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BRAIN ABSCESS: A REVIEW
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M. A. A. MAGOHA and N. J. MWANGOMBE

ABSTRACT

Objective: **To carry out a current review of brain abscess**
data source: review of all the published literature on the brain abscess until august 2016 was carried out through internet, google, pubmed and medline searches.
Data selection: **Published data on brain abscess were included in the review.**
Data extraction: **Abstracts of relevant articles identified were assessed, read and analyzed to determine their relevance to the brain abscess, the subject under review.**
Data synthesis: **After establishing relevance from the abstract, the entire paper was read and the significant points included in the subject under review.**
Conclusion: **Brain abscesses are rare with significant consequences of missed or delayed diagnosis, but remain one of the most common neurological emergencies especially in developing countries, being 8% of intra-cranial space occupying lesions compared to 1%-2% in the developed countries. In the pre-antibiotics, CT, and MRI eras, brain abscess was almost always 100% fatal. The reduction in morbidity and mortality over the past five decades is attributed to recent advances and increased availability of computer tomography with double contrast enhancement which provides early and reliable diagnosis, localisation, and characterisation of abscesses and monitoring the effectiveness of treatment. Magnetic resonance imaging (MRI) with gadolinium enhancement has much greater sensitivity and specificity than CT making it the procedure of choice, while MRI together with diffusion weighted imaging with a sensitivity and specificity of 90% distinguishes brain abscesses from necrotic brain tumours. Advances in microbiological isolation techniques, efficient combination anti-microbial, anti-tuberculus and anti-fungal therapy, stereotactic aspiration and technology assisted neurosurgical techniques have resulted in significant reduction in morbidity and mortality globally.**

INTRODUCTION

Brain abscess is an intra-parenchymal localised collection of pus, immune cells and other materials within the brain substance which can arise from a variety of infections, trauma or surgery, and may be in single or multiple sites. It is a serious and life threatening clinical entity. The incidence of brain abscess is approximately 8% of intra-cranial space occupying lesions in developing countries including Africa, and 1-2% in developed including western countries (1,2). Brain abscess therefore remains one of the common neurological emergencies particularly in developing countries (3). Although brain abscesses are rare, the consequences of missed or delayed diagnosis are quite significant (4,5). The clinician is urged to have a high clinical index of suspicion of brain abscess in patients with headaches and focal neurological symptoms. Historically, the condition was considered almost always 100% fatal (6). The first successful operation for brain abscess was performed by a French surgeon, F.S. Morand in 1752 on a supratentorial abscess (7). However over the past three decades, in the developed and Western countries and specifically outside Africa, the incidence and mortality of brain abscess has been reported to be rapidly decreasing with incidence of 0.4-0.6 per 100,000 (8). This reported reduction in morbidity and mortality is largely attributed to the rise and availability of modern diagnostic techniques in neuroimaging such as computer tomography (CT) and magnetic resonance imaging (MRI) over the past three decades. Despite the recent advances in microbiological isolation and neuroimaging techniques, neuroanaesthesia, anti-microbial and anti-fungal treatment, and neurosurgical techniques including technology assisted and precise neurosurgical interventions, brain abscess continues to remain a very challenging clinical problem to neurosurgeons globally, with significant morbidity and mortality, still leading to some case fatalities (9,10).

By the second part of the twentieth century, neurosurgical services in Africa was still mostly lacking, or very poor when available due to lack of medical infrastructure, qualified neurosurgical personnel and relevant equipment necessary for the effective investigation, localisation and management of brain abscess. One of the first neurosurgical units to be established in sub-Sahara Africa was at the University of Ibadan in Nigeria in 1965, from where brain abscess in Africans was later reported by Adeloye to comprise 2-5% of the intra-cranial space occupying lesions (10,11). Currently in some select well equipped African centers with well trained neurosurgical personnel, there has been increased utilisation of computerised tomography scanning as the most dependable diagnostic tool in the management of brain abscesses resulting in some reduction in morbidity and mortality (12-14).

However data from within the African continent and other developing countries is minimal and often disjointed and therefore mostly unable to provide a complete objective and holistic picture of the true impact of the advent of computerised tomography and magnetic resonance imaging in the management of brain abscesses in the continent. The exception here is with the many emerging university and other specialised hospitals in many African urban centers that are much better equipped with these facilities in addition having increasing numbers of well trained neurosurgical personnel to adequately support the treatment process.

