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Bacteriological Findings of Acute Maxillary Sinusitis in Young Adults

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Bacteriological findings in 339 sinus secretions obtained by puncture were investigated in 238 young adult patients with acute maxillary sinusitis. Aerobic and anaerobic cultures were performed immediately. A total of 76% of the secretions were positive. The most common pathogens isolated were *Haemophilus influenzae* (50%), *Streptococcus pneumoniae* (19%), *Streptococcus pyogenes* (5%), and *Branhamella catarrhalis* (2%). Coagulase-negative staphylococci and *Staphylococcus aureus* were isolated in 8 and 1% of the specimens, respectively. The staphylococci were almost invariably present in low numbers and, therefore, probably represented nasal contamination. Other aerobic species were found only occasionally. Anaerobes were isolated in 5% of the secretions. In one-half of these, a low concentration of *Propionibacterium acnes* was the sole anaerobe that was found, and it was usually mixed with a facultative organism (suggestive of contamination with nasal flora). Only 2% of the sinuses were considered to have true anaerobic infections (high concentrations of several species typical of anaerobic infection), indicating that anaerobes are not a significant cause of acute maxillary sinusitis in a young adult population. The high recovery of *H. influenzae* in this study indicates that aminopenicillins may be a more appropriate choice than conventional penicillin in the antimicrobial therapy of acute maxillary sinusitis (only 2 of 168 *H. influenzae* strains produced β-lactamase).

Upper respiratory tract infections may be complicated in 0.5 to 5% of cases by acute sinusitis (32). Since adults experience, on average, two to three upper respiratory infections per year, sinusitis is a relatively common affliction (11). Despite the frequency of infection, acute maxillary sinusitis (AMS) may be difficult to diagnose on clinical grounds only, since the main symptoms, malaise, tiredness, rhinitis, and fever, are also common in other respiratory infections (2, 11).

Identification of acute purulent sinusitis is important, because the infection in a closed space carries a risk of complications and may warrant an active therapeutic approach, including drainage of secretions and administration of antimicrobial agents (2, 8, 19, 30). Radiological examination is the most reliable method of diagnosing AMS and differentiating it from rhinitis (2, 12). Aspiration is important for the demonstration of secretions in the sinus (2) and for the identification of the specific etiology by culture, which may be useful as a guide for antimicrobial therapy (1, 6).

The etiology of acute purulent sinusitis is primarily bacterial. *Streptococcus pneumoniae* and *Haemophilus influenzae* are the main etiological agents and are present in over half of the cases of AMS (1, 6, 8, 11, 12, 17, 20, 21, 30).

Lately, *Branhamella catarrhalis* has also been implicated as a pathogen in sinusitis (4, 5, 7, 33, 34). *Streptococcus pyogenes* is a relatively uncommon pathogen in AMS, with frequencies of between 1 and 3% (1, 8, 11, 34). The role of *Staphylococcus aureus* as a sinus pathogen is now considered almost insignificant since antral aspirates have replaced irrigation specimens for etiological diagnosis (1, 20).

The role of anaerobes in chronic and dentogenic sinusitis is well established (10, 11, 28), but their occurrence in AMS is less clear (3, 6, 19, 29, 31, 33, 34).

The purpose of this study was to collect up-to-date information on the bacterial etiology of short-term AMS in a homogeneous population of young adults by paying special attention to the collection and processing of specimens. The results suggest that there is a need to reconsider the wisdom of using penicillin as the conventional therapy for AMS.

