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ORIGINAL ARTICLES

ASSOCIATION NEWS:

Association of Otolaryngologists of Andhra Pradesh Annual

Conference; September-14th 15th & 16th 2013 at GUNTUR
From: Dr. S. Muneeruddin Ahmed, Editor, A.O.I. A.P. Branch, Hyderabad, Andhra Pradesh.  

Dear members,

This issue will be the last and 4th one during my tenure as the Editor of our E-Journal of AOI AP Branch. It includes 4 original papers reported from Osmania Medical College/ Government ENT Hospital, Koti, Hyderabad. I am very thankful to all the members of the Association for their valuable advices in bringing about all the issues of the journal during this period. Please visit our website www.aoiapstate.com.

I look forward to your company with your families at the South Zone & Annual meet of our Association at GUNTUR between 14th and 16th of September 2013.

Thanking You

Yours sincerely

(DR.S.MUNEERUDDIN AHMED)

Cell: 98482 14061

Email ID: ahmedmunirent@gmail.com
PRESIDENT'S MESSAGE

Dear Colleagues,

President AOI AP State
PRESIDENT'S MESSAGE
Dear Friends,

Warm Greetings to all of you

I really deem it a great pleasure and honour to say that our official Journal of AOI AP State which is being brought by our Editor Prof. Muneeruddin Ahmed who is very keen to raise awareness among members to contribute to this E-journal.

I really appreciate the post graduate students in contributing to bring out this Journal. It really allows all of us to share experiences with articles and case studies which, ultimately raises the overall standards of patient care. I request all the members to contribute articles to encourage our editor. Suggestions of our members will be well taken.

Hope we all meet at GUNTUR from 13th - 15th Sept. 2013 during our 30th AOI AP CON 2013 and

Long live AOI

With warm regards

DR. Phanindra Kumar
President
AOI AP BRANCH
HYDERABAD
Dear Members,

I am happy to know that the AOI AP Branch is releasing the 4th issue of e-journal in my term as Hony. Secretary from October 2011 to September 2013. I request the members to contribute more number of articles, events conducted and any latest information in the field of ENT Head & Neck Surgery.

The Editor e-journal Dr. S. Muneeruddin Ahmed, of AOI AP Branch is taking pains to collect the information and Articles from the members for publication in the e-journal. I request the members to send case reports and original articles for the e-journal. I also request the members to send advertisements for the e-journal, so that we can print the journal (Hard Copies) in addition to the e-journal.

I am informing the members through e-mails and SMSes to go through our website, www.aoiapstate.com so that they can know all the information about the activities of our Association.

With regards,

Date: 28-06-2013

Dr. L. SUDARSHAN REDDY
Hony. Secretary
AOI AP State Br.
FROM THE DESK OF TREASURER

MESSAGE

I am glad that the next edition of e-journal is ready and I request all the members to send articles of information and innovation to enrich the journal.

I also request all the members to encourage non-members to become members to strengthen the Association.

Dr.K.V.N.Durga Prasad
Treasurer
AOI AP BRANCH
HYDERABAD
1. **A clinical study of ossiculoplasty in the treatment of C.S.O.M**

Dr. Swetha; P.G; Dr. S. Muneeruddin Ahmed; Dr. T. Shankar; Dr. L. Sudarshan Reddy; Dr. Sridhar Reddy; Dr. Indira Devi; Dr. C. Ramakrishna; Dr. Venkata Ramana and Dr. Vishnuvardhan Reddy.

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**Abstract**

Ossiculoplasty done in 50 patients while treating surgically for CSOM safe and unsafe types using synthetic, allograft and Homograft material, follow up for a period of 2 years showed improvement in Air conduction in 85% of cases, Closure of A-B gap up to 26.6dB in 76% of cases, Absence of graft rejection with allograft, homograft and synthetic material used. Binaural acuity improved and inter-aural difference was below 20dB in 48% of cases.

**Key Words:** Ossiculoplasty, allograft, Homograft, Silastic, columella, AB gap, Auditory gain.

**INTRODUCTION**

Hearing is one of the vital senses of man. Deafness upsets the tranquility of life. When such a great vital sensation is lost, life naturally loses its charm.

In India, especially in Andhra Pradesh, the incidence of Chronic Suppurative otitis media (CSOM) is very high. About 30% of patients who attend ENT Outpatient Department suffer from CSOM.

The management of chronic Suppurative otitis media had witnessed a profound change over the last 100 years, from the early attempts at surgical exposure of the middle ear in 1889 to the present day techniques of Tympanoplasty.

For a successful ossicular reconstruction an air-filled middle ear and a functioning Eustachian tube are very important prerequisites. The tympanic membrane must be intact, healthy and mobile. The ossicular reconstruction must be secure and stable.

Grafts and biomaterials chosen for use in middle ear reconstruction ideally should not induce a sustained foreign body reaction, extrude or biodegrade.
Historical review of ossiculoplasty:

The surgery of Otosclerosis has profound effect on Tympanoplasty techniques. In 1956, Shea performed the first Stapedectomy, and replaced the stapes with a Teflon replica.

In the late 1950's, Dr. David Austin, Dr. Beverly Armstrong began using heat-flared segments of polyethylene tubing to bridge the gap between the foot-plate (and graft) and the drum.

Polyethylene-tube umbrella (Oppenheimer and Harrison, 1963) Polyethylene tube-wire mesh "Sunflower columella" (House & Sheehy, 1963) Teflon Umbrella (Austin 1963)

Hall & Rytzner (1957) performed the first ossicular chain reconstruction using autologous chain.

Tympano malleo stapediopexy Bell (1958) Similar malleus transposition were described by Hall & Rytzner (1957); Farrior (1960) and Portmann (1961).

House, Patterson and Linthicum (1966) introduced the incus allograft preserved in 70% ethyl alcohol prior to use.

Tympanic membrane to stapes head and tympanic membrane to foot plate interpositions, malleus to stapes and malleus to foot plate assemblies by Hough (1958), Zollner (1960, 1969), Farrior (1960, 1966), Klay and Draf (1965) and TOS (1974).

Jansen (1972) reinforced long cartilate columella with stainless steel wire, a procedure also adopted by Smyth (1969) in his 'boomerang start'.

Proplast I was first used by Janeke & Shea (1975) as a total ossicular replacement prosthesis.

Plastipore was first used successfully by Shea (1976) as Total ossicular Replacement prosthesis.

EMBRYOLOGY

DEVELOPMENT OF TYMPANIC CAVITY & AUDITORY TUBE:

The tympanic cavity which originates in the endoderm is derived from the first pharyngeal pouch. By the 4th week stage this pouch expands in a lateral direction and comes in contact with the floor of the first pharyngeal cleft. The distal part of the pouch, the Tubo tympanic recess, widens and gives rise to the primitive tympanic cavity and the proximal part remains narrow and forms the auditory tube (Eustachian tube), through which the tympanic cavity communicates with the Naso pharynx.
OSSICLES:

The malleus and incus are derived from cartilage of the first pharyngeal arch, and the stapes is derived from that of the second arch. Although the Ossicles appear during the first half of fetal life, they remain embedded in mesenchyme until the eight-month when the surrounding tissue dissolves.

AUDITORY OSSICLES

The auditory Ossicles extend like a chain across the tympanic cavity to connect functionally the tympanic membrane with the vestibular (oval) window. This compound osseous system acts like a bent lever to convert the vibrations of the tympanic membrane into intensified thrusts of the stapes against the perilymph.

PHYSIOLOGY OF HEARING

Physics of sound: The understanding of several of the physical properties of sound energy is significant to the understanding of the mechanics of sound conduction. These properties are outlined.

The Acoustic transformer.

The major contributors to the human acoustic transformer are the pinna, the external auditory canal and the middle ear sound conduction system.

Pinna: The pinna, because of their location and shape, serve to gather sound arriving from an arch of 135° relative to the direction of the head. The horn-shaped concha then acts like a megaphone to concentrate the sound at the entrance of the auditory canal. This action increases sound pressure as much as six decibels (2 times),

External auditory canal: The external auditory canal has a resonant frequency centering at 4000 Hz. This resonance, acting in concern with the effect of the pinna, can increase sound pressure at the tympanic membrane by 15 - 22 decibels at 3000 Hz. These effects, however, can vary greatly among individuals.
**Middle ear transformer mechanism:** The transformer system of the middle ear, although working as a complex whole, may be divided into 3 stages; that provided by the ear drum (catenary lever), that provided by the ossicles (ossicular lever), and that provided by the difference in area between the tympanic membrane and the stapes foot-plate (hydraulic lever).

**Cantenary lever:** Helmholtz, in 1863, was first to propose the concept of a catenary level to the action of the tympanic membrane. The familiar example of this type of lever is the tennis net. It is estimated that even though the curvature of the TM is variable, the centenary lever provides at least a two times (2x) gain in sound pressure at the malleus.

**Ossicular lever:** Dahmann 26, proposed that the malleus and incus acts as a unit, rotating around an axis running between the anterior malleolar ligament and the incudal ligament. This concept generally accepted today, measures the lever arms from the rotational axis to the tip of the malleus and to the tip of long process of the incus. This lever ratio is 1.15:1.

**Hydraulic lever:** Helmholtz's third concept of impedance matching involved what is today commonly referred to as a the areal ratio. Briefly stated, sound pressure collected over the large area of the tympanic membrane and transmitted to a smaller foot plate area results in an increase in force proportional to the ratio of the areas. This idea is valid as long as both areas are vibrating in a piston Pike manner. This ratio average is 20.8:1.

**Sound pressure transformer:**
- Cantenary lever: Force acting on TM/Force acting on malleus
- Ossicular lever: Force acting on Malleus I Force acting on stapes.
- Areal ratio: Area of tympanic membranelarea of footplate
- Total lever advantage
- External ear contribution
- Total system gain

**Phase protection:**

The electrical analogue of a pure-tone sound is the sine wave. The fluids of the inner ear are incompressible; resulting in sounds arriving at the oval and round window, at the same phase exerts a push push effect and will not enter the labyrinth. If the two sound energies arriving at the two windows are 1800 out of phase (push-pull), there is maximum transfer of energy to the cochlear fluids. The middle ear provides phase protection to the windows.

**PATHOLOGICAL CONDITIONS AFFECTING SOUND CONDUCTION**

1. Tympanic Membrane Perforation
Two factors combine to affect the conductive system when a perforation of the tympanic membrane is present. The first is due to the entrance of in-phase sound energy through the perforation, which interferes with the vibration of the remaining drumhead and with the stapes by reaching the round window directly. This factor affects chiefly low-frequency transmission and becomes less significant in larger perforations. The major factor influencing hearing loss with tympanic membrane perforations is the loss of areal ratio due to the reduction of drumhead area. The hearing loss associated with a perforation is directly proportional to the size of perforation.

2. Perforation with Ossicular Interruption

Approximately 60% of patients undergoing surgery for chronic ear disease have perforation with ossicular interruption. The typical hearing loss is worse at the lower frequencies and averages 38 dB. Larger perforations cause slightly worse hearing, but this difference is variable. The components of this hearing loss are believed to be assignable as follows: loss of hydraulic lever 26.5 dB, loss of ossicular-catenary lever 7.3 dB, and phase cancellation, 5.0 dB, for a total of 38.3 dB.

3. Total Loss of Tympanic Membrane and Ossicles

Much less frequent is this form of pathology. As reported by Austin the contour of the hearing loss is the same as the previous group but more severe, averaging 50 dB. The greater hearing loss is probably due to increased phase cancellation at the round window. Components of this loss are believed to be assignable as follows: loss of hydraulic lever 26.5 dB; loss of ossicular-catenary lever 7.3 dB; phase cancellation 16.2 dB, for a total of 50 dB.

4. Ossicular Interruption with an Intact Tympanic Membrane

Interruption of the ossicular chain in the presence of an intact eardrum is seen more often as a consequence of surgery than a disease process. It is most often due to disarticulation of the incudostapedial joint either from a prosthesis problem or from erosion of the long process of the incus. The result is a flat hearing loss averaging 54 dB. The components of this loss are believed to be, first, a loss of the transformer system causing a 38 dB deficit and, second, an added loss caused by the obstruction to the passage of sound of the tympanic membrane. This latter factor reduces the sound pressure by 15 to 20 dB. To put it another way, the loss is the same as that seen with interruption of the ossicular chain with a perforation (38 dB) plus the additional 15-dB loss of sound pressure due to blocking by the presence of the drumhead.

Functional examination of hearing:

The hearing loss is CSOM can be attributed to four basic dysfunctions (Prasansuk and Hinchcliffe 1982).

1. Impairment of the tympano-ossicular impedance matching mechanism,

2. Reduction of the baffle effect on the round window.
3. Underlying middle ear pathology such as mucosal edema, fluid granulations, cholesteatoma, osteitis and ossicular necrosis which impairs the tympano-ossicular mechanism.

4. Underlying cochlear dysfunction.

**SURGICAL MANAGEMENT OF CHRONIC OTITIS MEDIA:**

The management of chronic ear disease has undergone considerable technical advances during past 30 years. This is mainly because of the use of operating microscope, electric drill, microsurgical instruments and the extensive practical training of temporal bone surgery in addition to the development of many broad spectrum antibiotics.

In light of these developments, now it is possible to remove the disease process meticulously from the tympanomastoid area, which enables the surgeon to achieve desired dry and a safe ear. The most important results of these developments to the present day otolaryngologists is reconstruction of tympanum to improve functional hearing level along with clearance of disease in majority of cases. Thus mastoidectomy and tympanoplastic procedures together are essential in achieving the objective of healing and hearing.

**OSSICULOPLASTY IN CLOSED AND OPEN CAVITY PROCEDURES:**

In the present study the following classification is used.

**Ausin/Kartush Classification:**

0) Ossicular chain intact (M+I+S+)

A) Malleus present, stapes present (M+S+)

B) Malleus present, stapes absent (M+S-)

C) Malleus absent. Stapes present (M-S+)

D) Malleus absent, stapes absent (M-S-)

E) Ossicular head fixation

F) Stapes fixation

**GRAFTS CURRENTLY USED IN MIDDLE EAR RECONSTRUCTION:**

Autograft: Describes a Graft taken from one site of an individual and placed on another site of the same individual.- Eg. Ossicular bone, cortical bone, cartilage.

Isograft: Describes a graft exchanged between genetically identical individuals.
Allograft (Homograff): Describes a graft transfer from one individual to another (species-specific). Eg. Tympano-ossicular incorporating malleus + incus, malleus, incur and stapes.

Xenograft Describes a graft between different species.

Orthotopic graft: Describes a graft transplanted to its normal anatomic environment.

Heterotopic graft: Describes a graft transplanted into a non-anatomic environment for the grafted material.

Materials used for Ossicular Reconstruction

AUTOGRAFT
- Malleus
- incus
- Tragal and conchal cartilage
- Cortical bone
- Tympanic spine

HOMOGRAFT
- Septal spur cartilage
- incus
- Malleus

Bio materials

1. Biotolerent materials

Metals Polymers

Stainlesssteel Polyethylene
Tantalum Polytetra fluroethylene (TEFLON)
Platinum Polydimethylsiloxane (SILASTIC)
Titanium Porous
PTFE carbon fibre composite (Proplast-1) PTFE A12O3 composite (Proplast- 2) High density polyethylene (Plastipore)

Ultrahigh molecular weight polyethylene (Polycel)

Light Harness satin- weave carbon fibre impregnated with phenolic resin (Carbon).

