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A correlative manometric and endoscopic study of tubal function in dry central perforation of the tympanic membrane

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Abstract
Since good ventilation of the middle ear is a pre-requisite for successful myringoplasty, it was our policy to investigate the tubal function in dry central perforation of the eardrum and to correlate the manometric and endoscopic findings. Nasal endoscopy proved to be indispensable in diagnosing mechanical tubal obstruction and in localizing and even treating 'hidden' lesions in key areas, with probable normalization of the tubal function. The correction of the mechanical tubal obstruction must precede ear surgery. Whenever tubal obstruction is diagnosed as functional or idiopathic, the ventilation of the middle ear should be guaranteed during ear surgery by addition of a tympanostomy tube to the graft or drum remnant, and a guarded prognosis given.

Introduction

Pre-operative evaluation of Eustachian tube function in a patient with chronic perforation of the tympanic membrane may be helpful in determining the potential results of tympanoplasty surgery (Siedentop *et al.*, 1968; Bluestone, 1990). Holmquist (1970) found that the operation had a high rate of success in patients with good preoperative tubal function, but in those without good tubal function, tympanoplasty was usually unsuccessful, resulting in a marked negative middle ear pressure, otitis media with effusion, or failure of the graft to close the perforation.

The major cause of abnormal tubal function appears to be obstruction which is either mechanical or functional. Manometry (Miller, 1965; Bluestone *et al.*, 1972; Moustafa *et al.*, 1979; Cantekin *et al.*, 1979), radiography (Ferber and Holmquist, 1973), fluorescein (Rogers *et al.*, 1962) and radioisotope studies (Lafaye *et al.*, 1974) have been used to diagnose tubal obstruction. Whenever the tubal obstruction was diagnosed and the aetiology was obscure, it was considered as functional or idiopathic (Bluestone, 1990).

TABLE I
standard parameters of the tubal function

(1) Passive opening pressure
  (a) 330 ± 70 mm H_2O
  (b) Above 400 mm H_2O
(2) Capacity for equilibrating overpressure
  (a) Equilibration to O-level directly or stepwise.
  (b) Residual positive pressure.
(3) Capacity for equilibrating underpressure.
  (a) Equilibration to O-level directly or stepwise
  (b) Residual negative pressure.
(4) Mean percentage of swallows which opened the eustachian tube.

In this report, it has been our intention to test tubal function by the inflation-deflation method (Bluestone *et al.*, 1972) and the to use the rigid nasal endoscope to test tubal patency, to visualize the tubal orifice and to detect hidden pathology in key areas that may be responsible for the obstruction. The correlation between endoscopic and manometric results can have implications on the technique chosen for ear surgery.

Material and methods

The tubal function of 80 adult cases with a dry central

TABLE II

	Eustachian Tube Function	No. of cases
I.	Normal Eustachian tube function (normal manometry, normal fluorescein-endoscopy)	48
II.	Mechanical tubal obstruction (Abnormal manometry, abnormal fluorescein-endoscopy)	
(a)	Extrinsic obstruction	
	Persistent adenoid mass	2
	Nasopharyngeal tumour	1
(b)	Intrinsic obstruction	
	Allergy	5
	Atrophic rhinitis	1
	Salpingoscleroma	1
	Stenotic middle meatus	7
	Ethmoiditis and/or antritis	5
III.	Functional tubal obstruction (Abnormal manometry + normal fluorescein-endoscopy	
	Posterior septal impaction	1
	Occult submucous cleft palate	1
	Increased compliance of the tube	3
	Idiopathic	5
	Total	80

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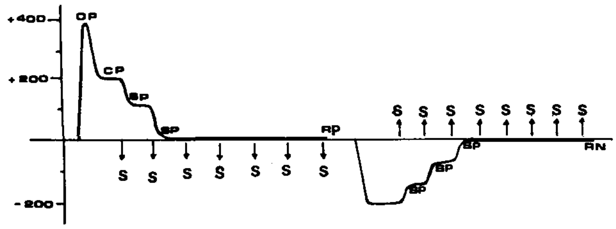

FIG 1

A manogram showing the results of the inflation-deflation test in a normal Eustachian tube. OP: Opening pressure; RP: Residual positive pressure; CP: Closing pressure; RN: Residual negative pressure; SP: Pressure after swallow; S: Swallow.

perforation of the eardrum was investigated both manometrically and endoscopically.

