SURGICAL PLANNING OF FUNGAL SINUSITIS WITH INTRACRANIAL EXTENSION IN IMMUNE-COMPETENT PATIENTS ACCORDING TO RELATION TO IMPORTANT NEURO VASCULAR STRUCTURES

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SURGICAL PLANNING OF FUNGAL SINUSITIS WITH INTRACRANIAL EXTENSION IN IMMUNE-COMPETENT PATIENTS ACCORDING TO RELATION TO IMPORTANT NEURO VASCULAR STRUCTURES

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Abstract

Background: Fungal sinusitis is a common disease in healthy young adults in our locality. It may destroy the skull base and invade the intra-cranial and intra-orbital compartments causing neurological and ocular manifestations.

Objectives: The aim of this study is to evaluate the results of combined neurosurgical and ENT surgical managements for patients with fungal sinusitis with intracranial extension.

Methods: We managed 10 cases with fungal sinusitis with intracranial extension. All patients were immune-competent. The average age of patients in this study was 31.5 year (range 17 - 46 years). There were 6 males and 4 females. All patients presented with headache, 5 with nasal obstruction and polyps, 5 with unilateral Proptosis, one case with trigeminal neuralgia and squint, one case with epilepsy and 2 with deterioration of level consciousness. CT was done in all cases, MRI in 8 patients, CT angiography and conventional cerebral angiography in one patient. Surgical intervention was decided according to the relation of...
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Traditionally, fungal infections of the paranasal sinuses have been considered uncommon and were thought to occur only in immune compromised individuals. However, the occurrence of fungal sinusitis has increased recently in the immune competent population (1). It is now believed that the fungi are important etiologic agents of sinusitis (2).

The intracranial extension generally presents with neurological symptoms, and the patient often

the fungal granuloma to important intracranial structures. Endonasal approach alone was done when the granuloma not related to the optic nerve, internal carotid artery "ICA" or cavernous sinus (n=3). Combined subfrontal and endonasal approaches were used when granuloma closely related to one or more of the previous structures (n=5). Transcranial approach alone was done in 2 patients with isolated sphenoid fungal sinusitis, that was associated with a mycotic ICA aneurysm in one patient and with a temporal lobe abscess in the other. In addition antifungal treatment was used for 8-12 weeks. patients were followed up clinically and radiologically for 3 months period.

Results: Showed one patient died 2 months post-operatively from fungal meningitis. No morbidity related to the operative procedures were recorded in this stud. Proptosis was completely corrected in the 5 cases. Follow up CT showed eradication of the fungal granuloma in all surviving patients. Histologically fungal infection included Aspergillosis and mucormycosis.

Conclusion: Team ENT and neurosurgical work and early diagnosis are mandatory in the management of fungal sinusitis with intracranial extension in immune-competent patients. Surgical planning to the relation of fungal granuloma to important neurovascular structures is the corner stone for safe removal of granuloma.

Key words: Invasive fungal sinusitis - intracranial fungal granuloma - mycotic fungal cerebral aneurysm - fungal brain abscess.

Introduction

Traditionally, fungal infections of the paranasal sinuses have been considered uncommon and were thought to occur only in immune compromised individuals. However, the occurrence of fungal sinusitis has increased recently in the immune competent population (1). It is now believed that the fungi are important etiologic agents of sinusitis (2).
consults a neurosurgeon or an ophthalmic surgeon. So, it is very important for these surgeons to recognize fungal sinusitis as the cause. Although, it seems that this entity is more common in the immune compromised, especially poorly controlled diabetic patient. It is also prevalent in the immune competent population\(^3\).

Paranasal sinus mycoses were first reported by Mackenzie\(^4\). Since then, several varieties have been identified, including allergic, indolent and invasive forms\(^5\). Not uncommonly, the fungal granuloma will erode the skull base and extend into the intracranial and intraorbital compartments. However, bone destruction is not necessary for the development of intracranial or intraocular complications, because the fungus can extent along vascular channels. Ocular sequelae can include diplopia as a result of involvement of the extra-ocular muscles, as well as proptosis, chemosis and loss of vision. Neurologic sequelae can include meningitis, brain abscess and cavernous sinus thrombosis\(^6\).