MATERIALS AND METHODS

Patients. The study group consisted of 238 consecutive patients with AMS; 9 were women and 229 were men (ages, 17 to 46 years; mean, 21 years) serving in the Finnish military service who were sent to the Ear, Nose, and Throat Department of the Central Military Hospital, Helsinki, between September 1983 and March 1986 for consultation and medical care. None of the patients had experienced symptoms for more than 3 weeks. AMS was clinically suspected in patients presenting with acute respiratory infection combined with symptoms and signs, including occurrence of nasal discharge, stuffiness, pain or sensation of pressure or fullness on maxillary sinus regions, and general symptoms such as fever and malaise. The diagnosis was confirmed by radiological examination performed at four conventional projections and at the tilted projection, when necessary. Only patients with abnormal sinus radiographs indicative or suggestive of air-fluid level (with or without mucosal thickening), full opacity of the sinus, or mucosal thickening (≥6 mm) were included in the study (2). Patients with a concomitant dental root canal infection suggesting dentogenic sinusitis were excluded. The patients had not received antimicrobial agents during the 2 weeks before the ear, nose, and throat examination or earlier for the present infection. Informed consent was obtained from the patients before the invasive procedures were performed.

Specimen collection. Altogether, 339 sinus secretion specimens were collected for bacteriological analysis by the methods used by Axelsson and Brorson (1). The area of the nasal cavity below the anterior part of the inferior turbinate was first sprayed with 10% xylocaine and then swabbed with

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a cotton-tipped pin soaked in 2% tetracaine to anesthetize and disinfect the portal of puncture. After 10 to 20 min a sterile puncture needle (diameter, 2 mm) connected to a 20-ml syringe was introduced into the maxillary antrum and aspiration was performed. If aspiration failed to yield any secretion, the needle was held in place and 1 to 2 ml of sterile physiologic saline was injected into the sinus and aspirated again. Air was expelled from the syringe and needle and the syringe containing the specimen was carefully plugged and transported within 5 min to the nearby Anaerobe Reference Unit of the National Public Health Institute, Helsinki, where it was processed immediately.

Culture and identification. In the laboratory the samples were inspected for macroscopic purulence (16a) and homogenized for about 10 s in the syringes by using a Vortex mixer (Vortex-Genie; model K-550-GE; Scientific Industries Inc., Bohemia, N.Y.). They were then inoculated with a calibrated loop (10 μl) onto the following media: blood and chocolate agar for the isolation of aerobes; crystal violet-nalidixic acid-gentamicin-agar (22) for the selective isolation of pneumococci; vitamin K_1 and hemin-supplemented, non-selective brucella blood agar for all anaerobes; kanamycin-vancomycin-laked blood-agar for *Bacteroides* sp.; neomycin-vancomycin-agar for fusobacteria (26); tryptic-soy-serum-bacitracin-vancomycin-agar (25) for *Actinobacillus actinomycetemcomitans* (now reclassified as *Haemophilus actinomycetemcomitans*) and corroding gram-negative anaerobes; and cadmium fluoride-acriflavine-tellurite-agar (35) for *Actinomyces* sp. A few drops of the specimen were also inoculated into supplemented thioglycolate broth for enrichment (26), and a drop (purulent part, when present) was smeared onto a microscopic slide for Gram staining to examine the number of leukocytes and the bacterial morphotypes (16a).

Aerobic cultures were incubated at 36°C in an atmosphere containing 5% CO_2 and examined after 24 and 48 h; anaerobic cultures were incubated in jars filled by the evacuation-replacement method with mixed gas (10% H_2, 10% CO_2, and 80% N_2) for up to 7 days, with examination every 48 h. The thioglycolate broth was subcultured aerobically and anaerobically when growth appeared or after 5 days if no growth was visible. The isolated aerobic bacteria were quantitated, identified, and typed by standard methods (18). Coagulase-negative staphylococci were not typed further by biochemical tests. Anaerobic cultures were processed and identified by the methods of Sutter et al. (26) and Holdeman et al. (15). Nitrocefin disks (Biodisk AB, Solna, Sweden) were used to test the β-lactamase production of isolates. Viral cultures were not performed. Paired sera for viral serology were drawn, and the results will be published separately (S. Savolainen, J. S. Ylikoski, and H. Jousimies-Somer, manuscript in preparation).

RESULTS

In 137 of the 238 patients (58%), sinus secretions were obtained from one sinus only. The right sinus was affected in 92 and the left sinus in 45 of these patients. In the remaining 101 patients (42%), secretions were obtained bilaterally. Of the total of 339 specimens, 244 were sinus aspirates (right, 140; left, 104) from 189 patients, and 95 were injection-aspiration (IA) samples (right, 53; left, 42) from 80 patients obtained when direct aspiration did not yield a secretion.