In the pre-antibiotic era, the mortality rate of brain abscess was reported to be as high as 61%, reducing on the introduction of antibiotics to a mortality rate of about 10-40% (10). The successful management of brain abscess is effected through a multidisciplinary approach with effective clinical teamwork. The team is lead by a neurosurgeon working in close association with a neurologist, an infectious disease specialist, a neuroradiologist and well trained and experienced laboratory scientist with good functional laboratories and imaging facilities for diagnostic purposes (15).

AETIOLOGY

Brain abscess can be caused by bacteria, fungi, or parasites which include helminthes, Protozoa, and viruses. The aetiological causative agent of the brain abscess cannot be identified in a significant number of cases. Brain abscess may result from traumatic brain injury, prior neurosurgical procedure, contiguous infective spread from a local source such as mastoiditis, paranasal sinusitis, or dental infection, or haematogenous spread from of a systemic infection such as endocarditis or bacteremia. Bacteria enter the brain through contiguous spread in about half of the cases, and through haematogenous dissemination in about one third of the cases with unknown mechanisms accounting for the rest. In most cases, brain abscess results from several predisposing factors such as infection with human immunodeficiency virus (HIV), history of treatment with immunosuppressive drugs like in organ transplant patients (10). HIV infection is associated with brain abscess caused by Toxoplasma gondii and in some cases mycobacterium tuberculosis (16,17). Patients who have received solid organ transplant are at risk of norcardial and fungal brain abscess by aspergillus or candida species (18).

The causative organisms in brain abscess varies according to the age and immunological status of the patient. In adults aerobic, macroaerophilic and anaerobic streptococci are found in 60-70% of cases and are common in abscesses from dentogenic infection and sinusitis. Anaerobic bacteroides species and enteric bacteria including *E. Coli, Proteus,* and *Pseudomonas* are present in 10-15% of cases, and are the most common isolates in brain abscesses arising from penetrating cranial trauma such as gun shot injuries to the head or neurosurgical procedures (10,19). The cause of infection in brain abscess is identifiable in many cases but the source of infection still remains unidentifiable in approximately 25% of cases even, after thorough investigations have been carried out to identify the isolates (4,19,20). Multiple organisms have been isolated in approximately 18% of cases (19). Brain abscess in neonates is a frequent complication of meningitis with the most frequently isolated organisms being gram negative organisms such as *Escherichia Coli, Proteus, Serratia, and Citobacter* species (19,21).

The pathogens involved in pyogenic brain abscesses usually depend on the predisposing condition, the host immune status and the mode of acquisition. Brain abscesses that are attributed to haematogenous spread accounts for 9-43% of all brain abscesses, and includes infective endocarditis, like in congenital cyanotic heart disease, or pulmonary infections such as pneumonia, empyema thoracis, bronchiectasis and lung abscess. Infection from any other systemic source may also lead to severe bacteremia and subsequent spread to the brain parenchyma even in the absence of cyanotic heart disease, resulting in brain abscess formation. Brain abscesses of haematogenous origin are most common in the distribution areas of the middle cerebral artery, followed by the distribution areas of the anterior cerebral and posterior cerebral arteries respectively (10,19,22). Contiguous spread of infection may originate from adjacent bone, teeth, sinus mucosa, mastoid, internal auditory canal or cochlear structures and travel into the intra-cranial vault via venous drainage, thus inoculating, the intra-cranial compartment and leading to brain abscess formation, and represents 14-58% of all brain abscesses. Direct extension usually causes a single brain abscess and may occur from necrotic areas of osteomyelitis in the frontal, ethmoidal, and sphenoidal sinuses (4,23,24). Invasive and recent neurosurgical procedures are also one of the known risk factors for the development of brain abscesses and accounts for 0.2-18% of all brain abscesses (25).

Following neurosurgery or penetrating cranial trauma such as in gunshot injuries, the most likely pathogens causing brain abscess are *staphylococcus aureus*, coagulase-negative *staphylococci, pseudomonas aeruginosa, enterobacter* species, some *streptococci,* and *clostridium* species. In our locality Mwangombe reported trauma to be the commonest cause of brain abscess in Africans at Kenyatta National Hospital, Nairobi Kenya, and *staphylococcus, streptococci, Klebsiella* and *haemophilus influenzae* as the most commonly isolated organisms, with a mortality rate of 30.7% (26). In another current 2016 unpublished study on brain abscess at Kenyatta National Hospital Nairobi, Hitimana and Mwangombe again reported cranial trauma followed by paranasal sinus infections as the most common causes of brain abscess 26. These findings were similar to those later reported by other African authors at Umtata General Hospital and Nelson Mandela Academic Hospital in Eastern Cape, South Africa where the most common cause of brain abscess was reported as trauma (26). In chronic pulmonary infection such as lung abscess, empyema thoracis or bronchiectasis, common organisms isolated are *Fusibacterium* species, *anaerobic streptococci* and *anaerobic Bacteroides, Nocardia* species and *Actinomyces* . Miscellaneous causes of brain abscess in the normal host which only account for a very small percentage of cases, include Protozoa such *entamoeba histolytica, schistosoma*, and heminths such as Tania solium which causes neurocysticercosis (15).