Bio ceramics classification

<table>
<thead>
<tr>
<th>Product</th>
<th>Appearance</th>
<th>Prostheses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Bioinert Aluminium oxide ceramics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FRIALIT</td>
<td>Dense white</td>
<td>Partial and total ocicular replacement prostheses.</td>
</tr>
<tr>
<td>BIOCEREAM</td>
<td>Dense white</td>
<td>CORP-P &amp; CORP-T</td>
</tr>
<tr>
<td>MACOR</td>
<td>Dense white</td>
<td>Partial and total ocicular replacement prostheses.</td>
</tr>
<tr>
<td>II. Bioreactive Glass ceramics.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIOGLASS</td>
<td>Dense Transparent</td>
<td>Partial and total ocicular replacement prostheses.</td>
</tr>
<tr>
<td>CERAVITAL</td>
<td>Dense White</td>
<td>Partial and total ocicular replacement prostheses.</td>
</tr>
<tr>
<td>III. Bloactive Calcium phosphate ceramics</td>
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<tr>
<td>Hydroxylapatite</td>
<td>Dense White</td>
<td>Partial and total ocicular replacement prostheses.</td>
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</table>

PRINCIPLES OF HEARING RECONSTRUCTION

The tympanic membrane being the most important contributor to sound transmission because of hydraulic head and should be firm so that the maximum energy may be transmitted without distortion. Ideally the ossicular coupling should not change the mass or stiffness of the system. Because the ossicular lever is a minor contributor to the middle ear transformer well incorporated columella may provide good hearing.
Because the stapes has a piston like movement under physiological stimuli, the reconstructed middle ear should provide a stable, natural interface at the stapes, so that the foot plate may vibrate in normal manner.

Controlled healing to prevent scarring of the reconstructed hearing mechanism is essential.

FACTORS THAT INFLUENCE HEARING RESULTS

1. Condition of the middle ear mucosa.
2. Graft material
4. Patency of the Eustachian tube orifice.
5. Staged procedure when required.
6. Proper post operative follow up.

SURGICAL TECHNIQUE:

Most of the ossiculoplasty procedures for chronic ear disease with or without cholesteatoma have been standardized.

In all possible cases, after meticulous clearing of the disease process, the undersurface TM grafting with ossicular reconstruction was carried out, depending on type of ossicular pathology.

In these days more and more emphasis is given for refinement of techniques in ossicular reconstruction in order to get better hearing results.

REQUIREMENT FOR PRIMARY OSSICULOPLASTY

1. Presence of normal or hypertrophied middle ear mucosa.
2. Patent Eustachian tube orifice
3. Mobile stapes foot plate

PREPARATION OF THE PATIENT

Hair is removed about 1cm above and behind the auricle and rest of the hair kept away from the operating field by means of adhesive plasters. Few drops of xylocaine 4% are instilled into the middle ear to anaesthetize and also to protect the middle ear mucosa.
After, the ear and surrounding area is prepared by using methylated spirit or betadine. Local anesthetic drug (1% xylocaine with 1 in, one lakh adrenaline) is infiltrated first in the external auditory canal in 4 to 5 points at bony cartilaginous junction and then in the post auricular area by classical Heerman's technique. Later, draping and thorough washing of the external auditory canal and middle ear with normal saline is carried out to clean cerumen and purulent material, if any.

PROCEDURE

Incision: Post aural incision taken for both intact canal wall technique or canal wall down procedures. Ossicular reconstruction was done subsequently after complete removal of disease.

TYPES OF OSSICULAR RECONSTRUCTION INCUS PROBLEMS

Necrosis

Figure 1-1  Figure 1-2  A-D

Figure 1-1 demonstrates commonly found clinical problem due to chronic middle-ear-space infection. The lenticular process of the incus has necrosed. This is commonly due to the poor blood supply to this area.

Restoration of ossicular continuity may be brought about by either using a sculptured incus homograft or the sculptured auto graft (Figure 1-2A) disarticulating the head of the malleus and sculpturing it for placement as a columella (Figure 1-28), employing an incus homograft or the auto graft incus (Figure 1-2C), or using a PORP with a small piece of cartilage or autogenous tissue juxtaposed against the manubrium of the malleus (Figure 1-21D). Some surgeons place the head of the PORP partially against the tympanic membrane.

Dislocation

...
Figure 1-3 demonstrates dislocation of the lenticular process from the capitulum of the stapes. If technically feasible, re-approximation at this joint without stress would be an optimal restorative procedure; however, this is seldom possible.

Figure 1-4 demonstrates the placement of a small piece of bone between the lenticular process of the incus and the capitulum of the stapes.

Figure 1-5 demonstrates a sculptured incus auto graft being used to restore the conductive mechanism.

Figure 1-6 demonstrates the traumatic disruption of the incudo-malleolar joint and epitympanic displacement of the incus. The surgeon must be careful when manipulating the incus to define the extent of dislocation with the superstructure of the stapes if any exists. A small insert demonstrates an atraumatic severing of the long process of the incus, leaving it attached to the stapes capitulum.

Figure 1-7 demonstrates the use of the body of the incus as strut between the manubrium and the distal portion of the long process of the incus previously severed.

Figure 1-8 shows a sculptured incus columella.

Figure 1-9 demonstrates fibrous adhesion between the long process of the incus and the manubrium of the malleus, indicating that separation from the stapes superstructure has occurred.
As shown in Figures 1-7 and 1-8 the body of the incus may be separated from its long process and used as a sandwich columella-type graft, or as shown in Figure 1-10 may be as a sculptured incus graft.

Fixation

Figure 1-11 demonstrates fixation of the incus. As previously mentioned, the reestablishment of a mobile ossicular chain is the goal of the ossiculoplasty.

Fig. 1-11 Fig. 1-12 Fig. 1-13 Fig. 1-14
- In Figure 1-12 a sculptured incus is placed between the manubrium and the capitulum of the stapes.
- Figure 1-13 demonstrates the alternative positioning of the sculptured incus.
- Figure 1-14 demonstrate the sculptured malleolar head grafted into place.

Absence

Absence of the incus is most commonly due to trauma or prior surgery (Figure 1-
Following demonstration of a mobile stapes footplate, a sculptured malleolar head graft is placed (Figure 1-16). The insert in Figure 1-16 shows the amputation of the malleus head using the House Dieter malleus nipper.

Alternatively, autogeous material such as cartilage may be employed to act as a strut (Figure 1-17).

STAPES PROBLEM Absence

The stapes, like the malleus and incus, may be traumatized or subjected to fixation secondary to inflammation (Figure 1-18).

After conforming that the stapes footplate is mobile, satisfactory demonstration of a mobile footplate, an autogenous graft may be placed over the mobilized footplate or a piston may be placed (Figure 1-19A). Figure 1-198 demonstrates the placement of a cartilage columella, and Figure 1-19C) demonstrates the placement of the autograft incus. Figure 1-190) demonstrates the placement of a TORP that may, as previously noted, juxtapose the manubrium of the malleus or partially juxtapose the malleus and the tympanic membrane. We recommend the placement of cartilage between the tympanic membrane and lateral portion of the TORP.
Fracture and Dislocation: Figure 1-20 demonstrates the fracture of the stapes cura.

- Figure 1-21 represents essentially an open reduction and fixation of the stapes suprastructure placed back in its anatomic position. Gelfoam is placed about the fracture site.

- Figure 1-22 shows that the fractured stapes suprastructure has been removed and a House-wire has been placed between the long process of the incus and the mobile footplate.

- Figure 1-23 shows that the stapes suprastructure has been traumatically dislocated from footplate region.

- Figure 1-24 demonstrates the placement of autogenous cartilage over the mobile footplate from the lenticular process of the incus.

- Figure 1-25 demonstrates the placement of a Teflon wire piston in traditional stapedotomy technique fashion.

Absence of Malleus and Incus
Figure 1-26 demonstrates the absence of both malleus and incus.

Figure 1-27 shows placement of autogenous graft material in a Type III tympanoplasty on the mobile stapes superstructure.

Figure 1-28 demonstrates the use of a homograft incus that has been sculptured to create a larger tympanic space.

Figure 1-29 illustrates placement of a PORP; again, the objective is to create a larger tympanic space.

Absence of Malleus, Incus, and Superstructure of Stapes (Mobile Footplate)

Figure 1-30 demonstrates absence of malleus, incus, and stapes superstructure.

Figure 1-31/A shows placement of a graft directly on the mobile footplate, as routinely performed with Type IV tympanoplasty. Figure 1-31B illustrates placement of a sculptured malleus columella strut between graft and mobile footplate, along with a head of the malleus, which creates an air space in the mesotympanum. Figure 1-31C shows placement of an incus columnella homograft and Figure 1-31 D, placement of a TORP, Note the positioning of cartilage between the tympanic membrane and lateral portion of the TORP.
Tympano meatal flap reposited in its original position. Small pieces of gelfoam, antibiotic ribbon gauze placed in the external auditory canal.

Incision closed with mersilk 3-0. Mastoid dressing applied. Outer dressing and cotton bud in the external auditory canal changed on the third post operative day. Most of the patients discharged on 3" 4u' post operative day.

Patient reviewed on 7th P.O.D. for suture removal and reviewed again after 3 4 weeks P.O.D. for P.T.A. and again at the end of third month for P.T.A.

PROBLEMS AND SOLUTIONS

The otologist must be aware of the fact that technique and appropriate choice of grafting material play a large part in the success of graft placement. Attention to the finest details of size and location of graft placement will contribute to a successful outcome; conversely, failure to follow meticulous procedure principles will most assuredly result in a failed graft.

A lateralized incus homograft is demonstrated in Figure 1-32 retraction may displace the medial end of the homograft into the vestibule. A connective tissue graft should be placed over the oval window.

Figure 1-33 shows a sculptured malleus homograft that has lateralized.

The malleus-to-oval window wire piston prosthesis placement is technically difficult. The shaft and crook shown in Figure 1-34 are lateralized. Commonly, the wire has not been crimped well to the manubrium (see section on stapedectomy in fenestrated ear in Chapter 9).

A sculptured incus homograft or autograft may become fixed to the facial ridge, cochleariform process, the promontory, or the bony rim of the annulus. (Figure 1-35). Retraction may separate the interposition graft incus from the malleus laterally.
Figure 1-36 shows migration of a PORP and subsequent disruption of the manubrium to oval window columella.

As shown in Figure 1-37 the problem illustrated in Figure 1-36 may be overcome by placing a piece of cartilage between the head of the PORP and the tympanic membrane.

IMPORTANT POINTS TO REMEMBER TO GET GOOD HEARING RESULTS

1. One stage Tympanoplasty with ossicular reconstruction in all possible areas.

2. Under surface TM grafting is essential for undisturbed healing of the I'M and stability of the graft.

3. Procedure should be staged, if the disease mucosa is completely removed.

4. Well collected homograft ossicular and cartilage bank is essential.

5. Proper sculpturing of ossicles or cartilage instead of alloplastic material.

6. Stabilization of the graft in place by using gelfoam around.

7. Silastic sponge or sheet should be inserted between the bony graft and the promontory, facial canal and the cochleariform process to prevent ankylosis.

8. Tight packing or sheet should be inserted between the bony graft and the promontory, facial canal and the cochleariform process to prevent ankylosis.

9. Tight packing of the E.A.C. should be avoided.

10. Immediate treatment of cold with antihistamine, decongestant and nasal drops.

11. If there is retraction or serous otitis media post operatively, insertion of grommet should be done.

12. Post operative audiogram after 3 months to determine hearing improvement and the test is repeated after 6 months or a year.
AIMS AND OBJECTIVES

1. To study commonest ossicular pathology in CSOM.
2. Reconstruction of ossicular chain using various grafts.
3. To compare pre-operative and post-operative hearing thresholds (air bone gap dB)

MATERIALS AND METHODS

Fifty patients underwent ossiculoplasty procedure over a 2 year period between August 2010 to August 2012 at Government E.N.T. Hospital, Koti, Hyderabad. Patients of both safe and unsafe type of chronic Suppurative otitis media with good cochlear reserve and good Eustachian tube function were selected. Both intact canal wall and canal wall down procedures were included.

The operations were performed under local or general anesthesia. Post aural incision used. After clearing of disease from the middle ear cleft as necessary, the status of ossicular chain was assessed. Ossicular reconstructive procedure was planned according to the status of the ossicular chain. Temporalis fascia was used as an underlay grafting to close the TM perforation.

In the present study the material used are autologous cartilage (Conchal) or autogenous Ossicles (incus remnant), homograft septal cartilage, Silastic TORP and PORP.

1. Malleus and head of stapes (malleus-stapes assembly) –
2. Between malleus and footplate (malleus footplate assembly) –
3. Stapes head and newly constructed tympanic membrane (short columella).
4. Footplate and newly constructed tympanic membrane (long columella)

All patients underwent audiometry assessment before surgery and three months and six months after surgery. Pure tone averages (500Hz, 1000Hz & 2000Hz) were compared between pre-operative and post-operative results.
Abstract

Clinical evaluation of 25 patients presenting with vertigo was done followed by Audiological and vestibular evaluation done. Out of 25 patients

Introduction: If the mechanism of balance is disrupted, one experiences a variety of sensations which can be included under the banner of ‘Vertigo’. According to Lord Russell Brain, “Vertigo is an awareness of disordered orientation of the body in space.” Peripheral vertigo is characterized by sudden onset, episodic and objective feeling of swaying. Cochlear symptoms, nausea and vomiting are characteristics of peripheral vertigo. Vertigo with abnormal caloric response together with hearing loss signifies a peripheral pathology. It is an unpleasant truth that patients with vertigo get little justice from a clinician. The underlying cause is not that we do not know the subject, but we presume that little can be done to these distressed patients and we have nothing in our hand but a vague assurance and consolation to offer. Though vertigo is a multidisciplinary subject, peripheral vertigo is a classical entity of E.N.T. domain and as such this review study is conceptionised. This is an evaluation of peripheral vestibular disorders, based on clinical, radiological and relevant audio-vestibular studies to establish the site, type and severity of the lesions

Classification

Vertigo is classified into either peripheral or central depending on the location of the dysfunction of the vestibular pathway, although it can also be caused by psychological factors.

Peripheral
Vertigo caused by problems with the inner ear or vestibular system, which is composed of the semicircular canals, the otolith (utricle and saccule), and the vestibular nerve is called "peripheral", "otologic" or "vestibular" vertigo. The most common cause is benign paroxysmal positional vertigo (BPPV), which accounts for 32% of all peripheral vertigo.

Other causes include Ménière's disease (12%), superior canal dehiscence syndrome, labyrinthitis and visual vertigo. Any cause of inflammation such as common cold, influenza, and bacterial infections may cause transient vertigo if they involve the inner ear, as may chemical insults (e.g., aminoglycosides) or physical trauma (e.g., skull fractures). Motion sickness is sometimes classified as a cause of peripheral vertigo.