The current management strategy calls for a multimodality approach, including aggressive surgical debridement, the use of antifungal and/or anti-allergic agents\(^7,8\). It is not yet understood which combination of these therapies constitutes optimal management. Furthermore, in case of intra cranial extension, it is not clear which surgical (endonasal, transcranial or combined) approach has to be used \(^6,7,8,9\). So the aim of this study is to evaluate the results of combined neurosurgical and ENT surgical approaches for immune-competent patients having fungal sinusitis with intracranial extension, according to the relation of the granuloma to eloquent neurovascular structures.

**Materials and Methods**

This study included 10 immune-competent patients with fungal sinusitis that invaded the skull base and had an intracranial extension.

Complete history taking and full ENT, ophthalmic and neurological examinations were done for all patients with special concern
about:

- History of absence of diabetes or immunodeficiency state. All patients were cancer free and none had received immunosuppressive therapy.
- Symptoms of headache, nasal obstruction or discharge, anosmia, vomiting, nausea, epistaxis, pre-orbital pain, facial pain, facial swelling, altered sensorium, seizures, weakness of limbs, diplopia, visual disturbance and fever.
- Presence of blackish or brownish discharge, pale or dark mucosa in the nose, ophthalmoplegia, chemosis, proptosis, raised intracranial pressure, visual blurring or hemiparesis.

Radiological evaluation was done pre and postoperatively:

- **Preoperative:**
  C-T was done for all patients to assess soft tissue extension and bony erosion. In fungal sinusitis, CT will show central sinus high attenuation \(^{(10,11)}\). MRI, was performed in 8 patients for better visualization of the intracranial extension and to identify the relation of the fungal granuloma to important neurovascular structures namely, the optic nerves, ICA and cavernous sinuses. A decrease in signal intensity on T1 and a marked decrease in signal intensity (signal void) on T2 weighted images were reported to be characteristic of fungal disease \(^{(11,12)}\).

In addition, CT angiography and conventional cerebral angiography were done for one case with subarachnoid hemorrhage (SAH).

- **Post operative:**
  C-T was done 1 month and 3 months post operatively.

Laboratory and histopathological examinations:

- **Preoperative:**
  Complete laboratory investigations were done for all patients for selection of immune-competent patients and preparation for surgery.

  Fungal culture and biopsy:
  There are special stains required for detecting the fungus. These include methamine silver for mucor, rhizopus and absidia. The aspergillus has uniform septate
hyphae branching at 45 degree. The mucor shows non septate, non uniform branching at 90 degrees. Copious mucin, abundant eosinophils and charcot - lyden crystals are characteristic of allergic fungal sinusitis (AFS) and one has to stain deeply to look for fungal hyphae \(^3\). The culture used is sabauraud media. The biopsy from the middle turbinate and polyps were examined histopathologically.

- **Post operative:**

  All surgical specimens were examined histopathologically.

  Operative techniques:
  
  a. Endonasal approach alone was used when the granuloma not related to the optic nerve, ICA or cavernous sinus.

  b. Combined subfrontal and endonasal approach were used when the granuloma closely related to optic nerve, ICA or cavernous sinus.

  In the first part of operation, craniotomy was done to remove the intracranial and intraorbital components of the granuloma extradurally. Then, the granuloma within the frontal, posterior ethmoidal and sphenoid sinuses was removed under vision to decompress the optic nerves, ICA and cavernous sinus. Periosteal graft was used to secure the defect in the skull base. After closure of the cranial wound, endonasal removal of the granuloma within the anterior ethmoid and maxillary sinuses was done endoscopically by ENT team.

  c. Transcranial approach alone was done for patients with isolated sphenoid fungal sinusitis.

  Postoperative antifungal treatment was used for 8-12 weeks. Fluconazole was used in 8 patients and amphotericin B was used in 2 patients.

**Results**

Clinical characteristics of the patients are listed in table 1.

Age ranged from 17 to 46 years with average of 31.5 year.

There were 6 males and 4 females patients.
The most common presentation of the disease was headache in all patients, nasal abstraction and polyps in 5 cases, unilateral proptosis in 5 cases, trigeminal neuralgia and squint in one case, epilepsy in one case and deterioration of level of consciousness in 2 cases.

**Radiological findings (table 2):**

As diagnosed by CT, 8 patients had fungal pansinusitis and two had isolated sphenoid fungal sinusitis.