Most brain abscesses usually affect the frontal lobe, but may also occur in any other anatomical location of the brain. The location of the brain abscess is usually very closely associated with the original source of the infection. For example abscesses associated with paranasal sinusitis are predominantly frontal in location. The paranasal sinuses are a common source of purulent infection spread occurring through the frontal sinus infection into the frontal lobe forming abscess, while abscesses associated with otogenic and sphenoid sinus infections usually affect the temporal lobe of the brain and the cerebellum (4,22). Abscesses may be single or multiple. A significant proportion of patients 9.3-28% develop multiple brain abscesses (22,23). Fungal infections, toxoplasmosis, *staphylococcus* species, *streptococcus* species and pseudomonas are identified in immunosuppressed patients with HIV infection, organ transplantation, chemotherapy or steroid usage (28). The mortality rates from fungal abscesses are very high and sometimes range from 75%-100% despite treatment with anti-fungals such as amphotericin B (29). Immunosuppression increases the risk of brain abscess formation. For example, solid organ transplantation increases the risk of infection and subsequent fungal abscess formation from *Aspergillus* species, although other species of fungi such as *Candida, Dematiaceous* fungi or phacohyphomyctes may produce localised infection. Nocardia infection is not common in solid organ transplant patients and bone marrow transplant patients. Tuberculous abscess is present in about 1% of solid organ transplant patients. Immunocompromised patients infected with HIV AIDS are more likely to have multiple abscesses including abscesses from Toxoplasma gondii, and tuberculous abscesses. This group of patients are also more susceptible to infections from Nocardia, Listeria, and *Cryptococcus* leading to brain abscess formation (22,29).

DIAGNOSIS

The clinical presentation of patients with brain abscesses are variable and non specific. The most common symptoms are headache, fever, focal neurological symptoms, altered mental status, nausea and vomiting. About one third of cases may present with seizures that are frequently generalised in nature, and often associated with frontal lobe abscesses. Status epilepticus, neck stiffness and meningismus are more scarce but have been previously reported. Since most patients present with none specific and unclear symptoms a high index of clinical suspicion is necessary in order to avoid unnecessary delay in diagnosis. Patients with headaches associated with signs of increased intra-cranial pressure or gradual onset of neurological deficit fall into this cartegory (8,10,29). Laboratory data are non specific and therefore of very limited assistance in the diagnosis of brain abscess except for blood cultures which should be performed early in suspected patients. The reported positive yield though only modest at 14-50% has great potential value for the identification of the causative organism in the circumstances where collection of abscess material cannot be performed promptly or is not advisable due to associated risks (4,29). Cerebrospinal fluid (CSF) analysis may reveal pleocytosis, elevated protein, and decreased glucose but remains normal in a significant number of patients. Lumbar puncture is considered as hazardous in patients with brain abscess and should be performed only when there is strong clinical suspicion of meningitis or abscess rupture into the ventricular system, and when there are no contraindications to lumbar puncture like brain shift on cranial neuroimaging, or the presence of known coagulation disorders. This is mainly because the procedure can lead to rapid neurological deterioration such as downward herniation of the brain in as many as 20% of patients with brain abscess (10,30).

Plain radiography is only of limited value in the diagnosis of brain abscesses. Radiographic findings are usually limited to opacification of the paranasal and mastoid sinuses. The findings on radiography of air fluid levels within the cranium or gas bubbles may be significant and indicate communication with the paranasal sinuses or nose and the possible presence of gas producing organisms. Direct evidence of osteomyelitis of the skull is generally of mixed pattern lucency with the destruction of outer or inner tables of the skull. Occasionally foreign bodies such as in gunshot wounds or osteomyelitis of the maxillary bone may indicate the probable source of brain abscess. Bone destruction of the roof, floor or lateral wall of the sinuses may indicate aggressive osteomyelitis with extension into the intra-cranial space. Air fluid levels in the cranial vault however strongly suggest the early stages of abscess formation. The use of ultrasound scanning in the diagnosis brain abscess is depicted as a complex cystic pattern with ecogenic wall and hypoecholic or mildly hyperecholic central zone necrosis. Brain ultra-sonography is rarely useful in the evaluation of brain abscess in adult patients, except for its role the intra-operative guidance for aspiration procedures, because the intact skull is a barrier to the procedure. In neonates however, brain abscesses can be diagnosed by ultra-sonographic images through the anterior fontanelle of the skull. Brain ultra-sonography can reveal the size, number and location of the brain abscesses in the neonate. The ultrasound guided aspiration of brain abscesses through a burr hole has been performed with good results results. Ultra-sonography examination has proved to be an excellent tool not only for the initial diagnosis but also in follow up of brain abscess in neonates (31).