Patients with peripheral vertigo typically present with mild to moderate imbalance, nausea, vomiting, hearing loss, tinnitus, fullness, and pain in the ear. In addition, lesions of the internal auditory canal may be associated with ipsilateral facial weakness. Due to a rapid compensation process, acute vertigo as a result of a peripheral lesion tends to improve in a short period of time (days to weeks).

Central

Vertigo that arises from injury to the balance centers of the central nervous system (CNS), is generally associated with less prominent movement illusion and nausea than vertigo of peripheral origin. Central vertigo has accompanying neurologic deficits (such as slurred speech and double vision), and pathologic nystagmus (which is pure vertical/torsional). Central pathology can cause disequilibrium which is the sensation of being off-balance. The balance disorder associated with central lesions causing vertigo are often so severe that many patients are unable to stand or walk.

A number of conditions that involve the central nervous system may lead to vertigo including: lesions caused by infarctions or hemorrhage, tumor, epilepsy, cervical spine disorders, degeneration, migraine headaches, lateral medullary syndrome, multiple sclerosis, parkinsonism, as well as cerebral dysfunction. Central vertigo may not improve or may do so more slowly than vertigo caused by disturbance to peripheral structures.

Signs and symptoms

Vertigo is a sensation of spinning while stationary. It is commonly associated with vomiting or nausea, unsteadiness, and excessive perspiration. Recurrent episodes in those with vertigo are common and they frequently impair the quality of life.

Blurred vision, difficulty speaking, a lowered level of consciousness, and hearing loss may also occur. Central nervous system disorders may lead to permanent symptoms.
The signs and symptoms of vertigo can present as a persistent (insidious) onset or an episodic (sudden) onset.

The characteristics of persistent onset vertigo is indicated by symptoms lasting for longer than one day and caused by degenerative changes that affect balance as we age. Naturally, the nerve conduction slows with aging and a decreased vibratory sensation is common. Additionally, there is a degeneration of the ampulla and otolith organs with an increase in age. Persistent onset is commonly paired with central vertigo signs and systems.

The characteristics of an episodic onset vertigo is indicated by symptoms lasting for a smaller, more memorable amount of time, typically lasting for only seconds to minutes.

Pathophysiology

The neurochemistry of vertigo includes 6 primary neurotransmitters that have been identified between the 3-neuron arc that drives the vestibulo-ocular reflex (VOR). Many others play more minor roles.

Three neurotransmitters that work peripherally and centrally include glutamate, acetylcholine, and GABA.

Glutamate maintains the resting discharge of the central vestibular neurons, and may modulate synaptic transmission in all 3 neurons of the VOR arc. Acetylcholine appears to function as an excitatory neurotransmitter in both the peripheral and central synapses. GABA is thought to be inhibitory for the commissures of the medial vestibular nucleus, the connections between the cerebellar Purkinje cells and the lateral vestibular nucleus, and the vertical VOR.

Three other neurotransmitters work centrally. Dopamine may accelerate vestibular compensation. Norepinephrine modulates the intensity of central reactions to vestibular stimulation and facilitates compensation. Histamine is present only centrally, but its role is unclear. It is known that centrally acting antihistamines modulate the symptoms of motion sickness.

The neurochemistry of emesis overlaps with the neurochemistry of motion sickness and vertigo. Acetylcholine, histamine, and dopamine are excitatory neurotransmitters, working centrally on the control of emesis. GABA inhibits central emesis reflexes. Serotonin is involved in central and peripheral control of emesis but has little influence on vertigo and motion sickness.

Diagnostic approach
BPPV is normally diagnosed with the Dix-Hallpike test. Tests of vestibular system (balance) function include electronystagmography (ENG), rotation tests, caloric reflex test, and computerized dynamic posturography (CDP).

Tests of auditory system (hearing) function include pure-tone audiometry, speech audiometry, acoustic-reflex, electrocochleography (ECoG), otoacoustic emissions (OAE), and auditory brainstem response test (ABR; also known as BER, BSER, or BAER).

Other diagnostic tests include magnetic resonance imaging (MRI) and computerized axial tomography (CAT or CT).

Treatment

Definitive treatment depends on the underlying cause of the vertigo.

- benign paroxysmal positional vertigo (BPPV) is treated with repositioning maneuvers designed to move the otoconia (crystals) back into the utricle where they belong. The most common maneuver is the Epley maneuver (performed by a doctor, audiologist, physical therapist)
- anticholinergics
- antihistamines

Epidemiology: Vertigo is a frequent symptom in the general population with a 12-month prevalence of 5% and an incidence of 1.4% in adults. Its prevalence rises with age and is about two to three times higher in women than in men. It accounts for about 2-3% of emergency department visits.

Investigations

- Audiological- 1. PTA
  2. Impedence
  3. BERA
- Vestibular tests- 1. Dix hallpike test
  2. ENG
  3. Caloric test
- Radiological test- 1. x-ray-mastoids/cervical spine
  2. CT/MRI
AIMS AND OBJECTIVES:

This study is an evaluation of peripheral vestibular disorders, based on clinical, radiological and relevant audiovestibular studies to establish the site, type and severity of the lesions and treat them accordingly.

MATERIALS & METHODOLOGY: This study was conducted in Govt ENT hospital, koti, Hyderabad, over a period of 2 years.

25 cases of vertigo without a history of surgery or established pre-existing disease of the ear were selected based on thorough anamnesis, otoneurological examination and relevant audiovestibular studies.

After a detailed history, clinical examination was performed in every case which included detailed ear, nose and throat examination, cranial nerves examination, cerebellar function tests and position tests.

Total No. of cases: 25

<table>
<thead>
<tr>
<th>Male</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
</tr>
</tbody>
</table>

Observations

Males are more predominant than females. **Age distribution:**

<table>
<thead>
<tr>
<th>Age</th>
<th>No. of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>0</td>
</tr>
<tr>
<td>11-20</td>
<td>0</td>
</tr>
<tr>
<td>21-30</td>
<td>6</td>
</tr>
</tbody>
</table>
Vertiginous disorders were more commonly seen in 4th and 5th decade of life.

The disease was less common above 60 years and was rare below 20 years.

Site of lesion:

<table>
<thead>
<tr>
<th>Site</th>
<th>No. of cases</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle ear</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Inner ear</td>
<td>15</td>
<td>60</td>
</tr>
<tr>
<td>Systemic lesion</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>others</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
<td>100</td>
</tr>
</tbody>
</table>

Maximum number of cases were due to inner ear disease (60% each).

The rest of cases were mainly due to other causes (20%) and lesions in middle ear were (12%).

**Middle ear lesions:**

<table>
<thead>
<tr>
<th>Lesion</th>
<th>No. of cases</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Otosclerosis</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>12</td>
</tr>
</tbody>
</table>

Amongst the middle ear lesions, otosclerosis was found in 12% cases.

**Inner ear lesions:**

<table>
<thead>
<tr>
<th>Lesion</th>
<th>No. of cases</th>
<th>Percentage</th>
</tr>
</thead>
</table>
Amongst the inner ear pathology, BPPV (36%) formed the major part. while the incidences of Meniere's Disease 24%

**Systemic disorders :**

<table>
<thead>
<tr>
<th>Lesion</th>
<th>No. of cases</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertebro basilar insufficiency</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Astrocytoma/medulloblastoma</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>24</td>
</tr>
</tbody>
</table>

Systemic disorders manifesting as vertigo were detected in vascular lesions (4%), which included vertebro-basilar insufficiency.

A case of astrocytoma/medulloblastoma was seen.

**Others :**

<table>
<thead>
<tr>
<th>Lesion</th>
<th>No. of cases</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cervical spondylosis</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>Psychological</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
<td>20</td>
</tr>
</tbody>
</table>

Other lesions included cervical spondylosis (16%) and psychological cause (4%)

**MATERIALS & METHODS:**

This study was conducted in Govt. ENT Hospital, Koti, Hyderabad, over a period of 6 months.
25 cases were selected based on thorough History, Otoneurological examination and relevant Audio-vestibular studies.

**INVESTIGATIONS**

Audiological Investigations: 1. PTA 2. Impedance and 3. BERA

Vestibular tests: 1. Dix - Hall pike test 2.ENG 3. Caloric tests

**CALORIC TEST**

ENG

Radiological tests- 1. X ray-Mastoids/cervical spine 2. CT/MRI 3. Carotid Doppler

**CAROTID DOPPLER**

Hematological tests- Routine and Specific as needed

**CHAMP**

**COCHLEOGRAPHY.**

**OBSERVATIONS:**

Males (15) were more predominant than females (10)

**AGE DISTRIBUTION**

Vertiginous disorders were more commonly seen in 4th and 5th decade of life. The disease was less common above 60 years and was rare below 20 years.

<table>
<thead>
<tr>
<th>Age in Yrs</th>
<th>No. of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>0</td>
</tr>
<tr>
<td>11-20</td>
<td>2</td>
</tr>
<tr>
<td>21-30</td>
<td>5</td>
</tr>
<tr>
<td>31-40</td>
<td>3</td>
</tr>
<tr>
<td>41-50</td>
<td>7</td>
</tr>
<tr>
<td>51-60</td>
<td>5</td>
</tr>
<tr>
<td>61-70</td>
<td>3</td>
</tr>
</tbody>
</table>
SITE OF LESION

Maximum number of cases was due to inner ear and systemic lesions. (32% each). The rest of cases were mainly due to lesions in middle ear (16%).

<table>
<thead>
<tr>
<th>Site</th>
<th>No. of Cases</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle Ear</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>Inner Ear</td>
<td>8</td>
<td>32</td>
</tr>
<tr>
<td>Systemic</td>
<td>8</td>
<td>32</td>
</tr>
</tbody>
</table>

Lesion

<table>
<thead>
<tr>
<th>Lesion</th>
<th>No. of Cases</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post Trauma</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Others</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
<td>100</td>
</tr>
</tbody>
</table>

MIDDLE EAR LESIONS

Amongst the middle ear lesions, CSOM (AAD) was found in 12% cases, post operative vertigo was found in nearly 4% of the cases.

<table>
<thead>
<tr>
<th>Lesion</th>
<th>No. of Cases</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSOM (AAD)</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Post Mastoidectomy</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>4</td>
<td>16</td>
</tr>
</tbody>
</table>

INNER EAR LESIONS: Amongst the inner ear pathology, Meniere's Disease (24%) formed the major part, while the incidences of labyrinthitis was 8%.

<table>
<thead>
<tr>
<th>Lesion</th>
<th>No. of Cases</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meniere’s</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>Labyrinthitis</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>32</td>
</tr>
</tbody>
</table>

SYSTEMIC DISORDERS
Systemic disorders manifesting as peripheral vertigo were detected in cervical spondylosis (24%), and vascular lesions (4%), which included vertebro-basilar insufficiency. A case of astrocytoma/medulloblastoma was seen.

<table>
<thead>
<tr>
<th>Lesion</th>
<th>No. of Cases</th>
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</thead>
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<td>24</td>
</tr>
<tr>
<td>Vertebro-basilar Insufficiency</td>
<td>1</td>
<td>4</td>
</tr>
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<td>1</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8</strong></td>
<td><strong>32</strong></td>
</tr>
</tbody>
</table>

Post traumatic vertigo was seen in 8% of cases. Other lesions included Ametropia and Psychological causes (4% each).

DISCUSSION:

Vertiginous disorders of peripheral origin are more commonly found in older age groups i.e. in 3rd and 4th decade of life. The disease is less common above 50 years and is rare below 20 years of age.

The male and the female ratio of peripheral vertigo is 3:2.

BPPV appears to be the commonest disorder.

Its frequency is probably greater than indicated, because the physicians tend to refer these cases less, being aware of its specificity and good prognosis.

Meniere’s disease is also a common peripheral vestibular disorder (Mawson and Ludman 1979). The diagnosis presents problems and various centres have their own parameter to diagnose this condition.

We diagnosed them on the basis of clinical history with the classical triad of episodic vertigo, fluctuating hearing loss and tinnitus. Recruiting type of sensorineural hearing loss is present in all patients as revealed by audiometry.

It can not be overemphasized that in any vertiginous patient, middle ear disease must be excluded before other avenues of investigations are pursued.

A fistula sign may be positive, but even if this is negative, it may be necessary to proceed to operative inspection, before finally excluding middle ear disease as a cause of labyrinthine erosion. Systemic disorder masquerading as peripheral vertigo is not uncommon.
ENG generally demonstrates "major butterfly Pattern" or may show directional preponderance. Vestibular function tests (ENG & CCG) usually but not always show abnormalities.

The finding of a normal canal sensitivity on the side of the lesion in a case of audiologically, radiologically or clinically suspected case of acoustic neuroma, should probably be a case of meningioma and not a case of acoustic neuroma.

☐ To make a diagnostic evaluation of peripheral vertigo, prime importance should be given to thorough history.

☐ Above examinations and investigations are done to confirm diagnosis and it is likely that in 80% of cases, if one does not have an idea of the diagnosis at the end of history, one is unlikely to have it at the end of the examinations and investigations, which are procedures mainly for confirmation.

☐ Simple procedures like caloric test can still offer a lot before recourse is made to more sophisticated methods of investigations.

☐ Special emphasis should be given to thorough neurological examinations.

☐ With the help of thorough history, and relevant investigations, one can diagnose a peripheral vertigo.

☐ Management becomes easy once the site and type of the lesion are known.

radiation outside of recurrent, disfiguring lesions is required.
3. CLINICO PATHOLOGICAL STUDY OF FUNGAL SINUSITIS

Dr. Vankataratnam, P.G. in MS ENT, Dr. S. Muneeruddin Ahmed; Dr. T. Shankar; Dr. Sreedhar Reddy; Dr. Imtyaz Khan; Dr. Rathod; Dr. Srinivas

Abstract:

Introduction:

Rhinosinusitis comprises a spectrum of inflammatory and infectious diseases that involve one or more of the four paired paranasal sinuses and nasal mucosa. It is a common disorder with various etiological factors e.g. allergy, infection and mechanical obstruction. Less common causes include aspirin hypersensitivity and cystic fibrosis. Infections are mostly due to viruses, bacteria and fungi.

Fungal rhino sinusitis may occur in immunocompromised as well as immune competent individuals. Sinusitis Disease in immune competent individuals is chronic or indolent. However, in immune compromised patients disease is rapidly progressive and results in disseminated fungal infection.

Although once considered a rare disorder, fungal rhinosinusitis has recently gained importance as an increase incidence has been observed during the past two decades. The role of fungi in the etiopathogenesis of chronic rhino sinusitis is being increasingly recognized. This form of disease is referred to as allergic fungal rhino sinusitis (AFRS) or eosinophilic fungal rhino sinusitis (EFRS) and was first recognized by Katzenenstein in 1983.

As immunocompromised population forms an important risk group for invasive fungal infections, the growing number of such individuals can be also considered responsible for increased incidence of fungal rhino sinusitis. On the basis of clinical, histopathological, radiological and mycological features, there are currently five diagnostic categories of fungal sinusitis recognized today: fulminant invasive, chronic invasive, granulomatous invasive, sinus mycetoma and allergic fungal sinusitis.

