Comparison of the Nasal Bacterial Floras in Two Groups of Healthy Subjects and in Patients with Acute Maxillary Sinusitis

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The nasal bacterial flora was studied in 183 healthy men entering military service (entry group), 103 healthy recruits in service (service group), and 185 recruits with acute maxillary sinusitis. The 267 nasal and ipsilateral sinus aspirate findings in the same patients with acute maxillary sinusitis were compared pairwise. In the entry group presumed sinus pathogens were only rarely isolated from the nasal cavities: Haemophilus influenzae in 4%, Streptococcus pneumoniae in 1%, Branhamella catarrhalis in 3%, and Streptococcus pyogenes in 0%. The corresponding isolation frequencies in the service group were 19, 13, 3, and <1%, respectively, and those in the group with acute maxillary sinusitis were 61, 25, 7, and 6%, respectively. Suppression of the major components of the normal nasal flora, Corynebacterium sp., coagulase-negative staphylococci, Propionibacterium acnes, and Staphylococcus aureus, was seen in the group with acute maxillary sinusitis and also occasionally in the service group. When a sinus aspirate culture yielded a presumed sinus pathogen, the same pathogen was found in the nasal samples in 91% of the cases. The predictive value of a pathogen-positive nasal finding was highest (93.8%) for S. pyogenes, followed by 77.7% for H. influenzae and 68.7% for S. pneumoniae, and lowest (20%) for B. catarrhalis.

The bacterial flora of the nasal cavity has been extensively studied to define the composition of the normal flora at this site and also to identify nasal carriers of certain bacterial species, such as Staphylococcus aureus or Streptococcus pyogenes, for epidemiological purposes. Because of the communication of the nasal cavity and the maxillary sinuses, the nasal flora has also been of interest to investigators studying the bacteriology of maxillary sinusitis.

The main components of the normal flora of the nasal cavity are coagulase-negative staphylococci (reported to be present in widely varied percentages, ranging from 12 to 81%), aerobic diphtheroids (6 to 68%), and S. aureus (6 to 34%) (1, 3, 7, 18, 29, 34). Other aerobic species, such as streptococci of the viridans, meningococci, enteric bacteria, and Moraxella sp., have been isolated occasionally (1, 3, 4, 7, 11, 29, 34). Potential sinus pathogens have been relatively rarely recovered from healthy nasal cavities: Streptococcus pneumoniae in 0.5 to 15%, Haemophilus influenzae in 0 to 6%, S. pyogenes in 0 to 1%, and Branhamella catarrhalis in 0 to 4% (1, 3, 7, 11, 18, 29, 34). In one study, higher percentages of S. pneumoniae (57%) and H. influenzae (14%) were found in nasal cultures from healthy children (5). Anaerobic bacteria have been studied in the nasal flora by only a few investigators, whose main interest has been the occurrence of Propionibacterium sp., found in 8 to 100% (12, 18, 33). We have recently shown that also other anaerobes, such as Peptostreptococcus sp. and Bacteroides sp., can occasionally inhabit the healthy nasal cavity (29, 35).

The nasal bacterial flora in patients with verified sinusitis has been shown to be substantially different from that of the healthy nose. The isolation frequency of coagulase-negative staphylococci and aerobic diphtheroids are reduced (1, 3, 7), whereas those of potential sinus pathogens are significantly elevated to 36% for S. pneumoniae, over 50% for H. influenzae, 6% for S. pyogenes, and 4% for B. catarrhalis (1, 3, 7, 16, 19, 25).

In many studies of the nasal bacterial flora in sinusitis, a simultaneous sinus aspirate culture from the same patient has been lacking (7, 19, 25). The few studies comparing nasal and sinus findings in the same patients with acute maxillary sinusitis (AMS) (1, 9, 10) or with chronic sinusitis (7, 16) have concluded that their correlation is poor. However, in preliminary analysis among military recruits (30) we found a much better correlation for potential sinus pathogens in AMS.