Imaging of the brain is critical to the effective diagnosis and management of brain abscesses. Plain radiographs of the paranasal sinuses can only suggest a possible aetiology of brain abscesses. Computerised tomography (CT) scanning has made other tests such as cerebral angiography, ventriculography, and radionuclide brain scans almost obsolete. In the earliest stages of evolution of a cerebral abscess, a computerised tomography (CT) scan of the brain may be negative or it may show subtle non specific findings. The early findings of computerised tomography (CT) examinations are therefore non-specific for the diagnosis of the early stages brain abscess formation. Computerised tomography (CT) scanning with contrast enhancement provides a very reliable and rapid means for early detection of the size, number, exact localisation, and accurate characterisation, and staging of the brain abscesses. Computerised tomography (CT) scanning also detects increased intra-cranial pressure, brain oedema, and other associated infections like cerebritis, ventriculitis and subdural empyema, and is therefore significant in the subsequent planning for the treatment of brain abscesses. The early stages of cerebritis are well characterized on non contrast computerised tomography (CT) scanning by localised hypoattenuation . Contrast enhancement is variable and may demonstrate a modular or ring like pattern. Double contrast computerised tomography (CT) scanning is useful in diagnosing encapsulation of cerebral abscess as compared to conventional computerised tomography (CT) scanning. A serial computerised tomography study is also very useful in the assessment of the effectiveness of treatment and subsequent patient follow up. Haematogenous abscesses which are usually associated with bacterial endocarditis as a result of congenital cyanotic heart disease, pulmonary vascular malformations and cardiac shunts are in most cases multiple, and identified by computerised tomography scanning at the junction of grey and white matter of the brain, and located in the middle cerebral artery territory. Computerised tomography (CT) scanning of the brain is also capable of effectively diagnosing hydrocephalus (4,20,32,33).

Magnetic resonance imaging (MRI) has much greater sensitivity and specificity as compared to computerised tomography (CT) scanning in identifying pyogenic brain infection and abscess and other intra-cranial space occupying lesions. Magnetic resonance imaging (MRI) with the use of gadolinium enhancement is the imaging procedure of choice for the accurate diagnosis of brain abscesses, when available (10,34). Positive labeling in radionuclide imagining with lll-lndium labeled leukocytes, C-reactive protein, 99m TC-hexamethylpropylene amine oxime leukocyte scintigraphy, diffusion weighted magnetic resonance (MR) imaging, Thallium-201 single proton emission computed tomography and proton magnetic resonance spectroscopy (MRS) all effectively assist in differentiating brain abscesses from brain tumours (4,36). Magnetic resonance imaging (MRI) together with Diffusion-Weighted Imaging (DWI) has a sensitivity and specificity of over 90% for distinguishing brain abscess from necrotic brain tumor. Diffusion weighted imaging (DWI) has a very high sensitivity to detect any early acute changes in the cortical and deep less vascularised white matter of the brain that occurs in infectious vasculitis. The cellular and viscous pus in the brain abscess produces very low hypointense diffusivity on apparent diffusion coefficient (ADC) which distinguishes it from the increased hyperintense diffusivity visible in necrotic brain tumours and from the normal or slightly low diffusivity in the demyelinating plaque. Proton nuclear magnetic resonance (1H NMR) spectroscopy has been used the for differentiation of brain abscesses from cerebral tumours with central necrosis or metastasis. It has also been useful in the differentiation of bacterial abscess from tuberculous and fungal brain abscesses (37,38).There are however three stringent criteria for firmly establishing the diagnosis of tuberculous brain abscess which include, macroscopic evidence from surgical or autopsy material of true abscess formation within the brain substance, histological confirmation that abscess was composed of predominantly of vascular granulomatous tissue containing acute and chronic inflammatory cells particularly polymorponuclear leukocytes, and a positive culture for mycobacterium tuberculosis or demonstration of acid fast organisms in the pus or abscess wall. The incidence of tuberculous brain abscess is only 4-8% among cases without HIV infection (39). Positron Emission Tomography (PET) scanning utilising radiotracers 18F-fluoro-2-deoxyglucose and methyl (methyl-11C)-L-methionine consistently indicate increased tracer accumulation in brain abscesses, but may also show increased uptake in brain tumours as well, making it a less efficient definite diagnostic tool. As such Positron Emission Tomography (PE) scanning is currently of limited utility in differentiating brain abscesses from brain tumours, and therefore will not spare patients from biopsy for diagnostic purposes (40).