In the group of patients with fungal pansinusitis (n=8), the fungal granuloma caused destruction of the anterior skull base (posterior wall of the frontal sinus, cribiform plate of ethmoid and/or planum sphenoidale). Five of them also had intra-orbital extension. Subfrontal fungal granuloma was observed in all 8 patients and, in addition, suprasellar granuloma was seen in 2 patients.

On the other hand, patients with isolated sphenoid fungal sinusitis (n=2) had destruction of the body of the sphenoid sinus. Both patients had left parasellar fungal granuloma and one of them, in addition, had a suprasellar granuloma.

One patient had SAH in the suprasellar cistern. In this patient, CT angiography and 4-vessels angiography confirmed the presence of a 10 mm left ICA bifurcation aneurysm.

As shown in MR imaging, the fungal granuloma was intimately related to the optic nerve in 6 patients, ICA in 5 patients and cavernous sinus in 2 patients. One patient had left temporal brain abscess.

**According to surgical approaches:**

a. Endonasal approach alone was used in 3 cases.
b. Combined subfrontal and endonasal approaches were used in 5 cases.
c. Transcranial approach alone was done in 2 cases.

**Regarding to laboratory and histopathological results:**

There were 8 cases with aspergillusosis and 2 cases with mucormycosis.
There were 5 patients with allergic fungal sinusitis and 5 with chronic invasive fungal sinusitis.

**Case presentation:**

**Case 1:** Twenty Seven years old male patient presented with chronic headache for two years. CT and MR showed fungal pansinusitis with small intracranial component due to destruction of the cribriform plate. However, the fungal granuloma was not intimately related to the optic nerve, ICA or the cavernous sinus (figure 1). The fungal granuloma was removed via endonasal approach. CT showed no evidence of recurrence of the fungal infection after three months.

**Case 2:** Forty-two years old male patient presented with left proptosis and chronic headache for one year. CT and MR scan showed fungal pansinusitis with small intracranial component due to destruction of the cribriform plate and planum sphenoidale. The fungal granuloma was intimately related to the optic nerves and left ICA (figure 2). Combined transcranial and endonasal approach was used to eradicate the fungal granuloma. Through a bifrontal craniotomy, the fungal granuloma at the base of the skull and within the sphenoid, frontal and posterior ethmoid sinuses was removed extradurally under direct vision. After closure of the cranial wound, endonasal approach was used to remove the granuloma within the anterior ethmoid and maxillary sinuses microscopically. CT showed no evidence of recurrence of the fungal infection after three months.

**Case 3:** A female patient, 46 years old, was admitted through ER with fever, deterioration of the level of consciousness, and neck stiffness. She was referred to our hospital as a case of pituitary apoplexy. CT showed sphenoid fungal sinusitis, destruction of the body of the sphenoid, supra- and left para-sellar fungal granuloma, together with SAH in the suprasellar cistern. Routine preoperative CT angiography showed 10 mm left ICA bifurcation aneurysm that was closely related to the parasellar lesion. Four-vessels angiography confirmed the diagnosis of the aneurysm (Figure 3). Patient was operated through a left fronto-
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temporal craniotomy. First, clipping of the aneurysm was done intradurally. The wall of the terminal part of left ICA was thicker than normal and whitish in colour. Also, the dura covering the sellar region was thick and inflamed. No intradural fungal granuloma was found in the para- or suprasellar regions. After closure of the dura, the fungal granuloma (fungal balls) in the supra- and left parasellar region and within the sphenoid sinus was removed extradurally. The planum sphenoidale and left wall of the body of the sphenoid bone was already destructed by the granuloma. Histopathological examination showed mucormycosis. Follow-up CT showed removal of the fungal granuloma. The patient showed good post-operative recovery and was stable for 3 weeks. However, she died 2 month post-operatively from uncontrolled fungal meningitis.

**Case 4**: 41 years old male patient presented with intractable left trigeminal pain and diplopia due to 6th nerve palsy for several months. CT and MR showed isolated sphenoid fungal sinusitis, destruction of the body of the sphenoid, left parasellar fungal granuloma and small left temporal cystic lesion most probably a chronic abscess (Figure 4). Patient was operated through left temporal craniotomy. Intraoperatively, he had a purulent infection involving the sphenoid sinus, body and left greater wing of sphenoid. Adjacent dura and brain was infiltrated by the purulent infection. The fungal granuloma was removed and the fungal brain abscess was also drained. Histopathology showed mucormycosis. Patient did well postoperatively and was maintained on antifungal treatment for 3 months. Follow-up CT brain showed removal of the fungal granuloma. After 3 months, the trigeminal pain greatly improved and epilepsy is controlled by carbimazepine.