The purpose of the present study was to characterize the aerobic and anaerobic nasal flora, paying special attention to the occurrence of presumed sinus pathogens. Two groups of healthy young men, recruits entering military service and those in service, were compared with recruits hospitalized for AMS. The bacteriological findings in the sinus aspirates of these patients have been published (15), and this data base made it possible to compare the nasal and sinus aspirate findings in the same patients. We specifically wanted to examine in detail the predictive value for etiology of AMS of finding a presumed sinus pathogen in the nasal cavity.

MATERIALS AND METHODS

Healthy subjects. The study included two groups of healthy subjects. The first group (entry group) consisted of 183 young men (ages, 17 to 26 years; mean, 20 years), of whom 97 were applicants for pilot education in the Finnish Air Force in May 1984 and 86 were recruits at the entry of their military service in October 1984. All subjects in the entry group entered the military service from civilian living conditions and thus represented a civilian population. Nasal samples were obtained at the time of application and entry to service. Bacteriological findings of the nasal cavities in these subjects have been partially described (29, 35). All of the subjects considered themselves completely healthy. In an examination performed by an ear, nose, and throat specialist (S.S.), including anterior rhinoscopy in all subjects, none of...
the study subjects had significant infectious symptoms or signs from the nasal cavity or the paranasal sinuses.

The second group (service group) consisted of 103 recruits (ages, 17 to 28 years; mean, 20 years) in military service and hospitalized for acute audistia at the Ear, Nose, and Throat Unit of the Central Military Hospital, Helsinki, between March 1987 and November 1988. The acousti
cusia was diagnosed between 4 and 318 days (mean 151 days) in service, and the samples were taken between 2 h and 6 days (mean, 2 days) after the trauma and always before the possible hyperbaric oxygen therapy. In the service group
27% of the subjects were recruits during their first 2 months of service, 28% were sergeant or officer trainees (2 to 11
months of service), and 45% were conscripts who had been in service for 2 to 8 months. All participated in outdoor activities and combat-training training exercises and lived in open barracks of 8 to 16 beds per room. All of the subjects in this group underwent an ear, nose, and throat examination conducted by the same specialist as subjects in the first group. All also had sinus radiographs taken to exclude contraindications for possible hyperbaric oxygen therapy in a pressure chamber. No nasal or sinus symptoms suggestive of respiratory tract infection were discovered at the time of examination.

Patients with AMS. The study group consisted of 185
patients diagnosed with AMS (AMS group), based on clini
cal and radiographic findings, enrolled in a recent bacteriological survey (15). Of the 238 patients described in the report (15), 53 were excluded from the present study because nasal swabs were not available. Of the 185 patients 5
were men and 180 were women (ages, 17 to 46 years; mean, 21 years). The military occupational specialties, activities, or living conditions of the patients and the service group were comparable. None of the patients had experienced symp
toms for more than 3 weeks. Patients with a concomitant dental root canal infection suggesting dentogenic sinusitis were excluded (15). Informed consent was obtained from the patients before the invasive procedures were performed.

None of the healthy subjects or the patients with AMS had received antimicrobial agents during the 2 weeks before the examination or earlier for the present infection (AMS group).

Specimen collection. Altogether 366 nasal samples from the 185 healthy subjects of the entry group and 206 samples from the 103 healthy subjects of the service group were collected
through a nasal speculum, by a sterile cotton swab soaked in activated charcoal, from the posterior parts of both nasal cavities (care being taken to avoid contamination from the vestibule). The samples were transported to the Anaerobe
Reference Unit, National Public Health Institute, Helsinki, in modified Stuart transport medium (Transpocult; Orion
Dagnostica, Helsinki, Finland) and processed within 30 min
of collection.

