabetes Mellitus	1	14.3%
Hydrocephalus	3	42.8%
Eye Lid Abscess, Cavernous Sinus Thrombosis	1	14.3%
Postmeningitic	1	14.3%
SLE	1	14.3%
Total	**7**	**100%**

Table 8. The imaging tools used to diagnosed brain abscess.

Diagnostic tools	Frequency	Percent %
Brain CT scan with contrast	45	83.3%
Brain MRI with contrast	9	16.7%
Total	**54**	**100.0%**

Table 9. (a) The location of brain abscess in cerebral hemisphere; (b) The involved brain lobes; the distribution of brain abscesses in the main lobes of the brain; (c) The other affected brain regions; other affected brain regions apart from the main brain lobes.

(a)

Location	Frequency	Percent %
Right	27	50.0%
Left	27	50.0%
Total	**54**	**100.0%**

(b)

Affected Lobe	Frequency	Percent %
Frontal	19	35.2%
Parietal	14	25.9%
Temporal	5	9.3%
Occipital	4	7.4%
Cerebellar	1	1.9%
Other	11	20.4%
Total	**54**	**100.0%**

(c)

Affected Brain Regions	Frequency	Percent %
Basal Ganglia	1	9.1%
Frontoparietal	6	54.5%
Frontoparietotemporal	1	9.1%
Parietooccipital	1	9.1%
Temproparietal	2	18.2%
Total	**11**	**100%**

Table 10. The type of surgical procedure used to treat brain abscess.

Type of Surgical Procedure	Frequency	Percent %
Burr Hole and Needle Aspiration	25	46.3%
Craniotomy and Excision of Membrane	29	53.7%
Total	**54**	**100.0%**

3.12. The Microbiological Organisms Isolated in the Culture

In most of the cases (85.2%) there were no organisms separated in the culture. 8/54 cases had positive cultures, 7/8 were bacterial and only one (1/8) was fungal. (Table 11(a)).

Only (7/54) organisms were isolated, 6 bacteria and 1 fungus. The isolated fungus was Actinomyces. The isolated bacteria were as follows (Table 11(b)).

To better analysis the outcome of each surgical procedure and for the ease of description, the patients were divided into two groups; the craniotomy group (29/54) and the burr hole group (25/54) (Table 10).

3.13. Length of Antibiotic Use Postoperative

Most patients received antibiotics for 45 days in both craniotomy and burr hole groups (Tables 12(a)-(e)).

Table 11. (a) The type of organism isolated in culture; (b) The specific micro-organism detected in culture.

(a)

Organisms Isolated	Frequency	Percent
Bacteria	7	13.0%
Fungi	1	1.9%
No Growth	46	85.2%
Total	**54**	**100.0%**

(b)

Bacteria Isolated	Frequency	Percent %
Kelebsella	1	14.3%
Pesudomonas	1	14.3%
Staph. aureus	1	14.3%
Partonella	1	14.3%
Strepto. pneumonae	1	14.3%
Staph. epiderms	1	14.3%
Strepto. viridans	1	14.3%
Total	**7**	**100%**

Table 12. (a) and (b) The antibiotic duration length among patient underwent craniotomy and excision of membrane; (b) The antibiotic length among craniotomy group; (c)-(e) The antibiotic duration length among patient underwent burr hole and aspiration of the brain abscess; (d) and (e) The antibiotic length among burr hole group; (f) The antibiotic use among both groups.

(a)

Mean	42.69
Median	45.00
Range	180
Minimum	0
Maximum	180

(b)

Antibiotic Duration after Craniotomy	Frequency	Percent %
0 - 15 days	4	13.8%
16 - 30 days	2	6.9%
31 - 45 days	21	72.4%
46 - 60 days	1	3.4%
More than 60 days	1	3.4%
Total	29	100.0%

(c)

Mean	44.40
Median	45.00
Mode	45
Range	30
Minimum	30
Maximum	60

(d)

Duration of Antibiotics after Burr Hole	Frequency	Percent %
30 days	2	8.0%
45 days	22	88.0%
60 days	1	4.0%
Total	**25**	**100.0%**

(e)

Antibiotic Duration after Burr Hole	Frequency	Percent %
21 - 40 days	2	8.0%
41 - 60 days	22	88.0%
More than 60	1	4.0%
Total	**25**	**100.0%**

(f)

Antibiotic Duration	Craniotomy	Burr Hole
0 - 15 days	4	0
16 - 30 days	2	2
31 - 45 days	21	22
46 - 60 days	1	1
More than 60 days	1	0
Total	**29**	**25**

For the ease of description both groups were gathered together and it showed nearly the same duration of antibiotic use among both groups (Table 12(f)).

