Surgical approaches in Rhino-orbito-cerebral Mucormycosis

Ram Raj Yadav, Vishwambhar Singh, Siva S, Rajesh Kumar, Ashvaneek Kumar Chaudhary, Rajat Saini, Shishupal Yadav, Silky Silky, Deepak Kumar Gupta, Arpit Goyal, Akshat Panday

Corresponding Author:
Dr. Vishwambhar Singh
Department of Otorhinolaryngology,
Institute of Medical Sciences,
Banaras Hindu University, Varanasi, U.P.

Abstract:
Mucormycosis is an opportunistic infection which is caused by fungus of the order Mucorales most common one is Rhizopus oryzae. These infections are more common in patients which are suffering from diabetes mellitus, malignancy, burn, severe trauma, malnutrition, renal failure, prolong neutropenia, immunosuppressed, long term steroid therapy or immunosuppressive therapy, hematopoietic stem cell transplant and solid organ transplant recipients. Patients with serious illness are 10 times more prone to develop bacterial or fungal secondary infection than secondary viral infection. Commonest form of presentation of Rhino-orbito-cerebral mucormycosis dental pain, dental loosening, orbital pain, facial numbness, conjunctival suffusion, diminution of vision to complete ophthalmoplegia, blindness, cavernous sinus thrombosis, multiple cranial nerve palsies, edema of eyelids orbital inflammation blepharoptosis, proptosis, acute ocular motility changes, headache and acute vision loss. Management of mucormycosis comprises of medical and surgical management. Various surgical management are explained.

Introduction:
Mucormycosis is an opportunistic infection which is caused by fungus of the order Mucorales most common one is Rhizopus oryzae. These are of four types 1) Rhino-orbito-cerebral 2) Pulmonary 3) Gastrointestinal 4) Cutaneous 5) Disseminated. Rhino-orbito-cerebral is the most common clinical form of disease These infections are more common in patients which are suffering from diabetes mellitus, malignancy, burn, severe trauma, malnutrition, renal failure, prolong neutropenia, immunosuppressed, long term steroid therapy or immunosuppressive therapy, hematopoietic stem cell transplant and solid organ transplant recipients. Patients with
serious illness are 10 times more prone to develop bacterial or fungal secondary infection than secondary viral infection. \[1-5\]

**What is mucormycosis?**

Mucormycosis (earlier called Zygomycesis) is a rare but severe fungal infection caused by a group of molds called mucoromycetes. It is a potentially very lethal infection primarily infects immunocompromised patients.

**Clinical presentation**

Commonest form of presentation of Rhino-orbito-cerebral mucormycosis dental pain\(^4\), dental loosening, orbital pain, facial numbness, conjunctival suffusion, diminution of vision to complete ophthalmoplegia, blindness, cavernous sinus thrombosis, multiple cranial nerve palsies, edema of eyelids orbital inflammation blepharoptosis, proptosis, acute ocular motility changes, headache and acute vision loss.\(^2\)

Sign: Tenderness of all sinuses, blackening of turbinate, fungus in nasal cavity, absence of light reflex, decreased visual acuity, loosening of tooth, palatal ulcer.

**Management**

Management of mucormycosis comprises of medical and surgical management.

**Medical Management-**

**Antifungal therapy**

1) **Conventional Amphotericin-B**

Test dose: 1 mg in 20 mL of 5% dextrose solution IV over 20-30 min; patient's temperature, pulse, respiration, and blood pressure should be recorded every 30 minutes for 2 to 4 hours Loading dose in patients with well tolerated test dose and good cardio-renal function: 0.25 mg/kg IV QID Day\(^3\) Severe and rapidly progressive fungal infection: 0.3 mg/kg IV QID Day Impaired cardio-renal function or severe reaction to test dose: Initiate therapy with smaller daily doses, i.e., 5 - 10 mg Maintenance: Depending on the patient's cardio-renal status, doses may gradually be increased by 5 to 10 mg per day to final daily dosage of 0.5 to 0.7 mg/kg\(^3\)

2) **Liposomal Amphotericin-B.**

The antimicrobial (pre- and post-surgery) was: intravenous liposomal amphotericin b (2 mg/kg/24h increasing dosing to 5 g/kg/24h and 10 mg/kg/24h suspecting intracranial progression). Both orbital cavities and nasal sinuses were irrigated with amphotericin b deoxycholate diluted in glucose serum at 5% intra operatively and post-surgically once a day.\(^3\)