Fungal sinusitis can be considered a disease of altered hosts, which can be in the form of immune suppression or hypersensitivity in a patient. Glucose rich, acidic environment provided by diabetic ketoacidosis facilitates tissue invasion. In addition polymorphonuclear leucocytes, which form nonspecific defense against fungi, have decreased phagocyte activity in diabetic patients. These two factors in combination lead to increased incidence of this disease in diabetic patients. Metabolic acidosis also plays a significant role in the incidence of this disease in patients with severe diarrhea and renal failure. The Patients with leukemia
tend to develop a profound mucositis facilitating entrapment of spores, which may cause fulminant infection.

A prospective study was conducted on 70 patients attending the GOVERNMENT ENT HOSPITAL, KOTI, HYDERABAD over a period of 2 years from September 2010 to August 2012.

In the present study, an attempt has been made to determine the most common chief complaints, clinical presentation, computerized tomographic findings, microscopic histopathological findings in different types of fungal sinusitis and culture was done to identify the etiological fungi. History was taken to identify the risk factors and associated disease conditions if any.

Out of a total number of 1,50,000 outpatients 30% were with nasal symptoms. Out of 30% about 500 patients underwent nasal surgery, in that only 70 cases(0.05%) were found with histopathological features of fungal sinusitis.

In the present study all the suspected fungal sinusitis patients were admitted and all the investigations done, more importance given for absolute eosinophil count, CT PNS both axial and coronal views. Depending on the CT findings surgery was planned.

All the patients were underwent endoscopic sinus surgery, and excised sinus tissue. Nasal polyps, sinus secretions, invasive debris, nasal crust, necrotic materials from nose and paranasal sinuses were collected as samples. Samples were placed into sterile sealable containers containing normal saline to keep the tissue moist. Confirmation of the diagnosis made by histopathology and fungal culture. Predominant clinical features noted and correlated.

Post operatively treated with systemic antibiotic course; in a few patients with antifungal medication and steroids where required. Patients were followed up for a period of 6 months after surgery with nasal endoscopy done on monthly basis to look for recurrences, with further follow up plan.

REVIEW OF LITERATURE

Review of literature highlights certain points such as the historical aspects, terminology, clinical presentation and behaviour, pathological aspects, diagnostic criteria and management modalities in cases of fungal sinusitis.

Fungi are ubiquitous organisms in our environment. As fungi are normally found everywhere in nature as spores, it is reasonable to suggest that most people have fungal
colonization in the nasal cavity. There is poor understanding of when fungi are present as pathogens or simply a part of normal flora.

For some years, fungal rhinosinusitis has become increasingly recognized although the classification and treatment are still under debate and much remains to be learnt about its optimal management. Inspite of interesting and more sensitive techniques of sampling and identification, the role of fungal agents in the pathogenesis of sinus disease remains unclear. However, it is possible to distinguish noninvasive and invasive fungal rhinosinusitis based on the presence or not of fungi in sinus mucosa (submucosa, vessels or bone). A range of acute and chronic manifestations is described. Several fungal organisms may be involved in these various pathologies, such as Aspergillus, Scedosporium, Alternaria, Curvularia and Mucor.

The most accepted classification is represented by the system proposed by deShazo et al [1].

Classification of fungal disease in nose and sinuses.

<table>
<thead>
<tr>
<th>S.no</th>
<th>Syndrome</th>
<th>Common causes</th>
<th>Clinical presentation</th>
<th>Histopathology</th>
<th>Treatment</th>
<th>Prognosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Allergic fungal rhinosinusitis</td>
<td>Bipolaris, Curvularia, Aspergillus</td>
<td>Chronic pansinusitis, nasal polyps, expanded opacities in CT scan, proptosis</td>
<td>Sparse fungal elements in dense, eosinophil rich allergic mucin</td>
<td>Debridement, aeration, corticosteroids and (?) immunotherapy</td>
<td>Recurrence common</td>
</tr>
<tr>
<td>2.</td>
<td>Sinus fungal ball</td>
<td>Aspergillus fumigatus, A.flavus, Scedosporium</td>
<td>Rhinosinusitis (often unilateral), nasal obstruction, nasal discharge, calcification in sinus on CT</td>
<td>Dense accumulation of fungal elements in mucoid matrix forming expansile mass</td>
<td>Debridement, aeration; antifungal agents</td>
<td>Excellent</td>
</tr>
<tr>
<td>3.</td>
<td>Acute invasive fungal sinusitis</td>
<td>Mucorales, Aspergillus Fever, cough, crusting of nasal mucosa, epistaxis, headache, mental status change</td>
<td>Fungal elements in mucosa, submucosa, blood vessels or bone, with extensive tissue necrosis and neutrophilic infiltration</td>
<td>+ Radical debridement until histopathologically normal tissue is evident, antifungal agents, treatment of underlying conditions</td>
<td>Fair when limited to sinus; poor with intracranial involvement</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Chronic invasive fungal rhinosinusitis</td>
<td>Aspergillus fumigatus Orbital apex syndrome, nerve palsy</td>
<td>Necrosis of mucosa, submucosa, bone and blood vessels with low-grade inflammation</td>
<td>+/- Radical debridement, antifungal agents</td>
<td>Variable</td>
<td></td>
</tr>
</tbody>
</table>
5. Granulomatous invasive fungal rhinosinusitis  Aspergillus flavus  Unilateral proptosis  Granuloma with multinucleated giant cells and palisading histiocytes  Debridement, aeration, antifungal agents  Good, but can recur

TERMINOLOGY

Terminology is also a subject of confusion as many terms are used to define similar pathologies. The state of immunologic competence of the host is of importance in predicting the aggressiveness of fungal organism or the various manifestations of fungal sinusitis. Prognosis and treatment vary dramatically depending on whether fungal sinusitis is invasive, noninvasive or secondary to a hypersensitivity reaction.

NONINVASIVE FUNGAL SINUSITIS:

FUNGUS BALL – Is defined as the presence of tangled mats of hyphae in one or more sinus cavities without mucin. It occurs in immunocompetent patients without invasion of mucous membrane on histopathology. Incidence seems to correlate with geographic factors such as humidity. Maxillary sinus was followed by the sphenoid sinus are the main locations, though any sinus may be involved alone or in association with others. Unilateral postnasal discharge and cacosmia are the most common clinical presentations, but patient may remain asymptomatic. Nonspecific changes are seen with nasal endoscopy. CT scan is the most reliable radiological examination. Heterogeneous opacification is the most common appearance, associated with bony thickening or sclerosis of the involved sinus wall. Calcification corresponding to dense hyphae is frequently observed but not specific. Bone erosion may be observed when there is significant inflammatory reaction of the mucous membrane.

Diagnosis is confirmed by histopathology. It is an extramucosal disease. H & E stains used routinely to reveal fungi, but sometimes special stains such as GMS are recommended.

Aspergillus is the most common agent involved; especially Aspergillus fumigatus, but Aspergillus flavus or Scedosporium may also be found. Treatment consists of surgical removal of fungus ball by an endonasal endoscopic approach after enlargement of the natural ostium of the infected sinus. The fungus ball is aspirated away from the underlying mucous membrane. No medical treatment is required and recurrence or relapse is exceptional usually due to residual debris.

ALLERGIC FUNGAL SINUSITIS – Is defined as an immunocompetent patient with an allergy to fungus. Since initial publications, [3,4] approximately 7% of all chronic
rhinosinusitis cases requiring surgery have been diagnosed as allergic fungal sinusitis. The fungi which are the cause of hypersensitivity (IgE mediated) reside in the mucin and provide continued stimulation. The most common fungi reported are dematiaceous species (Bipolaris, Curvularia, Alternaria) and rarely Aspergillus. Areas where the climate is warm and humid are more commonly represented.

The pathophysiology remains subject to considerable discussion as several factors are probably necessary for the development of disease. One of the hypothesis is represented by the inhalation of ubiquitous fungi which in cases of atopic patients provokes an antigenic stimulus and an inflammatory response of the mucous membrane [5]. The resulting oedema is associated with ‘allergic mucin’, defined as a thick green to grey lamellate of dense inflammatory cells, mostly eosinophils, in various stages of degranulation (often necrotic) in wave like concentric layers, Charcot-Leyden crystals and fungal hyphae [6]. Most important diagnostically is finding of hyphal fragments scattered throughout the eosinophilic mucin. According to recent studies the term ‘eosinophilic mucin with or without fungus’ seems to be more appropriate. A new hypothesis suggested concerning the presence and production of microbial T cell superantigen, but this theory requires further studies and analysis to be definitely accepted.

The criteria for diagnosis are still under debate. The presence of allergy manifested as type I hypersensitivity increasingly essential for diagnosis. Most patients are in a younger age group (approximately 30 years), either male or female. Bilateral (approximately 50%), but also unilateral because the fungal stimulus is only present unilaterally thus sparing remaining sinuses, polyps in the nose associated with complete opacification of sinus cavities on CT scan, frequently with bone expansions, no direct invasion of dura or periorbita. The presence of hyphae in the mucin associated with eosinophils is one of the major criteria for diagnosis. Other investigations such as total eosinophil count, total serum IgE, antigen specific IgE or IgG, are suggested to reinforce the diagnosis. IgE levels are frequently higher than in normal. Allergic rhinitis is more frequently found in cases of AFRS.

AFS is frequently recurrent, chronic, almost never life threatening and best treated by surgery, steroids and probably post operative immunotherapy; though the treatment is controversial and an area still under debate. Prednisone is the oral steroid most commonly given whose length and dosage are clearly not defined. Simultaneously, topical intranasal steroid is prescribed for at least one year. Steroids act by down regulating the eosinophilic activity and act to induce apoptosis in eosinophils. Topical and systemic antifungal therapy are not usually considered sufficiently efficacious in this condition. Immunotherapy after complete removal of the allergic mucin and conservation of underlying mucosa, reduces the necessity for systemic and nasal corticosteroids and it also limits recurrences [10].
INVASIVE FUNGAL SINUSITIS:

CHRONIC INVASIVE FUNGAL SINUSITIS – Is probably one of the less frequent forms of fungal sinusitis, most of them being reported in northern Africa and Asia [11]. Two forms are usually described: granulomatous and nongranulomatous based on the presence or absence of granulomas within tissue [1]. Occurs in healthy individuals, sometimes after a previous history of chronic rhinosinusitis. It appears that most patients are immunologically competent. The pathophysiology remains unknown. Among the more important aetiological agents of chronic invasive sinusitis are Alternaria, Aspergillus, Bipolaris, Curvularia and Exserohilum species.

Pain is the main symptom. An asymptomatic period frequently occurs, symptoms occur only when the orbit or skull base are involved. Chronic headache, proptosis and cranial nerve deficits have been reported. Maxillary sinus seems to be the major site. Nasal endoscopy reveals nasal congestion or polypoidal mucosa and sometimes a soft tissue mass covered by a normal or ulcerated mucosa. Radiology shows opacification with bone erosion, MRI is helpful to confirm extension in soft tissues. Biopsies, usually taken under general anesthesia, are required when diagnosis is suspected. Histopathology reveals invasion of tissue: bone, mucous membrane, vessels.

Treatment is not totally evaluated due to few reported cases. Most have been treated with a combination of surgery and antifungal chemotherapy. While deShazo et al [1] are in favour of surgery alone, others suggest need for a prolonged course of antifungal agents, the duration of which is still under debate. A long term clinical and radiological follow up is required to identify and treat recurrent disease.

ACUTE FULMINANT FUNGAL SINUSITIS – Is characterized by a mycotic infiltration of the mucous membrane of the nasal cavity and/or paranasal sinuses. It occurs in immunocompromised patients (AIDS, haematologic disease, type I diabetes mellitus) with a fatal outcome in the absence of treatment. The initial symptoms are often subtle. Fever of unknown origin or rhinorrhoea are the most common first symptoms. Later, proptosis, ophthalmoplegia and focal neurological signs occur. Meticulous nasal endoscopy is the crux of diagnosis to identify discoloration, granulations, ulceration or crusts in the nose. The most frequent sites are near the middle turbinate, the septum and more rarely the inferior turbinate. A presumptive diagnosis can be made histologically with H & E stains, GMS or PAS and Gridley. The inflammatory tissue reaction reflects the host’s immunologic status. Fungi show a marked predilection for vascular invasion with direct invasion of the walls of large and small arteries and sometimes veins, causing thrombosis. Mucoraceae and Aspergillus are frequently isolated. A normal MRI & CT scan especially at the beginning reinforces the necessity for a careful endoscopic nasal evaluation and biopsy in ‘at risk’ patients.
Treatment is a combination of antifungal antibiotics, aggressive surgical debridement and reversal, when possible, of underlying immunocompromising condition. If Amphotericin is the conventional therapy, especially for mucormycosis, new drugs (azoles, capsofungine) are now proposed with a high degree of efficacy for other fungal species, the choice being modified by the result of culture. However, control of the primary disorder is the most important determinant of survival as is an early Diagnosis. Despite this, fatalities of 25 to 100 % have been reported.

HISTORICAL REVIEW

The genus Aspergillus was so named by Micheli in 1729 because of the organism’s rough-appearing heads [12].

Plaignaud [13] reported the first case of possible fungal sinusitis in 1791.

Aspergillus was identified as a pathogen in 1844 by Bennet [14].

In 1885, Schubert [15] described a nasal infection with Aspergillus fumigatus.

Mucormycosis (also known as zygomycosis or phycomycosis), was first described by Paulltauf [16] in 1885. Typically developed by poorly controlled diabetic patients, this opportunistic infection is characterized by a very acute onset. It produces vascular thrombosis and tissue necrosis and the most frequent form is the rhino-orbito-cerebral [17].

Mackenzie [18], in 1893, published the first case report of aspergillosis of the maxillary sinus.

The first published attempt to classify FRS (fungal rhinosinusitis) came in 1965, when Hora [19] recognized two categories: one was noninvasive, behaving clinically like chronic bacterial sinusitis, and the other invasive, in which the infection results in a mass that behaves like malignant neoplasm, eroding bone and spreading into adjacent tissue. The invasive nature of the disease was further confirmed on histopathology.

In 1969, Milosev [20] et al. reported on 17 cases occurring in the Sudan of primary aspergilloma of the maxillary and other paranasal sinuses.

Allergic fungal sinusitis was first described as a distinct clinical entity by Safirstein [21] in 1976. He noted a combination of nasal polyposis, crust formation, and sinus cultures yielding Aspergillus species, and observed the clinical similarity that this constellation of findings shared with allergic bronchopulmonary aspergillosis (ABPA).
McGuirt and Harrill [22] in 1979 reviewed 115 cases of paranasal sinus aspergillosis from the world literature.

McGill et al. in 1980, reported a third type of FRS in immunocompromised patients: a fulminant form with rapid and malignant course. He described 4 patients and termed “fulminant aspergillosis”.

In a study conducted on 86 patients, Lee K concluded that transnasal endoscopic sinus surgery, followed by postoperative sinus cavity and paranasal sinus irrigation, is effective as a primary treatment for paranasal sinus fungus ball.

Han DH et al. in a retrospective study of 239 cases of fungal sinusitis, concluded that noninvasive paranasal sinus aspergillosis was the most common and successfully treated by endoscopic sinus surgery with postoperative sinus irrigation. For the treatment of fungal sinusitis, endoscopic sinus surgery with or without antifungal agents and control of predisposing factors for secondary cases are recommended.