Rapidly developing brain abscess may mimic bacterial or septic meningitis. The clinical presentation of temporal lobe abscesses may resemble that of herpes simplex virus encephalitis. More slowly developing abscesses may be mistaken for primary or metastatic tumours (10,35). Radiological and imaging features alone are inadequate to differentiate pyogenic brain abscess from tuberculous, nocardial, or fungal abscesses, inflammatory granuloma, neurocysticercosis, toxoplasmosis, glioma, metastasis, resolving haematoma, infarct, hydatid cyst lymphoma andradionecrosis. Tuberculous brain abscess should be considered as a differential diagnosis for pyogenic abscesses especially in developing countries, as it is difficult to differentiate between them on the basis of clinical and radiological findings. However, fever, meningism, raised ESR, multilocularity, leptomeningeal or ependymal enhancement, reduction of ring enhancement in delayed computer tomography (CT) scan, and finding of gas within the lesion favour a diagnosis of abscess. Brain abscesses presenting with abrupt change in the patients condition may occasionally be mistaken for evolving cerebral or brain stem infarction, and cerebral or sub-arachnoid haemorrhage (41).

MANAGEMENT

The management of brain abscess involves prompt and comprehensive clinical evaluation, and early diagnosis, followed by prompt administration of appropriate combination antibiotics, surgical drainage or excision, control of cerebral oedema, and eradication of the primary infected foci. Many brain abscesses contain multiple organisms requiring the administration of combination of two or more antibiotics covering both aerobic and anaerobic organisms (10,35). The appropriate management of brain abscess requires a multimodal approach involving both medical and surgical therapies. Non surgical empirical medical treatment is possible and efficient in a select group of patients with brain abscess with concomitant meningitis, multiple and deep seated abscesses, neonates and infants, abscesses located in the eloquent area of the brain or brain stem where surgical excision would be inappropriate especially where the aetiological agent is known as a result of positive cultures from blood, cerebrospinal fluid (CSF), and drainage from the ears or sinuses.

Medical treatment is also recommended if the abscess is less than 2.5 centimeters in diameter, and in those infected with toxoplasmosis in a person with human immune deficiency virus (HIV), and in patients with shunts in the brain for hydrocephalus treatment. Patients with intact mental status, and without signs of increased intra-cranial pressure, and in whom there is a high index of suspicion should also be considered for purely anti-microbial therapy (42). A delay in the initiation of empirical anti-microbial therapy can result in poor outcome. Initial therapy should be commenced with broad spectrum antibiotics which cross blood brain and blood cerebrospinal fluid (CSF) barriers in adequate concentrations. In most cases surgical drainage of purulent material from the abscess is necessary for the abscess resolution. Stereotactic drainage under computer tomography (CT) guidance is the intervention of choice, but en block excision may be considered as initial therapy in particular circumstances. The choice of surgery remains a matter of significant debate. Because the administration of anti-microbial agents before stereotactic aspiration under computer tomography (CT) guidance of the abscess may reduce the yield of bacterial cultures, it is reasonable to postpone the therapy until after the neurosurgery has been performed, but only if the disease is not very severe, the patients condition is clinically stable, and the surgery can be performed within a few hours of presentation. Adequate caution must be taken to this approach due to the fact that the abscess may sometimes progress very rapidly and unexpectedly irrespective of the initial level of severity of the disease (4,43).

The original choice of anti-microbial therapy should be based on the organisms that are the most likely cause of the abscess as determined on the basis of the mechanisms of infection and the patients predisposing condition, on patterns of anti-microbial susceptibility, and on the ability of the anti-microbial agent to adequately penetrate the abscess (10,44).