From the 185 patients with AMS, 334 samples of visible
secretion were collected with a swab in the nasal cavity or, when no secretion was present, from the middle meatus close to the ostium before the nasal cavity was prepared for
antral puncture. The samples were transported as described above. After the puncture site was anesthetized, 267 sinus secretions from the same patients were collected by antral
aspiration, immediately transported in syringes, and quantita
tively cultured for aerobic and anaerobic bacteria as de
scribed previously (15).

Culture and identification. In the laboratory the nasal
samples were inoculated onto the following media: blood
and chocolate agar for the isolation of aerobes; crystal
violet-nalidixic acid-gentamicin agar (24) for the selective
isolation of pneumococci; vitamin K, and hemin-supple
mented, nonselective brucella blood agar for all anaerobes;
and kanamycin-vancomycin-laked blood agar for Bacteroi
des sp. (31). The swab was soaked in supplemented thio
glycollate broth and firmly pressed against the wall of the
tube to elute material from it into the medium for enrichment
(31).

The sinus aspirates were quantitatively inoculated to the
media described above and also onto several other media for
the selective isolation of anaerobic bacteria as described
(15).

Aerobic cultures were incubated at 36°C in an atmosphere
containing 5% CO2 and examined after 24 and 48 h; anaer
obic cultures were incubated in jars filled by the evacuation
replacement method with mixed gas (10% H2, 10% CO2, and
80% N2) for up to 7 days, with examination every 48 h. The
thioglycolate broth was subcultured aerobically and anaero
bically when growth appeared or at the latest after 5 days.

The numbers of bacterial colonies were semiquantitated as
follows: heavy growth (>100 colonies), moderate growth (20
to 99 colonies), and light growth (<20 colonies). "Enrich
ment only" describes isolations that were negative after
direct plating on agar media but positive after subculturing
the thioglycolate broth. The isolated aerobic and anaerobic
bacteria were identified and typed by standard methods (13, 17, 31).

Statistical methods. The data were analyzed by the chi
square test or the Fisher exact test (when individual data
points were less than 5). The predictive values were deter
mined as described by Vecchio (52).

RESULTS

Altogether, 366 samples from the nasal cavities of the 183
healthy subjects in the entry group and 206 samples from the
103 healthy subjects in the service group were analyzed. In
103 (56%) of the patients with AMS, secretion was obtained
from one sinus only (unilateral sinusitis cases). In the
remaining 82 patients (44%), secretion was obtained from
two sinuses (bilateral sinusitis cases). A sample was ob
tained from 334 nasal cavities; from both sides in all 82
patients with bilateral sinusitis (164 ipsilateral and contralat
eral samples) and from the diseased side in all of the
unilateral cases (103 ipsilateral samples) but only 67 samples
from the opposite (contralateral) side (Table 1).

Aerobic bacterial findings. All of the samples from the
nasal cavities of both the healthy subjects and the patients
with AMS yielded aerobic bacteria by culture. The maxi
mum number of aerobic isolates from one nasal cavity was 6.
The culture findings in the ipsilateral and the contralateral
nasal cavities of the patients with AMS are presented sepa
rately in Table 1. There were, however, no significant
differences between the two sides in the isolation frequency
of any bacterial group. For statistical comparisons, the
findings from the ipsilateral side only were used.

Major components of normal nasal flora (coagulase-nega
tive staphylococci, Staphylococcus epidermidis sp., and
streptococci of the viridans group) were frequently recov
ered from the nasal samples of both the healthy subjects and
the patients with AMS. There were, however, differences
between the groups of study subjects in the isolation fre
quency of these bacteria. Coagulase-negative staphylococci
were most often recovered from the nasal samples of healthy
subjects in the entry group (76%), less often from the service
group (62%, P < 0.01), and least often from the AMS group
TABLE 1. Aerobic bacteria in the nasal cavities of patients with AMS and two groups of healthy subjects (both nasal cavities sampled)