Of the 244 sinus aspirates, 191 (78%) were positive by culture. Aerobic bacteria were cultured from 189 aspirates (223 isolates). In seven of these there was mixed aerobic and anaerobic growth. Only anaerobes were recovered from two sinuses.

A complete list of the aerobic isolates is presented in Table 1. The most common bacterial species were *H. influenzae* (52%), *Streptococcus pneumoniae* (21%), *Streptococcus pyogenes* (6%), coagulase-negative staphylococci (6%), *B. catarrhalis* (2%), and *Staphylococcus aureus* (1%). Thus, *H. influenzae*, *Streptococcus pneumoniae*, *Streptococcus pyogenes*, and *B. catarrhalis*, which are commonly regarded as pathogens in sinusitis, accounted for 198 (89%) of the aerobic isolates.

Of the 95 IA samples, 67 (71%) were positive by culture. Aerobic bacteria were isolated from 65 specimens (84 isolates), of which 7 yielded mixed aerobic and anaerobic growth. Only anaerobes were recovered from two sinuses. *H. influenzae* was cultured in 42%, *Streptococcus pneumoniae* in 16%, *Streptococcus pyogenes* in 3%, viridans group streptococci in 3%, and *B. catarrhalis* in 2% of the IA samples (Table 2). Coagulase-negative staphylococci were encountered in 14% of the IA samples, which was more than twice that encountered in the aspirates. *H. influenzae*, *Streptococcus pneumoniae*, *Streptococcus pyogenes*, and *B. catarrhalis* together (60 isolates) accounted for 71% of the aerobic isolates.

Table 3 summarizes the aerobic findings, combining the two specimen categories (aspiration and IA samples) and results from both sinuses of each patient. *H. influenzae*, *Streptococcus pneumoniae*, *Streptococcus pyogenes*, and *B. catarrhalis* together (258 isolates) accounted for 84% of all the aerobic isolates. These species alone, or in combination with each other or with other bacteria, were involved in the etiology of sinusitis in 178 (75%) of all the patients; and their share among the culture-positive patients was 92%. In bilateral sinusitis (42% of all cases), *H. influenzae* was the most commonly found isolate, occurring more than twice as often as *Streptococcus pneumoniae*.

H. influenzae, *Streptococcus pneumoniae*, *Streptococcus pyogenes*, and *B. catarrhalis* were most often isolated in pure culture (72%); but sometimes they were isolated in combination with other pathogens (17%), and their quantity often (66%) exceeded 10^4 CFU/ml (Table 4). Infections with

TABLE 1. Aerobic bacteria isolated from 244 sinus aspirates of 189 patients with AMS

Bacterium	Isolates		% of positive aspirates (n = 191)
	No.	% of all aspirates	
Haemophilus influenzae	128	52	67
Streptococcus pneumoniae	51	21	27
Streptococcus pyogenes	15	6	8
Coagulase-negative staphylococci	15	6	8
Branhamella catarrhalis	4	2	2
Staphylococcus aureus	3	1	2
Corynebacterium sp.	1	<1	<1
Streptococcus anginosus	1	<1	<1
Viridans group streptococci	1	<1	<1
Streptococcus faecalis	1	<1	<1
Acinetobacter calcoaceticus	1	<1	<1
Escherichia coli	1	<1	<1
Moraxella spp.	1	<1	<1
Total aerobes	223		
Common sinus pathogens	198		
Negative culture[a]	53	22	

[a] Two sinuses contained anaerobes only (see Table 5).

