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Submucous resection

The treatment of choice in the Nose-Ear Distress Syndrome

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Abstract

THE combination of nasal septal deviation and Eustachian tube dysfunction, in the absence of any other pathology, constitutes the Nose–Ear Distress Syndrome.

We have undertaken a clinical assessment of the relationship between uncomplicated deviation of the nasal septum and Eustachian tube dysfunction in Naval Personnel who are serving in environments of primarily increased barometric pressure.

120 candidates to the Submarine, Diving and Aircrew branches of the Royal Navy who presented with the Nose–Ear distress syndrome were initially surveyed. None were able to equilibrate their middle ear pressures at an increased ambient pressure of 3 metres of water. Submucous resection was performed on 116, of whom 110 (94·83 per cent) were able to equilibrate their middle ear pressures at an increased ambient pressure of 9 metres of water post-operatively.

Xenon 133 Scintigraphy was performed on a further 25 recruits to delineate the post-nasal airflow. This investigation was performed pre- and post-operatively. Pre-operatively, Scintigraphy showed the presence of turbulence in the post-nasal space, while post-operatively the turbulence was absent. All the candidates were unable to equilibrate their middle ear pressures pre-operatively, but after submucous resection 24 (96 per cent) were able to equilibrate their middle ear pressures at an increased barometric pressure of 9 metres of water.

Introduction

It is both an historically and currently held view of most Otorhinolaryngologists that deviation of the nasal septum with associated secondary infection and/or oedema in the paranasal sinuses, nasal fossae and post-nasal space is a frequent factor in the causation of tubal dysfunction. It is also widely accepted that deviation of the nasal septum alone is an unlikely cause of Eustachian tube dysfunction. The available authoritative text-books concur with this view.

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Whilst there is an obvious cause-effect relationship between infection and oedema on the one hand and Eustachian tube dysfunction on the other, the authors noted that many subjects being presented for assessment for Submarine Escape Tank Training at HMS Dolphin were found to have tubal dysfunction in association with some degree of septal deviation, either cartilaginous or bony, or both. This finding was in the complete absence of infection or clinically recognizable oedema as ascertained by anterior and posterior rhinoscopy in the Outpatient department, or examination under general anaesthesia.

Since the subjects being surveyed were Royal Naval Personnel who had volunteered to serve in environments of primarily increased barometric pressure, it was decided to survey clinically the cause/effect relationship of uncomplicated nasal septal deviation and Eustachian tube dysfunction.

It had been noted by the authors individually for three years prior to the survey that adequate submucous resection of the nasal septum in patients who were unable to equilibrate their middle ear pressures in environments of increased ambient pressure, almost invariably resulted in restoration of normal Eustachian tube function.

No investigation into the air currents in the nose or post-nasal space were performed either pre-operatively or post-operatively in the first 120 cases. Nevertheless, we were of the opinion that distortion of the normal airflow in the post-nasal space in the presence of a nasal septal deviation was a prime cause for the resulting tubal dysfunction. When the means of investigating the airflow in the post-nasal space became available to us, 25 candidates to the Submarine Branch of the Royal Navy underwent Xenon 133 Scintigraphy.

Ventilatory function of the Eustachian tube

To the Eustachian tube is normally attributed the following functions:

1. Middle ear ventilation.
2. Equilibration of pressures on each side of the tympanic membrane.
3. Middle ear drainage.
4. Protection of the middle ear from sudden changes in barometric pressure.
5. Protection of the middle ear from loud noise introduced into the post-nasal space.

Various factors may affect the normal function of the Eustachian tube:

1. Hydrostatic pressure of the venous system in the tubal and peritubal tissues.
2. Obstruction of the tubal orifices by an hypertrophied pad of adenoids.
3. Obstruction of tube to due inflammation or oedema of the tubal mucosa, due to either an infectious or an allergic cause.

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4. Failure in the functional integrity of the tubal mucociliary system or lymphatic drainage.
5. The integrity of the opening mechanism of the Eustachian tube.
6. Abnormal airflow in the post-nasal space.

Tubal opening

When Eustachius first described the pharyngotympanic tube in the 16th century, he believed that the tube was normally open. Not until 1853 did Toynbee demonstrate that the tube was normally closed, and that swallowing was the mechanism that opened the tube and on this depended the ventilation of the middle ear cleft.