<table>
<thead>
<tr>
<th>Bacterium or parameter</th>
<th>% of patients with the indicated isolate</th>
<th>P for difference between groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Patents with AMS</td>
<td>Healthy subjects</td>
</tr>
<tr>
<td></td>
<td>Ipsilateral</td>
<td>Contralateral</td>
</tr>
</tbody>
</table>

**Major components of normal nasal flora**
- Coagulase-negative staphylococci
  - 59% of patients with AMS (P < 0.001 between the AM\S and entry groups). The isolation frequency of *S. aureus* was lowest in the AMS group (18%) compared with both groups of healthy subjects (entry group, 36%; service group, 34%; P < 0.001 in both cases). *Corynebacterium* sp. were isolated most often in the service group (70%), less often in the entry group (43%), and least often in the AMS group (19%). The differences of isolation frequencies between each group were highly significant (P < 0.001). Streptococci of the viridans group were more often found in the service group (20%) than in the entry group (11%) or the AMS group (10%) (P < 0.01 for the entry and AMS groups).

Presumed sinus pathogens were each significantly (P < 0.05) more often isolated from patients with AMS than from either group of healthy subjects. *H. influenzae* was the predominant organism recovered in the AMS group (61%), outnumbering even the isolation rate of coagulase-negative staphylococci within the group. However, the isolation rate of *H. influenzae* was also higher in the service group (19%) than in the entry group (4%) (P < 0.001 in each case). The distribution of the isolation rates of *S. pneumoniae* among the study groups resembled that of *H. influenzae* (AMS group, 25%; service group, 13%; entry group, 1%). *B. catarrhalis* was found much less often, in 3% of the healthy subjects and in 7% of the patients with AMS (P < 0.05 between these groups). The same trend was seen for the isolation rates of *S. pyogenes*. None of the healthy subjects in the entry group harbored *S. pyogenes*, and it was recovered from only one nasal cavity in the service group. In contrast, 16 patients (16 ipsilateral nasal cavities) in the AMS group had a positive culture for *S. pyogenes* (P < 0.01).

Differences of isolation rates were also found between healthy subjects and patients with AMS among other bacteria, including *Neisseria meningitidis*, *Moraxella* sp., and species of the family *Enterobacteriaceae* (P < 0.05 for each of these). The mean number of aerobic bacterial isolates per nasal cavity was 1.9 in the entry group, 2.4 in the service group, and 2.3 in the AMS group. The majority (93%) of the pathogen-positive nasal cultures from patients with AMS were also positive for other bacterial species (Table 1), and two to three other bacterial species (maximum number, five) were recovered in more than one half of these cultures.

**Anaerobic bacterial findings.** Anaerobic bacteria were less often recovered in the nasal cultures. The highest isolation rate for anaerobes (Table 2), 74%, was encountered among the healthy subjects of the entry group, followed by rates of 55% in the AMS group and 51% in the service group. The maximum number of anaerobic isolates from one nasal cavity was five. *Propionibacterium acnes* was the most commonly isolated anaerobe in all groups of subjects. It was also clearly more common in the entry group (73%) than in either the patients with AMS (46%) or the service group (47%, P < 0.001 in both cases). *Peptostreptococcus magnus* was the second most commonly isolated anaerobic species among all the subjects studied. There were no significant differences between the three study groups in the isolation rates of *P. magnus* or other anaerobic species.
TABLE 2. Anaerobic bacteria in the nasal cavities of patients with AMS and two groups of healthy subjects (both sides sampled)

<table>
<thead>
<tr>
<th>Bacterium or parameter</th>
<th>% of patients with the indicated isolate</th>
<th>P for difference between groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Patients with AMS</td>
<td>Healthy subjects</td>
</tr>
<tr>
<td></td>
<td>Ipsilateral</td>
<td>Contralateral</td>
</tr>
<tr>
<td>Propionibacterium acnes</td>
<td></td>
<td>&lt;1</td>
</tr>
<tr>
<td>Propionibacterium sp.</td>
<td></td>
<td>&lt;1</td>
</tr>
<tr>
<td>Peptostreptococcus asaccharolyticus</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Peptostreptococcus magnus</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Peptostreptococcus productus</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Peptostreptococcus sp.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bacteroides capillosus</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bacteroides corporis</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Bacteroides intermedius</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Bacteroides melaninogenicus</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Bacteroides oralis</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Bacteroides ovatus</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bacteroides ureolyticus</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Eikenella corrodens</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Eubacterium sp.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fusobacterium nucleatum</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Veillonella parvula</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

