Oral and Respiratory Flora of Individuals with Normal and Repaired Palatal Clefts

JAMES J. CRAWFORD, B.A., M.A., Ph.D.
NEWTON D. FISCHER, B.S., M.D
Chapel Hill, North Carolina 27514

Introduction

High incidences of recurrent upper respiratory infections, middle ear infections and mild to severe hearing loss have been reported among children with palatal clefts (*10, 11, 18, 22*).

In our cleft palate speech and dental rehabilitation clinics, we have observed many children with palatal clefts who continue to exhibit signs of chronic upper respiratory infections and recurrent middle ear infections despite previous surgical closure of their palatal clefts. While anatomical deficiencies of the Eustachian tubes and nasal passages that impair adequate drainage are strongly implicated in these conditions, little detailed evidence is available to define the varieties of bacteria in the oropharyngeal and nasal passages of these individuals that may be involved in or contribute to these conditions (*18*).

Before surgical closure of palatal clefts, the nasal passages are open to extensive contamination by heavy populations of aerobic and anaerobic bacteria in the saliva. Preliminary bacteriologic examination of five patients with unrepaired palatal clefts revealed bacteria in the exposed nasal passages in four that closely resembled the aerobic flora of the oral cavity. We wished to learn whether palatal closure establishes separation of the oral flora from the nasal passages comparable to that seen in individuals without palatal defects. If separation is not achieved, to what extent is the nose parasitized by pathogenic oral yeasts and anaerobic microbial species that can produce disease in oral and systemic tissues (*4*)? We also wished to determine whether pathogenic bacteria for the upper respiratory passages and the middle ear were unusually prevalent in the oropharynx and nasal passages of patients with repaired clefts.

A culture medium developed for this study has proven effective to

James J. Crawford, Ph.D., is Associate Professor, Department of Endodontics, Dental Research Center, University of North Carolina School of Dentistry and Newton D. Fischer, M.D., is Professor of Surgery, Division of Otolaryngology, University of North Carolina School of Medicine.

This paper was presented at the 26th Annual Meeting of the American Cleft Palate Association, Miami Beach, Florida, April 26, 1968.

This investigation was supported by PHS Research Grant No. DE02352 and in part by No. FE05333.

survey *Haemophilus* species pathogenic for the upper respiratory passages (*8*). This medium may be of value in epidemiologic studies and in assessing any efforts to control these organisms among cleft palate patients or other individuals with a high risk of infection.

Materials and Methods

SUBJECTS. Subjects studied consisted of two groups (I, II) of patients with repaired palatal clefts and a group (III) of control subjects.

Groups numbered I and II respectively consisted of 46 and 36 patients with surgically closed palatal clefts, ranging from 7 to 21 years of age. These were patients in temporary residence at Story Book Farm in Chapel Hill, N. C., receiving therapy in the University of North Carolina Cleft Palate and Speech Rehabilitation Program. Upper respiratory bacterial flora was monitored on a bi-weekly basis to aid early detection of pathogens among the resident patients.

Patients in Group I were surveyed in a pilot study to gain a working definition of their flora and to define suitable clinical and laboratory methodology and direction. More than half of the patients in Group I exhibited signs of chronic and repeated nasal irritation as well as frequent ear infections. Detailed clinical evaluations were not obtained for this group.

Patients in Group II were studied in greater detail. Twenty of these 36 patients had frequent or chronic ear infections or significant measurable hearing loss. The two conditions occurred together in 13 of the 20 patients. Among the remaining 7, two had frequent respiratory infections without ear infections, and records were not complete for five. Twenty-one of the 36 patients exhibited abnormal swelling of the nasal tissues, thick or purulent exudates and crusting in the nasal passages suggesting chronic low grade nasal infections.

Control subjects comprising Group III were 26 individuals without clefts of the palate or lip from the surrounding population, without respiratory illness ranging from 9 years of age to mature adults. Most were children from the public schools of Roanoke Rapids, N. C. For comparison, Groups II and III were examined by the same methods. Approximately 72% of individuals in these two groups were between seven and thirteen years of age, and had similar socio-economic backgrounds.

Sampling and Culturing Procedures. Samples were collected with swabs from three areas: (a) the oropharynx; (b) the floor of the anterior nasopharynx; and (c) the nasal vestibule and transported in broth (*6, 8*). Nasopharyngeal samples were collected via the nares with flexible wire swabs wrapped with alginate wool. (Consolidated Laboratories, Chicago Heights, Illinois.) Nasopharyngeal samples were collected in Groups II and III via an aural funnel inserted into the nares beyond the vibrissae to avoid staphylococcal contamination from the anterior nares.