After the pus is drained and the antibiotic sensitivity reports become available, specific antibacterial agents for the organism cultured should be administered. If the culture is negative for the organism, then broad spectrum antibiotics should be continued taking into consideration the most likely predisposing causes. The complexity of microbial flora in brain abscesses necessitates empirical antibiotic therapy against both aerobic and anaerobic organisms. More than one third of otogenic and metastatic brain abscesses are polymicrobial (45). Serial computerised tomography scanning should be should be repeated on a weekly basis for a minimum of two weeks. This can however be performed more frequently and for a longer duration in case of clinical deterioration. Increase in the size of the abscess, swift clinical deterioration in the absence of reduction in size on serial computerised tomography (CT) imaging despite treatment for four weeks is an absolute indication for immediate surgical intervention without further delay (46). The successful treatment of pyogenic brain abscess remains very challenging despite recent advances in laboratory, surgical and imaging techniques, and craniotomy still retains a significant role in surgical treatment (47).

A delay in the initiation of anti-microbial therapy can result in poor outcome. Because most brain abscesses are caused by multiple organisms, the best medical approach is institute a combination of two or more antibiotics. Historically, penicillin G and chloramphenicol were the antibiotic combination of choice in the treatment of brain abscess. Penicillin penetrates well into the abscess cavity, and is active against non beta lactamase producing anaerobes and aerobic organisms. Beta-lactamase resistant penicillin such as oxacillin and methicillin are quite active against methicillin sensitive staphylococcus aureus. Chloramphenicol penetrates well into the intra-cranial space and is also active against haemophilus species, pneumonia, and most obligate anaerobes. The emergence of antibiotic resistance, and the development of antibiotics with improved tolerability have led to a shift in preferred antibiotics over the past several decades. Administration of a combination of vancomycin to a third generation cephalosporin and metronidazole has been reported to provide very satisfactory results. Vancomycin is most effective against methicillin resistant staphylococcus aureus (MRSA) and and staphylococcus epidermidis as well as anaerobic streptococci as well as aerobic and anaerobic streptococcus and clostridium species. Third generation cephalosporins such as ceftriaxone and cefotaxime provide adequate therapy for anaerobic gram-negative organisms as well as macroaerophilic and anaerobic streptococci, while fourth generation cephalosporins such as ceftazidime or cefepime are effective against pseudomonas species. Metronidazole penetrates well into the CNS and is active against anaerobic bacteria. After organ transplantation, patients should receive empirical treatment with a third generation cephalosporin, in combination with metronidazole for bacterial brain abscess, trimethoprim-sulfamethoxazole or sulfadiazine for infection with Nocardia species, and voriconazole for infection with fungal species especially aspergillus (4,10,48,49).

For the initial treatment of HIV infected patients, the addition of an agent that targets toxoplasmosis such as pyrimethamine plus sulfadiazine or alternatively clindamycin is recommended in those with positive test results for anti-toxoplasma IgG antibodies (14). Treatment for tuberculous brain abscess leading to complete cure consists of multiple aspirations and chemotherapy including isoniazid, rifampicin, pyrazinamide and ethambutol. Large tuberculous abscesses of greater than 3 centimeters in diameter invariably require surgical excision through burr hole and computer tomography (CT) under stereotactic guidance, while smaller ones resolve completely with adequate duration of anti tuberculous treatment (41). Parenteral antibiotics should be continued for a minimum of six to eight weeks. A two to three month course of oral antibiotics should follow the completion of intravenous therapy in case of pyogenic brain abscesses (50). Duration of anti-microbial therapy in the immunocompromised patients should be extended although there is little agreement regarding the optimal duration of treatment. Recommended length of Parenteral antibiotic treatment ranges from twelve weeks to one year, which should also involve careful clinical evaluations and serial imaging follow ups (29,51).

The ideal method of surgical intervention in brain abscess remains controversial. Neurosurgery is imperative for the identification of the causative pathogen in brain abscess if this has not been diagnosed through other means. En bloc excision had historically been the approach of choice, but in the preceding several decades, computer tomography (CT) guided stereotactic aspiration has become the more commonly practiced initial intervention. The improved outcome and prognosis of brain abscess in the computer tomography (CT) era is largely credited to the feasibility and availability of stereotactic drainage. Despite this, open craniotomy and excision of brain abscess has several advantages and a minority of surgeons still prefer this method from the outset.