Rich in 1920 demonstrated that the normally closed tube opens when yawning and swallowing.

The only muscle which is functionally related to the Eustachian tube is the tensor veli palatini. The contraction of this muscle produces dilatation of the tubal lumen as well as the tubal orifice (Rich, 1920; McMyn, 1940). The opening of the Eustachian tube and its orifice occurs due to anterior displacement of the fibromembranous wall of the tube from the cartilaginous wall of the tube. The constrictor muscles play no part in this function. Relaxation of the tensor veli palatini results in the passive apposition of the tubal walls.

The Eustachian tube does not open during quiet or forced respiratory movements and is not affected by mouth breathing or by simple elevation of the soft palate.

The levator veli palatini and the other accessory palatal muscles have very little influence on the lumen of the tube. It has been suggested that the levator veli palatini may passively elevate the floor of the Eustachian tube, thus reducing the resistance in widening the tubal lumen (Proctor, 1967; Perlman, 1967).

Deglutition occurs approximately once per minute in individuals who are awake, while during sleep deglutition occurs approximately once every five minutes (Graves and Edwards, 1944). Though deglutition may occur, the Eustachian tube does not necessarily open with every swallow (Perlman, 1951; Naunton and Galluser, 1967). The period during which the Eustachian tube remains open varies from 0·12 to 0·6 seconds (Perlman, 1967; Miller, 1965). The necessity to equilibrate the middle ear pressure with that contained in the post-nasal space and the barometric pressure applied to the lateral aspect of the tympanic membrane results from the pressure gradients developed between the middle ear cleft and the post-nasal space, as a result of a change in the pressure in the middle ear cleft with respect to external barometric pressure.

During closure of the Eustachian tube, the middle ear cleft, including the mastoid air cell system, becomes a closed space containing gas. There is a continuous slow absorption of oxygen and carbon dioxide by the mucosa

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of the middle ear cleft, which results in a difference in composition of the gas in the middle ear from that of the external environment (Ingelstedt and Jonson, 1967). A slight negative pressure is created in the middle ear; this is equalised with atmospheric pressure during the intermittent opening of the Eustachian tube during deglutition. Should the Eustachian tube remain closed so that equilibration cannot take place, gas absorption continues until the partial pressures of the gases contained in the middle ear cleft and the blood vessels of the surrounding tissues are in balance. Thus a greater negative pressure is created in the middle ear cleft (Flisberg *et al.*, 1963; Holmgren, 1940; Perlman, 1943).

The role of the Eustachian tube is to equilibrate the pressure on each side of the tympanic membrane. With reference to the previous paragraph, it can be seen that a continued development of a slight negative pressure in the middle ear cleft is a normal feature, before equilibration of middle ear and environmental pressure occurs.

Jerger *et al.* in 1972 showed that by using electro-acoustic impedance techniques most normal individuals demonstrate a maximum static compliance at -20 to -30 mm H_2O. Over-pressure in the middle ear cleft may passively open the Eustachian tube. This has been shown by Armstrong and Heim (1937) who demonstrated passive Eustachian tube opening with middle ear pressures of $+200$ mm of water. Perlman in 1943 also produced similar figures at a pressure of 270 mm of water. Flisberg in 1966 has also confirmed that the normal Eustachian tube cannot equilibrate a negative middle ear pressure without the muscular activity affected by deglutition, except in cases of patulous Eustachian tube. The nasopharyngeal tube may be opened at its orifice, if there is sufficient pressure applied to the opening in the nasopharynx. The nasopharyngeal pressure may be increased either by using the autoinflation technique of Valsalva or by performing Politzer's manoeuvre, thereby forcing air into the middle ear cleft. Van Dishoeck (1952) found $+300$ mm of water to be necessary, while Perlman (1943) found that the increase in pressure approached $+600$ mm of water.

The locking phenomenon

As extratympanic pressure increases, a negative middle ear pressure develops (Armstrong and Heim, 1937). The pressure gradients are equilibrated when the Eustachian tube opens by contraction of the tensor veli palatini. When the external pressure reached 80–90 mm Hg (1,000 mm of water), the membrano-cartilaginous tube was tightly collapsed and muscular activity could not overcome the pressure gradient.