Use of many selective culture media is not routine, but was found essential to the detection of all species sought: *Mitis-Salivarius* Agar

(Difco); selective agar for pathogenic *Neisseria* species (Difco); *Veillonella* agar (Difco) and selective agar for *Haemophilus* species (*8*).

Other varieties of bacteria and *Candida* yeasts were cultivated on two additional sheep blood agar plates under aerobic and anaerobic incubation.

Identification of Microorganisms. Each specimen was surveyed for 20 or more varieties of microorganisms. Aerobes were classified according to standard hospital laboratory procedures (*2*). Colony morphology was determined with a dissecting microscope. Gram positive non-chain forming cocci, other than *Staphylococcus aureus*, were designated as "micrococci". Streptococci common to the mouth such as *S. mitis* and *S. salvarius* were recorded as "non-pathogenic streptococci". *H. influenzae* and *Neisseria meningititidis* were not investigated in the nasal vestibule. Anaerobic *Neisseria* and *Veillonella* species were listed together. Other anaerobes were identified by standard characteristics and by production of catalase. (*4, 21*). Procedures to further characterize pathogenic species by serologic means were not utilized at this time.

Results

Table 1 lists a summary of bacteria cultivated from 62 samples that were collected from an initial survey of the respiratory passages of the 46 patients with repaired clefts in Group I.

Detailed results of the flora of 36 patients with repaired clefts (Group II) and 25 control subjects (Group III) are tabulated in Tables 2–7.

Organisms most common to the nasal passages (i.e., *S. aureus*, micrococci, and diphtheroids) were detected more frequently in the nasopharynx of the controls than the patients (Table 2, 3). Enteric and related gram negative rods (i.e., *Aerobacter-Klebsiella* species, *E. coli* and *Pseudomonas* species) of importance in middle ear infections were a little more

TABLE 1. Group I. Varieties of microorganisms detected in respiratory passages of 46 patients with repaired clefts

Microorganisms	*Area Sampled*		
	Oropharynx	*Nasopharynx*	*Nasal Vestibule*
Staphylococcus species	32%	52%	58%
Diphtheroids	6%	15%	13%
D. pneumoniae	13%	18%	11%
Haemophilus species	24%	16%	—
Neisseria species	47%	22%	13%
Streptococcus species (non-path.)	98%	47%	39%
Veillonella-Neisseria species	18%	0%	3%
Enteric Rods	6%	5%	5%
Bacteroides species	2%	2%	2%
Number of Specimens	62	62	62

TABLE 2. Group II. Varieties of microorganisms detected in respiratory passages of 36 patients with repaired clefts

Microorganisms	*Area Sampled*		
	Oropharynx	*Nasopharynx*	*Nasal Vestible*
Staphylococcus aureus	10%	35%	59%
Micrococci	19%	26%	46%
Diphtheroids	21%	25%	43%
Streptococcus pyogenes	0%	0%	0%
Aerobacter-Klebsiella species	4%	7%	3%
E. coli	3%	4%	2%
Pseudomonas species	2%	0%	0%
Candida species	3%	3%	3%
Number of Specimens	68	72	61

TABLE 3. Group III. Varieties of microorganisms detected in respiratory passages of 25 persons without clefts

Microorganisms	*Area Sampled*		
	Oropharynx	*Nasopharynx*	*Nasal Vestible*
Staphylococcus aureus	20%	47%	61%
Micrococci	20%	35%	52%
Diphtheroids	34%	50%	42%
Streptococcus pyogenes	3%	0%	0%
Aerobacter-Klebsiella species	0%	3%	0%
E. coli	0%	3%	0%
Pseudomonas species	0%	0%	0%
Candida species	0%	3%	0%
Number of Specimens	35	34	31

frequently detected as a whole in the patients than in controls (Table 2, 3).

Common oral *Streptococcus* and *Neisseria* species were more frequently detected in the nasopharynx of patients than of controls (Table 4, 5).

Anaerobic species associated with oral and gingival diseases were detected generally infrequently in the nasopharynx of both groups (Table 6, 7). These were also detected to a lesser extent in the oropharynx of the patients than of the controls.