TABLE 2. Aerobic bacteria isolated from 95 IA samples from 80 patients with AMS

Bacterium	Isolates		% of positive IA (n = 67)
	No.	% of all IA	
Haemophilus influenzae	40	42	60
Streptococcus pneumoniae	15	16	22
Coagulase-negative staphylococci	13	14	19
Streptococcus pyogenes	3	3	4
Viridans group streptococci	3	3	4
Branhamella catarrhalis	2	2	3
Neisseria meningitidis group B	2	2	3
Corynebacterium sp.	2	2	3
Staphylococcus aureus	1	1	1
Streptococcus agalactiae	1	1	1
Beta-hemolytic streptococci group G	1	1	1
Enterobacter cloacae	1	1	1
Total aerobes	84		
Common sinus pathogens	60		
Negative culture[a]	28	29	

[a] Two sinuses contained anaerobes only (see Table 5).

dual aerobic etiologies were encountered in 22 sinuses of 19 patients (8% of all of the patients). *H. influenzae* was present in all specimens. It was isolated from 19 sinuses with *Streptococcus pneumoniae*, from two sinuses with *Streptococcus pyogenes*, and from one sinus with *B. catarrhalis*. Prolonged incubation (48 h) proved necessary to yield visible growth of some *H. influenzae* strains. Coagulase-negative staphylococci were found only eight times in pure culture, and they were always found in low numbers ($<10^2$ CFU/ml). They were often (20 times) detected only after enrichment and, thus, were originally present in quantities of less than 10^2 CFU/ml, which was the lower limit of detection by direct plating. *Staphylococcus aureus* was isolated only twice in pure culture. In one case it was present in a quantity exceeding 10^4 CFU/ml. The Gram-stained smear of this purulent secretion revealed polymorphonuclear leukocytes and gram-positive cocci (16a).

Anaerobic bacteria were recovered from 18 of 339 (5%) of the sinuses (8% of the patients). They all grew from only one sinus of each patient. In the six patients with bilateral sinusitis, the other sinus was negative by culture in three patients and positive for *H. influenzae* in two patients and for *Streptococcus pneumoniae* in one patient. Because of the heterogeneous nature of the anaerobic findings, a list of patients harboring these organisms is given in Table 5. Only four sinuses yielded only anaerobes. All the remaining 14 sinuses also contained aerobes. Three specimens (patients 1 to 3) yielded a typical finding of anaerobic infection with abundant growth of multiple anaerobic species; in only one specimen they were mixed with a strain of *Streptococcus anginosus* (a microaerophilic organism that commonly accompanies anaerobes). On the other hand, in 10 specimens (patients 9 to 18) the only anaerobe recovered was *Propionibacterium acnes*. It was recovered in low numbers and was often accompanied by aerobes commonly recovered from patients with sinusitis. The remaining five specimens (patients 4 to 8) yielded anaerobes in quantities of less than 10^4 CFU/ml. In two of them, anaerobes were recovered in pure culture; in one it was *Bacteroides intermedius* and in the other it was *Peptostreptococcus magnus*. In the three remaining specimens with low counts, *Peptostreptococcus magnus*, *Bacteroides asaccharolyticus* (both 10^2 CFU/ml), and a combination of *Bacteroides intermedius* (10^2 CFU/ml) and *Bacteroides oralis* (10^3 CFU/ml) were all recovered, along with *H. influenzae*; and one specimen contained a viridans group streptococcus.

None of the *H. influenzae* strains were of type b, and only 2 of 168 (1.2%) strains were β-lactamase producers. One of the six *Branhamella catarrhalis* strains produced β-lactamase. Five of the seven *Bacteroides* spp. tested (71%) were β-lactamase producers.

TABLE 3. Aerobic bacteriological findings from the 339 sinus secretions (aspiration and IA) in the 238 patients with AMS