Computer tomography (CT) and magnetic resonance imaging (MRI) guided stereotactic aspiration of the purulent centre of brain abscess is performed for the purposes of decompression, including the removal of the purulent centre, reduction of intra-cranial pressure, confirmation of diagnosis and the institution of appropriate anti-microbial therapy by aspiration of its contents and identification of the offending organisms, unless otherwise contraindicated due to the patients prior poor clinical condition. Aspiration also results in rapid reduction of intra-cranial pressure (52,53). The main aim of diagnostic aspiration is to achieve maximum drainage of pus from the abscess, making it more amenable to anti-microbial treatment. Continuous drainage through a catheter in the abscess cavity has been advocated by some authors as means of reducing reoperation, and for administration of anti-microbial agents directly into the abscess cavity, but this technique remains controversial and is not routinely recommended (54). If brain imaging does not indicate central cavity in the abscess, careful consideration should be given to the choice between performing computer tomography guided stereotactic biopsy of the area of presumed cerebritis and the administration of empirical anti-microbial treatment with follow up cranial imaging. Computer tomography guided stereotactic burr holes aspiration of brain abscess is simpler than open excision and spares the patient the morbidity associated with complications of extensive surgical trauma. It is relatively safe and may therefore be performed in patients who are poor surgical candidates. The biggest drawback of computer tomography guided stereotactic burr holes aspiration is that the abscess capsule is left intact, and the removal of purulent material is usually incomplete often resulting in multiple aspiration procedures in order to achieve complete resolution of the abscess. It is the preferred method in multiple or deep seated abscesses (10,41,45,55). When stereotactic navigation for burr hole aspiration is not available, intraoperative ultra-sonography can be performed through a burr hole or small craniotomy in order to direct abscess drainage, but this approach is not recommend for small abscesses in deep brain locations (56).

Although an abscess of more than 2.5 centimetres in diameter is an indication for surgical intervention either through burr hole aspiration or craniotomy, for patients in whom the smaller abscesses causes brain shift, leading to brain herniation, urgent neurosurgical intervention is be indicated irrespective of the abscess size (57).

Open craniotomy for surgical excision of brain abscess allows the complete removal of purulent material and the surrounding abscess capsule and is associated with much lower rates of abscess recurrence and reaccumulation. In situations where a structural abnormality underlines the development of brain abscess, open craniotomy and surgical excision is indicated for definitive treatment. This applies to cases where the abscess has resulted from contiguous primary source such as osteomyelitis from sinus infection, and a fistulous connection or retained foreign bodies from penetrating cranial trauma (37,58). A combination of the surgical aspiration or excision of all abscesses larger than 2.5 centimetres, a six week or longer course of intravenous antibiotics and serial weekly CT or MRI imaging results in cure in more than 90% of the abscess cases. It is significant to follow up the patients carefully with weekly serial computerised tomography (CT) scanning, or magnetic resonance (MRI) imaging until the abscess has completely resolved (4).

COMPLICATIONS AND PROGNOSIS

Complications of brain abscess include interventricular rupture, obstructive hydrocephalus, brain damage, life threatening meningitis, seizures, and recurrence. Focal neurological symptoms and deficits such as hemiparesis, loss of vision, and dysphasia are not uncommon and may develop in response to abscess growth or surrounding brain oedema (58). Adjunctive glucocorticoid therapy may reduce severe cerebral oedema likely to lead to cerebral herniation, and has been used in about half of the patients with brain abscess (35). Multilocular brain abscesses and those close to and bulging into the ventricular wall are more likely to rupture into the ventricles. Interventricular rupture is a very serious clinical complication which results in ventriculitis and often leading to hydrocephalus and even death of the patient. The condition is recognized by a very rapid onset of severe headaches, meningeal irritation, and abrupt deterioration of the mental state requiring urgent imaging and emergency open surgical evacuation through a craniotomy or aspiration followed by lavarge and ventriculostomy for drainage through an external ventricular catheter for intraventricular administration of antibiotics, sampling of cerebrospinal fluid (CSF) and monitoring of intra-cranial pressure (59,60). Patients often progress poorly despite these interventions, with significant morbidity and very high mortality of 27-85%, and therefore patients with significant structural risk factors for interventricular rupture should be treated surgically from the initial stages (28). An obstructive hydrocephalus is not an uncommon complication of brain abscess with significant morbidity and mortality. Hydrocephalus usually results from the occlusion of the ventricular system from mass effect, and is also common in patients with abscesses in the posterior cranial fossa, and urgent cerebrospinal fluid (CSF) diversion with ventrriculostomy is the accepted intervention in the symptomatic patients (28,61). Neurological deficit will be found in 35-55% of patients surviving brain abscess and are incapacitating in 17% (19). This may be due to complications of the brain abscess itself, or to complications of surgical intervention.