Respiratory pathogens, *Diploccus pneumoniae* and *Haemophilus* species, showed a high incidence in both patients and controls, all being slightly more frequent in the patients (Table 4, 5). When the presence of either *D. pneumoniae* or *Haemophilus* species or both was considered, 45%

TABLE 4. Group II. Varieties of microorganisms detected in respiratory passages of 36 patients with repaired clefts

Microorganisms	*Area Sampled*		
	Oropharynx	*Nasopharynx*	*Nasal Vestible*
D. pneumoniae	25%	22%	11%
Haemophilus species (path.)	40%	19%	15%
Neisseria meningitidis	7%	1%	—
Haemophilus species (hemolytic)	18%	4%	2%
Neisseria species (non-path.)	82%	46%	43%
Streptococcus species (non-path.)	98%	49%	36%
Number of Specimens	68	72	61

TABLE 5. Group III. Varieties of microorganisms detected in respiratory passages of 25 persons without clefts

Microorganisms	*Area Sampled*		
	Oropharynx	*Nasopharynx*	*Nasal Vestibule*
D. pneumoniae	23%	21%	13%
Haemophilus species (path.)	37%	12%	10%
Neisseria meningitidis	14%	3%	0%
Haemophilus species (hemolytic)	17%	0%	0%
Neisseria species (non-path.)	86%	38%	39%
Streptococcus species (non-path.)	100%	35%	32%
Number of Specimens	35	34	31

TABLE 6. Group II. Varieties of microorganisms detected in respiratory passages of 36 patients with repaired clefts

Anaerobic Microorganisms	*Area Sampled*		
	Oropharynx	*Nasopharynx*	*Nasal Vestibule*
Veillonella-Neisseria species	27%	6%	15%
Fusobacterium species	12%	3%	2%
Actinomyces-Bacterionema species	6%	1%	1%
Leptotrichia buccalis	2%	3%	2%
Bacteroides species	3%	4%	3%
Number of Specimens	68	72	61

TABLE 7. Group III. Varieties of microorganisms detected in respiratory passages of 25 persons without palatal clefts

Anaerobic Microorganisms	*Area Sampled*		
	Oropharynx	*Nasopharynx*	*Nasal Vestibule*
Veillonella-Neisseria species	43%	9%	6%
Fusobacterium species	49%	6%	0%
Actinomyces-Bacterionema species	3%	0%	0%
Leptotrichia buccalis	14%	3%	0%
Bacteroides species	3%	3%	3%
Number of Specimens	35	34	31

of nasopharyngeal specimens from the patients were positive, as compared with 33% from controls.

H. influenzae was detected approximately four times more frequently than *H. parainfluenzae* in both groups.

The more virulent *H. influenzae* comprised 78% of *Haemophilus* species detected in the oropharynx of patients and 54% of *Haemophilus* species in the control subjects. These differences were not significant for the population sizes examined. They do indicate a trend that has been significantly borne out in subsequent studies.

Streptococcus pyogenes was of particular concern because of its ability to initiate acute pharyngitis, to become involved in otitis, and to produce rheumatic fever. This organism was not detected in a carrier state or in association with acute or chronic respiratory diseases among the patients in Group I or II (Table 2). In similar groups totaling about 100 patients surveyed subsequent to Groups I, II, and III, *S. pyogenes* was detected in six instances over a two-year period. These instances coincided with outbreaks of streptococcal pharyngitis in the community. Treatment of these patients controlled spread of the infections in the groups.

Passing the flexible nasopharyngeal swabs through a sterile speculum inserted into the nasal vestibule to avoid bacteria in the nasal vestibule produced some, but not a statistically significant, effect in reducing the incidence of *S. aureus* detected in the nasopharyngeal specimens in Groups II and III as compared with Group I (Tables 1, 2, 3). The difference may have been significant on a quantitative basis, but that was not determined.

The extent of parasitization of the nasopharynx by one or more species was also considered. Only three of the nasopharyngeal specimens from the Group II patients and none of the specimens from Group III control subjects were actually sterile. Single bacterial strains were detected in six samples from the Group II patients consisting of one nonpathogenic *Neisseria* strain and five strains of *S. aureus*. Only four specimens from the control group yielded single bacterial strains. These were *S. aureus, Neisseria, Streptococcus mitis,* and diphtheroid bacteria.

Infectious yeasts, i.e. *Candida albicans*, were not commonly detected in any of the groups (Tables 1, 2, 3).

Because *Candida* is frequently active in oral infections associated with wearing of dentures, five patients in Group II who wore speech appliances were examined a total of 26 times over a two-year period. On only one occasion, a 17-year-old female patient complained of irritation from her appliance. Examination revealed pruritis and erythema under the appliance from which a heavy growth of an infectious yeast, *Candida albicans*, was obtained.