**Outcome**:

No morbidity or mortality related to the operative procedures was observed in our patients. However, case number (9) died two months post-operatively from fungal meningitis although she was recieving amphotricin. Proptosis was com-
pletely corrected in the five patients. Headache also improved post-operatively in all surviving patients. Follow-up CT showed eradication of the fungal granuloma in all survivors with no evidence of recurrence during the follow-up period.

Table 1: Clinical characteristics and surgical treatment in study group.

<table>
<thead>
<tr>
<th>Case No</th>
<th>Age/Yrs</th>
<th>Sex</th>
<th>Main presentation</th>
<th>Location</th>
<th>Type of surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>27</td>
<td>M</td>
<td>Headache, nasal obstruction, polyps</td>
<td>PNS, IC</td>
<td>Endonasal approach</td>
</tr>
<tr>
<td>2</td>
<td>22</td>
<td>M</td>
<td>Headache, nasal obstruction, polyps</td>
<td>PNS, IC</td>
<td>Endonasal approach</td>
</tr>
<tr>
<td>3</td>
<td>35</td>
<td>F</td>
<td>Headache, unilateral proptosis</td>
<td>PNS, IC, IO</td>
<td>Combined subfrontal and endonasal approach</td>
</tr>
<tr>
<td>4</td>
<td>42</td>
<td>M</td>
<td>Headache, nasal obstruction, polyps, unilateral proptosis</td>
<td>PNS, IC, IO</td>
<td>Combined subfrontal and endonasal approach</td>
</tr>
<tr>
<td>5</td>
<td>25</td>
<td>M</td>
<td>Headache, unilateral proptosis</td>
<td>PNS, IC, IO</td>
<td>Combined subfrontal and endonasal approach</td>
</tr>
<tr>
<td>6</td>
<td>17</td>
<td>M</td>
<td>Headache, nasal obstruction, polyps</td>
<td>PNS, IC</td>
<td>Endonasal approach</td>
</tr>
<tr>
<td>7</td>
<td>26</td>
<td>F</td>
<td>Headache, unilateral proptosis, deterioration of level of consciousness</td>
<td>PNS, IC, IO</td>
<td>Combined subfrontal and endonasal approach</td>
</tr>
<tr>
<td>8</td>
<td>34</td>
<td>F</td>
<td>Headache, nasal obstruction, polyps, unilateral proptosis</td>
<td>PNS, IC, IO</td>
<td>Combined subfrontal and endonasal approach</td>
</tr>
<tr>
<td>9</td>
<td>46</td>
<td>F</td>
<td>Headache, deterioration of level of consciousness, epilepsy</td>
<td>PNS, IC</td>
<td>Transcranial approach</td>
</tr>
<tr>
<td>10</td>
<td>41</td>
<td>M</td>
<td>Headache, trigeminal neuralgia, squint</td>
<td>PNS, IC</td>
<td>Transcranial approach</td>
</tr>
</tbody>
</table>

PNS = Paranasal sinuses    IC = Intracranial     IO = Intraorbital
Table 2: Radiological findings in study group (n=10):