According to Daudia A and Jones NS, surgery remains the treatment of choice for mycetoma of the paranasal sinuses. Itraconazole has a useful role in reducing both the amount of surgery required and the amount of peri-operative bleeding in allergic aspergillosis, and continuing its use postoperatively for six weeks appears to reduce the recurrence rate.

According to Babinski D et al. noninvasive fungal sinusitis is usually found in one sinus and most frequently caused by Aspergillus. The clinical symptomatology mimics chronic rhinosinusitis and radiology helps for making decision of surgery. The authors presented 4 cases of sinus fungal ball, where histopathology revealed hyphae of Aspergillus without evidence of tissue invasion.

According to Pasqualotto AC, the experimental data suggested that Aspergillus flavus is more virulent than Aspergillus fumigatus. No conclusive virulence factor has been identified for Aspergillus species. Aspergillus flavus is a common cause of fungal sinusitis. The bigger size of Aspergillus spores, may favour their deposit in the upper respiratory tract.

Based on a study on 59 patients of AFS, according to Al-Dousary SH [29], AFS is a newly recognized entity consisting of pansinusitis with allergic mucinous infiltrates in all involved sinuses. Historically mistaken for a paranasal sinus tumor, AFS is believed to be an allergic reaction to aerolized environmental fungi, usually of dematiaceous and Aspergillus species.

According to P.V. Venugopal [30] et al. who conducted a prospective study on 20 patients of chronic fungal sinusitis, the presenting symptoms were purulent nasal discharge and obstructions. Diagnosis of AFRS was established in 9 cases by characteristic CT scan
findings, extraction of copious mucinous debris at surgery, presence of allergic mucin without invasion, fungal hyphae, and Charcot-Leyden crystals in histological sections.

According to Epstein VA & Kern RC [31], acute fulminant invasive sinusitis in an immunocompromised host and bacterial rhinosinusitis with intracranial or orbital extension are challenging to manage and constitute true otolaryngic emergencies. In the absence of rapid diagnosis and treatment, these diseases can be fatal. The complications being categorized into local, orbital, and intracranial. They vary in characteristics and severity according to their location, duration and specific symptoms.

According to Soontrapa P [32] et al. most of the fungal rhinosinusitis cases were attributed to Aspergillosis. The clinical presentations were nasal stuffiness, nasal discharge, facial pain, fever and headache. Early antifungal therapy and surgical drainage were associated with a survival advantage.

According to Piao YS [33] et al. eosinophilic mucin is the typical histopathological feature of AFS. PAS and GMS staining methods can be used to detect fungal species in mucin. Accurate diagnosis of AFS requires correlations among clinical findings, radiologic examinations, laboratory tests and histopathologic features. However, the ultimate diagnosis requires a histopathologic confirmation.

AIMS AND OBJECTIVES
1) To study the clinical presentation of fungal sinusitis by history.
2) To evaluate features of fungal sinusitis by diagnostic nasal endoscopy.
3) To evaluate presentation of fungal sinusitis radiologically by computed tomography of paranasal sinuses.
4) To identify the causative organism by mycological study.
5) To corroborate the clinico-pathological behaviour by histopathology.
6) To study the management of allergic fungal sinusitis medically and surgically.
7) To follow these cases for recurrence and improve the treatment protocols for complete cure of the disease.

MATERIALS AND METHODS
Seventy patients suitable for the study purpose are included in this study.
1. INCLUSION CRITERIA FOR THE STUDY:

The patients included in this study are diagnosed with fungal sinusitis hospitalized in our hospital, over a period of two years (September 2010 to August 2012)

1. Patients with the history of chronic rhinosinusitis (>3 months duration) with or without nasal polyposis with clinical features suspicious of fungal sinusitis

2. Patients of chronic rhinosinusitis with raised IgE titres in serum

3. Patients of chronic rhinosinusitis with radiological features (CT PARANASAL SINUSES) of fungal sinusitis

4. Patients with underlying immune suppression /diabetic mellitus having features of invasive fungal sinusitis

5. The patients in whom diagnosis was confirmed by histopathological study

2. EXCLUSION CRITERIA FOR THE STUDY:

The following exclusion criteria are used:

1. Age below 10 years;

2. Prior history of nasal trauma;

3. History of sinonasal surgery.

A prospective study on 70 patients of fungal sinusitis were evaluated. The preoperative diagnosis was established by detailed clinical history, diagnostic nasal endoscopy, fungal smear and CT scan of paranasal sinuses findings. All the patients underwent endoscopic sinus surgery during the study period from September 2010 to August 2012 at our institution. The diagnosis of fungal sinusitis was done intra-operatively, on visualising the fungal debris hidden behind the nasal polyps, presence of nasal crusts or necrotic material in the nose and paranasal sinuses.

Post-operative Confirmation of the diagnosis was made by histopathology, KOH mounted fungal smear. The predominant histopathological features noted were eosinophilic infiltrates, Gaint cell granulomas, allergic mucin deposits, non-invasive fungal colonies and charcot-leiden crystals in allergic fungal sinusitis. The fungal staining with histochemical stains such as GMS or PAS were performed when routine H & E stains demonstrated suspicious mucin. The fungal cultures grew colonies of aspergillus and other fungal species on sabaroud’s dextrose agar medium under standard conditions.
Predominant clinical features and histopathological features noted and correlated. Postoperatively treated with systemic antibiotic course; in a few patients with antifungal medication and steroids where required. Patients were followed up for a minimum period of six months after surgery with nasal endoscopy done on a monthly basis to look for recurrences, with further follow up plan.

RESULTS AND OBSERVATIONS

This study was conducted between September 2010 to August 2012 in this hospital includes 70 patients who were suffering from fungal sinusitis, confirmed by fungal smear examination, culture and histopathology. Most of the patients (n1=11; n2=10) are in the age group of 21 – 25 years and 36 – 40 years with a mean age of 34.5 years (range 12 to 66 years).
The male to female ratio is 1:1.322

Among the study group of 70 patients with fungal sinusitis, 46 patients are diagnosed to have allergic fungal sinusitis, 15 patients with sinus fungal ball, chronic invasive granulomatous fungal sinusitis in 2 patients, chronic invasive non-granulomatous fungal
sinusitis in 4 patients and acute fulminant fungal sinusitis in 3 patients (Table 3).

Nasal obstruction and nasal discharge are the common chief complaints in these patients. Other complaints included headache and heaviness of head, post nasal drip, sneezing, visual complaints and pain (Table 4).
Nasal obstruction followed by nasal discharge (anterior and posterior) were the common chief complaints in 38 out of 46 (82.60%) patients of allergic fungal sinusitis; nasal obstruction in 10 out of 15 (66.66%) patients of sinus fungal ball; in 2 (100%) patients of chronic invasive granulomatous fungal sinusitis. Facial pain in 2 out of 4 (50%) patients followed by nasal discharge in 2 out of 4 (50%) patients were the chief complaints in cases of chronic invasive non-granulomatous fungal sinusitis. Ophthalmic symptoms like eye pain and swelling, decreased vision followed by nasal obstruction in 3 (100%) patients of acute fulminant fungal sinusitis.

Associated conditions and immune compromised states like - diabetes mellitus is present in 5 patients (2 patients of chronic invasive granulomatous fungal sinusitis, 1 patient of chronic invasive non-granulomatous fungal sinusitis and 2 patients of acute invasive fungal sinusitis); AIDS in 1 patient of acute fulminant fungal sinusitis; tuberculosis in 1 patient of chronic invasive granulomatous fungal sinusitis; bronchial asthma in 9 patients (8 patients of allergic fungal sinusitis, 1 patient of chronic invasive non-granulomatous fungal sinusitis); allergic rhinitis in 21 patients (16 patients of allergic fungal sinusitis, 5 patient of sinus fungal ball) (Table 5).

In the hematological tests conducted on the study group, percentage of eosinophils in the differential count was estimated considering the laboratory normal values between 2-4%. It was found that the percentage of eosinophils is raised, on average by 4.95% in 30 patients (42.86%) of which 25 patients are cases of allergic fungal sinusitis. The absolute eosinophil count laboratory normal range is below 440 / cu.mm. The count was
found be raised on average 688.38 / cu.mm in 23 patients (32.86%) of which 20 patients are cases of allergic fungal sinusitis.

The immunological studies were conducted on selective patients (i.e. in 20 cases of allergic fungal sinusitis), due to their economical constraints. Total IgE levels estimated as it was the most specific and sensitive as found by Kuhn and colleagues [34]. The total IgE levels were raised with a mean of 750 IU/mL in 16 out of 20 patients (80%) that are cases of allergic fungal sinusitis.

Mycological tests conducted on all patients in the study group. Nasal and sinus secretions / debris collected during diagnostic nasal endoscopy and intra-operatively, subjected to studies like KOH mount direct smear microscopic examination and cultured on Sabouraud’s dextrose agar medium and tested for sensitivity.

Direct microscopic examination was negative for fungal elements in 8 patients. Out of the 62 patients where fungal elements were positive, fungal hyphae & conidia (Figure 1a) are present in 32 patients, only conidia (Figure 1b) present in 18 patients, only hyphae in 05 patients and budding yeast cells in 07 patients.

![Fungal elements](image)

**Figure 1** – Fungal organisms on direct microscopy.
1a) Pseudallescheria boydii colony with mycelia, hyphae and conidia

1b) Conidia of Aspergillus niger

Aspergillus flavus (Figure 2a) and Aspergillus niger (Figure 2b) were the most common organisms cultured on the media, the rest being Pseudallescheria boydii, Aspergillus versicolour, Madurella mycetomatis, Fusarium oxysporium, Acremonium kiliense, Curvularia lunata, Candida glabrata, Aspergillus nidulans and Aspergillus terreus. Culture was sterile after 14 days of incubation in 5 patients. The organisms were tested for sensitivity to few antifungal agents. 26 of them were sensitive to Itraconazole, 22 were sensitive to ketaconazole, 6 to micanozole, and 4 to flucanazole and Griseofulvin.

Aspergillus flavus (in 21 patients) and Aspergillus niger (in 12 patients) were the most frequently isolated organisms in 46 cases of Allergic fungal sinusitis. Aspergillus flavus (in 7 patients), Aspergillus niger (in 6 patients) and Madurella mycetomasis (in 2 patients) were
the most frequently isolated organisms in 15 cases of sinus fungal ball. Madhurella mycetoma (in 2 patients), Aspergillus flavus (in 2 patients) were the isolated organisms in 4 cases of chronic invasive nongranulomatous fungal sinusitis. Aspergillus flavus is the isolated organisms in 2 cases of chronic invasive granulomatous fungal sinusitis. Madhurella mycetoma were the organisms isolated in 3 patients of acute fulminating fungal sinusitis.
Diagnostic nasal endoscopy revealed multiple polypi (Figure 3) (in 35 patients) and polypoidal changes (Figure 4) (in 13 patients) as an important feature noted in majority of cases. Other features noted were mucoidal and mucopurulent discharge (Figure 5), fungal mucin and debris, bone erosions. Normal findings noted on nasal endoscopy in 3 patients (Table 8).
Radiological imaging with CT scan of paranasal sinuses revealed the following findings. In 46 patients of allergic fungal sinusitis, unilateral pansinusitis (Figure 6) involvement was the most common finding (in 23 patients), followed by bilateral pansinusitis (Figure 7 & 8) (in 13 patients), unilateral maxillary and ethmoidal sinus involvement (in 6 patients) and only unilateral maxillary sinus involvement (in 4 patients). Complete opacification of the involved sinus with hyperattenuated areas (Figure 6b & 7b) observed in 35 patients (76.08%), remodeling of bone (Figure 9) (ethmoidal roof and lamina papyraceae) in 11 patients (23.91%)
Figure 6 – CT scan (coronal plane) pictures of AFS.

6a) Unilateral pan-sinusitis  6b) Hyper attenuated areas

Figure 7 – CT scan (coronal plane) pictures of AFS.

7a) Bilateral pan-sinusitis  7b) Hyper attenuated areas
Figure 8 – CT scan (axial & parasagittal planes) pictures of AFS.

8a) 8b)
Bilateral pan-sinusitis Hyper attenuated areas

Figure 9 – CT scan (coronal plane) picture of AFS.

Bony remodeling of lamina papyracea
In 15 patients of sinus fungal ball, unilateral maxillary sinus involvement is seen in 10 patient and unilateral maxillary and ethmoidal sinus involvement in 4 patients and unilateral sphenoid sinus involvement in 1 patient. Heterogenous opacification with calcifications seen in all patients (100%) and sclerosis / thickening of sinus wall is seen in 8 patient (53.33%) (Table 10).
In 2 patients of chronic invasive granulomatous fungal sinusitis, unilateral maxillary and ethmoidal sinuses involvement in 1 patient and bilateral maxillary sinus involvement in 1 patient. Opacification of involved sinuses seen in all 2 patients (100%), with erosion of bony sinus wall in 2 patient (100%) (Table -11)

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<th>CT scan findings in chronic invasive granulomatous fungal sinusitis patients</th>
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<td>no. of patients</td>
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<td>unilateral maxillary &amp; ethmoidal</td>
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<td>Unilateral pansinusitis</td>
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In 4 patients of chronic invasive nongranulomatous fungal sinusitis, maxillary and ethmoidal sinuses were involved in 4 patients. Hyperdense opacification within the involved sinuses in seen in 3 patients (75%), erosion of bony sinus wall in 1 patient (25%)

In 3 patients of acute fulminant fungal sinusitis, unilateral (right side) pansinusitis (Figure 10) seen in 1 patients; and unilateral (right side) ethmoidal and maxillary sinuses involvement in 2 patient. Homogenous opacification with thickening of sinus lining observed. Bone erosion and orbital invasion (Figure 10) seen in 3 patients (100%).

Figure 10 – CT scan (coronal plane) pictures of acute fulminant fungal sinusitis.
Histopathological studies revealed the following data. In 46 patients of allergic fungal sinusitis, histopathological examination showed branching noninvasive hyphae scattered throughout within eosinophilic infiltrate (Figure 11) and Charcot-Leyden crystals present in 32 patients. Histopathology picture in AFS.
Fungal hyphae scattered sparsely in eosinophilic mucin

Extensive eosinophilic infiltration with patchy stromal edema present. In 15 cases of sinus fungal ball, hyphae present with no evidence of allergic mucin and no invasion of mucous membrane. In 3 patients of acute fulminant fungal sinusitis, invasion of arteries and veins causing thrombosis (Figure 12a), infarction (Figure 12b) and necrosis of tissues noted. Figure 12 – Histopathology pictures in acute fulminant fungal sinusitis.

12a) 12b)
Vascular thrombosis Areas of infarction

In 2 cases of chronic invasive granulomatous fungal sinusitis, fungal elements with localized tissue invasion and noncaseating granulomas (Figure 13) with gaint cells present. Multiple lobules of mucous glands and thin plates of lamellar bone in deeper tissues. Histopathology picture in chronic invasive granulomatous fungal sinusitis.
Noncaseating granulomas with gaint cells + local tissue invasion

In 4 patients of chronic invasive nongranulomatous fungal sinusitis, lymphocytic and plasma cell infiltration with fungal elements infiltrating the stroma (Figure 14) at ulcer base. Invasion of tissue; mucous membrane and vessels noted. Histopathology picture in chronic invasive nongranulomatous fungal sinusitis.