Bacterium	Isolates from:					
	Sinuses			Patients		
	No.	% of all secretions	% of positive secretions (n = 258)	No.	% of all patients	% of culture-positive patients (n = 194)
Haemophilus influenzae	168	50	65	129	54	67
Streptococcus pneumoniae	66	19	26	48	20	25
Coagulase-negative staphylococci	28	8	11	27	11	14
Streptococcus pyogenes	18	5	7	14	6	7
Branhamella catarrhalis	6	2	2	6	3	3
Staphylococcus aureus	4	1	2	4	2	2
Viridans group streptococci	4	1	2	4	2	2
Corynebacterium sp.	3	<1	1	3	2	2
Neisseria meningitidis group B	2	<1	<1	2	<1	1
Streptococcus agalactiae	1	<1	<1	1	<1	<1
Streptococcus anginosus	1	<1	<1	1	<1	<1
Beta-hemolytic streptococci group G	1	<1	<1	1	<1	<1
Streptococcus faecalis	1	<1	<1	1	<1	<1
Acinetobacter calcoaceticus	1	<1	<1	1	<1	<1
Enterobacter cloacae	1	<1	<1	1	<1	<1
Escherichia coli	1	<1	<1	1	<1	<1
Moraxella spp.	1	<1	<1	1	<1	<1
Total aerobes	307					
Common sinus pathogens	258					
Negative culture	81	24		44	18	

TABLE 4. Combinations and quantity of the six most common bacterial species isolated from sinus aspirates and IA samples (n = 339) from patients with AMS

Bacterium and combinations	No.	No. of isolates at quantities (CFU/ml) of:			
		$>10^4$	$<10^4$–10^3	$<10^3$–10^2	$<10^2$
Haemophilus influenzae	168	103	22	35	8
In pure culture	123	78	12	29	4
With other sinus pathogens	22	14	4	3	1
With other bacteria	23	11	6	3	3
Streptococcus pneumoniae	66	51	8	6	1
In pure culture	44	39	4	0	1
With other sinus pathogens	20[a]	10	4	6	0
With other bacteria	2	2	0	0	0
Streptococcus pyogenes	18	15	1	2	0
In pure culture	16	14	1	1	0
With other sinus pathogens	2	1	0	1	0
Branhamella catarrhalis	6	1	2	3	0
In pure culture	3	0	1	2	0
With other sinus pathogens	1	0	0	1	0
With other bacteria	2	1	1		
Staphylococcus aureus	4	1	1		2
In pure culture	2	1			1
With common sinus pathogens	1				1
With other bacteria	1		1		
Coagulase-negative staphylococci	28	0	1	7	20
In pure culture	8				8
With common sinus pathogens	16	0	1	5	10
With other bacteria	4	0	0	2	2

[a] Two different serotypes in one sinus aspirate.

DISCUSSION

Many earlier studies dealing with the bacterial etiology of AMS have been compromised by technical problems, beginning from specimen collection to the final steps of identification of the organisms, especially the fastidious ones such as *H. influenzae* and anaerobic bacteria (17, 20, 28). Lystad et al. (20) have demonstrated that nasal contaminants like staphylococci are more often isolated from specimens obtained by irrigation than from those obtained by direct needle aspiration.

Accordingly, needle aspiration was used in this study to obtain the specimens, and when it failed to yield a secretion, a small amount of physiological saline was injected through the original needle into the sinus and aspiration was repeated. Axelsson and Brorson (1) used the same methodology and found that the IA samples yielded fewer bacterial pathogens than the aspirates did. The difference in our results was less pronounced, although primary aspiration, in general, more often yielded a purulent secretion. However, direct puncture and aspiration does not always yield secretion, and then instillation of saline is necessary to obtain the often small volume of secretion (8, 11, 12).

To study the role of anaerobic bacteria in infectious processes, prompt transport and processing of the specimens are essential (26). The use of selective media along with nonselective ones, coupled with prolonged incubation, are among the critical prerequisites for success in the isolation of these organisms (16). Techniques recommended by Sutter et al. (26), including rapid transport of specimens, were used to isolate and identify anaerobic bacteria in this study. Enrichment in thioglycolate broth used to supplement direct plating yielded only nine more pathogens (Table 4), but it seemed to enrich the coagulase-negative staphylococci, which probably were nasal contaminants. Our conclusion is that enrichment does not add much to the pathogen yield. Furthermore, it is difficult to evaluate the possible pathogenic role of bacteria that were initially present in low enough numbers to need enrichment for recovery.