The external ear canal was fitted with a rubber ear tip to maintain an air-tight seal. The ear tip was connected to the manometer pump portion of an electroacoustic impedance bridge Danplex ZA28. The inflation-deflation test was then performed. In this, the middle ear was inflated with a constant flow of air until the Eustachian tube opens passively (the opening pressure). The pressure remaining in the middle ear after passive opening and closing of the tube was termed the 'closing pressure'. The middle ear pressure was further equilibrated by repeated swallowing (active tubal function). The time interval between each swallow should be 20 seconds to avoid strain on the pharyngeal muscles. The pressure remaining in the middle ear after five consecutive swallows without a change is termed the 'residual positive pressure'. The pressure drop per swallow and the mean percentage of swallows which opened the tube were also recorded. The deflation phase of the test was then performed. A pressure of −200 mm H_2O was applied to the middle ear and the patient was instructed to swallow. The pressure remaining in the middle ear after five consecutive swallows without a change was termed the 'residual negative pressure' (Table I).

The patient then laid on his back with the head elevated 45°, because tubal function is reduced by two-thirds if the body is in horizontal position (Jonson and Rundcrantz, 1969). The nose was sprayed with 2% lignocaine. We used Storz rigid endoscopes 18 cm long with 0°, 30° and 70° deflection angles and 4.0 mm external diameter. In adults with a stenosed meatus and in children, we used endoscopes with 2.7 mm external diameter. When indicated, endoscopic pictures were taken by coupling the endoscope with Ricoh camera XR-X and using a Storz cold light fountain with flash generator. The endoscope was passed into the nasopharynx along the middle and inferior meatus thus allowing the surgeon to check key areas for hidden pathology. The ciliary beat was examined in the light reflex over the mucosa of the tube. Fluorescein (Thilo) was then instilled into the middle ear, and the tubal patency was tested by asking the patient to swallow five times whilst searching for fluorescein in the nasopharynx. Fluorescein glowed yellowish-green if the light cable was stained by a blue textliner (Faber-Castell).

Results and discussion

According to the results of this study, the patients were classified into three groups (Table II).

The first group (48 cases) had normal tubal function as indicated by the normal manometric and endoscopic findings. They had a mean passive opening pressure of 330 mm H_2O ± 70 mm H_2O (Cantekin *et al.*, 1979), zero residual positive pressure, zero residual negative pressure and the percentage of swallows which opened the tube was 100% (Fig. 1). The endoscopic findings were the appearance of fluorescein in the nasopharynx (tubal patency) (Fig. 2), normal opening and closing mechanisms of the tubal orifice when the patient was asked to swallow and normal ciliary beat in the light reflex (Fig. 3). These patients with normal tubal function are expected to have successful myringoplasty. The perforation closure rate in this group was 95.8 per cent.