A decline in consciousness may be caused by seizures or status epilepticus (62). The incidence of seizures in different series has varied from 11-35% of patients and usually occurs within twelve months of the surgery (19,62). Seizures and other neurological symptoms such as speech problems or paralysis are the long term risks which occur in patients suffering from brain abscess, and their effects vary depending on the anatomical location of the abscess, the severity of the infection, and the effectiveness of the treatment. Epileptic seizures are more common in patients treated with surgical excision, than in those treated with aspiration only. The latency period of onset can be as long as five years, but is significantly shorter in older patients. Patients with underlying diseases such immune compromised patients such as HIV AIDS, and chronic conditions like diabetes mellitus or cancer are less likely to recover fully from a brain abscess (18,63).

The prognosis of patients with brain abscesses has significantly improved over the past five decades following improvements in intra-cranial imaging techniques using computerised tomography (CT) scanning, and magnetic resonance imaging (MRI), the use of improved combination anti-microbial regimens, and the introduction of effective minimally invasive neurosurgical procedures. Brouwer and colleagues recently performed a meta-analysis of 123 studies including 9699 patients reported between 1935 and 2012 and recorded 20% mortality rate in brain abscess (35). Survival in brain abscess approaches 100% in patients who are fully alert at the time of presentation and remains over 90% in patients who are stuporous but not completely comatose when they first present (8). Adverse prognostic factors include delay in diagnosis, choice of inappropriate antibiotics, inadequate aspiration or drainage, multiple, large, deep, or multiloculated abscesses, posterior fossa abscesses, and interventricular rupture of abscesses (8,10,19,35).

Severity of residual neurological deficit is heavily influenced by the neurological status of the patient at the time of presentation and may also be better in cases successfully treated with antibiotics alone, or antibiotics and aspiration (22). In our locality at Kenyatta National Hospital Nairobi, Hitimana and Mwangombe reported similar neuorological sequelae among patients who underwent open craniotomy and various aspiration techniques for the treatment of brain abscess (26a). Mortality from Brain abscess has consequently reduced from the pre CT scan era of 40%-60% in the sixties to between 15%-32% in the past decade (35,58). Poor prognosis is reported in patients who are immunocompromised, having diabetes mellitus, or liver cirrhosis and a low Glasgow Coma Score (GCS) (65). Prognosis in immunosuppressed patients is poorer. Abscess from organisms such as Listeria, Nocardia, and Actinomyces commonly affecting immunosuppressed patients, presents a greater challenge in management and also indicates poor prognosis (9,64). Both mortality and morbidity from brain abscesses are higher with gram-negative than gram-positive infections (22). Routine follow ups of patients with abscesses is mandatory due to the fact that abscess recurrence could occur even many years after the initial onset. Recurrence may be due to inadequate duration or choice of the anti-microbial agent, but in other cases, no tangible explanation has been reported (4,35,66).

CONCLUSION

Brain abscesses are rare with significant consequences of missed or delayed diagnosis, but remain one of the most common neurological emergencies especially in developing countries, being 8% of intra-cranial space occupying lesions compared to 1%-2% in the developed countries. In the Pre-antibiotics, computer tomography (CT) scan, and Magnetic Resonance Imaging (MRI) eras, brain abscesses were almost always 100% fatal. The actual reduction in morbidity and mortality in brain abscesses over the past five decades is largely attributed to recent advances and increased availability of computer tomography with double contrast enhancement which has provided early and reliable diagnosis, localisation, and characterisation of brain abscesses, in addition to monitoring of the effectiveness of medical or neurosurgical treatment. Computer tomography scanning has also aided the very rapid detection of abscess recurrences and complications that accounted for a significant number of the deaths in the pre-CT scan era. Magnetic Resonance Imaging (MRI) with gadolinium enhancement has much greater sensitivity and specificity than computerised tomography, and is currently the procedure of choice in diagnosis when available, while Magnetic Resonance Imaging (MRI) together with Diffusion Weighted Imaging (DWI) with a sensitivity and specificity of over 90% reliably distinguishes brain abscesses from necrotic brain tumours. Recent advances in microbiological isolation techniques, efficient combination anti-microbial, anti-tuberculous and anti- fungal therapy, stereotactic aspiration, and technology assisted neurosurgical techniques have all together resulted in the significant reduction in the mortality and morbidity of brain abscesses. However, despite all these recent positive advances in diagnosis and treatment, currently the holistic management of brain abscesses, though greatly improved over the past five decades, still remains rather controversial including the need for, and when to institute the appropriate neurosurgical intervention, the optimal neurosurgical approaches, the choice and length of appropriate anti-microbial treatment to be instituted, and the need for and the length of monitoring using serial computer tomography scanning during and after treatment.

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