3.14. Length of Hospital Stay

Among craniotomy group, most patients stayed in the hospital for 10 days, the minimum duration of hospital stay was 7 days and the maximum duration was 50 days (Table 13(a))

When the durations were quoted in groups nearly half of the patients were found in the time range of 8 - 14 days (Table 13(b)).

Table 13. (a) Duration of hospital stay among craniotomy group; (b) Duration of hospital stay in groups among craniotomy group; (c) Duration of hospital stay among burr hole group; (d) Duration of hospital stay among those operated with burr hole in group; (e) The comparison of hospital stays between craniotomy and burr hole group.

(a)

Mean	15.97
Median	10.00
Range	53
Minimum	7
Maximum	60

(b)

Duration of Hospital Stay after Craniotomy	Frequency	Percent %
1 - 7 days	6	20.7%
8 - 14 days	12	41.4%
15 - 21 days	5	17.2%
More than 21 days	6	20.7%
Total	**29**	**100.0%**

(c)

Mean	15.88
Median	10.00
Mode	7
Range	37
Minimum	7
Maximum	44

(d)

Duration of Hospital Stay after Burr Hole	Frequency	Percent %
1 - 7 days	6	24.0%
8 - 14 days	9	36.0%
15 - 21 days	3	12.0%
More than 21 days	7	28.0%
Total	**25**	**100.0%**

(e)

Duration of Hospital Stay	Craniotomy	Burr Hole
1 - 7 days	6	6
8 - 14 days	12	9
15 - 21 days	5	3
More than 21 days	6	7
Total	**29**	**25**

Among burr hole group, most patients stayed for 10 days, the minimum duration among this group was 7 days and the maximum duration was 44 days (Table 13(c) and Table 13(d)).

When both groups were compared, those operated with craniotomy were found to have a relatively higher length of hospital stay, however no significant difference was found between both groups (Table 13(e)).

3.15. Early Postoperative Outcome

Early postoperative outcome was assessed in those operated on with craniotomy and it was found that the majority of the patients in this group improved or even cured completely (82.8%) (Table 14(a)). The same was found among burr hole group; those who improved or even cured completely were 88% of the patients in this group (Table 14(b)).

When both groups were compared, it was found that those operated with craniotomy had a high cure rate and less recurrence in comparison with burr hole group. On the other hand, Deterioration and death were significantly higher among the craniotomy group (Table 14(c)).

Those who died (3/54) one of them had septic shock and in the remaining 2 patients the cause of death was unknown. The patient with recurrence was operated on through a burr hole and after recurrence re-operated with craniotomy and complete excision of the abscess 2 weeks later.

Most of the improvement noted was in a form of the disappearance of the presenting symptoms and therefore most of them had subsided fever, convulsions and stoppage of ear discharge (Table 14(d)).

3.16. The Late Outcome Results

Upon assessing the late outcome among burr hole group, it is found that almost half of the patients had complete resolution of their abscess (Table 15(a)). On the other hand, in the craniotomy group, those who had complete evacuation of their abscesses were almost two-thirds of the patients in the group (Table 15(b)).

4. Discussion

In spite of the advances made in the 20th century in the imaging techniques, microbial isolation, antibiotic therapy and surgical techniques, brain abscess (BA) still show high morbidity and mortality rates specially in the developing countries and tropical regions [16] [17] [18]. In Nathoo *et al.* study which constitutes the biggest series published in the literature to date with 973 brain abscess patients where they found a mean age of 24.36 years and men mostly affected 74.2%. [19] In this study the majority of the affected patients were in the first 2 decades of life. This may be explained by the fact that, good bulks of cases in this study were having cardiac problems and otitis media. Males were representing almost two thirds of the cases of the series as most of the attributed risk factors for developing brain abscess are affecting mainly male population. The majority

Table 14. (a) The early postoperative outcome among craniotomy group; (b) The early postoperative outcome among burr hole group; (c) The comparison of the postoperative outcome among both two groups; (d) The improvement parameters among both groups.