Judged purely by clinical signs, acute upper respiratory viral infections appeared to occur no more frequently among the patients with repaired clefts than among children in the surrounding community and did not appear to account for the persistent nature of the chronic upper respiratory and middle ear conditions observed among the patients. However, viral infections appeared to contribute to the recurrence or increased severity of these conditions.

Discussion

Few published investigations have involved comprehensive efforts to survey the distribution of the bacterial flora throughout the oral and upper respiratory passages. The data presented provide a working definition of the detectable bacterial flora at a level of characterization feasible in a broad survey.

The results are of basic and clinical interest with particular regard to the persistent upper respiratory problems in the cleft palate patients studied.

One basic concern centered about whether the disturbed palatal anatomy and surgical intervention might have predisposed to growth of bacteria or fungi ordinarily considered foreign to the respiratory passages of individuals without palatal clefts. No such unusual microorganisms were detected by the anaerobic and aerobic culture methods employed. Those detected were in general agreement with the microflora of subjects without palatal defects (*7, 12, 13, 14, 15, 16, 23, 25*).

Another previously unexplored aspect was the possible effect of the disturbed oro-nasal anatomy on the distribution of the flora in the same passages. Of particular concern was whether the nasal passages and middle ear might have become parasitized by microaerophilic and anaerobic oral bacteria in the saliva, which organisms are capable of producing considerable local tissue response when displaced into pulmonary or systemic tissues, as seen in bronchiectasis or actinomycosis. Such bacteria produce considerable disease in the oral tissues that surround and support the teeth when allowed to accumulate uncontrolled in the gingival crevices (*4*). Only one anaerobic species has been frequently detected in human nasal passages (a diphtheroid) (*25*).

It appears that most oral anaerobes do not tend to survive long in the normal nasal passages as a result of possible accidental displacement

(Table 7). Results obtained from the patients (Table 6) suggest a lack of frequent regurgitation of saliva and oral bacteria into their nasal passages. Rare or infrequent displacement of contamination would not necessarily be ruled out. Some of the patients retained velopharyngeal insufficiencies for speech, but these could not be related specifically to any unusual distribution of anaerobic oral microflora.

Faulty function of the Eustachian tube could provide a suitable cavity in which to harbor oral anaerobes that may at one time or another find their way into nasal passages, e.g., from sneezing or when lying asleep. Little is still known about the actual involvement of anaerobic species in infections of the nasal sinuses and the middle ear in man. This was not specifically investigated in the present study.

Streptococcus pyogenes was of some clinical concern because of its tendency to initiate acute pharyngitis and rheumatic fever in children over three in the absence of other potentiating conditions (*9*). Carriers of *S. pyogenes* have been reported in other studies to range from 0.1 to 8% (*17, 21*). It was encouraging to learn that the patient groups examined showed no tendency toward an unusual carrier rate of this species. When this particular pathogen was detected in patients groups, it was associated with acute pharyngitis that coincided with outbreaks in the community at large.

Haemophilus species and *Diplococcus pneumoniae* were of concern because they are commonly involved as pathogens in mild to severe respiratory and middle ear infections. *H. influenzae* and *D. pneumoniae* are often recovered from mastoiditis, bronchitis, pneumonia or meningitis among children and adults (*1, 5, 9*). Involvement of *H. influenzae* in chronic obstructive bronchial disease has been recently stressed (*1*).

It is of interest that both patients and controls exhibited a rather high incidence of *Haemophilus* and *D. pneumoniae* bacteria. They parasitized controls without apparent signs of infection, while in the patient group they were associated with a high incidence of nasopharyngeal irritation. In fact, these same organisms were repeatedly detected in the patients over periods of weeks or months in some instances. This supports the concept that the cleft palate patient suffers from parasitization of his nasal passages with respiratory pathogens, with which he cannot adequately cope because of his altered upper respiratory anatomy and physiology.

Further studies (unpublished) have shown significant increases in numbers of respiratory bacteria and pathogens in the upper respiratory passages of the patients with signs of persistent upper respiratory irritation.

Speech appeared to improve in one patient with a marked velopharyngeal insufficiency when her nasal passages became occluded by an upper respiratory infection with *D. pneumoniae*. This suggested that sudden spontaneous speech improvement in such patients be considered as a possible sign of respiratory infection rather than just an indication of more effective effort on the part of the patient or of the speech therapist.