<table>
<thead>
<tr>
<th>Investigation</th>
<th>Findings</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT scan</td>
<td>Pan-sinusitis</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Isolated sphenoid sinusitis</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Destruction of anterior skull base</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Intra-orbital granuloma</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Destruction of the body of sphenoid</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Subfrontal granuloma</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Suprasellar granuloma</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Parasellar granuloma</td>
<td>2</td>
</tr>
<tr>
<td>MR</td>
<td>Granuloma not intimately related to neurovascular structures</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Granuloma intimately related to optic nerve</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Granuloma intimately related to ICA</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Granuloma intimately related to cavernous sinus</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Brain (left temporal) abscess</td>
<td>1</td>
</tr>
<tr>
<td>CT &amp; 4-vessels angiography</td>
<td>Left ICA bifurcation aneurysm</td>
<td>1</td>
</tr>
</tbody>
</table>
Figure 1: (A) Axial and (B) coronal CT images showed hyperdense lesion involving all paranasal sinuses suggesting fungal pansinusitis with intracranial extension through the cribriform plate of ethmoid. (C) The hypo-intense signal on T1-weighted axial MR image and the signal void on the T2 weighted coronal image (D) confirmed the diagnosis of fungal sinusitis. MR also showed that the fungal granuloma was not intimately related to eloquent brain structures. Endonasal removal of the granuloma was done in this patient. (E) three months follow-up CT brain showed no evidence of recurrence of the granuloma.
Figure 2: (A) Axial and (B) coronal CT images in this patient showed fungal pansinusitis with intracranial and intraorbital extension. (C) Axial MR image showed lateral displacement of both optic nerves by the granuloma. (D) The sagittal MR image showed subfrontal extension of the granuloma through the cribriform plate and planum spheniodale. Combined transcranial and endonasal approach was used to remove the granuloma and to decompress the optic nerves. Three months follow-up CT brain in (E) axial and (F) coronal section showed no evidence of recurrence of the granuloma.
Figure 3: The axial CT image in (A) showed isolated sphenoid fungal sinusitis with left parasellar extension. (B) showed SAH in the left side of suprasellar cistern. (C) Reformatted CTA image in the coronal plan showed left ICA bifurcation aneurysm. Four vessels angiography, A-P (D) and lateral (E) views confirmed the diagnosis of Left ICA bifurcation aneurysm. This patient was operated through right pterional approach for clipping of the aneurysm and for removal of the granuloma. (F) one month post-operative CT follow-up showed complete removal of the granuloma.
Figure 4: (A) Coronal and (B) axial CT (bone window) images in this patient showed isolated sphenoid fungal sinusitis with destruction of the body and left greater wing of sphenoid. (C) CT with contrast showed a small left temporal cystic lesion. (D) Signal void in the coronal T-2 weighted MR image strongly suggested cerebral fungal infection. (E) The ring enhancement in the sagittal T-1 weighted MR image suggested an abscess. This patient was operated by right temporal craniotomy to remove the fungal granuloma and to drain the abscess. (F) Three months post-operative CT follow-up showed disappearance of the abscess. (G) Histopathology showed the fungal (mucormycosis) hyphae and spores (small arrow) and granulomatous inflammation with multinucleated giant cells (large arrow) (PAS, x 400).
Several authors have reported on the aggressive and lethal nature of invasive fungal sinusitis in immunocompromized patients\(^{13,14}\). Although the lungs are the most common site of fungal infection in those patients, the paranasal sinuses and brain are the next most common sites\(^{15}\). Aspergillus was the most commonly reported organism\(^{8,13,16,17,18}\). However, mucormycosis, candidiasis, and other opportunistic fungal infections were also reported\(^{19}\). Despite the fact that invasive fungal disease is relatively rare, it is significant because of its rapidly progressive and lethal nature\(^{20,21}\).

Fungal sinusitis has been classified into five clinicopathologic forms: the three invasive forms include acute fulminant, chronic (indolent) and chronic sinusitis; and the two noninvasive forms include the fungal ball (sinus mycetoma) and the allergic fungal sinusitis\(^{22}\).

The acute fulminant form occurs mainly in immunocompromized patients with prolonged neutropenia. The chronic invasive form usually appears in immunocompetent hosts, and is characterized by an indolent clinical course. Most cases with the chronic invasive form were reported in the Sudan, India, and Pakistan and was caused by Aspergillus and dematiaceous fungi. Histopathologic evidence of soft-tissue invasion by fungal hyphae is required to make the diagnosis, which is often delayed. The granulomatous invasive form is characterized histologically by: a profuse fungal growth with tissue invasion, non-caseating granulomas with multinucleated giant cells, plasma cells, and fibrinoid necrosis. The invasive granulomatous form is usually caused by Aspergillus flavus\(^{22,23}\).