(a)

Outcome and Prognosis	Frequency	Percent %
Cured	16	55.2%
Improved	8	27.6%
Static	1	3.4%
Deteriorated	2	6.9%
Recurrence	0	0%
Died	2	6.9%
Total	**29**	**100.0%**

(b)

Outcome and Prognosis	Frequency	Percent %
Cured	14	56.0%
Improved	8	32.0%
Static	1	4.0%
Deteriorated	0	0%
Recurrence	1	4.0%
Died	1	4.0%
Total	**25**	**100.0%**

(c)

Outcome and prognosis	Craniotomy	Burr Hole
Cured	16	14
Improved	8	8
Static	1	1
Deteriorated	2	0
Recurrence	0	1
Died	2	1
Total	**29**	**25**

(d)

Improvement Parameters among Both Groups	Frequency	Percent %
Headache,	4	13.8%
Convulsion	5	17.2%
Fever	12	41.4%
Vomiting	4	13.8%

Continued

Ear Discharge	1	3.45%
Weakness	2	6.9%
Level of Consciousness	1	3.45%
Total	**29**	**100.0%**

Table 15. (a) The late outcome results among burr hole group; (b) The comparison of late outcome among both craniotomy and burr hole group.

(a)

Late Outcome among Burr Hole Group	Frequency	Percent %
Complete evacuation	14	56.0%
Remnant	7	28.0%
Recurrence	3	12.0%
Not Done	1	4.0%
Total	**25**	**100.0%**

(b)

Late Outcome among Craniotomy Group	Craniotomy	Burr Hole
Complete Evacuation	18	14
Remnant	6	7
Recurrence	3	3
Not Done	2	1

of patients were from Khartoum and the surrounding central area of Sudan as neurosurgical centers and facilities for established diagnosis and treating brain abscess are only available in this part of Sudan. Large number of patients was also found in the West of Sudan and this may be attributed to the poverty, illiteracy and poor sanitation created by the wars and conflicts in that region.

Due to the availability of the diagnostic tools in Khartoum and nearby states all patients were correctly diagnosed as having brain abscesses pre-operatively and the majority of the patients were abruptly operated in not more than 3 weeks from the time the diagnosis has been established. The clinical features of brain abscess is dependent on the origin of infection, site, size, number of lesions, specific brain structures involved, the anatomic disturbances to the cisterns, ventricles, and the Dural venous sinuses, and any secondary cerebral injury [6] [20] [21]. Among this series the majority of the patients presented with clinical features of raised intracranial pressure; including headache, vomiting and convulsions, or symptoms of mass effect like weakness, aphasia and decreased level of consciousness. Fever was the predominant presenting symptoms among those previously mentioned syndromes. This is similar to Nathoo's study who reported that headaches, fever, and nuchal rigidity are the commonest clin-

ical presentations. [19]

As Sudan is a wide country with the lack of neurosurgical facilities, diagnostic tools and the difficulties in transporting the patients from their sites of residency to neurosurgical centers in Khartoum, most of them presented with the duration of symptoms extending for an average of 2 months risk factors were traced in the patients in this series, one-third of the patients had no risk factors while the major risk factor seen in this study patients was neurosurgical procedures and this finding is consistent with what was mentioned in the literature.

The main imaging tool used in the diagnosis and follow-up was CT brain with contrast, as it is available in most diagnostic centers, cheap, and easily accessible.

All of the patients in this study presented in the late capsule stage and this may be explained by the late presentation of most of them.

The site of brain abscess provides an important clue on the possible causative factor. For example, abscesses from frontal and ethmoid sinusitis tend to be in the frontal lobe while those from otitis media tend to be in the temporal lobe and cerebellum. [8] In this series, most abscesses were found in the frontal and parietal lobes although none of the patients gave a past history of sinusitis. However, a reasonable number of patients had hydrocephalus for which the treating doctors used to do ventricular tapping from the frontal horn of the lateral ventricle to relieve the raised intracranial pressure. This may be one iatrogenic cause. The second thing is that some patients had infected ventriculoperitoneal shunt and retrograde spread of infection may be considered as another cause for this. Besides that, the bulk of patients had congenital heart diseases as a predisposing factor, and this causes brain abscess through haematogenous spread and abscesses tend to be distributed mainly among frontal, parietal and temporal lobes.

