

Roentgenographic Evaluation of Eustachian Tube Function in Infants with Cleft and Normal Palates

With Special Reference to the Occurrence of Otitis Media

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Middle ear fluid is almost invariably present in infants with unrepaired cleft palate and is persistent throughout infancy (1, 2, 3). It seems reasonable to assume that this may be associated with some abnormality of the Eustachian tube. In an attempt to evaluate both the structure and function of the Eustachian tube in these and other infants, a roentgenographic investigation of the nasopharynx, Eustachian tube, and middle ear was undertaken utilizing radiopaque contrast material and fluoroscopy with image intensification. Permanent records were obtained by means of video tapes and spot roentgenograms. The techniques used were modifications of those previously described by Wittenborg and Neuhauser (4), and by Compere (5).

Subjects and Method

During the past year, roentgenographic study of the Eustachian tube has been carried out in 74 infants and children. Their age range was from seven days to eight years but most were under two years of age.

Selection was initially random, but patients were later divided into three groups. Group 1 consisted of 25 children with unrepaired cleft palates, and Group 2, of 42 children with normal palates. All patients in these two groups had at one time or another received a myringotomy with fluid aspiration and tympanostomy tube insertion because of chronic or recurrent secretory otitis media. In some of them tubes were still in place; in others they had been extruded, with or without reaccumulation of middle ear fluid.

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Group 3 was composed of seven children who served as controls; they had no history of ear disease, and normal tympanic membranes.

Roentgenographic studies were performed with patients restrained, but unanesthetized and unsedated. Each child was placed on the fluoroscopy table in the supine position with shoulders and trunk elevated on a specially designed holder, and with head and neck in posterior extension. This position was found to afford optimal projection for visualization of the nasopharynx-Eustachian tube-middle ear-mastoid complex. A verticosubmental spot roentgenogram was obtained for later comparison. With the patients still in this position, 10 to 20 c.c. of a radiopaque contrast medium, sodium diatrizoate-50% weight/volume (viscosity 2.62 cps at 37°C), were slowly instilled through the nose with a soft rubber catheter under image-intensification fluoroscopic guidance, in order to coat the nasopharynx and to initiate repeated swallowing activity. Retrograde flow of the medium from the nasopharynx into the Eustachian tube was then observed on the television monitor. The examination usually lasted less than five minutes, since during that time 30-40 swallows could be observed. At the completion, a spot roentgenogram was obtained. The entire study was permanently recorded on video-tape (6).

The patient was then turned to the prone position for the prograde clearance study. If contrast material had entered the protympanic portion of the Eustachian tube and the middle ear during the foregoing retrograde examination, the patient was kept in the prone position for 10 minutes, a final submentovertical spot roentgenogram was obtained, and the degree of clearance of the contrast material from the middle ear was now noted.

If contrast material had not previously entered the middle ear, and if a tympanostomy tube was in place, some additional contrast material was instilled through the tube by means of a small bore needle. If the material had not cleared from the middle ear within 10 minutes, or if, on the other hand, it did clear, with good visualization of the middle ear and protympanic portion of the Eustachian tube, the study was terminated. However, if this low-viscosity medium cleared so rapidly that the Eustachian tube could not be adequately visualized, contrast medium of higher viscosity (sodium diatrizoate-90% weight/volume, 18.54 cps at 37°C, or iophendylate, 46.4 cps at 37°C) was introduced, and its clearance, or failure to clear, was observed.

This combined, roentgenographic study of the Eustachian tube, consisting of an evaluation of both retrograde function and prograde clearance, has been described in further detail elsewhere (3).

The *retrograde* function of the Eustachian tube at its nasopharyngeal end was classified into the following three types:

1. *Normal Retrograde Function*—at rest the normal Eustachian tube remained functionally closed, with no contrast material entering it. With each swallow, however, the tube opened, and radiopaque me-