Lymphocytic infiltration + fungal elements infiltration of stroma

The patients in study group were treated by endoscopic surgery and antifungal medication (Itraconazole 100 mg twice) and systemic and topical intranasal steroids where required and followed up for a minimum period of 6 months and their prognosis / recurrence evaluated. In 46 patients of allergic fungal sinusitis, Kupferberg endoscopic staging system was adopted to identify recurrences. 18 patients had stage 0 (normal mucosa), 22 patients had
stage 1 (edematous mucosa + allergic mucin), 3 patients had stage 2 (polypoidal mucosa + allergic mucin). Stage 1 and 2 patients are considered as cases of good prognosis and are on follow up. 3 patients had stage 3 (polyps + fungal debris) and underwent second surgery within the study period (Table 14).

In 15 patients of fungal ball, prognosis was excellent after endoscopic surgery except in 1 patient developed recurrence. Recurrences and/or recidivism requiring surgery were noted in 7 patients (10%) i.e in 4 patients of allergic fungal sinusitis, 1 patient of chronic invasive granulomatous fungal sinusitis, 2 patients of chronic invasive non-granulomatous fungal sinusitis and 1 patient of acute fulminant fungal sinusitis.

**DISCUSSION**

According to Manning and Holman [35], AFS is found in a slightly younger age group with an average of 23.3 years. They also found a male predominance. Other reviews by Corey [36] and his team, noted an equal male-to-female ratio and a mean age of 26 years. In our study, for cases of AFS, the mean age group was 33.76 years and noted male-to-female ratio i.e 1:1.42.9 (more females are involved)
Clinically, noninvasive form of Aspergillosis manifests with nasal obstruction, rhinorrhea, and headaches [4]. Nasal obstruction followed by nasal discharge (anterior and posterior) were the common chief complaints in 56% patients of noninvasive fungal sinusitis cases in our study.

In a review of the cases in the literature, according to Manning and Holman [35], only 63% of patients with AFS give a history of allergic rhinitis. However, many of these series never rigorously evaluated the subjects for allergies. In our study, there was a history of allergic rhinitis in 16 out of 46 patients (34.78%) of AFS.

According to Fergusson [7], asthma was present in 41% of AFS patients in a recent comprehensive review. Other series from Manning [35] and Corey [36] reported asthma rates ranging from 33 to 54%. In our study, 11 out of 46 (23.91%) AFS patients had bronchial asthma.

According to Lawlor [37], total IgE levels and absolute eosinophils are usually, but not always, elevated. In our study, the immunological studies were conducted on selective patients due to their economical constraints. The total IgE levels were raised with a mean of 750 IU/mL in 16 out of 20 patients (80%) who are cases of allergic fungal sinusitis. The absolute eosinophil count laboratory normal range is below 440 / cu.mm. The count was found to be raised on average by 688.38 / cu.mm in 32 patients (33%) of study group, which includes 20 out of 46 patients (43.48%) of allergic fungal sinusitis.

According to Kupferberg [38], fungal cultures were positive in approximately 70-80% of patients diagnosed with AFS. Unlike others, the Mayo Clinic reports virtually 100% positive fungal cultures on all patients, irrespective of pathology given by Ponikau et al [5]. In our series, 65 patients (92.86%) had fungal culture positive, which included 44 out of 46 patients (95.65%) of AFS. Culture was sterile after 14 days of incubation in 5 patients.

There are many species of Aspergillus, including Aspergillus fumigatus, A. flavus, A. niger, A. oryzae and A. nidulans. According to Mahgoub [39], although Aspergillus fumigatus is the most common pathogen, Aspergillus flavus has been more commonly identified in paranasal sinus infections. In our series, in 32 patients (45.71%) the organism isolated on culture was Aspergillus flavus.

The fungi causing AFRS are diverse, and in a review of the English literature, Manning and Holman [35] in 1998 reported 168 positive cultures, 87% of the cases due to dematiaceous fungi, and 13% yielded Aspergillus species. Cody et al [40] reported that a far larger number of patients with AFS grow Bipolaris or Curvularia, two fungi frequently implicated in other series of AFS, but rarely seen in the more recent Ponikau et al series [5]. In our series, Aspergillus species (Aspergillus flavus, A. niger, A. versicolour, A. nidulans, A. terreus) is isolated in 40 out of 46 (86.96%) patients with AFS.
According to Chakrabarti [41], in the Indian scenario, Aspergillus flavus was isolated in more than 80% of the cases of AFRS. In our study, Aspergillus flavus in 21 patients (45.65%) and Aspergillus niger in 12 patients (26.08%) were the most frequently isolated organisms in 46 cases of Allergic fungal sinusitis.

According to Chakrabarti [42] and colleagues, the granulomatous invasive type (fungal granuloma) is mainly described in chronic fungal sinusitis cases from Sudan, India, and Pakistan, where the patients are immunocompetent, almost exclusively identified with Aspergillus flavus. In our study, Aspergillus flavus was most frequently isolated organisms in 2 cases of chronic invasive granulomatous fungal sinusitis.

According to Fergusson [7], in AFS, unilateral sinus disease is present approximately 50% of the time. Patients with AFS may show unilateral disease, because the fungal stimulus is only present unilaterally, thus sparing the remaining sinuses. In 46 patients of AFS in our study group, unilateral pansinusitis involvement seen in 23 patients (50%), bilateral pansinusitis in 13 patients, unilateral maxillary and ethmoidal sinus involvement in 6 patients and only unilateral maxillary sinus involvement in 4 patients.

Mukherji et al [43], in a retrospective review of the CTs of 45 patients with AFS, found all patients had intrasinus high-attenuation areas and multiple sinus involvement was present in 43 of 45 patients. In our study, CTs of patients with AFS, complete opacification of the involved sinus with hyperattenuated areas observed in 35 of 46 patients (76.08%) and multisinus involvement was present in 42 of 46 patients (91.30%).

In a retrospective study of 142 patients with AFRS, Brain Nussenbaum [44] and his colleagues demonstrated bone erosion on CT scan in approximately 20% of patients. The most common eroded site was ethmoid sinus. The orbit and anterior cranial fossa were the most common adjacent anatomic spaces to exhibit disease extension. In our study, remodeling of bone (ethmoidal roof and lamina papyraceae) is seen in 11 of 46 patients (23.91%) with AFS.

In 50% of the cases reviewed by Jahrsdorfer et al [45] the maxillary sinus was singularly involved, followed by sphenoid, ethmoid, and frontal sinuses in order of declining prevalences. Combined paranasal sinus involvement, however, was the second most common presentation. In 15 patients of sinus fungal ball in our series, only maxillary sinus involvement is seen in 10 patient (66.67%) and both maxillary and ethmoids in 4 patients (26.67%) and only sphenoid involvement is seen in 1 patient (6.67%).

In an analysis of 119 patients by Seo [46] and colleagues, radiological features of sinonasal fungus ball were studied, where calcifications were noted on CT scans in 78 of 116 (67.2%) patients. In our study, CT scans of 15 patients with fungus ball, heterogenous
opacification with calcifications seen in all patients (100%) and in addition, sclerosis/thickening of sinus wall is seen in 8 patients (53.33%).

In a comparative study by Reddy et al [47], CT scans of 17 invasive fungal sinusitis (granulomatous and chronic invasive) and 12 AFS patients are compared. The earlier group showed homogenous opacity (isodense/hyperdense) on CT and involvement of one or two sinuses only. The later group showed heterogenous opacities with hyperattenuation areas and multisinus involvement. In our study, of 2 patients of chronic invasive granulomatous fungal sinusitis, unilateral pansinusitis involvement is seen in 1 patients, unilateral maxillary and ethmoidal sinuses involvement in 1 patient. Opacification of involved sinuses seen in all patients (100%), with erosion of bony sinus wall in 1 patients (50%). In 4 patients of chronic invasive nongranulomatous fungal sinusitis, maxillary and ethmoidal sinuses were involved in 4 patients. Hyperdense opacification within the involved sinuses in seen in 3 patients (75%) and erosion of bony sinus wall in 1 patient (25%).

In a prospective evaluation of AFS patients by Bent and Kuhn [9], pathologic examination uniformly revealed eosinophilic mucus without fungal invasion into soft tissue; Charcot-Leyden crystals and peripheral eosinophilia were each observed in 6 of 15 patients. In our study, histopathological examination showed branching noninvasive hyphae scattered throughout within eosinophilic infiltrate; Charcot-Leyden crystals and peripheral eosinophilia in 32 of 46 patients with AFS.

Schubert & Goetz [48] in 1998, reported decreased recidivism with the use of prolonged post-operative systemic corticosteroids and itraconazole therapy. In a prospective study made by Neeraj Singh and Bhalodiya [49], recurrence was noted in 11 of 251 cases with AFS treated by endoscopic sinus surgery and postoperative steroids and antifungal therapy. In our study, where 46 patients with AFS treated postoperatively by prolonged (minimum 6 months) antifungal medication and steroids, recurrence was seen in 3 of 46 patients with AFS necessitating second surgery and are on follow up.

Fungal sinusitis is increasingly being recognized as a cause of high morbidity and mortality in all parts of the world. In this study, we prospectively studied patients of fungal sinusitis in our institute. An attempt was made to study the clinical, radiological, mycological and histopathological features of the disease and correlate various parameters in these patients. Since the number of patients in this study is small, and the limited study period, the parameters in this study might not be representative of the entire population. Our study emphasizes the understanding of fungal diseases of paranasal sinuses to aid in predicting the course of disease, and propose to continue future research on a large scale population for a longer study period.
CONCLUSION

Fungal sinusitis has become the subject of increasing interest to otolaryngologists and related specialists. Fungal infections of nose and paranasal sinuses need to be recognized in order to avoid significant morbidity and mortality. Fungal sinusitis encompasses a wide spectrum of immune and pathological responses, including invasive, chronic, granulomatous and allergic diseases. Diagnosis is based on the clinical features, fungal culture, CT scans and histopathology. Various manifestations of fungal sinusitis depend on the immunologic competence of host. Prognosis and treatment vary dramatically depending on the organism as well as whether the disease is invasive or noninvasive or secondary to a hypersensitivity reaction.

Although certain symptoms and signs, as well as radiographic, intraoperative, and pathologic findings, may cause the physician to suspect fungal sinusitis, no standards have been defined for establishing the diagnosis. It is extremely important to recognize fungal sinusitis and differentiate it from chronic bacterial sinusitis, because treatment and prognosis of the disease vary significantly. However, consensus on terminology, clinical behaviour, pathogenesis and optimal management is lacking. The International Society for Human and Animal mycology convened a working group to attempt on the above. Recommendations for future research avenues were also identified.

In our study, most of the patients are young adults with mean age of 33.76 years, with more incidence in female. AFS was the most common diagnosis made in 35 patients, among different classes of fungal sinusitis. The commonest complaints were nasal obstruction and nasal discharge, and ophthalmic symptoms being rare and associated with acute fulminant variety.

Associated conditions like atopy, allergic rhinitis, bronchial asthma are common in patients of AFS and immunocompromised states like AIDS, diabetes mellitus, tuberculosis more common in invasive forms of fungal sinusitis. Peripheral eosinophilia and raised IgE being the most sensitive and specific, is found in patients of AFS.

Fungal culture was positive in 62 of 70 (94%) patients and most common isolated organism was Aspergillus flavus in 31 of 70 (44.28%) patients. The high frequency of Aspergillus flavus isolation may be due to higher prevalence of the fungus in the environment which is warm and humid. On nasal endoscopy, polypi and polypoidal changes were the most common observation made. Radiological features on CT scan revealed involvement of sinus(es) with hypodense or hyperdense attenuations, with erosions or remodeling of sinus walls in a few. Radiologically, involvement of maxillary and ethmoidal sinuses was more common and isolated frontal sinus involvement is not observed in fungal infections of
paranasal sinuses. Histology revealed fungal elements scattered in inflammatory cell(s) infiltrated background, allergic mucin in AFS and invasion of tissue in invasive forms of fungal sinusitis. Treatment with endoscopic sinus surgery in all and postoperative long term antifungal medication and steroids in selected (AFS) cases offered better outcome in terms of reduced recurrence.

Most of the results in our study are in consistent with the literature; and also emphasizes the awareness and understanding of the fungal diseases of paranasal sinuses to aid in predicting the course of disease process to plan rational therapy.

SUMMARY

This study of clinicopathological correlation in fungal sinusitis was done in our institution on 70 patients who were satisfying the inclusion criteria. This study was to be reported as a thorough study of clinical and pathological aspects of fungal sinusitis, with the help of acquiring data on clinical presentation and behaviour, haematological and immunological studies, mycological study, radiological features and histopathology.

In our study, most of the patients are young adults with mean age of 33.76 years, with almost equal sex incidence male-to-female ratio of 1:1.322. AFS was the most common diagnosis made in 46 of 70 (65.71%) patients, among different classes of fungal sinusitis. The commonest complaints were nasal obstruction (in 48 of 70 i.e 68% of patients) and nasal discharge (in 42 of 70 i.e 60% of patients), and ophthalmic symptoms being rare and associated with acute fulminant variety.

Allergic rhinitis (in 16 of 21patients), bronchial asthma (in 11 of 12 patients) are common in AFS and immunocompromised states like AIDS (in 1patient), diabetes mellitus (in 5 patients), tuberculosis (in 1 patients) more common in invasive forms of fungal sinusitis. Peripheral eosinophilia on average 688.38 / cu.mm in 30 of 70 (42%) patients in entire study group which includes 25 of 46 (54.34%) patients of AFS. Raised IgE with a mean of 750 IU/mL in 16 of 20 (80%) patients of AFS.

KOH mounted direct smear microscopic examination was positive for fungal elements in 62 of 70 (88.5%) patients. Fungal culture was positive in 64 of 70 (91.4%) patients and most common isolated organism was Aspergillus flavus in 31 of 70 (44.28%) patients. On nasal endoscopy, polypi in 25 of 70 (35%) and polypoidal changes in 13 of 70 (18.5%) were the most common observations made.

Radiological features on CT scan revealed the following. Unilateral pansinusitis in 23 of 46 (50%) patients, hyperattenuated densities in sinus(es) in 35 of 46 (76%) patients and remodeling of bone in 11 of 46 (23.09%) patients of AFS. Singular sinus involvement in 10 of 15 (66.66%) patients and heterogenous opacification with calcification in all patients of
sinus fungal ball. Unilateral pansinusitis and opacification on involved sinus in all patients with erosion of sinus wall in all patients of chronic invasive granulomatous fungal sinusitis. Unilateral pansinusitis in 4 (100%) patients and opacification in 3 of 4 (75%) patients of chronic invasive nongranulomatous fungal sinusitis. Unilateral pansinusitis in 2 of 3 (75%) patients, homogenous opacification of involved sinuses and bone erosion and orbital invasion in 3 (100%) patients of acute fulminant fungal sinusitis.