3) **Caspofungin**

4) **Posaconazole or Isavuconazole**
Posaconazole can be used for the treatment of rhino-maxillary mucormycosis in immunocompetent patients. Its efficacy against the fungus, minimal side effects and oral route makes it convenient both for the clinician and the patients though its efficacy against other forms of mucormycosis in immunocompromised patients.³

**Surgical management**

It involves debridement of sinuses, palate and orbital decompression or exenteration. Types of surgical intervention

1) **Endoscopic debridement**

   A) **Inferior turbinectomy** – In this remove bilateral inferior turbinate. It provides space for nasal douches. It can be done under general anaesthesia or local anaesthesia. In this a variety of tools and techniques used including: An **endoscope**, which is a thin, flexible tube with a light and camera on the end–a microdebrider, which is a rotary cutting tool to shave bone and other tissues, **cauterization**, which involves burning to remove or close off tissue, radio frequency, which uses a high-frequency electrical current to heat and destroy tissue. During the procedure, turbinate may be reduced (**turbinate reduction**) or removed (**turbinectomy**), Depending on your situation and your desired outcome and surgeons’ skill. Septoplasty (surgery to correct a deviated septum) or **sinus surgery** - done at the same time.

   B) **ESS (Endoscopic sinus surgery) or FESS (Functional endoscopic sinus surgery)** with debridement of all involved sinuses with or without orbital decompression or exenteration. Endoscopic sinus surgery is a procedure used to remove blockages in the sinuses. These blockages may cause pain, drainage obstruction, recurring infections, impaired breathing or loss of smell. This procedure is designed to improve the drainage of the sinuses and to improve airflow through the nose.

The goals of endoscopic sinus surgery include:

- Reduction in the number and severity of sinus infections
- Improvement in symptoms associated with sinusitis
- Improvement of airflow through the nose
- Improvement in the sense of smell
- Access for nasal rinses to reach the sinus cavities for cleaning and medication delivery

   C) **Endoscopic decker’s approach**- it allows complete exposure of anterior, inferior and lateral recesses of the maxillary sinus without gingivobuccal or transeptal incision. It provides straight entry to pterygopalatine and infratemporal fossa. In this under visualization 0-degree rod-lens endoscope 1% lidocaine HCL with 1:100,000 epinephrine is first injected into the anticipated incision sites along the nasal floor, lateral nasal wall, and anterior to the head of the inferior turbinate. A unipolar electrocautery with a guarded needle tip is used to incise the mucosa inferiorly at the junction of the nasal floor and lateral nasal wall, carrying the incision through the periosteum. A second mucosal incision is then made superiorly along the lateral nasal wall and carried anteroinferior to lie just in front of the anterior head of the inferior turbinate overlying the edge of the pyriform aperture. A subperiosteal dissection is performed with a suction Freer elevator to expose the anterior maxilla, the infraorbital foramen, and its neurovascular bundle as well as the lateral nasal wall. A high-speed drill use to create a bony window into the anterior maxilla,
taking care to stay inferior to the infraorbital nerve. Burs is used to connect the window to the inferior bony cut of the medial maxillectomy, thereby allowing access to the anterior portion of the maxillary sinus. The remaining bony and mucosal cuts are completed with burs, and endoscopic scissors. Specifically, a superior cut is made at the level of the roof of the maxillary sinus, an inferior cut at the junction of the nasal floor and medial maxillary wall, and a posterior cut along the posterior wall of the maxillary sinus.

D) **Mega-antrostomy and medial maxillectomy** - In patients with chronically diseased maxillary sinuses, poor mucociliary clearance may result from long-standing inflammation or scarring from previous surgery. This subset of patients often has persistent sinus disease despite medical therapy and adequate antrostomy. Endoscopic maxillary mega-antrostomy (EMMA) is a mucosal sparing technique that facilitates mucus clearance and sinus irrigation in terminally dysfunctional maxillary sinuses. EMMA involves extent ended antrostomy through the posterior half of the inferior turbinate down to the floor of the nose, creating a significantly enlarged antrostomy.\(^7\)

E) **Modified endoscopic pre lacrimal approach** - It is minimal invasive and safe as well as effective procedure. The surgery was performed under general anaesthesia. Nasal mucosal blood vessels were contracted with 0.01% epinephrine gauze. Endoscopic examination confirmed the extent of the lesion. The endoscopic resection of the uncinate process, open and enlarge the ostium of the maxillary sinus. If pathological results were not obtained before surgery, the tissue from the maxillary sinus was taken for pathological examination during surgery. The surgical approach was determined based on CT findings and the extent of the lesion seen during surgery. Prelacrimal recess approach (PLRA) was selected for complicated cases involving the alveolar crypts, prelacrimal recess, and antero-medial-inferior walls of the maxillary sinus, or with two or more root pedicles and with multiple areas of bone destruction in each wall of the maxillary sinus.\(^6\)