The fungal ball (sinus mycetoma) is characterized by a fungal ball within a single sinus. A dense collection of hyphae is observed microscopically with only a mild inflammatory response. Its growth pattern is noninvasive with sclerosis of the surrounding bone. However, an invasive variant has been reported. This invasive variant is characterized by profuse growth.
patterns and invasion of the surrounding structures.\(^{5,24,25,26}\)

The typical intraoperative finding is a purulent mass. The sphenoid sinus represents the primary site for intracranial or orbital invasion. This type is characterized by aggressive destruction of surrounding bony structures. It may also extend into the cavernous sinus and cause thrombosis.\(^ {27,28}\) All reported operative patients died from fungal meningoencephalitis.\(^ {22,23}\)

The allergic fungal sinusitis occurs in atopic, mostly young, immune-competent adults and presents clinically with a chronic infection.\(^ {29,30}\) It is the most common form of fungal sinusitis. Patients will have nasal polyps and chronic allergic rhinosinusitis, often produce nasal casts, and may occasionally present with proptosis from orbital extension of disease. The histopathology shows extramucosal allergic mucin that stains positive for scattered fungal hyphae and eosinophilic-lymphocytic sinus mucosal inflammation.\(^ {22,23}\)

According to histopathological results of our study, 5 patients with fungal pansinusitis can be classified as allergic fungal sinusitis and the other three patients with fungal pansinusitis as chronic invasive sinusitis. On the other hand, one of the two patient with isolated sphenoid sinusitis had granulomatous reaction and can be classified as invasive granulomatous fungal sinusitis. The other patient with sphenoid fungal sinusitis had a purulent fungal mass and bone destruction, a finding typically found in the invasive variant of the sinus mycetoma.

Only 14 cases of isolated fungal infection of the sphenoid sinus have been reported in the literature.\(^ {10,20,26,27,29,31}\) Eight out of those 14 patients were examined in neurosurgical departments because of neurological symptoms and a mass in the sella and sphenoid sinus. Other patients were treated in ENT departments because they presented with nasal symptoms.\(^ {10,14,26}\) All 14 patients were immune-competent and had aspergillosis infection. In our study, the 2 patients with isolated fungal sinusitis were
admitted in neurosurgical ward and both were immune-competent. One patient was referred as a case of pituitary apoplexy and the other as a left temporal abscess. In contrary to reported patients, isolated sphenoid sinus infection in our two patients was caused by mucormycosis.

Siddiqui et al\(^6\) observed three patterns of presentation in immune-competent patients with craniocerebral aspergillosis: (Type 1) intracerebral aspergillosis which was associated with the worst clinical outcome, (Type 2) intracranial extradural aspergillosis that had an intermediate outcome, and (Type 3) orbital and cranial base aspergillosis that had good recovery. They also observed that preoperative orally administered itraconazole could improve clinical outcome in patients with intracerebral aspergillosis. In our study, the 2 patients with temporal brain abscess would be classified as type 1, and the remaining patients as type 2. The results of our study indicate that combined oral antifungal medication and surgical eradication of the granuloma in immune-competent patients having fungal sinusitis with intracranial extension would be associated with excellent outcome.

Fungal mycotic cerebral aneurysms are rare. As a result, the ideal way of management is not clear. Chun et al\(^9\) reviewed the current multimodality of infectious intracranial aneurysms in general. They concluded that endovascular therapy would be the first option for patients in stable condition with ruptured aneurysms; surgical therapy would be the first option for patients in unstable condition with ruptured aneurysms and the second option for patients in stable condition who experience failure of endovascular therapy. On the other hand, patients with unruptured aneurysms should initially be treated medically and followed up by serial angiography. Medically treated patients with enlarging or dynamic unruptured aneurysms will also require direct surgical or endovascular intervention. We believe that this multimodality management can also be followed in cases with fungal mycotic aneurysms.
The exact mechanisms of fungal sinusitis are not clear, but the environmental load of the fungus and certain host conditions appear to be associated with its invasiveness and disease progression. Immunodeficiency and local tissue conditions, such as allergic mucosal hypertrophy and chronic bacterial sinusitis, can create an obstruction of the ostiomeatal unit and provide favorable conditions that allow the fungus to proliferate and invade\textsuperscript{[32]}. Fungal sinusitis is characterized by invasion of the organism into the vascular endothelium, which leads to subsequent tissue ischemia and necrosis. Fungal extension from the paranasal sinuses into adjacent structures such as the orbit and the intracranial cavity can occur with direct local extension or hematogenous spread\textsuperscript{[22]}.

Once the diagnosis of invasive fungal sinusitis is suspected and an otolaryngologic evaluation is obtained, anterior rhinoscopy can be performed to detect any necrosis or ulceration in the mucosa. CT is the best means to assess soft tissue extension and bony erosion, and it should be performed prior to surgery and again afterward as a follow up measure\textsuperscript{[10,11]}. Magnetic resonance imaging (MRI), with or without gadolinium, is better at defining intracranial extension, particularly cavernous sinus involvement. A decrease in signal intensity on T1- and a marked decrease in signal intensity on T2-weighted MRI is characteristic of fungal disease\textsuperscript{[10,11,12]}. Although CT and MRI can suggest fungal disease and might alert the physician, a definitive diagnosis can be made only after histological confirmation of the operative specimens.