McGibbon (1942) demonstrated that the immediate cause is a mechanical collapse of the membranocartilaginous tube from the isthmus to the nasopharyngeal orifice. As the atmospheric pressure increases, as is found in descent in an aircraft, or in a compression chamber, extra-tubal forces exert a pressure on the relatively soft fibrocartilaginous tube, which then

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closes before air can enter the nasopharyngeal orifice. The pressure is of such a degree that normal muscle activity cannot overcome it.

Personnel surveyed

The subjects included in this survey consisted of recruit volunteers to the Submarine, Diving and Fleet Air Arm branches of the Royal Navy. In the case of the recruits to the submarine service, all those seen were individuals who had otherwise been found medically fit for Submarine Escape Tank Training, but unfit because of their inability to auto-inflate their ears either at atmospheric pressure or when they were subjected to an increased barometric pressure equivalent to a depth of 3 metres of water (3,000 mm of water above atmospheric pressure). The same criteria apply to those recruits to the Diving Speciality.

The Aircrew candidates surveyed presented for otorhinological assessment as part of their initial examination, which included a general medical examination, prior to their being regarded as suitable for flying duties. Only those who were found to be medically fit but who were unable to auto-inflate their middle ear clefts are included in this survey.

All candidates who enter the three specialities covered by this survey are taught to ventilate their middle ear clefts either by repeated swallowing or by performing the auto-inflation technique of Valsalva when they are subjected to an increase in barometric pressure.

Demonstrably, we have investigated clinically a random selection of healthy young male adults, who were assessed as fit for military service by the most rigorous of medical standards.

The ages of the subjects surveyed ranged from 17 years to 35 years. 100 per cent of the candidates surveyed were, prior to otorhinological examination, totally unaware of symptoms associated with nasal obstruction and prior to being exposed to an environment of increased barometric pressure, 98 per cent of those surveyed had been totally unaware of any subjective difficulty in being able to auto-inflate their middle ear clefts.

The survey was carried out in the Ear, Nose & Throat Department at the Royal Naval Hospital, Haslar, over an elective period of 15 months during the years 1973/74 (McNicoll and Scanlan, 1975).

A total number of 120 candidates were seen in the initial group as broken down in Table I.

TABLE I

BREAKDOWN OF CANDIDATES INTO SPECIALISATIONS

Submariners	Aircrew	Divers	Total
106	11	3	120

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Biological parameters

Deviations of the nasal septum are generally accepted to be caused either by trauma or growth abnormality (Williams, 1971; Thompson and Negus, 1948). The trauma may be due to well remembered nasal injury, an injury during infancy or childhood, long forgotten or never recorded, or to birth injury. The growth abnormality is usually attributable to buckling of the nasal septum within fixed limits. The septal deviation is readily discerned on anterior rhinoscopy when, in addition, bony spurs are also clearly seen. Posterior rhinoscopy may reveal further deviations of the bony septum, which may be obscured on anterior rhinoscopy. Invariably compensatory hypertrophy of the inferior turbinate on the side contralateral to the major deviation is present.

For clinical purposes we have defined Eustachian tube dysfunction as a subjective inability to auto-inflate the middle ear clefts under normal atmospheric conditions whilst otoscopy reveals an immobile tympanic membrane, this latter finding being recorded as a negative valsalva.

Initial assessment

Each recruit referred had a complete otorhinological evaluation. This included a full history and examination. Of those surveyed 100 per cent gave no history of allergic rhinitis or previous sinus pathology. 98 per cent had no complaints referable to their ears. The 2 per cent who had a complaint referable to their ears, complained of inability to auto-inflate their ears when diving into a swimming pool, travelling in trains which entered tunnels and on the descent in aircraft. 100 per cent had no symptoms of nasal obstruction! Nevertheless, 100 per cent of those examined exhibited some degree of nasal septal deviation with an associated negative valsalva. In 78 cases (65 per cent) the negative valsalva was present on the side of the nasal septal deviation; whilst in the remaining 42 cases (35 per cent) with bilaterally negative valsalva, there was a combined cartilaginous and bony nasal septal deformity involving both nasal airways. Apart from these findings no other abnormality of the upper respiratory tract was found.