No. of patients: 185 Ipsilateral, 183 Contralateral, 183 Entry group, 103 Service group
No. of nasal cavities sampled: 267 Ipsilateral, 366 Contralateral, 206 Entry group, 206 Service group
No. of isolates: 159 Ipsilateral, 134 Contralateral, 295 Entry group, 124 Service group
Mean no. of isolates per cavity: 0.6 Ipsilateral, 0.6 Contralateral, 0.8 Entry group, 0.6 Service group

* See footnote a to Table 1.
* NS, Not significant.
* Microaerophilic.
* See footnote g to Table 1.

Quantity of growth. To assess the quantity of bacterial growth in the nasal samples, semiquantitative culture results of the entry group were estimated and compared with those of the AMS group (Table 3). Enrichment was necessary to pick up 10.5% of all the isolates in the AMS group and 5.8% in the entry group. Of the major components of normal nasal flora, coagulase-negative staphylococci, P. acnes, and streptococci of the viridans group were usually present in relatively low numbers only (<20 colonies per plate). S. aureus was equally often present as heavy (>100 colonies per plate), moderate (20 to 99 colonies per plate), or light (<20 colonies per plate) growth in the patients with AMS but showed a tendency to heavy or moderate growth in healthy subjects. Also, Corynebacterium sp. isolates were most often present as heavy or moderate growth in both study groups.

TABLE 3. Semiquantitative nasal culture results of the common sinus pathogens and the major components of normal nasal flora in patients with AMS (ipsilateral side) and healthy subjects (entry group, both sides sampled)*

<table>
<thead>
<tr>
<th>Isolate</th>
<th>No. of samples containing the indicated isolate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Patients with AMS</td>
</tr>
<tr>
<td></td>
<td>Heavy growth</td>
</tr>
<tr>
<td>Major components of normal nasal flora</td>
<td></td>
</tr>
<tr>
<td>Coagulase-negative staphylococci</td>
<td>157</td>
</tr>
<tr>
<td>P. acnes</td>
<td>124</td>
</tr>
<tr>
<td>Corynebacterium sp.</td>
<td>50</td>
</tr>
<tr>
<td>S. aureus</td>
<td>49</td>
</tr>
<tr>
<td>Viridans group streptococci</td>
<td>24</td>
</tr>
<tr>
<td>All</td>
<td>39</td>
</tr>
<tr>
<td>Common sinus pathogens</td>
<td></td>
</tr>
<tr>
<td>H. influenzae</td>
<td>163</td>
</tr>
<tr>
<td>S. pneumoniae</td>
<td>67</td>
</tr>
<tr>
<td>B. catarrhalis</td>
<td>20</td>
</tr>
<tr>
<td>S. pyogenes</td>
<td>16</td>
</tr>
<tr>
<td>All</td>
<td>164</td>
</tr>
</tbody>
</table>
* Heavy, moderate, and light growth are defined as >100, 20 to 99, and <20 colonies per plate, respectively.
The presumed sinus pathogens were usually present as heavy or moderate growth in either group of subjects. An exception was *B. catarrhalis*, which was more often found as light growth in the healthy subjects. Thus, when presumed sinus pathogens were recovered from the nasal cultures of either the patients with AMS or healthy subjects, their numbers were usually higher than those of the major components of the normal nasal flora.