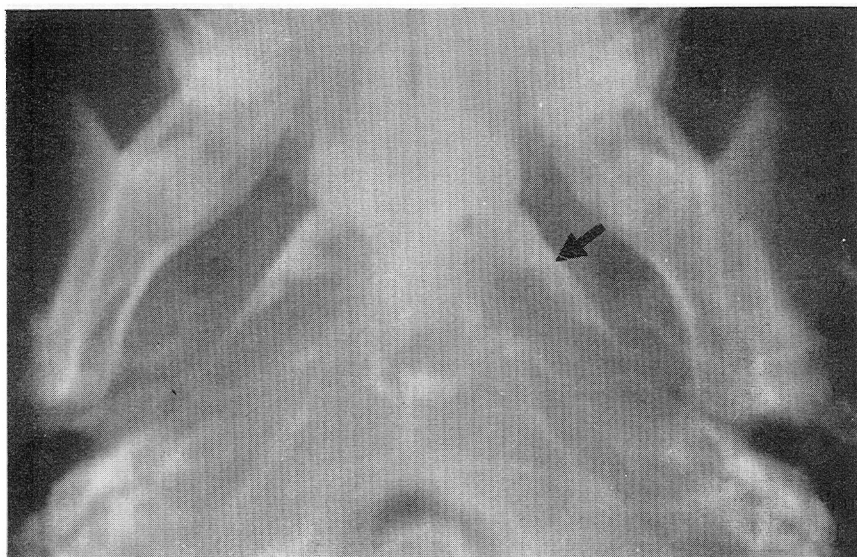


FIGURE 1. Normal retrograde function. During swallowing, radiopaque contrast material fills the nasopharyngeal portion of the Eustachian tube (arrow) of a child with a normal palate and normal tympanic membranes.

dium spurted jet-like into the proximal one-third or one-half of the tube and then immediately returned (Figure 1).

2. *Retrograde Obstruction*—the Eustachian tube was considered obstructed if (a) contrast material failed to enter the tube upon repeated swallowing over a period of five minutes (Figure 2), or, (b) the Eustachian tube opened only once or twice during the examination, with a smaller, or barely visible, stream traveling a shorter distance than in the normally functioning tube.

3. *Retrograde Reflux*—retrograde reflux was noted when, upon swallowing, contrast media traversed the entire length of the Eustachian tube and appeared to reflux into the protympanic portion of the Eustachian tube and the middle ear (Figure 3).

In the *prograde* studies, if contrast material cleared from the mastoid, middle ear, and protympanic portion of the Eustachian tube into the nasopharynx within 10 minutes, clearance was considered satisfactory. If not, and if the protympanic portion of the Eustachian tube could be visualized and appeared patent, the study was considered to indicate prograde obstruction of the Eustachian tube.

Results

The results of the retrograde function and prograde clearance studies in the three groups are described below, and summarized in Table 1.



FIGURE 2. Retrograde obstruction. During swallowing, contrast material fails to enter the Eustachian tube of a child with large adenoids and chronic secretory otitis media.

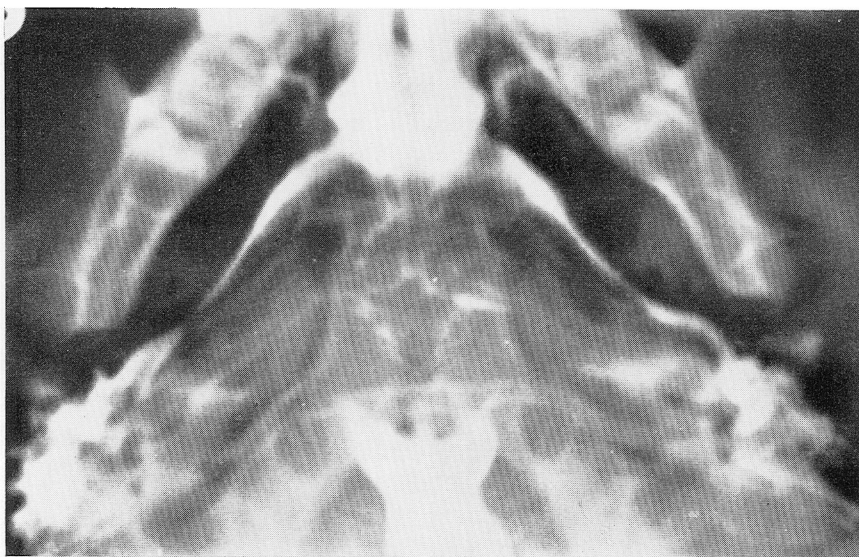


FIGURE 3. Retrograde reflux. During swallowing, radiopaque contrast material fills the Eustachian tube and middle ear.

TABLE 1. Roentgenographic studies of the Eustachian tube: prograde clearance and retrograde function in 74 patients.