All the subjects assessed underwent basic audiometric evaluation, either as an initial Naval Entry requirement, or as part of a concurrent survey of hearing loss in divers presently being conducted by the Haslar ORL Unit, under the auspices of the MRC. All the subjects surveyed were found to be within the audiometric norm. All the candidates were subjected to tympanometry using a Peters AP 61 Impedance Meter. 100 per cent of the candidates had middle ear pressures between -50 mm of water and $+10$ mm of water. These values are universally regarded as being within normal limits (Brooks, 1969; Feldman, 1967; Jerger *et al.*, 1972).

The tympanomanometric curves were of normal pattern. All those surveyed were resubjected to an increased barometric pressure equivalent to 3 metres of water, prior to commencing conservative treatment.

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Conservative approach to the syndrome

Initially an attempt was made to resolve this problem by what is generally regarded as conservative treatment. It was decided that a six-week course of conservative treatment should be instituted. The subjects were placed on nasal decongestant therapy, self politzerization and eustachian catheterization. In 72 cases (60 per cent) it was found that eustachian catheterization was physically impossible due to gross septal deviation. In the remaining 48 cases (40 per cent) although eustachian catheterization was successfully carried out, repeated attempts at auto-inflation of the middle ear clefts was attended by total failure to achieve a positive valsalva, or subjective clearance of the middle ears involved. Because compression chamber facilities were readily available to us, all the candidates who, after six weeks of conservative treatment, had failed to achieve a positive valsalva (i.e. 100 per cent of those subjects surveyed), were then further subjected to a controlled increase in barometric pressure equivalent to 3 metres of water. 100 per cent of candidates failed to equilibrate their middle ear pressures. This parameter was finally assessed as the ultimate criterion for advising submucous resection of the nasal septum.

Operative approach to the syndrome

In the presence of the total failure of conservative treatment there were two possible alternatives:

1. To make the recruit permanently unfit for Submarine Escape Tank Training, Diving or Aircrew duties.
2. To advise operative correction of the nasal septal deformity.

Four candidates refused operation, and those who were not volunteers for the submarine service were treated conservatively for a further six weeks. At the end of this time they were once again subjected to a controlled increase in barometric pressure in the compression chamber. All failed to equilibrate their middle ear pressures, and were therefore made permanently unfit for Submarine Escape Tank Training. The remaining 116 candidates were then subjected to the conventional operation of submucous resection of the nasal septum.

Post-operative assessment

Those who had undergone submucous resection of the cartilaginous and bony nasal septum were reviewed six weeks post-operatively. 12 candidates (10·43 per cent) were found to be valsalva negative. The remaining 104 candidates were readily valsalva positive (89·66 per cent). All 116 candidates were compressed. Those who were clinically found to be valsalva positive (89·66 per cent) were subjected to an increase in barometric pressure equivalent to 9 metres of water; all were able to equilibrate

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their middle ear pressures. The 12 candidates (10·34 per cent) who were clinically found to be valsalva negative were compressed to an increased barometric pressure equivalent to 3 metres of water. These 12 failed to equilibrate their middle ear pressures and were placed on a further six-week course of conservative treatment, at the end of which time they were once more subjected to a controlled increase in barometric pressure. 6 of the twelve (5·17 per cent) equilibrated their middle ear presures equivalent to 9 metres of water (Table II). The remaining 6 failed to equilibrate their

TABLE II

ASSESSMENT SIX WEEKS POST-OPERATIVELY

	Submariners	Aircrew	Divers	Total
Operations	102	11	3	116
Successes	90 (88·24%)	11 (100%)	3 (100%)	104 (89·65%)
Apparent failures	12 (11·76%)	0	0	12 (10·35%)

middle ear pressures (5·17 per cent) at a pressure equivalent of 3 metres of water. These six failures were placed once again on conservative therapy for a further six weeks at the end of which time they once again failed to equilibrate their middle ear pressures. These six consistently had normal middle ear pressures, as confirmed by tympanometry. They were therefore made permanently unfit for SETT. Of the 116 candidates subjected to operation, 110 (94·83 per cent) were able to equilibrate their middle ear pressures at an increased barometric pressure equivalent to 9 metres of water. The results are tabulated in Tables III and IV.