**Predictive value of nasal cultures.** The bacterial findings in sinus secretions of the patients with AMS have been presented in detail (15). In the 185 patients included in the present study, the frequencies of isolation of the common sinus pathogens were as follows: *H. influenzae* in 53%, *S. pneumoniae* in 18%, *S. pyogenes* in 6%, and *B. catarrhalis* in 2% (Fig. 1).

To assess the predictive value of the nasal culture findings for etiology of AMS, a pairwise comparison of the common sinus pathogens recovered from the nasal cavity and from the ipsilateral maxillary sinus was performed (Table 4). When the sinus aspirate was positive for a common sinus pathogen (208 times), the same pathogen was also isolated from the ipsilateral nasal sample in 91% (sensitivity of the nasal culture). When the sinus aspirate was negative for a common sinus pathogen (860 times), the nasal culture was also negative for that pathogen in 91% (specificity of the nasal culture). However, the nasal culture alone was positive 76 times (28.5%), when the corresponding pathogen was not isolated from the ipsilateral sinus aspirate (false-positive nasal culture). On the other hand, the sinus aspirate alone was positive 18 times (8.6%), when the corresponding pathogen was not isolated from the nasal sample (false-negative nasal culture).

When we were evaluating the likelihood of a nasal culture positive for a sinus pathogen in a patient with AMS to predict finding the same organism from the sinus aspirate (positive predictive value) and, on the other hand, the likelihood of a nasal culture negative for a common sinus pathogen to predict a negative sinus culture for that pathogen (negative predictive value), differences were seen among the bacterial species. The predictive value of a positive nasal culture was highest (93.8%) for *S. pyogenes*, 77.7% for *H. influenzae*, 68.7% for *S. pneumoniae*, and lowest (20%) for *B. catarrhalis*. On the other hand, the predictive value of a nasal culture negative for one of the common sinus pathogens was high (>99.5%) for all other pathogens except for *H. influenzae* (84.8%).

Because of the relatively low predictive values of nasal cultures positive for *S. pneumoniae* (68.7%) or *H. influenzae* (77.7%), we analyzed in more detail the nasal and sinus cultures that were positive for these organisms (Table 5). *H. influenzae* alone was isolated 120 times from the nasal samples and was recovered from 93 (77.5%) of the sinus aspirates of the same patients. Similarly, *S. pneumoniae* was the only isolate in 31 nasal samples and was recovered in 24

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**FIG. 1.** Major components of normal nasal flora and common sinus pathogens in nasal cultures of two groups of healthy subjects and patients with AMS compared with cultures from the sinus. Patterns from left to right are from healthy subjects entering military service, healthy subjects in military service, patients with AMS (nose), and the same patients with AMS (sinus secretion).

**TABLE 4.** Pairwise comparison of the common sinus pathogens in the maxillary sinus and the ipsilateral nasal cavity of patients with AMS

<table>
<thead>
<tr>
<th>Bacterium</th>
<th>Total no. of isolates from:</th>
<th>No. of samples isolated as follows*</th>
<th>Predictive value (%) of:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nose Sinus Sinus Sinus</td>
<td>Nose− Sinus Sinus Sinus Sinus</td>
<td>Positive Negative</td>
</tr>
<tr>
<td><em>H. influenzae</em></td>
<td>163 141</td>
<td>38 16 125 88</td>
<td>77.7 84.6</td>
</tr>
<tr>
<td><em>S. pneumoniae</em></td>
<td>67 47</td>
<td>21 1 46 199</td>
<td>68.7 99.5</td>
</tr>
<tr>
<td><em>B. catarrhalis</em></td>
<td>20 5</td>
<td>16 1 4 246</td>
<td>20.0 99.6</td>
</tr>
<tr>
<td><em>S. pyogenes</em></td>
<td>16 15</td>
<td>1 0 15 251</td>
<td>93.8 100.0</td>
</tr>
</tbody>
</table>

* A plus superscript indicates that the bacterium was isolated from that site. A minus superscript indicates that the bacterium was not isolated from that site.
TABLE 5. H. influenzae and S. pneumoniae isolated from the nose and maxillary sinus in patients with AMS