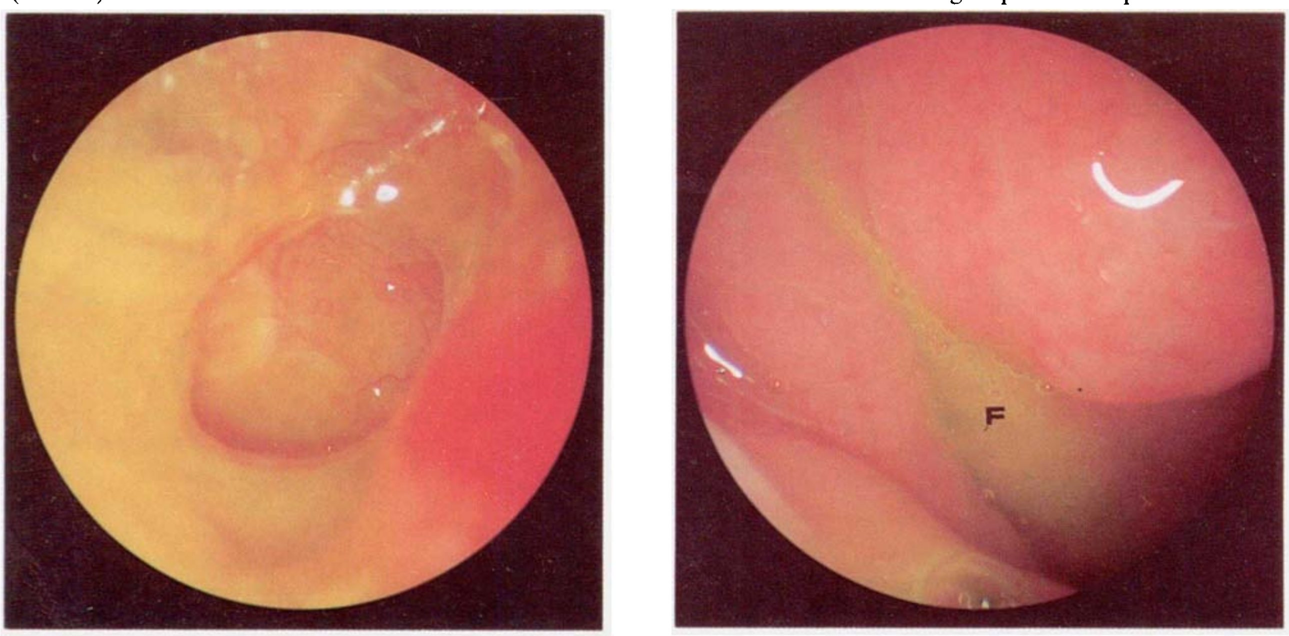

FIG. 2

Endoscopic pictures of (a) a dry central perforation with the middle ear empty from fluorescein and (b) a patent Eustachian tube as proved by appearance of fluorescein (F) around the tubal orifice.

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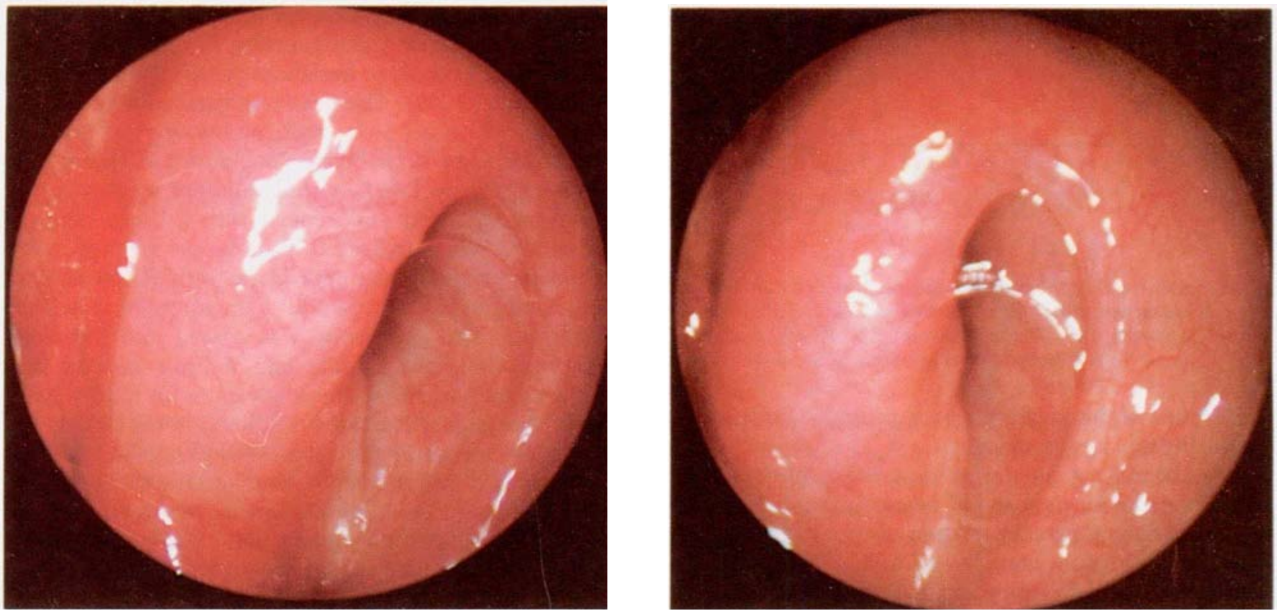

FIG. 3
Endscopic pictures of Eustachian tube with normal opening (a) and closing (b) mechanisms. Notice the ciliary beat in the 'light reflex'.