Due to the different ways used to report the occurrence of bacterial species in patients with AMS, e.g., per patient (28) or per sinus (1, 3, 6, 8, 20, 29, 33) or per positive culture only (11, 12, 21), it is often difficult to extract the pertinent etiological data. In the present study, we summarized our results (Table 3) and present the findings obtained by all these methods. Irrespective of the way of reporting, the trend remained identical.

In most studies of AMS, except those dealing with pediatric populations, the age range of the patients has been heterogeneic or not reported (1, 3, 6, 8, 11, 12, 19, 28). Over 90% of our patients were young adults from 17 to 21 years of age. The definition of AMS by duration of symptoms also varies or is not exactly stated in many studies (1, 3, 11, 20, 28, 29). Our patients were all symptomatic for less than 3 weeks, thus representing true acute infections.

In most studies of the bacteriology of AMS, *Streptococcus pneumoniae* has been the most commonly isolated pathogen. The actual frequencies have varied from between 20 and 40% (1, 3, 6, 11, 12, 17, 21, 30, 33, 34). In the present study *Streptococcus pneumoniae* was recovered from 19% of the specimens and from 20% of the patients with AMS. The results are in accordance with the lower frequencies reported in the literature.

In a few studies, *H. influenzae* has been a relatively frequent isolate, sometimes exceeding the frequency of

TABLE 5. Distribution of anaerobic bacteria recovered from nine sinus aspirates and nine IA samples from 18 patients with AMS

Patient no.	Sinus secretion[a]	Anaerobes[b]	Aerobes[b]
1	LA	*Bacteroides intermedius* (4), *Bacteroides melaninogenicus* (4), *Eubacterium lentum* (4), *Peptostreptococcus micros* (4)	
2[c]	RA	*Bacteroides intermedius* (4), *Bacteroides oralis* (4), *Fusobacterium nucleatum* (4), *Veillonella parvula* (4), *Peptostreptococcus micros* (4)	*Streptococcus anginosus* (4)
3[d]	LA	Mixed anaerobes	
4	LIA	*Bacteroides intermedius* (2), *Bacteroides oralis* (3)	*Haemophilus influenzae* (3)
5	LIA	*Bacteroides intermedius* (3)	
6	RIA	*Peptostreptococcus magnus* (2)	
7	RIA	*Peptostreptococcus magnus* (2)	*Haemophilus influenzae* (3), viridans group streptococci (1)
8	RA	*Bacteroides asaccharolyticus* (2), *Propionibacterium acnes* (2)	*Haemophilus influenzae* (3)
9–10	RA	*Propionibacterium acnes* (2)	*Haemophilus influenzae* (4), CNS[f] (1)
11[e]	RA	*Propionibacterium acnes* (2)	*Haemophilus influenzae* (4), CNS (1)
12	LIA	*Propionibacterium acnes* (2)	CNS (2), *Corynebacterium* sp. (2)
13[g]	LIA	*Propionibacterium acnes* (2)	*Haemophilus influenzae* (4), *Streptococcus pneumoniae* (4)
14[g]	RIA	*Propionibacterium acnes* (2)	*Branhamella catarrhalis* (3), *Enterobacter cloacae* (1)
15	RIA	*Propionibacterium acnes* (2)	CNS (1)
16[g]	LIA	*Propionibacterium acnes* (2)	CNS (2)
17	LA	*Propionibacterium acnes* (1)	*Haemophilus influenzae* (1)
18	RA	*Propionibacterium acnes* (2)	*Streptococcus pneumoniae* (4)

[a] Abbreviations: A, aspirate; IA, injection-aspiration sample; R, right; L, left.
[b] The results of quantitative culture, shown in parentheses, were as follows: 4, $\geq 10^4$ CFU/ml; 3, $<10^4$ to 10^3 CFU/ml; 2, $<10^3$ to 10^2 CFU/ml; 1, $<10^2$ CFU/ml.
[c] The IA sample from the left sinus yielded *H. influenzae* at $\geq 10^4$ CFU/ml.
[d] Both gram-positive and -negative organisms; culture accidentally lost before isolates were identified to the species level. The right sinus (IA) yielded *S. pneumoniae* at $\geq 10^4$ CFU/ml.
[e] The left aspirate yielded *H. influenzae* at $\geq 10^4$ CFU/ml.
[f] CNS, Coagulase-negative staphylococci.
[g] The aspirates from the opposite sinuses were negative by culture.