The incision was infiltrated with 1% lidocaine with 1:100,000 epinephrine solution. A curved mucosal incision on the lateral wall of the nasal cavity was made between the anterior aspect of the inferior turbinate and the edge of the pyriform aperture to the bone. The mucosa from the subperio steal level was elevated posteriorly to the insertion site of the inferior turbinate concha and then the bony attachment was disconnected. The bony inferior orifice of nasolacrimal duct (NLD) could be seen after the mucoperiosteum was elevated posteriorly. We chiselled off the anterior bony portion of the medial wall of the maxillary sinus (part of the maxillary frontal process), and after chiselling the bone posteriorly, the NLD was exposed and the inferior turbinate-nasolacrimal duct (IT-NLD) flap was formed. The IT-NLD flap was pushed medially and the antero-medial wall of the maxillary sinus was exposed. The maxillary sinus was entered through the antrostomy made at the prelacrimal recess. The maxillary sinus was exposed widely when the antrostomy was adequately enlarged, and all pathological tissues were removed under direct visualization. The IT-NLD mucosal flap was repositioned and the incision was sutured at the end of the operation.

F) **Canine fossa puncture (CFP) technique** - It is used for maxillary sinus. In particular, CFP consist in a trocar placed in the canine fossa. The landmarks in canine approach are: the mid pupillary line and horizontal line running along the lower border of nasal ala and lateral aspect of canine fossa high above the 3rd and 4th teeth (canine and premolar), inferolateral to infra orbital foramen. The trocar should be aimed toward the maxilloethmoidal angle to avoid pterygopalatine fossa and orbital lesions. In most patients the trocar was inserted using a gentle twisting motion. In some patients with thicker bone, gentle tapping with a hammer was required for the trocar to be
inserted. After removal of the trocar a 4 mm microdebrider blade was placed through the passage created by the trocar. The microdebrider blade was visualized in the maxillary sinus with a 40° or 70° endoscope via the middle meatal antrostomy. The diseased tissue can be removed from the maxillary sinus using the microdebrider.8

G) Ethmoidectomy –It involves removal of septa and bones between different cells of ethmoid sinus. The principal advantage of intranasal ethmoidectomy over external ethmoidectomy is the avoidance of a facial scar. Mosher described the intranasal ethmoidectomy as “the blindest and most dangerous operation in all surgery.” The world has changed since 1929. The availability of modern imaging, magnification, and endoscopes has dramatically altered sinus surgery. In a 1979 review of more than 1000 intranasal ethmoidectomy procedures, however, Freedman and Kern noted a complication rate of 2.8% without mortality or blindness. Before the adoption of modern endoscopes, they pointed out that the intranasal ethmoidectomy could be accomplished safely when the surgeon has complete knowledge of the anatomy and understands the surgical technique. This statement is no less valid today in the era of endoscopic visualization and intraoperative navigation. The ethmoid sinuses consist of a labyrinth containing 4 to 17 cells, with an average of 9 cells. These cells are arranged along the lateral nasal wall, roughly parallel to the plane of the middle turbinate, and extend 4 to 5 cm from anterior to posterior, 2.5 cm in height. It is critical to recognize that while the ethmoid sinuses are 1.5 cm wide posteriorly, the anterior ethmoid may be only 0.5 cm wide and the relatively narrow anterior ethmoid represents an area of potential danger in that penetration of the lateral margin of the ethmoid results in entry into the orbit. Intranasal ethmoidectomy may be undertaken with the patient under either general anaesthesia or local anaesthesia supplemented by intravenous sedation and monitoring.

Application of intranasal medication is necessary with either anaesthetic technique in that control of bleeding requires either topical application of vasoconstrictor substances or injection. We advocate the use of oxymetazoline 0.25% on cotton pledges employed topically. This is supplemented with lidocaine 1% with epinephrine 1: 100,000 injected into the mucosa of the anterior attachment of the middle turbinate. Powered tissue removal instruments are preferred over grasping instruments, in that they avoid the tearing and resultant bleeding that impairs visualization. The uncinate process is removed and the middle turbinate can be fractured medially or the anterior half removed in an effort to afford better exposure of the middle meatus and ethmoid labyrinth. When powered instruments are employed for ethmoidectomy, it is essential that the surgeon be acutely aware of the anatomy to avoid penetration of the orbit or central nervous system. Recall that the suction of powered instruments can draw orbital contents through bony dehiscence. Evidence of bone dehiscence or erosion is a relative contraindication to the use of power debriders. Intranasal tampons are placed at the end of the procedure.9