Histology revealed the following. Branching noninvasive hyphae scattered in eosinophilic infiltrate with Charcot-Leyden crystals, with patchy stromal edema in AFS. Densely accumulated hyphae with no allergic mucin and no invasion of mucosa in cases of sinus fungal ball. Invasion of mucous membrane with infiltration into mucosa, submucosa and vasculature in acute fulminant fungal sinusitis. Fungal elements with localized tissue invasion and noncaseating granulomas with gaint cells in chronic invasive granulomatous fungal sinusitis. Sparse lymphocytic and plasma cell inflammation with numerous fungal elements infiltrating the stroma in chronic invasive nongranulomatous fungal sinusitis.

Treatment with endoscopic sinus surgery in all and postoperative long term antifungal medication (itraconazole 100 mg twice daily) and steroids in selected (AFS) cases offered better outcome in terms of reduced recurrence and need for second surgery.

Methodical evaluation of above data enhances a better understanding of the clinicopathological behaviour in cases of fungal sinusitis and gives a scope to plan a rational management.

BIBLIOGRAPHY


Abstract:

**Introduction:** The successful management of the airway is of paramount importance. Airway control requires a logical and systematic approach guided by the principles of basic and advanced life support techniques and a working knowledge of relevant pharmacology. Most importantly, the health professional must possess a mastery of the anatomy and physiology of the upper aero-digestive tract.

The management of laryngeal and tracheal stenosis in adults is both challenging and intriguing. The diagnosis and evaluation of these lesions require a complete mastery of the anatomy and physiology of the upper aero-digestive tract. The incredible variability of stenotic areas in the adult larynx and trachea requires the head and neck surgeon carefully to individualize treatment and provide unique strategies for the management of these diverse lesions.

**Etiology:** There are many factors that can lead to laryngo-tracheal stenosis (LTS). Most cases of adult LTS result from external trauma or prolonged endotracheal intubation. External trauma causes cartilage damage and mucosal disruption with hematoma formation. These hematomas eventually or organize and result in collagen deposition and scar tissue formation. Endotracheal intubation can cause direct injury, and mucosal damage through pressure necrosis can result from the pressure of the endotracheal tube or cuff. Mucosal ulceration also leads to healing through collagen deposition, fibrosis, and scar tissue formation. Lesions from endotracheal intubation are usually located in the posterior part of the glottis, where the tube most often contacts mucosa, or in the trachea, where the cuff or tube tip causes mucosal damage. Low-pressure endotracheal tube cuffs have somewhat reduced the rate of cuff-induced damage. The length of intubation, tube movement, tube size, and gastro-esophageal reflux can also contribute to the development of LTS.

**Clinical Presentation:** The field management of the patient with suspected laryngeal injury consists of stabilization of the cervical spine and establishment of an airway. In the event of life-threatening airway compromise, intubation or tracheostomy in the field may be necessary after the patient is stabilized and other potential life-threatening injuries are under treated, the
physical examination and assessment of the neck may commence for evaluation for laryngeal trauma. The workup for laryngeal trauma consists of physical examination of the neck, fiber-optic laryngoscopic examination, radiologic examination, and operative laryngoscopy.

Stridor is the most common sign in patients with upper airway compromise. The type of stridor may be indicative of the location of the injury. Combined inspiratory and expiratory stridor suggests some degree of obstruction at the level of the glottis. Expiratory stridor is more consistent with a lower airway injury. On the other hand, inspiratory stridor is indicative of supraglottic airway obstruction. The presence of both stridor and hemoptysis has been associated with severe laryngeal trauma, including displaced fractures of laryngeal cartilage, significant endolaryngeal or laryngo-pharyngeal edema or hematoma, or large mucosal tears exposing cartilage. A thorough physical examination must be performed with special attention to the presence of neck tenderness, crepitus owing to subcutaneous emphysema, soft tissue swelling, and loss of thyroid cartilage prominence. Fiber optic laryngoscopy in the stable patient is an essential element of the physical examination and should focus on vocal cord mobility, tears, mucosal edema, hematoma, and dislocated or exposed cartilage.

If limited range of motion of the vocal cords is noted, a structural deformity or arytenoid cartilage dislocation is likely. On the other hand, immobility of the vocal cords suggests recurrent nerve injury. The patient presenting with soft tissue injury alone will often display edema, sub-mucosal hemorrhage, and ecchymosis. Laceration of the mucosa, exposed cartilage, arytenoid cartilage dislocation, and disruption of the laryngeal architecture are highly suspicious of laryngeal framework injury.

Classification

Since areas of LTS are so variable in their size, consistency, and location, a rigid classification scheme is essentially impossible, and the surgeon must describe and document the lesion in a way that is widely understandable and reproducible. The classification of LTS in adults begins with the anatomic location of the lesion as glottis, subglottis, trachea, or a combination of these. These stenotic segments may be further described as anterior, posterior, or circumferential. The diameter and length of the stenotic area are critical in classifying the lesion. The Myer-Cotton staging system is useful for mature, firm, circumferential stenosis confined to the subglottis. It describes the stenosis based on the percent relative reduction in cross-sectional area of the sub-glottis which is determined by differing sized endotracheal tubes. Four grades of stenosis are described with this system:

grade I lesions have less than 50% obstruction,

grade II lesions have 51% to 70% obstruction,

grade III lesions have 71% to 99% obstruction, and
grade IV lesions have no detectable lumen or complete stenosis.

The McCaffrey system classifies laryngotracheal stenosis based on the sub sites involved and the length of the stenosis. Four stages are described:

stage I lesions are confined to the subglottis or trachea and are less than 1 cm long,

stage II lesions are isolated to the subglottis and are greater than 1 cm long,

stage III are subglottic/tracheal lesions not involving the glottis, and

stage IV lesions involve the glottis.

Diagnostic Assessment

The evaluation of LTS must begin with a meticulous history and physical examination. Since most cases of LTS result from laryngo-tracheal trauma or endotracheal intubation, the timing of the predisposing incident should be recorded. Any previous airway evaluations or attempts at repair should also be noted. The patient should be questioned regarding the onset, duration, and severity of symptoms such as exercise intolerance, disruption of lifestyle, and tracheostomy dependence. Patients who do require a tracheostomy should be questioned as to how often the tube may be plugged. Symptoms of aspiration, voice change, or dysphagia may indicate the degree of glottic involvement.

The entire upper aerodigestive tract must be carefully examined in a patient with suspected LTS. Indirect laryngoscopy and flexible fiberoptic laryngoscopy offer critical information regarding the supraglottic airway and mobility of the true vocal folds. In extreme abduction, areas of subglottic stenosis may be visible using these techniques. Video documentation of these procedures offers a valuable method of treatment planning and patient education.

X RAY NECK

The antero-posterior airway is superb for examining the glottic and subglottic areas. During quiet inspiration, the vocal cords are abducted and the width of the upper airway almost equals that of the trachea. During phonation of the vowel “e,” the vocal cords adduct, resulting in narrowing of the glottic area. However, narrowing of the subglottic area should be considered abnormal.

Cross-sectional imaging also adequately shows the airway. Configuration of the airway on axial or transverse images varies depending on the level of the image. At the level of the epiglottis and aryepiglottic folds, the airway is elliptic. Approaching the false cords, the airway narrows and assumes a tear-drop shape. The airway becomes elliptic at the true cords. The
term rima glottidis refers to the airway at the level of the true vocal cords. The inter membranous portion of the Rima glottidis (glottis vocalis) consists of the ventral 60% of the cords, and the dorsal inter cartilaginous portion (glottis respirator) consists of the portion between the arytenoid cartilages. Below the cricoid cartilage, the airway appears circular. The posterior membrane of the trachea may posteriorly flatten, and the normal esophagus occasionally indents the airway silhouette.

**OTHER MODALITIES**

Although imaging studies such as airway radiographs, computed tomography, and magnetic resonance imaging occasionally provide useful information, the most valuable diagnostic assessment stems from the examination of the patient with endoscopy. After the patient has been examined by indirect laryngoscopy and flexible fiberoptic techniques, rigid endoscopic evaluation under general anesthesia should be performed in all patients with symptomatic airway abnormalities. Direct measurement and documentation of the diameter and length of stenotic areas are critical steps in the management of these lesions. Measurement of the diameter of stenotic segments is best evaluated by passing an endoscope, with a known diameter, that just fits through the stenotic area. Measurement of stenosis length may be performed by placing the endoscope at the distal end of the stenotic segment and marking the instrument at the incisors. The endoscope is withdrawn to the proximal aspect of the stenosis and remarked. The length of stenosis may be measured on the endoscope.

CT, MRI, VIRTUAL BRONCHOCAROGRAM are equally useful radiological investigation to reconstruct the images of airway in 3d format. Technological advances in CT scanning and MRI have greatly improved Radiologists' ability to image the upper airway. Spiral CT scanning and fast MRI techniques allow the use of rapid acquisition speeds that decrease degradation motion artifacts caused by patients breathing and swallowing and carotid artery pulsations. Spiral CT scanners rapidly, in less than 10 seconds, acquire the complete data set through the larynx, limiting the time during which the patient needs to remain motionless. Images can then be reconstructed to create overlapping sections, and coronal, sagittal, and even 3-D images can be generated from the same data set. Helical CT scanning with 3-D reconstruction and virtual endoscopy in neonates and infants can prevent additional diagnostic trachea-bronchoscopy in a high percentage of such patients who have tracheobronchial lesions.

**Treatment of Laryngotracheal Stenosis**

Medical
Prior to airway reconstruction, it is recommended that all pediatric patients be evaluated for GER with a dual 24hr pH probe (Cotton and Walner, 1999). Patients diagnosed with GER should be treated accordingly. Adults are not always subjected to an extensive workup for GER unless symptoms are present. Empiric peri-operative treatment with anti-reflux medications has been recommended by some authors and is practiced by many. In adults it is important to evaluate the patients general medical condition prior to performing any reconstructive procedures. Many of these patients underwent long periods of intubation secondary to severe medical problems. The decision to perform surgery should be made in consultation with the patient's primary or specialty physician (pulmonary, cardiology, nephrology, etc.). Relative contraindications to LTR in adults are renal failure, diabetes, severe coronary artery disease, severe COPD or restrictive lung disease, obstructive sleep apnea, and systemic steroid use. It is important to consider each patient's case on an individual basis and make the decision to proceed with surgery based on sound judgment.

Observation

Patients (children and adults) with Cotton-Myer grade I and mild grad II subglottic stenosis may sometimes be managed with close observation (Walner and Cotton, 1999). In adults, this will depend on the reliability of the patient for close follow-up and their symptomatology. Children may be watched closely if they have only occasional mild stridor without retractions or feeding difficulties and have not required hospitalization for episodes of croup or other airway-related illnesses. Walner and Cotton recommend repeat endoscopy every three to six months to measure the diameter of the airway to ensure that it is enlarging as the child grows. As stated previously, the child should be followed with growth curves by a pediatrician and/or neonatologist.

Surgical treatment options for subglottic stenosis:

I. Tracheostomy

II. Endoscopic

A. Dilation

B. Endoscopic laser excision

III. Open procedure

A. Expansion procedure (one-stage or with stent placement)

1. Anterior cricoid split +/- cartilage graft*
2. Posterior cricoid split +/- cartilage graft*

3. Anterior and posterior cricoid split + cartilage graft

4. Four quadrant LTR

B. Segmental resection (cricotracheal resection - CTR)

1. Primary CTR

2. Salvage CTR

3. Extended CTR – CTR with and ex-pansion

   procedure, arytenoid lateralization, or

   arytenoidectomy

Endoscopic Treatment

Some areas of LTS are amenable to endoscopic treatment techniques such as laser vaporization and dilation, excision using a micro trapdoor technique, or serial dilation with radial incisions of the stenotic segment. Intra-lesional corticosteroids may also be injected under endoscopic guidance. Lasers allow the precise treatment of tissue throughout the airway while avoiding external incisions and providing an excellent method of cutting, coagulating, or vaporizing tissue. Hemostasis may be achieved, and perioperative edema is often decreased with the use of lasers owing to smaller amounts of tissue sustaining thermal damage when compared to electro-cautery.

Owing to its precision (small spot size) and availability, the carbon-dioxide laser, which produces light in the mid-infrared region, remains the instrument of choice in the endoscopic management of LTS. It can be used to coagulate vessels up to 0.5 mm in diameter. If the stenotic area is vascular, a laser with better hemoglobin absorption, such as the potassium titanyl phosphate/532 (KTP/532) or neodymium: yttrium-aluminum garnet (Nd: YAG), is recommended. One further disadvantage of the carbon-dioxide laser is that it lacks a good fiberoptic delivery system and must generally be controlled with a micromanipulator system mounted on a microscope.

Laser ablation of stenosis is a useful technique that may be combined with dilation of the stenotic segment or placement of an intraluminal stent. This procedure is most successful in the management of early lesions composed mostly of granulation tissue that have not yet evolved into a mature scar. Stenotic segments less than 1 cm in length may also be addressed with this method.

Areas of circumferential stenosis may be
addressed endo-scopically by making radial incisions in the scar tissue with a laser and dilating the treated area with a bronchoscope or dilating instrument. The laser is used to create radial incisions in the scar tissue in four to six areas. The laser may be coupled to a ventilating bronchoscope if the patient is not tracheostomy dependent. The incisions break up the circumferential scar band and leave islands of intact mucosa. The leaving of areas of intact mucosa is critical to prevent circumferential areas denuded of mucosa that would ultimately reform scar tissue similar to the original lesion or possibly even make the scarring worse. The stenotic segment may be sequentially dilated. The procedure generally needs to be repeated at several 3- to 4-week intervals before an adequate airway is achieved.

Open Surgical Techniques

Severe areas of LTS that do not respond to endoscopic techniques require an open surgical procedure. Open techniques attempt to either excise the stenotic segment and re-anastomose the airway or augment the circumference of the stenotic segment with transplanted tissue. Stenoses that are longer than 1 cm, have glottic or extensive tracheal involvement, and have failed endoscopic treatment and near-complete Stenoses are candidates for an open technique. In patients with diabetes or severe systemic illnesses, open approaches must be considered with great care. Such patients suffer from poor wound healing, have a high risk of perioperative complications, and have a lower rate of successful outcome after open procedures. In these high-risk patients, a tracheostomy may be the most prudent choice of management.

Tracheal Resection and Re-anastomosis

Areas of cervical tracheal stenosis up to about 5 cm can generally be excised, and the proximal and distal tracheal segments re-anastomosed primarily. A supra-hyoid laryngeal release may be required to allow for closure under minimal tension. When performing this procedure, the surgeon must keep in mind the age and body habitus of the patient. Older patients tend to have calcifications between the tracheal rings, resulting in decreased tracheal elasticity. Patients with large, thick necks and older patients with cervical kyphosis also tend to lack tracheal mobility.

Crico-arytenoid Joint Fixation

The Crico-arytenoid joint is a synovial joint formed by the articulation of the arytenoid cartilage with the postero-superior aspect of the cricoid cartilage. The vocal process of the arytenoids cartilage is usually free to rotate in three dimensions to allow proper apposition of the true vocal folds. This normal mobility of the arytenoid cartilages can be impaired by several factors. Dislocation of the arytenoid cartilage may occur owing to external trauma or intubation. The arytenoid cartilage may be dislocated anteriorly or posteriorly, with anterior dislocation being slightly more common owing to the force vector exerted through the blade
of a laryngoscope. Several inflammatory disorders such as rheumatoid arthritis and gout may also involve the Crico-arytenoid joint and result in an abnormal “fixation” of the joint. Inflammatory disorders can result in unilateral or bilateral cricoarytenoid joint dysfunction. With cricoarytenoid arthritis, the patient generally presents with symptoms of stridor and dyspnea with a variable degree of dysphonia. The dysfunction results from fixing the vocal cords in the paramedian position and the inability to achieve normal apposition of the true vocal folds on phonation or normal abduction with inspiration. Also, denervation of the larynx may limit the normal mobility of the arytenoid cartilages.