<table>
<thead>
<tr>
<th>Growth in the ipsilateral nasal cavity (n)</th>
<th>No. of maxillary sinus samples positive for:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H. influenzae</td>
</tr>
<tr>
<td>H. influenzae (120)</td>
<td>92</td>
</tr>
<tr>
<td>S. pneumoniae (31)</td>
<td>1</td>
</tr>
<tr>
<td>H. influenzae plus S. pneumoniae (33)</td>
<td>9</td>
</tr>
</tbody>
</table>

(77.4%) of the corresponding sinus aspirates. However, when H. influenzae and S. pneumoniae were found together in the nasal samples (33 times), the same combination was isolated in only 45.5% of the sinus aspirates, whereas 16 of the 18 remaining aspirates were positive for either one of these organisms.

Other combinations of presumed sinus pathogens were also found in the nasal cultures. These included H. influenzae and B. catarrhalis (seven samples), H. influenzae and S. pyogenes (one sample), H. influenzae and a mixture of anaerobes (two samples), S. pneumoniae and B. catarrhalis (three samples), and S. pyogenes and B. catarrhalis (one sample).

In summary, when the nasal sample was positive for a combination of presumed sinus pathogens (47 times), both components of the combination were recovered in 16 (34%) of the ipsilateral sinus aspirates, and one or the other of them was recovered alone in 24 (51%) aspirates. Of the presumed sinus pathogens present in these combinations, B. catarrhalis was least often (one of eight) isolated from the corresponding sinus aspirate. Altogether, one-third of all false-positive nasal cultures (26 of 76) were derived from cultures positive for a combination of presumed sinus pathogens.

Another major group (13 of 76) of the false-positive nasal cultures was derived from patients with bilateral sinusitis, in whom the pathogen was, in fact, cultured from the contralateral sinus. Thus, these nasal cultures reflected the correct etiology of AMS in the patients. Of these 13, 9 were H. influenzae, 3 were S. pneumoniae, and 1 was B. catarrhalis. Similarly, four false-negative nasal cultures for H. influenzae and the only one false-negative nasal culture for S. pneumoniae were from bilateral sinusitis patients in whom the contralateral nasal cavity was, in fact, positive for this organism.

DISCUSSION

In this study the bacterial flora of the nasal cavities in healthy young men entering military service (from civilian living conditions) was found to differ substantially from that of recruits in service with no respiratory infection and of recruits in service with AMS (Fig. 1). To ensure the health status of the healthy subjects in both groups, only individuals free of infectious symptoms or signs from the respiratory tract at the time of examination were included. This was accomplished by taking histories and by an examination including anterior rhinoscopy performed by an ear, nose, and throat specialist. The diagnosis of AMS was based on clinical and radiographic findings and was accomplished by bacteriological cultures of sinus aspirates (15). The living conditions of patients with AMS were similar to those of men in the service group; both lived in open military barracks occupied by 8 to 16 men, whereas the men entering service represented a civilian population.

Nasal bacterial flora in healthy subjects. In the entry group the common sinus pathogens H. influenzae, S. pneumoniae, S. pyogenes, and B. catarrhalis were isolated only rarely from the nasal samples. This isolation rate of potential sinus pathogens differs from the definitely higher rates observed in children (5). Bacterial species considered as components of the normal nasal flora were found in frequencies comparable to previous reports in adults (1, 3, 7, 11, 18, 34). In those studies 8 to 50% of cultures were negative (1, 18, 34), whereas all nasal cultures in the present study were positive for bacteria. The higher isolation rates may be explained by prompt (<30 min) processing of the specimens and the use of enrichment, which yielded 6 to 11% of the isolates in each study group.