The choice of surgical approach depends on the site and extent of the involvement. The choice of options is guided by preoperative CT and MR findings, and options vary considerably. In our work we followed a team ENT and neurosurgical approach. Surgical approach was decided according to the relation of the fungal granuloma to the eloquent surrounding neurovascular structures namely: the optic nerves, ICA and cavernous sinus. Endonasal approach alone can be used for lesions not inti-
Combined transcranial and endonasal approach has to be used for save eradication of fungal pansinusitis with intracranial extension displacing or surrounding any of these structures. Transcranial approach alone has to be employed for isolated fungal infection of the sphenoid sinus causing major intracranial complications like mycotic aneurysm or brain abscess. No surgical morbidity or mortality was reported in our small group of patients using this surgical protocol.

The combination of aggressive surgical debridement and antifungal therapy has been the cornerstone of treatment of invasive variants of fungal sinusitis\(^{(25)}\). However, debridement carries the risk of inadvertent damage to the orbit, lacrimal system, dura, and brain, which can lead to a loss of vision, injury to the ICA, epiphora, cerebrospinal fluid leakage, and meningitis\(^{(30)}\). As indicated from our study, team approach and selection of surgical approach that will allow debridement under direct vision can minimize these complications. Amphotericin, ketoconazole and itraconazole have been used in the management of fungal sinusitis\(^{(19)}\). We used amphotericin in 2 patients with evidence of meningitis. Ketoconazole was used in the other patients. All survivors had no evidence of recurrence of fungal infection. We think that the use of amphotericin B should be reserved for patients with fungal meningitis to avoid its dose-related renal toxicity.

**Conclusion**

In summary, team ENT and neurosurgical approach is mandatory for the surgical management of fungal sinusitis having intracranial extension. Safe eradication of this type of fungal infection dictates selection of the surgical approach according to the relation of the granuloma to the optic nerve, ICA and cavernous sinus and according to the presence of associated intradural fungal infection. Fungal granuloma should also be included in the differential diagnosis of lesions in the sellar and parasellar regions.

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Tخطيط العلاج الجراحي للمرضى المصابين بالالتهاب الفطري للجنبوب الأنفي والأنف والنافذة داخل الجمجمة تبعاً لعلاقته لأجزاء المخ

المجلة: Benha Medical Journal

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في هذه الدراسة تم علاج عشرة مرضى مصابين بالألم الرئيسي للجيوب الأنفية متمدن إلى داخل الجمجمة جراحياً. تتم التخطيط للطريقة الجراحية المستخدمة تبعاً لعلاقة الكتلة الفطرية لأجزاء المخ المهمة كما يلي:

- استئصال الكتلة الفطرية عن طريق الأنف إذا لم تكن الكتلة الفطرية ضاغطة على عصب الإبهار وكبدة بعيدة عن الشريان المخى الداخلي (ثلاثة مرضى).
- استئصال الكتلة الفطرية بجراحة مزدوجة أولاً عبر الجمجمة ثم في نفس الجلسة. عبر الأنف إذا كانت الكتلة الفطرية ضاغطة على عصب الإبهار ومصاحبة لشريان المخى الداخلي (خمسة مرضى).
- استئصال الكتلة الفطرية عبر الجمجمة فقط إذا كانت الكتلة الفطرية ممتدة إلى داخل المخ نفسه (مرضى)

وأشارت نتائج الدراسة إلى وفاة أحد المرضى نتيجة الالتهاب الشوكي الفطرى، بينما تحسن حالة المرضى الآخرين. ولم تحدث لهم مضاعفات ناتجة عن الطريقة الجراحية المستخدمة. كما لم تسجل حالات ارتجاع للالتهاب الفطرى فيهم أثناء المتابعة. وتلخص هذه الدراسة إلى فاعلية استئصال الكتلة الفطرية الممتدة إلى داخل الجمجمة إذا ما تم التخطيط للعملية الجراحية تبعاً لعلاقة تلك الكتلة لأجزاء المخ.