Some patients were operated on through burr hole and some through craniotomy. To avoid any bias in evaluating which is better, the number of patients in both groups was almost 50:50, and all patients in both groups were offered the same antibiotics (Ceftriaxone, Vancomycin and Metronidazole) and for the same length of antibiotic use. In Nathoo *et al.* series (the biggest reported series) found that the commonest organisms isolated S. aureus and S. epidermis [22] Most of the patients in this study series had negative cultures and no organisms isolated owing to the pre-operative empiric use of antibiotics. Most of the isolated micro-organisms were bacterial and this may be due to the fact that most of the patients had neurosurgical procedures, congenital heart diseases and otitis media as the main predisposing factors for their brain abscesses.

Craniotomy patients in this study required relatively longer hospitalization as craniotomy is more invasive procedure and the patient requires closer monitoring in the intensive care unit and in the ward prior to discharge. Few of the burr hole patients required long hospitalization as their clinical condition didn't improve postoperatively and some of them required re-operation with craniotomy and evacuation of their abscesses. This is unlike what has been mentioned in

Mut *et al.* 2009, Tan *et al.* 2010 and Sarmast *et al.* 2012 series in which they reported that craniotomy patients significantly have shorter hospital stay and duration of antibiotic use when compared with burr hole group [23] [24] [25]. This can be simply justified with the fact that in this study we fixed the duration of antibiotic use for both groups to avoid any bias in the outcome as mentioned earlier.

Upon assessing the early outcome among both groups, it has been found that craniotomy patients have relatively higher recovery rates with no recurrences while on the other hand death and neurologic deterioration were higher in this group when compared with burr hole group. This may be justified by the reason that craniotomy is more aggressive and needs some manipulation of the brain tissue close to the abscess. The fact that the craniotomy group has fewer recurrences and a lower rate of surgeries is consistent with the findings in Mut *et al.* and Sarmast *et al.* studies. [9] [10] However when the overall outcome among the craniotomy group and burr hole group was found that there is no difference between both groups (P = 0.000). The patients among both groups were re-evaluated with CT brain with contrast in a mean duration of 4 months, and it has been found that no significant difference between both groups when talking in terms of long-term follow-up.

5. Conclusions

Brain abscess is still a challenging neurosurgical condition for most neurosurgeons in Sudan. The limited number of Sudanese neurosurgeons, neurosurgical centers and diagnostic facilities contributed to the delay in diagnosing brain abscess in most cases.

CT brain with contrast is a good imaging tool for assessing the size, site and stage of brain abscesses

The empiric uses of antibiotics pre-operatively aided to an increased prevalence of insignificant microorganism's growth in most specimens. Therefore, we recommend taking a biopsy of the brain abscess early before the antibiotic prescription. It is also important to check aerobes and anaerobes, gram staining and fungal growth in any brain abscess culture rather than just doing the routine bacterial culture only.

No difference between craniotomy or burr hole for removal of brain abscesses in terms of antibiotic use or duration of hospital stay. However, burr hole aspiration is associated with higher rates of recurrences. On the other hand, craniotomy and excision have relatively higher neurologic morbidity postoperative with expectantly higher post-operative hospitalization. Therefore, the selection of surgical technique should be individualized in each case based on the abscess site size source patient fitness for surgery and the neurosurgeon's preference.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Abbreviations

CHD—Cyanotic Heart Disease
MCA—Middle Cerebral Artery
HIV—Human Immunodeficiency Virus
CT—Computed Tomography
MRI—Magnetic Resonance Image
MHC—Major Histocompatibility Complex
IL 1—Interleukin 1
TNF—Tumour Necrosis Factor
CNS—Central Nervous System
MIP 2—Macrophage Inflammatory Protein 2
ICP—Intra Cranial Pressure
T1—Time 1
T2—Time 2
T1WI—Time 1 Weighted Image
T2WI—Time 2 Weighted Image
PCR—Polymerase Chain Reaction
DWI—Diffusion Weighted Image
ADC—Apparent Diffusion Coefficient
FA—Fractional Anisotropy
PMR—Perfusion Magnetic Resonance
MRS—Magnetic Resonance Spectroscopy
1HMRS—Proton Magnetic Resonance Spectroscopy
rCBV—relative Cerebral Blood Volume
LP—Lumbar Puncture
CSF—Cerebro-Spinal Fluid
ESR—Erythrocytes Sedimentation Rate
SD—Standard Deviation
NCNS—National Centre for Neurological Sciences
Fig—Figure
OM—Otitis Media
VP—Ventriculo-Peritoneal
EVD—External Ventricular Drain
VSD—Ventricular Septal Defect
SLE—Systemic Lupus Erythematosus
BA—Brain Abscess
SPSS—Statistical Package for the Social Sciences