The second group (22 cases) had mechanical tubal obstruction as indicated by the abnormal manometric findings (Fig. 4) and failure of fluorescein to pass into nasopharynx after five consecutive swallows (Fig. 5). Nasal endoscopy played an important role in detecting and localizing the mechanical tubal obstruction. Extrinsic mechanical obstruction was the result of a small nasopharyngeal tumour hidden in the fossa of Rosenmuller (one case) (Fig. 6) or a persistent adenoid mass (two cases) (Fig. 7). The most common cause of intrinsic mechanical obstruction was found to be inflammation; allergy (5 cases) and infection (7 cases). One case was due to primary atrophic rhinitis with crusts obstructing the lumen of the tube and another due to salpingoscleroma (Gamea, 1990). Nasal endoscopy proved to be indispensable in detecting hidden pathology in the ostiomeatal area. Hypertrophied agger nasi cells, concha bullosa, paradoxically bent middle turbinate, pneumatized uncinate process, large bulla ethmoidalis, septal spurs and a small polyp in the middle meatus (Fig. 8) were good examples. They interfere with the ventilation and drainage of large sinuses and cause a disturbance in the transport routes for mucociliary clearance into the nasopharynx (Stammberger, 1986). A disturbance in the ciliary beat was easily seen in the light reflex over the

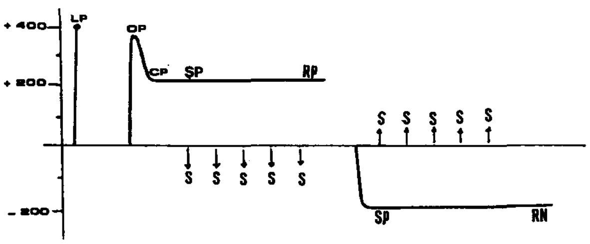

FIG. 4
A manogram showing the results of the inflation deflation test in an obstructed eustachian tube. LP: Limit of pressure; RP: Residual positive pressure; OP: Opening pressure; RN: Residual negative pressure; CP: Closing pressure; S: Swallow; SP: Pressure after swallow.

mucosa of the tube. Nasal endoscopy detected also the presence of ethmoiditis and antritis (5 cases). The abnormal secretion passed directly over the tubal orifice, producing congestion and inflammation of its tissues, thus impeding ventilation of the middle ear. These endoscopic findings were rarely visible to the naked eye. Most of this group were diagnosed in the past as functional or idiopathic tubal obstruction. Moreover, functional endoscopic surgery had enabled us to clear diseased or stenosed areas, re-establishing normal drainage and ventilation of the sinuses, leading to normalization of the tubal function before myringoplasty can be performed.

In the remaining 10 cases, manometric findings showed a tubal obstruction, while fluorescein-endoscopy proved tubal patency. This means 'functional tubal obstruction'. Ability to equilibrate positive pressure with inability to equilibrate negative pressure means increased compliance with locking of the tube (3 cases). A case of posterior septal impaction was diagnosed by the 0° telescope. Swallowing in this case resulted in an initial positive nasopharyngeal pressure with insufflation of infected secretions into the middle ear. It was followed by a negative pressure phase with locking of the tube. One case of occult submucous cleft palate was diagnosed by the 70° telescope. Whenever tubal dysfunction was diagnosed and the aetiology was obscure, the dysfunction was termed 'idiopathic' (5 cases). The cause may be a congenital defect in the anatomy of the base of the skull (Bluestone, 1990).