In the patient with suspected cricoarytenoid joint dysfunction, the differential diagnosis is three-fold. First, the posterior cricoarytenoid muscle may be denervated. Second, the arytenoids cartilage may be dislocated. A history of trauma should be carefully elicited in this group of patients. Finally, the joint may be fixed owing to an inflammatory condition. The proper location of the arytenoid cartilage and mobility of the cricoarytenoid joint are best assessed under general anesthesia by gently rocking the arytenoid cartilage back and forth. A “fixed” cricoarytenoid joint can be diagnosed with this method. An electromyogram of the intrinsic laryngeal musculature can determine if the immobility is caused by denervation or is secondary to fixation of the cricoarytenoid joint. A careful history aids in the diagnosis of a systemic inflammatory condition.

The treatment of cricoarytenoid joint dysfunction must be carefully individualized to the patient and the disease process. A patient with an inflammatory disease should be treated medically with the aid of a rheumatologist. Stable patients who are able to phonate, breathe, and swallow well without aspiration may be safely observed.

Unstable patients or patients who do not improve on medical and rehabilitative strategies must be treated surgically. Patients with inadequate ventilation may undergo a tracheostomy, which would likely results in maintenance of an excellent voice owing to the medial position of the vocal cords. Patients who wish to be decannulated can be offered a cordectomy or arytenoidectomy, but they must be carefully counseled that a more patent airway will result in an inferior voice. A successful treatment strategy requires excellent communication between the surgeon and the patient and intensive patient education and counseling.

LARYNGOTRACHEAL STENTS

Laryngeal and tracheal stents are solid or hollow absorbable or non-absorbable tubes of various shapes, sizes, and materials. Stents are used as primary treatment for lumen collapse or to stabilize a reconstructive effort of the larynx or trachea to prevent collapse. Stents can be used for the larynx and the trachea individually, or they can be used interchangeably or concomitantly.
History of the Procedure

The word stent is derived from Charles B. Stent, a British dentist who practiced in the late 19th century. Stent developed material that was used for dental impressions and, later, to support skin grafts. In current practice, the word stent refers to material that supports some form of tissue against collapse. Most often, stent describes devices that maintain the lumens of tubular organs.

In 1965, Montgomery described the use of silicone prostheses for tracheal stenting. Surgeons in other subspecialties, such as gastro-esophageal, genitourinary, and vascular surgery, developed stents that remain useful in expanding lumens in these areas. This evolution increased the interest of otolaryngologists to develop stents for the larynx and tracheobronchial tree.

Indications

Laryngeal stents are often used to keep the airway expanded after surgical reconstruction or trauma. Occasionally, laryngeal stents can be used for expansion of a disease process. Stents can be used for similar reasons in the trachea, especially to maintain lumen patency to prevent death. Stenting in the tracheobronchial tree is usually used as a last resort for severe conditions such as recurrent carcinoma and severe tracheal collapse that results in periods of prolonged apnea.

The most common indication for laryngeal stenting follows reconstruction of laryngo-tracheal stenosis. Laryngeal stents can be used to keep the laryngeal lumen open and the reconstruction supported and stable. Occasionally, laryngeal stents are used following trauma to the larynx resulting in laryngeal fracture or injury. Stenting may help maintain lumen patency and prevent mucosal lacerations from scar-ring.

Laryngotracheal stenosis

The first reason to use stents in cases of LTS is to support the larynx, typically with some form of autologous cartilage, after a reconstructive technique has been performed. A stent can be used to stabilize the cricoid plate once it has been divided anteriorly or posteriorly, with or without cartilage placement, to keep the complex in an expanded formation during healing. Stenting to help stabilize the laryngeal structure normally lasts for 2-6 weeks. Zalzal has showed that when a cartilage graft is inserted, the minimum time necessary for a posterior cricoid split to heal in a distracted manner is 2 weeks. If stenting is performed for a shorter duration, the graft may prolapse into the lumen.

For anterior graft placement only, stenting commonly lasts for a week or less, which usually occurs while a patient is endotracheal intubated in an intensive care unit (ICU). If the
cartilage graft is made into a boat formation with flanges over the edge of the intraluminal portion of the graft, thus providing stabilization and preventing pro-lapse, see the images below, then ventilation with an endotracheal tube is not necessarily used for support but for protection of the air-way while the edema resolves and the air leak around the reconstructive effort seals.

This helps prevent pneumo mediastinum, pneumothorax, or both in concert. Often, a child can be extubated within a few days following surgery. With this graft design, a stent is not always required because the reconstructive area is already stabilized, provided no air leak has developed.

The second reason for stent placement in LTS repair is to counteract scar contraction. Theoretically, this requires stenting for a 6-month period. In general, guidelines to determine the duration of stenting depend on the consistency of the stenosis, the anatomical distortion of the disease process, and the stability of the reconstructive areas.

Laryngeal web or atresia

For a child with laryngeal web or atresia, a keel stent, shown below, is often placed to prevent the laryngeal web from reforming. Frequently, this stent is left in place for several weeks.

Laryngeal keel.

Tracheal lesions

The purpose of stenting for tracheal lesions varies from palliation, to cure, to stabilization while a reconstructive effort heals. In adults, primary cancer of the tracheobronchial tree or cancer from the head, neck, or chest that extends into the tracheobronchial tree frequently causes lumen compromise and airway obstruction.

The intraluminal component can be removed with laser treatment, mechanical debulking, electrocautery, brachytherapy, photodynamic therapy, or cryotherapy. A stent can then be placed to maintain the airway lumen following debridement to counteract collapse or edema. Alternatively, stents can be placed that help compress any lesion extending into the trachea or bronchi, without the need for debulking. Stents have been used successfully to palliate patients with inoperable bronchogenic cancer, primary tracheal tumors, and metastatic malignancies. Placing a stent in a patient with a terminal illness allows that patient to breathe comfortably and prevents death from asphyxiation.

Stenting of the trachea following surgical resection or reconstruction
If tracheomalacia or stenosis occurs following the resection of lesions, stents can be placed in the trachea to prevent scarring or to provide support for the operated segment while it heals.

In most situations, surgical correction as primary treatment for a disease process is preferred to stenting alone because complications are decreased. However, situations arise in which patients cannot undergo formal corrective surgery, and stent placement is the only way to prevent a severe apneic event or death. Tracheal stents have been placed following unsuccessful tracheal repairs, post anastomotic stricture after sleeve resection for lung transplantation, and following malacia from infections such as tuberculosis.

Following lesion excision

Any time the airway is opened to excise a lesion of the larynx, a stent can be considered for stabilization, scar prevention, or airway protection while edema resolves and the area heals. Frequently, this requires several days of intubation in the ICU, with the endotracheal tube acting as a temporary stent.

Types of stents

Different stents have different indications. Types include primarily laryngeal stents, primarily tracheal stents, combination tracheal and laryngeal stents, and stents that can be used either in the larynx or trachea.

Laryngeal stents

If stenosis is confined to the larynx (i.e., glottic, subglottic) the stenting can be short- or long-term. Short-term stenting is defined as stenting for less than 6 weeks. Long-term stenting is defined as stenting for more than 6 weeks.

Place a short-term stent for 6 weeks or less because granulation tissue forms at the lower end of the stent above the tracheotomy, potentially leading to tracheal stenosis or collapse above the tracheotomy site. Use short-term stenting for stabilization of cartilage grafts following Laryngotracheal reconstruction (LTR) and/or for separation of mucosal surfaces during healing following laryngeal trauma, repair of web formation or atresia, or excision of a laryngeal lesion. Stents for these indications include Aboulker stents, silicone stents, Montgomery laryngeal stents, endotracheal tubes, and laryngeal keels.

Occasionally, long-term stenting is required when the trachea above the tracheotomy tube requires stenting for either collapse or stenosis following reconstruction. In this case, a long stent wired to the trachea, shown in the images below, or a tracheal tube (T-tube), such as the Montgomery T-tube, shown below, can be used.
Radiographic lateral neck view of a long stent connected to a metal Jackson tracheotomy tube at the bright inferior portion of the picture. The stent is seen in the airway as an oblong translucent area, with a rim of opacification around it that extends up through the larynx. A thin wire is seen connecting the stent and the T-tube.

A long Aboulker stent wired to a metal Jackson tracheotomy tube.

Montgomery T-tube (7 mm) stent with caps:

A Montgomery T Tube is a soft silicone tube that is shaped like a ‘T’. T Tubes are used for many reasons, the main being to support the upper airway and after reconstructive surgery and to support the upper airway that would have ordinarily collapsed thus allowing the child to breathe in the 'normal' way. The distinctive shape of the T Tube allows part of the tube to support (or stent) the upper airway whilst the lower part act like a tracheostomy tube, allowing the child to breathe easily.

It is an artificial airway and must be supervised at all times by someone competent in its care.

The T Tube sits in the same place as the tracheostomy would have been, between the 3rd and 4th tracheal rings. A Montgomery T Tube, like a tracheostomy, is life saving but can become life threatening unless the airway is kept clear from secretions 24 hours a day.

Figure 1: Parts of the oronasal cavity and upper-respiratory tract showing the position of a Montgomery T Tube

The T Tube has five parts: external limb, upper limb, lower limb, a ring and a cap.

External limb

The external limb is what can be seen protruding from the child’s neck. This limb is connected to the upper and lower limbs.

Upper limb

The upper limb rests in the child’s upper airway, it supports or stents the airway after reconstructive surgery. The upper limb extends to an area just below, at, or just above the vocal cords. The length will vary so it is essential that practitioners know the exact length of the upper limb, for suctioning purposes. This should be in the operation notes but contact surgeons if it is not.

Lower limb
The lower limb extends down the trachea and acts as a tracheostomy tube, allowing the child to breathe. As above this length will vary; so it is essential that practitioners are aware of the length.

Ring

The ring sits on the external limb between grooves; they support and position the T Tube by minimizing its movement back and forth. The ring should not be pushed flush to the skin as this may create pressure-causing discomfort and probably skin irritation and/or breakdown.

Cap

The cap fits into the external limb, and can be used when children are able to breathe through their (normal) upper airways; this will be individually assessed and determined and therefore should not always be used. Alternatively the cap is left off and the child breathes through the external and lower limbs, just as they would through a tracheostomy.

Figure 2: Parts of the Montgomery T Tube

Humidification

Maintenance of the humidity and warmth of inspired air is an es-sential part of tracheostomy management, as the normal functions of the upper respiratory tract have been bypassed (Harking and Russell, 2001). The nose and naso-pharynx normally ensure that inspired air reaches a temperature of 37°C and 100% relative humidity. Bypassing these with a tracheostomy dedicates such functions to the lower airways, which are poorly suited to the task. Inspiration of cool and dry air may create many problems for the tracheostomised child. Impairment and destruction of cilia reduces the proximal transportation of mucus (Jackson, 1996). Secretions become increa-singly thick and tenacious, making their expulsion difficult. This may lead to blockage of the tube. Additionally, cold inspired air increases heat loss from the respiratory tract, is a particular danger for the small infant. It is essential that there is a delivery of inspired air at 37°C and 100% relative humidity to maintain the natural defence mechanisms (Ryan et al, 2003).

Montgomery T Tube Formation: Initial Care

Actions during the first few days following formation of the T Tube concentrate on maintaining the patency of the new tube, stoma maintenance and training. Most patients having the T Tube would have already had a tracheostomy; the initial few weeks are a period of huge readjustment for the patients. Most patients will have already been familiar with tracheostomy care and so familiarisation rather than re-teaching is required.
The patient must be supervised at all times by someone competent in suctioning of at least the lower limb.

Observations

We should also carry out routine non-invasive observations to rule out these potential, initial complications such as observing for neck swelling (emphysema), inspecting the chest for bilateral chest movement and auscultating the chest for equal air entry (pneumothorax/tube position). A flexible endoscopy may be performed post-operatively if the patient is distressed and or coughing.

Complications

Initial complications are largely avoidable if the procedure is care-fully performed together with careful and effective post-operative management.

Other initial complications include:

- Hemorrhage: May be primary, reactionary or secondary. A large haemorrhage may be fatal.
- Tube Blockage At least:
   - ½-hourly suction for the first 12–24 hours (Yaremchuck, 2003; Onakoya et al, 2003; Friedman et al, 2003; Seay et al, 2002; Park et al, 1999)

- Accidental decanulation/tube displacement
- Infection (chest/stoma site)
- Surgical emphysema Air may leak around the tube into the surrounding tissue. This is particularly problematic if the patient has had neck sutures inserted.

If there have been no previous feeding concerns, the patient may recommence their normal feeds after a specified time of being ‘nil orally’. This is normally 4–6 hours post-operation but practitioners must confirm this with the anesthetic chart.

Discharge Planning

T Tube sizes do not relate directly to the size of tracheostomy tubes. In most cases the T tube will be much bigger than the original tracheostomy tube.
Most patients would have had a tracheostomy and so would be familiar in its care and techniques, so attention must be directed in providing training to the carers in the following:

- Competence in Tracheostomy care
- Suctioning of both the upper and lower limbs
- Stoma care and removal of cap
- Advice on occluding the outer limb (if applicable)

A T Tube is held in place only by the upper and lower limbs. Therefore undue pressure or pulling of the T Tube should be discouraged. Stomal cleaning is normally performed daily. A clean with normal saline and gauze is all that is required. Observe for skin breakdown and granulation tissue and treat accordingly.

Crusting may also need to be removed from the T Tube and/or cap.

Suctioning a Montgomery T Tube

Airway suctioning is a common practice in the care of a patient with a Montgomery T tube, and is undertaken to remove secretions from the child's respiratory tract. A child with a Montgomery T Tube may find it difficult to clear their secretions effectively therefore suction is an essential aspect of their care. Suctioning is associated with many potential complications and is now only recommended when there are clear indications that the patency or ventilation of the patient could be compromised (Czarnik et al, 1991; Fiorentini, 1992; Raymond, 1995; Gemma et al, 2002; Dellinger, 2001; Spence et al, 2003; Ahn and Kwang, 2003).

- Hypoxia
- Formation of distal granulation tissue/ ulceration
- Cardiovascular changes
- Pneumothorax
- Atelectasis
- Bacterial infection
- Intracranial changes

A clean technique must be used, and the catheter should be discarded if the tip is contaminated with hands, cot sides etc.
Distal tracheal damage and hypoxia are potential complications especially with the paediatric airway. These complications can be reduced by having:

- A suction catheter's diameter less than half the diameter of the T Tube (Ahn and Hwang, 2003; Odell et al, 1993; Glass and Grap, 1995; Wood, 1998). As a guide practitioners should double the size of the tube to obtain the appropriate catheter size, for example an equivalent T Tube to a 4.0 ID tracheostomy tube is a size 8fg catheter. A suction catheter should be less than half the size of the trachea.