H) Sphenoidotomy-In this natural Ostia of sphenoid sinus widened to various degree. After a posterior ethmoidectomy has been performed, identify the superior turbinate and its horizontal lamellae. Remove the lower half of the superior turbinate to identify and then enlarge the natural ostia. It is safest to find the ostia in its medial location and then, using a J-curette, fracture the anterior sphenoid face in a lateral direction. Enlarge the antrostomy by using an up biting through-cutting instrument, Kerrison rongeur, or straight mushroom punch.10

I) Image guided surgery (IGS)- It is near to three-dimensional mapping system. This is done using CT scan and infrared signals.
Role of IGS in sinus surgery
The main contribution of IGS is the possibility of 3D visualization of the sinonasal cavities, compared to the 2D view of endoscopy. The 3D information provided by comparison with the preoperative scans adds depth to the endoscopic images, minimizing localization error. The risk of major complications in endoscopic sinus surgery is low (0–3%), but the potential morbidity and mortality associated with per- and postoperative complications are severe, including blindness, double vision, brain lesion, CSF leakage, epistaxis and death.

J) Endoscopic orbital decompression
All decompressions were performed using a trans nasal endoscopic approach. Orbital decompression was immediately preceded with ipsilateral comprehensive endoscopic sinus surgery including uncinectomy, maxillary mega-antrostomy, anterior and posterior ethmoidectomy, frontal sinusotomy and sphenoidotomy. The lamina papyracea and orbital floor was carefully elevated and removed with blunt dissection.

The posterior extent of decompression was the Annulus of Zinn at the orbital apex. Anteriorly, the limit of the decompression was the basal lamella and nasolacrimal sac. The superior extent of the medial wall decompression was the ethmoid artery. The lateral extent of the orbital floor decompression was the infra orbital nerve. Medial and inferior longitudinal incisions were made in the periorbita to allow the medial rectus at the most posterior extent and the orbital fat to herniate into the sinonasal cavity, effectively decompressing the contents of the orbit. Orbital fat was teased into the middle meatal cavity using blunt instrumentation and a strip of periorbita was not preserved over the medial rectus in these cases.

2) Open surgeries –

A) Caldwell-Luc Operation-It is external approach for surgical treatment of maxillary sinus. Done in either general anesthesia or local anesthesia. The Upper lip is retracted and the tissues just above the gingivalabial reflection. Infiltrated with 1 ml 1:200 000 solution of adrenaline or mixed with 1 % xylocaine in cases of local anesthesia. The incision is placed 3 mm above the line of reflection and starting at the canine ridge runs laterally for 3.5–4 cm parallel to the teeth. Elevation of periosteum over canine fossa till Infraorbital foramen, not to injure the nerve. Antrum is opened at canine fossa either by gouge and hammer or cutting burr. The eventual size of the bony opening should be approximately circular and 1.5–2 cm in diameter. Dealing with pathology/removal of sinus mucosa. Making nasoantral window which helps in natural way to remove packing from the antrum, drainage of postoperative collection after pack removal, aeration. Packing the sinus cavity and nasal cavity with single long ribbon gauge soaked in Betadine ointment with free end placed anteriorly in the vestibule of nose which provides adequate hemostasis. Suturing sublabial incision with chromic catgut with good approximation of edges.  

B) Prelacrimal approach –The prelacrimal approach to maxillary sinus allow

Access to all aspect of maxillary sinus while preserving the inferior turbinate and lacrimal duct.
C) Radical operation – for ethmoid and frontal sinus

D) Nasomaxillary frame translocation in medial maxillectomy - Medial maxillectomy is the standard operation for en bloc resection of the lateral nasal wall with portions of the maxillary and ethmoid sinuses. Although most reports comment on good to excellent cosmetic results, nasal collapse is a possible complication of the procedure and is best explained by the loss of lateral nasal wall support. To overcome this problem, we describe a technique with temporary mobilization of a bone frame around the ipsilateral pyriform aperture, including one nasal bone, and fixing it to its original position at the end of the operation.12