Streptococcus pneumoniae (8, 20, 23). van Cauwenberge et al. (30) showed, in a retrospective analysis of AMS bacteriology between 1963 and 1975, that the frequency of *H. influenzae* isolations in sinusitis had an increasing trend. In the present study, *H. influenzae* was definitely the most commonly isolated bacterial species; it was recovered more than twice as often as *Streptococcus pneumoniae* from patients with AMS. This finding thus differs greatly from those of most earlier studies. There is no apparent explanation for this difference. It may be partially due to the young male population in our study and their conditions of living; for example, life in military barracks may contribute to a greater chance of cross-infection. *H. influenzae* may also be more common in true acute infections. All our patients had an acute infection, with symptoms for less than 3 weeks. On the other hand, the high incidence of *H. influenzae* and the lower frequency of *Streptococcus pneumoniae* in this patient population resembles the ratio of these two pathogens in the nasal cavity and epipharynx of healthy young men of the same age (24; J. Ylikoski, S. Savolainen, and H. R. Jousimies-Somer, Oto-Rhino-Laryngol. [Basel], in press). In those studies, *H. influenzae* was recovered from the nasal cavity of 5% of 97 healthy subjects and from the epipharynx of 19.5% of 86 subjects, while the corresponding figures for *Streptococcus pneumoniae* were 0.5 and 7%. Thus, *H. influenzae* appears to be available more often than *Streptococcus pneumoniae* in the adjacent normal flora as a potential cause of infection.

In recent studies (1, 8, 11, 12), *Streptococcus pyogenes* has been reported in 1 to 3% of patients with sinusitis. Our results were somewhat higher (6%). However, the high isolation rate can be explained by three outbreaks that were observed during the study. Thus, only one patient positive for *Streptococcus pyogenes* was identified during the first 1.5 years of the study. Then, suddenly, eight cases appeared from February to April 1985 and two cases appeared in September 1985. Three additional cases appeared again in February and March 1986 (H. R. Jousimies-Somer, S. Savolainen, and J. S. Ylikoski, manuscript in preparation). Furthermore, we did not isolate a single strain of *Streptococcus pyogenes* from the nasal cavities of 97 healthy subjects (24).

The low frequencies of *Branhamella catarrhalis* in the present study were similar to those seen in most other studies (1, 5, 6, 8), and differed from the deflnitely higher isolation rates in children (33, 34).

The frequency of *Staphylococcus aureus* isolations has decreased since aspiration replaced irrigation specimens for culture (1, 20). It is a commonly held opinion that the presence of *Staphylococcus aureus* is often an indication of nasal contamination (1, 20). *Staphylococcus aureus* is indeed common in the normal flora of the nose; in the study mentioned above (24), we found it in 34% of the subjects. In the present study, *Staphylococcus aureus* was recovered from only four patients, in one of whom it was probably the causative agent of sinusitis.

Coagulase-negative staphylococci are also common inhabitants of the nasal cavity. We isolated them in 79% of healthy subjects (24). The number of coagulase-negative staphylococci in this study seems high (28 strains). However, they were cultivable by direct plating in only 8 cases, whereas the remaining 20 strains were detected after enrichment, and thus were present in small numbers only, which is suggestive of nasal contamination. This interpretation was also supported by the negative Gram-stained preparations (16a).