TABLE III

BREAKDOWN OF OPERATIVE RESULTS INTO SPECIALIZATIONS

	Submariners	Aircrew	Divers
Operations	102	11	3
Successes	96	11	3
Failures	6	0	0
% success	94·12%	100%	100%

TABLE IV

TOTAL RESULTS

Total operations	116
Total successes	110
Total failures	6
% operative success	94·83%

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Delineation of airflow in the post-nasal space in 25 candidates by use of Xenon 133 Scintigraphy

In November 1974 a method of assessing the airflow in the post-nasal space was devised in the Department of Nuclear Medicine, Royal Naval Hospital, Haslar. The patient inhaled Xenon 133 through his nose during normal respiration and a gamma ray scintillation camera was used to detect nuclear emissions from the Xenon 133. These were recorded on videotape.

Xenon 133 Scintigraphy was performed on 25 candidates suffering from the nose–ear distress syndrome. The candidates underwent Xenon 133 Scintigraphy pre-operatively and post-operatively. The subject having inhaled Xenon 133 was then requested to auto-inflate his middle ear clefts. All the subjects failed to introduce the Xenon 133 into their affected middle ears. Post-operatively the same procedure was performed. 24 subjects (96 per cent) successfully auto-inflated their middle ear clefts, this being demonstrated by the presence of Xenon 133 in the middle ears. It was clearly seen pre-operatively that on inhalation of the Xenon 133 there was marked turbulence of the airflow in the post nasal space. Post-operatively (there now being no nasal septal deviation) the airflow in the post-nasal space did not exhibit any turbulence.

Only one subject failed to auto-inflate his middle ear cleft and persistently failed after further conservative treatment.

Combined results

The combined total of candidates involved in the survey was 145. Four candidates refused treatment. The total number who were subjected to adequate submucous resection of the cartilaginous and bony nasal septum was 141. Of the 141 candidates, 134 (95·04 per cent) were able to successfully equilibrate their middle ear pressures when subjected to an increase in barometric pressure equivalent to 9 metres of water. 7 candidates failed to equilibrate their middle ear pressures at an increase in barometric pressure equivalent to 3 metres of water (4·96 per cent).

There was a 100 per cent success recorded in the Aircrew and Divers groups, while in the group of submarine candidates there was an overall success of 94·5 per cent. The results are tabulated in Table V.

TABLE V

BREAKDOWN OF COMBINED SERIES

	Submariners	Aircrew	Divers	Totals
Operations	127	11	3	141
Successes	120	11	3	134
Failures	7	0	0	7
% success	94·5%	100%	100%	95·04%

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Conclusion

We would like to emphasise that the conclusion we have drawn from this clinical trial is based on the assessable sequence of events which resulted from the correction of a readily recognizable septal deformity. We have assessed the post-nasal airflow using Xenon 133 and have shown that in the presence of a nasal septal deformity marked turbulence in the airflow in the post-nasal space is produced. In the series that we have investigated there has been also eustachian malfunction in association. We have also shown that the turbulence of the air flow in the post-nasal space may be abolished and normal eustachian function regained by adequate submucous resection of the nasal septum.

We would further conclude that a physiologically normal Eustachian tube is prohibited from fulfilling its normal function of equilibrating the middle ear pressure, not by any inherent pathology as a result of distortion of the air current delivered to the nasopharyngeal orifice of the Eustachian tube, due to abnormality of the nasal airway.

We also believe that the turbulent airflow in the post-nasal space has a marked drying effect on the mucous film in the post-nasal space, especially in the region of the tubal orifice. This drying effect would increase the viscosity of the mucus at the tubal orifice, rendering it impossible for the mucous film to separate as it would do in a normal Eustachian tube, when the tube opens. Perlman (1951, 1967) has suggested, and experiments performed by Flisberg *et al.* (1963) confirm, that the tubal opening begins on the tympanic side of the Eustachian tube and proceeds to the nasopharyngeal opening and that the mucous film breaks towards the nasopharynx.

Clinical evidence of tubal normality in our series was gauged by the complete competence of the Eustachian tube to drain the middle ear clefts involved; there were no cases of secretory otitis media or glue ear in any of the candidates surveyed. Also, tympanometry in all the cases produced normal middle ear pressure and normal tympanometric curves.

The success rate that we have achieved, we believe, confirms the hypothesis from which this work first originated. We are not suggesting that submucous resection of the nasal septum should be performed in all cases of eustachian malfunction. But what we do suggest is that, in cases of eustachian malfunction in which there is no history of paranasal sinus disease or allergic rhinitis, but where there is some degree of nasal septal deformity found on examination, be it mild or gross, adequate resection of the cartilaginous and bony septum will be of marked benefit.

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