Whether *Haemophilus* and *D. pneumoniae* were involved in the middle ear infections of patients in the present study can only be inferred from detection of these pathogens in their upper respiratory passages. It is not uncommon to find a specimen taken from the nasopharynx to be positive while another taken by myringotomy is sterile. Support for the involvement of these pathogens derives especially from clinical findings of Mortimer and Watterson that bacteria involved in middle ear infections are also detectable as part of the flora in the patient's posterior nasal passages (*19*). *H. influenzae* has also been reported from a middle ear infection in a child with a palatal cleft (*26*). Similar pathogens are detected in infected ears of children and adults without palatal clefts. These include *H. influenzae, S. pyogenes, S. aureus* and *D. pneumoniae*. Studies for *Mycoplasma* species and viruses were negative (*12*). Chronic mastoiditis in children with normal palates involves the same organisms with the exception of *S. pyogenes,* but includes *Pseudomonas* and other gram negative enteric bacteria and *Candida* yeasts (*20*). Chronic purulent sinusitis, a condition described among 11–30 year old individuals without clefts, also involves *H. influenzae* and *D. pneumoniae* as the main detectable pathogens (*16*).

The actual extent to which various deformities among the control subjects and patients influenced nasal carriage of bacterial species was not investigated in the present study.

A relatively high incidence (50%) of nasal deformities is observable among subjects with normal palates while an even higher incidence of more severe nasal deformities is observable among patients with palatal clefts (*24*).

In persons without palatal clefts, upper respiratory infections with *Haemophilus* species and *D. pneumoniae* are believed by some to be mainly secondary to respiratory viral infections (*5, 9*). It is generally accepted that any disturbance of normal self-cleansing mechanisms can predispose to infections by local bacteria. This would apply to disturbances in developmental respiratory anatomy as readily as disturbances created by viral infection. Periodic acute upper respiratory infections with sudden onset, resembling viral infections appeared to aggravate the upper respiratory conditions in the patients with repaired clefts. However, most exhibited unusual difficulty in reestablishing control of their respiratory health.

Palatal surgery and physical growth of the patient can reduce the incidence of middle ear infections (*10, 18*). The effects of both of these factors apparently were not sufficient to produce normal physiology and to eliminate the recurrent and persistent respiratory and middle ear infections in the groups of patients examined in this present study. Nor do various available therapeutic measures alter patients' immunity (*3*).

While much worthwhile study is being directed towards prevention of viral infections, reason for greater interest in the prevention of infections caused by *D. pneumoniae* and *H. influenzae* and related bacterial pathogens among groups of persons with increased risk of infection has been recently stressed (*1*). Renewed development of preventive measures to

control *D. pneumoniae* that were abandoned with the advent of penicillin has been made public by the United States Public Health Service. Some measures developed for the present study (*8*) (as well as an unpublished improved serologic test for typing strains of *H. influenzae*) may prove useful in the development and evaluation of a *Haemophilus* vaccine. The benefit of bacterial immunizations to help control or prevent the particular infections observed in the patients with repaired palatal clefts associated with impaired upper respiratory clearance and ventilation of the middle ear will remain to be evaluated.

Acknowledgements: We wish to acknowledge the assistance and consultation service of Mr. Mark Johnson, Department of Biostatistics, University of North Carolina School of Public Health. We would also like to acknowledge Dr. Donald W. Warren, Dental Research Center, Department of Ecology, University of North Carolina School of Dentistry, Dr. Erle E. Peacock, Department of Surgery, University of North Carolina School of Medicine and the staff of the University of North Carolina Cleft Palate and Speech Rehabilitation Center for their cooperation in this study, and Richard Noel, Louise Barden, and Edward Sayre for their laboratory assistance. Consultation of members of the Department of Pediatics, University of North Carolina School of Medicine is also gratefully acknowledged.