Anaerobic bacteria have been isolated from a considerable

proportion (up to 52%) of patients with chronic or dentogenic sinusitis (10, 11, 28). Their role in AMS is less clear, and reports of their frequency show wide variations (from 0 to 23%) (3, 6, 19, 29, 31, 33, 34). The lowest isolation rates (0 and 1%) have been reported in children (33, 34). Axelsson and Brorson (1) studied both sinus and injection aspirates and found anaerobic streptococci in 6 and in 8% of the specimens and anaerobic, gram-negative rods in 3 and 7%, respectively. van Cauwenberge et al. (29) isolated anaerobes from 26 of 66 patients. Of these 26, 19% (5 patients) had AMS, but the duration of symptoms and a detailed description of the bacterial isolates from the patients with AMS were not given. Carenfelt et al. (6) isolated anaerobes from 23% of their 153 patients with AMS, but again, the anaerobes were not identified to the species level. Hamory et al. (12) did not identify their anaerobes to the species level. These anaerobes consisted of 12% of the bacterial strains recovered in their 81 patients. Evans et al. (8) found anaerobes in only 1 of their 17 patients with AMS. Lundberg et al. (19) have presented data on 30 selected cases of anaerobic sinusitis. Microaerophilic streptococci and anaerobic gram-positive cocci predominated, followed by gram-positive, non-spore-forming rods, *Bacteroides* species, and fusobacteria. Quantitation of the findings was not performed, because the specimens were enriched in broth before they were plated.

Because many of the published studies are missing data on the specific species and the quantity of the anaerobic bacteria isolated from patients with AMS, it is difficult to differentiate between probable nasal contaminants and anaerobes which might be true pathogens in the infection (6, 20, 28, 29). For example, *Propionibacterium acnes* has been isolated from the nasal cavities of 74% and *Peptostreptococcus magnus* has been isolated from the nasal cavities of 4% of healthy subjects (24). Accordingly, when these bacteria were recovered from sinus secretions in low numbers, they probably represent contamination (8). On the other hand, a mixed polymicrobial flora is often characteristic of anaerobic infections (9). Therefore, the pathogenic role of anaerobic bacteria is supported by their isolation in high quantities and the fact that they are accompanied by other anaerobes, and it is further enforced if the isolations include species such as *Bacteroides fragilis* and *Bacteroides asaccharolyticus*, which have known virulence factors, such as capsules.

In the present study we isolated anaerobes from only 8% of the patients with AMS. When we excluded all of the patients with *Propionibacterium acnes* as the sole anaerobic isolate (usually in quantities of 10^2 CFU/ml) and two patients with low quantities (10^2 CFU/ml) of *Peptostreptococcus magnus* and one patient with *Bacteroides asaccharolyticus* (10^2 CFU/ml) together with *Propionibacterium acnes*, only 2% (5 patients) of all our patients continued to be considered as having true anaerobic sinusitis. The species of bacteria in these patients was typical for anaerobic infections, and they were present in high quantities.

The low incidence of anaerobes in our patients is in accordance with the findings in children (33, 34) and may reflect a less complicated nature of short-term AMS in young individuals. The exclusion of patients with dentogenic sinusitis, which may not have been done in all previous studies, may also in part explain the lower isolation rate of anaerobes from our patients. We conclude that anaerobes are not a common cause of AMS in a young adult population.

Only a small fraction (0.8%) of the major aerobic pathogens (and 1.2% of *H. influenzae*) isolated in this study from patients with AMS were β-lactamase producers. β-Lactamase production among *Bacteroides* species was much higher (five of seven isolates). Our findings are in accordance with the increased frequencies reported lately on β-lactamase production among anaerobic bacteria isolated from the respiratory tract (9, 13, 14, 27; H. R. Ingham, M. S. Sprott, and J. B. Selkon, Letter, Lancet **ii**:748, 1980). However, considering their overall low incidence in this patient group, they hardly pose a problem for the antimicrobial therapy of AMS.

The high incidence of *H. influenzae* found in the patients examined in this study has changed our therapeutic policy so that we no longer consider penicillin the drug of choice for the treatment of AMS, but prefer to administer aminopenicillins, provided that the patient is not allergic to them. However, there is so far no need to abandon β-lactam drugs because of the low incidence of β-lactamase production.

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