Out of the 32 cases with tubal obstruction, normalization of tubal function by correction of the nasal and peritubal pathology could be achieved in 17 cases, in whom myringoplasty was performed, with a perforation closure rate of 94.1%. In the remaining 15 cases, the ventilation of the middle ear was guaranteed at the time of ear surgery by addition of a tympanostomy tube to the graft or drum remnant, and a guarded prognosis (66.7%) given.

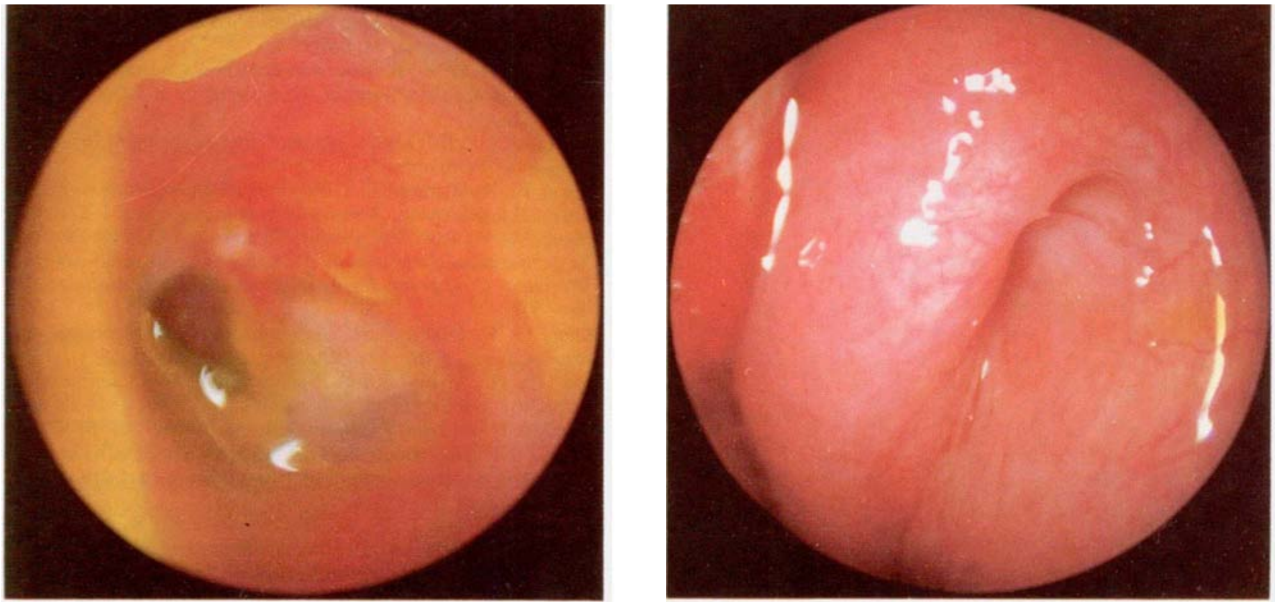

FIG. 5

Endoscopic pcitures of (a) a dry central perforation with the middle ear full of fluorescein and (b) an obstructed Eustachian tube with failure of fluorescein to pass into nasopharynx.

Conclusion

Since good ventilation of the middle ear is a prerequisite to successful myringoplasty, it was our policy to study the tubal function in dry central perforation of the drum and to correlate the manometric with the endoscopic findings.

Normal manometric results with patency of the tube (as proved by fluorescein-endoscopy) meant good tubal function, with good prognosis for myringoplasty.

Abnormal manometric results with failure of fluorescein to pass into the nasopharynx meant mechanical tubal obstruction which was, in most cases, correctable. Nasal endoscopy proved to be indispensable in diagnosing, localizing and even treating 'hidden' lesions in their key areas, with probable normalization of the tubal function. The correction of the mechanical tubal obstruction must thus precede ear surgery.

Whenever tubal obstruction is diagnosed as functional or idiopathic, the ventilation of the middle ear should be guaranteed during ear surgery by addition of a tympanostomy tube to the graft or drum remnant, with guarded results.