<i>retrograde function</i>	<i>number of Eustachian tube/middle ears</i>				
	<i>group 1 unrepaired cleft palate (25 patients)</i>		<i>group 2 normal palate, prior middle ear fluid (42 patients)</i>		<i>group 3 controls (7 patients)</i>
	<i>prograde</i>		<i>prograde</i>		<i>prograde</i>
	<i>clearance</i>	<i>obstruct</i>	<i>clearance</i>	<i>obstruct</i>	<i>not tested</i>
normal	0	0	24	0	14
obstructed	42	2	3	27	0
reflux	0	0	9	0	0
total	44		63		14

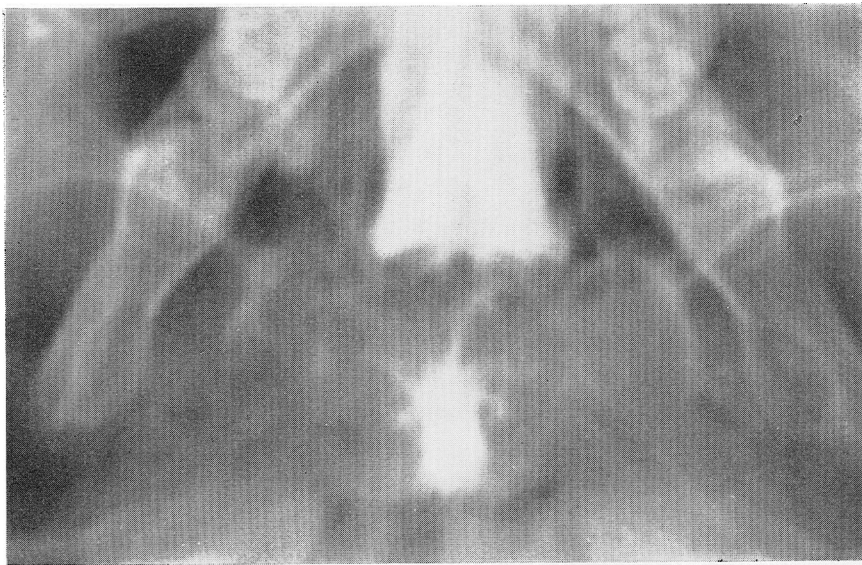


FIGURE 4. Retrograde obstruction in a child with cleft palate. During swallowing, radiopaque contrast material fails to enter the Eustachian tube.

Group 1—Unrepaired Cleft Palate. After instillation of low-viscosity radiopaque medium into the nasopharynx of 25 patients with unrepaired cleft palate, *retrograde* flow into the Eustachian tube consistently failed to occur, suggesting that the nasopharyngeal orifice of the tube was either blocked or not opening in this group of patients (Figure 4). On the other hand, *prograde* clearance of contrast material from the middle ear occurred in 42 of 44 ears, but the degree of clearance varied with the

viscosity of the medium. In many instances the aural orifice and protympanic portion of the Eustachian tube were visualized and appeared patent.

Group 2—Normal Palate, Prior Middle Ear Fluid. The findings were variable in this group of 42 patients in whom 63 ears were studied. About half the ears (33) showed normal *prograde* clearance associated with either normal or reflux *retrograde* function, while slightly fewer (27) showed a combination of *prograde* and *retrograde* obstruction (Figure 4). In three instances there was good *prograde* clearance despite *retrograde* obstruction.

Group 3—Controls. All the patients with normal tympanic membranes and no history of ear disease had normal *retrograde* function bilaterally. *Prograde* clearance could not be studied in the children in this group, as contrast material did not enter the middle ear in any of them during the retrograde study.

Discussion

In a previous investigation (3) radiopaque contrast media were instilled at the time of myringotomy into the middle ears of infants with unrepaired cleft palates who had middle ear fluid. Roentgenographic study revealed that obstruction at the aural end of the Eustachian tube appeared to prevent *prograde* clearance of the media. However, when the studies were repeated two weeks or more after removal of the middle ear fluid, aeration, and intubation, *prograde* clearance of the media from the middle ear and Eustachian tube usually now occurred, but clearance varied with the viscosity of the medium. The aural orifice and protympanic portion of the Eustachian tube were visualized and appeared patent. *Retrograde* obstruction was a regular finding. The present study confirms and extends those preliminary findings: infants with unrepaired cleft palates whose middle ears have been aerated usually have good *prograde* clearance from the middle ear, but they invariably show *retrograde* obstruction of the Eustachian tube.