Bibliography

1. Austrian, Robert, The flora of the respiratory tract. Some knowns and unknowns. *Yale J. of Biology and Medicine, 40,* 400–413, 1968.
2. Bailey, W. R. and E. G. Scott, *Diagnostic Microbiology.* C. V. Mosby Co., St. Louis, pp. 75–286, 1962.
3. Bauer, F., Treatment of "glue ear" by intratympanic injection of urea. *Jour. Laryng. 82,* 717–722, 1968.
4. Burnett, G. W. and H. W. Scherp, *Oral Microbiology and Infectious Disease.* Williams & Wilkins Co., Baltimore, 3rd ed. pp. 273–524, 1968.
5. Chanock, R. M., and R. H. Parrott, Acute respiratory disease in infancy and childhood. *Pediatrics 36,* 21–29, 1965.
6. Commission on acute respiratory diseases (In collaboration with Mickle, W. A. and Oliver, T. J.), Problems in determining the bacterial flora of the pharynx. *Proc. Soc. Exper. Biol. & Med. 69,* 45–52, 1948.
7. Commission on acute respiratory diseases (In collaboration with Plummer, N.) Problems in determining the bacterial flora of the pharynx. *Proc. Soc. Exper. Biol. & Med. 69,* 45–52, 1948.
8. Crawford, J. J. and J. B. Kirkman, Jr., Selective medium to survey the incidence of *Haemophilus* species. *Appl. Microbiol. 18,* 646–649, 1969.
9. Glezen, W. P., W. A. Clyde, R. J. Senior, C. I. Sheaffer, and F. W. Denny, Group A streptococci, mycoplasmas and viruses associated with acute pharyngitis. *Jour. A.M.A. 202,* 455–460, 1967.
10. Graham, M. D., Longitudinal study of ear disease and hearing loss in patients with cleft lips and cleft palates. *Ann. Otol., Rhinol. and Laryngol., 73,* 34–47, 1964.
11. Graham, M. D., J. W. Scheiger, and W. H. Olin, Hearing loss and ear disease in cleft palate patients with obturators. *Plast. & Reconst. Surg. 30,* 348–358, 1962.
12. Grönroos, J. A., A. E. Kurtekangas, L. Ojala, and M. Vuori, The etiology of acute middle ear infections. *Acta Otolaryng. 58,* 149–158, 1964.
13. Harvey, H. S. and M. B. Dunlap, Seasonal prevalence of upper respiratory pathogens. *New Eng. Jour. of Med., 264,* 684–686, 1961.
14. Jacobson, L. O. and G. F. Dick, Normal and abnormal bacterial flora of the nose. *Jour. A.M.A. 117,* 2222–2225, 1941.

15. KAPLAN, S. W., B. LARKIN, and R. HOTZ, A method for estimating the bacterial population of the oropharynx. *Jour. Lab. & Clin. Med., 50,* 330–334, 1957.
16. KINMAN, J., C. W. LEE, and S. H. PARK, Bacterial flora in chronic purulent maxillary sinusitis. *Acta Otolaryng. 64,* 37–44, 1967.
17. LODA, F. A., W. A. CLYDE, W. P. GLEZEN, R. J. SENIOR, C. I. SHEAFFER, and F. W. DENNY, JR., Studies on the role of viruses, bacteria and M. pneumoniae as causes of lower respiratory tract infections in children. *Jour. Ped. 72,* 161–176, 1968.
18. MASTERS, F. W., H. G. BINGHAM, and D. W. ROBINSON, The prevention and treatment of hearing loss in the cleft palate child. *Plast. and Reconst. Surg. 25,* 503–509, 1960.
19. MORTIMER, E. A. and R. L. WATTERSON, A bacteriologic investigation of otitis media in infancy. *Pediatrics 17,* 359–366, 1956.
20. PALVA, T., I. FRIEDMANN, and A. PALVA, Mastoiditis in children. *Jour. Laryng. 78,* 977–991, 1964.
21. ROSEBURY, T., *Microorganisms Indigenous to Man.* McGraw-Hill Book Co., N. Y., Chapt. 10, 310–330, Chapt. 3, 48–98, 1962.
22. SKOLNIK, E. M., Otologic evaluation in cleft palate patients. *The Laryngoscope 68,* 1908–1949, 1958.
23. TURK, D. C., Nasopharyngeal carriage of *Haemophilus influenzae* Type B. *Jour. Hyg. Camb. 61,* 247–256, 1963.
24. WARREN, D. W., L. F. DUANY, and N. D. FISCHER, Nasal pathway resistance in normal and cleft lip and/or palate subjects. *IADR Abstracts, 46th Gen. Meeting No. 445,* 149, 1968.
25. WATSON, E. D., N. J. HOFFMAN, R. W. SIMMERS, and T. ROSEBURY, Aerobic and anaerobic bacterial counts of nasal washings: Presence of organisms resembling *Corynebacterium acnes. Jour. Bact. 83,* 144–148, 1962.
26. YOUNG, A., The state of ears in children with cleft palate deformity. *Jour. Laryng. 82,* 707–716, 1968.