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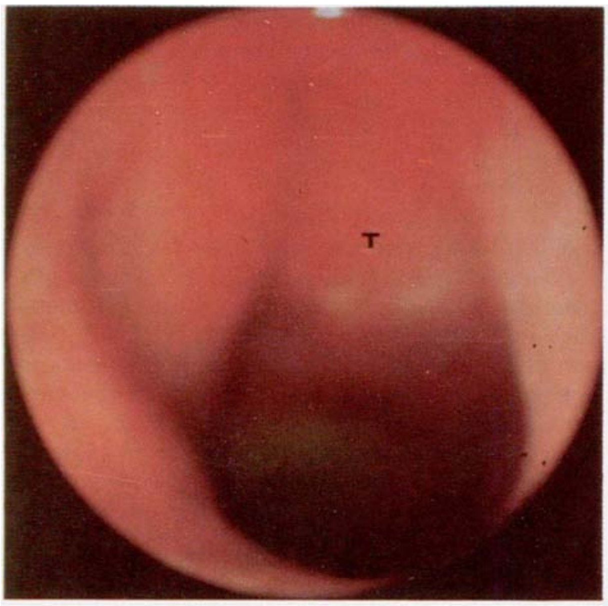

FIG. 6

An endoscopic picture of a small nasopharyngeal tumour (T) hidden in the fossa of Rosenmüller.

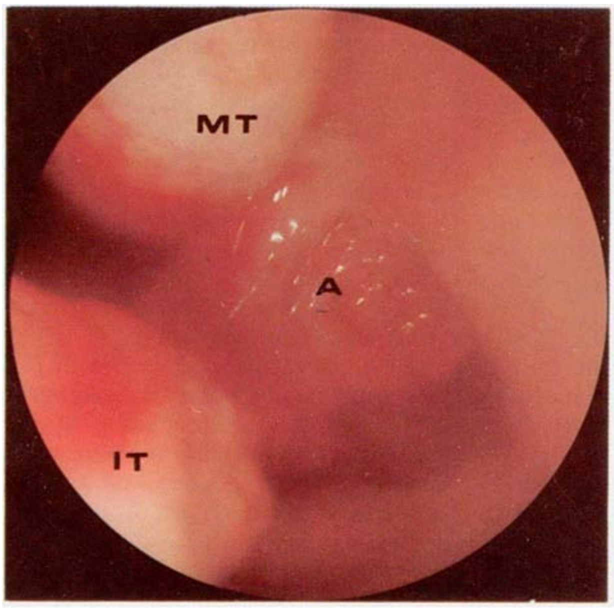

FIG. 7

An endoscopic picture of a persistent adenoid mass (A) [MT = middle turbinate, IT = inferior turbinate].

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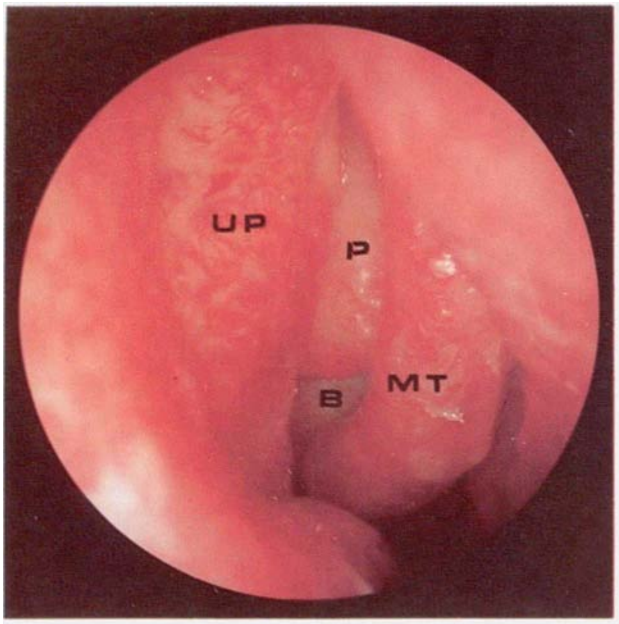

FIG. 8

An endoscopic picture of a small polyp (P) hidden in the right middle meatus [UP = uncinate process, MT = middle turbinate, B = bulla ethmoidalis].

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