By contrast, in the group of patients with normal palates who had had middle ear disease, but whose middle ears had been intubated and aerated, *retrograde* obstruction of the Eustachian tube, when it occurred, was usually associated with *prograde* obstruction (and correspondingly, normal *retrograde* function was invariably associated with *prograde* clearance).

The significance of the *retrograde* reflux found in 9 of 63 Eustachian tubes studied in this group of infants remains unclear; this finding is currently receiving further study.

In the infants and children studied, the nasopharyngeal orifice of the Eustachian tube appears to act as a one-way valve. Fluid (and presumably, air) is able to clear passively in a *prograde* direction from the tube into the nasopharynx, but the orifice must open actively to allow the *retrograde* flow of fluid, or probably, air. Since normal opening appears to depend on contraction of the tensor palati (7, 8), this muscle's failure to

function effectively, for whatever reason, may be integrally involved in the retrograde Eustachian tube obstruction of infants with cleft palate. Such obstruction must result in persistent inability to maintain middle ear aeration, which eventuates, in turn, in chronic secretory otitis media.

Summary

In an attempt to evaluate the structure and function of the Eustachian tube in infants with cleft and normal palates, roentgenographic investigation of the nasopharynx, Eustachian tube, and middle ear-mastoid area was undertaken.

In a group of infants with normal palates and middle ears, and no history of middle ear disease, the nasopharyngeal orifice of the Eustachian tube was observed to open with every swallow, allowing retrograde entry of radiopaque medium into the nasopharyngeal portion of the tube, followed by almost immediate clearance.

By contrast, in infants with unrepaired cleft palates, the nasopharyngeal orifice of the Eustachian tube failed to open on swallowing, so that retrograde flow of contrast medium into the tube did not occur. This finding was constant whether or not at the time of study the infants' middle ears were aerated by means of a functioning tympanostomy tube. In this same group of infants, however, when radiopaque contrast material was instilled through a previously inserted tympanostomy tube into an aerated middle ear, prograde clearance of the material from the middle ear and Eustachian tube into the nasopharynx could be observed.

In a third group of infants with normal palates who had previously had middle ear disease and whose middle ears were now intubated and aerated, retrograde obstruction of the Eustachian tube occurred in slightly fewer than half the cases; when it occurred, it was usually associated with prograde obstruction.

In the present study, abnormal Eustachian tube function occurred in association with middle ear disease in infants and children with both cleft and normal palates, but the type of abnormality appeared different in the two groups: those with cleft palates invariably demonstrated obstruction at the nasopharyngeal end of the Eustachian tube, but the obstruction was of a one-way, functional type, i.e. to retrograde flow only; those with normal palates, on the other hand, if they had obstruction at all, tended to have roentgenographic findings compatible with two-way, mechanical obstruction.

Inability to maintain middle ear aeration, due in turn to inability to open the nasopharyngeal end of the Eustachian tube, is probably an important, if not the major factor in the pathogenesis of middle ear disease in infants with unrepaired cleft palate.

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References

1. STOOL, S., and RANDALL, P., Unexpected Ear Disease in Infants with Cleft Palate, *Cleft Palate J.*, *4*, 99-103, 1967.
2. PARADISE, J. L., BLUESTONE, C. D., and FELDER, H., The Universality of Otitis Media in Fifty Infants with Cleft Palate, *Pediatrics*, *44*, 35-42, 1969.
3. BLUESTONE, C. D., Eustachian Tube Obstruction in the Infant with Cleft Palate. Presented as a Candidate's Thesis to The American Laryngological, Rhinological, and Otological Society, Inc., October, 1970. *Annals Otol.*, Supplement No. 2, 1-30, August, 1971.
4. WITTENBORG, M. H., and NEUHAUSER, E. B. D., Simple Roentgenographic Demonstration of Eustachian Tubes and Abnormalities, *Amer. Jour. Roentgen.*, *89*, 1194-1200, 1963.
5. COMPERE, W. E., JR., The Radiologic Evaluation of Eustachian Tube Function, *A.M.A. Archives Otolaryngology*, *7*, 386-389, 1960.
6. GIRDANY, B. R., and GAITHER, E. S., Televex-Tape-Kinescopy and Cineradiography, *Radiol.*, *79*, 752-754, 1962.
7. RICH, A. R., Physiological Study of Eustachian Tube and Its Related Muscles, *Bul. Johns Hopkins Hospital*, *31*, 206-214, 1920.
8. HOLBOROW, C. A., Deafness Associated with Cleft Palate, *J. Laryng. Otolaryng.*, *76*, 762-773, 1962.