E) Lateral rhinotomy –

Like the midface degloving approach, the lateral rhinotomy incision provides adequate exposure for medial maxillectomy with or without ethmoidectomy. The incision is made from just above the medial canthus along the lateral aspect of the nose into the alar crease. Wider exposure may be gained by splitting the lip with care made to mark the vermilion border in order to allow for appropriate reapproximation at closure. The periosteum and soft tissue is elevated off the anterior wall of the maxilla laterally to the lateral aspect of the maxillary antrum and superior to the orbital rim. Care is taken to protect the infraorbital nerve. The periorbita is then undermined off the lamina papyracea, dislocating the lacrimal sac out of the lacrimal fossa. The lacrimal duct is then traced and transacted as far distally as possible, allowing for exposure of the medial third of the orbital floor. The anterior and posterior ethmoid arteries are then identified and preserved to provide landmarks for the frontoethmoidal suture, the superomedial limit of the resection. The mucosa along the piriform aperture is incised to enter the nasal cavity. To avoid narrowing of the nasal vestibule, the nasal ala is kept intact.

F) Weber Fergusson approach - The Weber Ferguson approach is indicated for access for disease involving the maxilla extending superiorly to the infraorbital nerve and into or involving the orbit. It provides a wide access to all areas of the maxilla and orbital floor. The patient is placed in a supine position with the entire face prepared and draped into the surgical field. Tarsorrhaphy sutures are placed in the eyelids. The incision line is drawn through the vermillion border, along the filtrum of the lip, extending around the base of the nose and along the facial nasal groove. It then extends infraorbitally 3-4 mm below the cillum to the lateral canthus. The incision can be extended laterally or superiorly as necessary for surgery.

The incision is made through skin and subcutaneous tissue along the nose. The full thickness upper lip is transected and the labial artery ligated or coagulated. It then extends sublabially along the mucobuccal fold preserving as much mucosa as possible, up to the maxillary tuberosity. The subciliary component extends through the orbicularis oculi muscle and then down to bone in the preseptal plane. The cheek flap is elevated off the maxilla to its lateral border in a subperiosteal plane with electrocautery. A supraperiosteal dissection plane will be necessary in the subcutaneous tissues if there is tumor invasion of the Antero lateral maxillary wall. In most cases the infraorbital nerve is sacrificed to facilitate tumor removal. After surgery, the orbicularis oculi muscle is approximated with absorbable sutures. The subcutaneous tissues are also closed with absorbable sutures, as is the orbicularis oris muscle. The vermilion border is reapproximated accurately and the skin is closed. (Fig-3)
G) Midfacial degloving – A Bucco-gingival incision was made in the maxillary vestibule approximately 5 mm superior to the mucogingival junction and extended from the second molar to the contralateral second molar. Periosteal elevators were used to elevate the tissues in the subperiosteal plane fist over the anterior maxilla and then extending widely to encompass posterior tissues behind the zygomaticomaxillary buttress. The infraorbital neurovascular bundle was identified superiorly and dissected. Subperiosteal dissection along the piriform aperture stripped the attachments of the nasal labial musculature to allow its complete release from the midface skeleton. The mucoperiosteal flap was elevated up to the piriform aperture. The intercartilaginous incision divided the junction between the upper and lower lateral cartilages. An incision was made along the inferior border of the upper lateral cartilage, beginning at the lateral end and extending medially curved into the membranous septum anterior to meet transfixion incision.

Laterally, the incision was sufficient that it extended to the piriform aperture. The lower lateral cartilage was eventually displaced superiorly during the degloving procedure, whereas the upper lateral cartilage remained attached to the midface skeleton. The transfixion incision was used to separate the membrane septum/columella from the cartilaginous septum. An incision was made along the caudal border of the septal cartilage from the medial end of the intercartilaginous incision toward the anterior spine.

The intranasal incision was made by a full-thickness incision down through the periosteum of the piriform margin and the nasal floor. The dissection should be within the sub perichondrium plane to prevent injury to the overlying musculature and blood vessels of the nose. Elevation extended laterally to the nasomaxillary sutures and superiorly to the glabella. Elevation of the soft tissue laterally to the piriform aperture was also performed so that the maxillary vestibular dissection was easily connected to this pocket. After the connection of the nasal and oral incisions, the midface was degloved. The midface skin was separated from the maxilla and the nasal pyramid. The upper lip and the intact nasal columella, nasal tip, and alar cartilages were then retracted by two Penrose drains introduced through the nostrils over the nose to the level of the inferior orbital rim. This approach provided visualization of the medial maxillary wall, pterygoid junction, nasofrontal suture, infraorbital rim, and laterally to the temporal process of the zygoma.¹³ (Fig-2)

**Palatal surgery**

It involves partial or total maxillectomy and mandibulectomy. Patient was operated under general anaesthesia and surgical debridement was done. The necrosed tissue was removed along with involved teeth. (Fig-4)

**References**