Potential sinus pathogens, especially H. influenzae and S. pneumoniae, were 5 to 10 times more common in the service group than in the entry group. The high isolation rate of H. influenzae (19%) in the service group resembles that reported in children (5). These higher isolation rates of potential pathogens may reflect a high rate of transmission of microbes in military barracks, resembling the high rate of cross-infection among children in day-care centers (14). The nasopharyngeal carrier rate of meningococci and pneumococci has been shown to increase during military service (2, 6, 21, 22). Likewise, viral infections are known to spread rapidly in the military (26, 27), and we have previously shown elevated antiviral (mainly to adenoviruses and influenza viruses) antibody titers in 7% of a comparable service group with acoustic trauma (28). Virus-induced impairment of the local host defenses may facilitate colonization of the upper respiratory tract by potentially pathogenic bacteria (8, 23).

The isolation rates of Corynebacterium sp. and streptococci of the viridans group were higher in the service group than in the entry group, but that of coagulase-negative staphylococci was lower. These changes in the normal flora may reflect incompletely understood facets of bacterial interference in maintaining a balance between components of the resident flora and the transient invaders (20).

Thus, our results suggest that military service increases nasal colonization with pathogenic bacteria accompanied by changes in the balance of the major components of the normal flora. The nasal carriage of presumed pathogens may also predispose the recruits to AMS; however, this was not assessed in the present study.

Nasal bacterial flora in patients with AMS. In the AMS group the isolation frequencies of all the common sinus pathogens were significantly higher (P < 0.05) than those in the healthy subjects and closely resembled the isolation frequencies in the corresponding sinus aspirates of the same patients (Fig. 1). On the other hand, the isolation frequencies of normal flora components (Corynebacterium sp., coagulase-negative staphylococci, P. acnes, and S. aureus) were decreased compared with those in both the entry and service groups. Similar findings have been described earlier for Corynebacterium sp. (3, 7), coagulase-negative staphylococci (1, 7), and S. aureus (1).
Correlation of nasal and sinus culture findings. When a sinus aspirate grew a presumed sinus pathogen, the same pathogen was found in the nasal samples in 91% of the cases, thus giving a fairly high sensitivity for a pathogen-positive nasal culture. However, there were clear differences between the bacterial species in the predictive value of a positive finding.

Thus, when a nasal sample in a patient with AMS was positive for S. pyogenes, there was a high (93.8%) likelihood that the same pathogen had invaded the sinus. Moreover, when the nasal culture was negative for this pathogen it was never isolated from the sinus either. Although the predictive values of positive nasal cultures for H. influenzae (77.7%) or S. pneumoniae (68.7%) were lower, the sensitivity of these findings was definitely higher than described in most other studies (1, 9, 10). The true predictive value of cultures positive for these two organisms could, in fact, be considered better on the patient level, taking into account patients with bilateral sinusitis, in whom the pathogen was isolated from the contralateral sinus, and patients in whom the nasal cultures were positive for two pathogens, only one of which was recovered in the sinus. By contrast, a positive nasal culture for B. catarrhalis was of no predictive value (20%). This is consistent with the relatively low pathogenic potential of this organism in sinusitis of adults.

Axelsson and Brorson (1) compared bacterial findings in 51 samples from the middle meatus and the ipsilateral sinus and found the same bacteria from both in 50% and a difference of one bacterial species in 28%. These data cannot be compared with ours, since these authors did not specify the bacterial species (which probably included components of the normal flora). In the present study 93% of the pathogen-positive nasal cultures contained, in addition to the pathogen, one or more bacteria of the normal nasal flora, which was irrelevant to the etiology of sinusitis in the patient. Evans et al. reported a very high rate of false-negative nasal cultures, but the material was small (only 24 patients) (9). Also Gwaltney et al. (10), who studied AMS, and Kessler (16), who studied chronic sinusitis, considered the correlation of nasal and sinus cultures to be poor, whereas Björkwall (3) found a high overall sensitivity (95%) of a positive nasal culture in 95 patients with AMS.

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LITERATURE CITED


