The Journal of Laryngology and Otology
March 2000, Vol. **114,** pp. 184–188

Microbiology of the middle meatus: a comparison between normal adults and children

Frans Gordts, M.D., Stijn Halewyck, M.D., Denis Pierard, M.D., Ph.D.*, Leonard Kaufman, Ph.D.†, Peter. A. R. Clement, M.D., Ph.D.

Abstract

Middle meatal samples were obtained from 52 carefully selected healthy adults. In 75 per cent of the test subjects bacterial organisms were cultured. However, growth was often poor and the predominant species suggest a commensal flora: coagulase-negative staphylococci were retrieved from 35 per cent, *Corynebacterium* sp. from 23 per cent and *Staphyloccus aureus* from eight per cent of the adults.

These data are very different from those previously obtained among children where – even in the absence of obvious ENT pathology – the most frequently cultured organisms were typical sinusitis pathogens: *Haemophilus influenzae* present in 40 per cent, *Moraxella catarrhalis* in 34 per cent and *Streptococcus pneumoniae* in 50 per cent of children. Furthermore, *Streptococcus viridans* and *Neisseria* sp., both organisms that might be able to inhibit colonization by some of the pathogens and found commonly among children, are virtually absent in healthy adults.

Key words: Microbiology; Bacteriology; Nasal cavity

Introduction

In adults, the middle meatus is supposed to be a key area with respect to sinus health.[1] The theory that even a minor obstruction in a critical area of the ostimeatal complex can lead to chronic sinusitis has been virtually unchallenged for many years. Even today, recent publications testify to a sustained interest for the microbiology of the middle meatus.[2,3] However, according to a recent MEDLINE database search (from 1985 to September 1999) no other publication compares the adult middle meatal microbiology with the data available from children.[4,5] This paper therefore explores and compares the middle meatal flora in adults and children.

Materials and methods

This prospective study was carried out from February 1999 until May 1999. The study protocol was approved by the ethical committee of the University Hospital. All volunteers participated after informed consent. Subjects were excluded if they had a history of systemic disease (cystic fibrosis, ciliary dyskinesia, diabetes mellitus, human immunodeficiency virus (HIV) infection or other immunodeficiency); a history of ENT disease (inhalant allergy, known chronic sinusitis, nasal polyps, previous sinus- or nose surgery, an upper respiratory tract infection in the past eight weeks); signs or symptoms suggestive of nose or sinus disease (purulent nasal secretions or post-nasal drip, nasal obstruction, headache or facial pain, diminished smell or taste, visible septal deviations or other significant anatomical anomalies); or if they had taken systemic or topical medications in the previous two months (antibiotics, steroids, nasal sprays).

Both nasal cavities were sprayed with a mixture of 0.1 per cent xylometazolin and one per cent tetracaine. After 10 minutes, secretions, if any, were aspirated from both nasal cavities. The skin of the vestibulum nasi was disinfected with a 0.5 per cent chlorehexidine alcohol solution.[6] Additional contamination was avoided by using a sterile speculum to by-pass the vestibulum nasi. Extreme care was taken not to touch the nasal mucosa at sites other than within the middle meatus. Samples were collected from the middle meatus on both sides and immediately transferred into Stuart transport medium. Culture results are reported as the number of subjects who grew a particular bacterium per total number of test subjects. Swabs were cultured on horse blood agar supplemented with hemine and NAD, sheep blood agar supplemented with nalidixic acid, manitol-salt agar and MacConkey agar incubated aerobically, as well as fastidious anaerobe agar® (LabM, Bury, UK) supplemented with horse blood, nalidixic acid and Tween 80 incubated anaerobically. After swabbing the plates, the swabs

From the Departments of Otorhinolaryngology and Microbiology*, and the Department of Biostatistics and Medical Informatics†, University Hospital (Vrije Universiteit Brussel), Brussels, Belgium.
Accepted for publication: 1 December 1999.

TABLE I
STUDY GROUP

n	52
Male	20
Female	32
Average age	24.2 years
Range	19–42 years

were enriched in fastidious broth (FB). Aerobic cultures were read after 24 hours and – if negative – the FB was subcultivated on agar. Anaerobic cultures were read after one week. The presence of fungi and yeasts was examined two and 14 days after sampling. All organisms grown were identified by standard bacteriological methods.

Results

The study criteria were fulfilled by 52 subjects (Table I). Twenty-five of these subjects belonged to the hospital staff, the others were recruited from outside. The entire study group included 10 subjects who smoked. In 13 subjects (25 per cent) cultures remained negative. Among the 39 adults (75 per cent) with positive cultures, the number of different organisms per subject ranged from one to three (Table II). Although a semiquantification was pursued, in 86 per cent of cultures enrichment was needed to detect bacterial organisms. The more eleborate semiquantification used in our previous study could therefore not be applied.[5]

Aerobic bacteria were cultured in 24 subjects (46 per cent), anaerobic in six persons (12 per cent), while a combined aerobic/anaerobic growth was observed in nine adults (17 per cent). The different organisms as well as the corresponding number of subjects in whom these species were cultured are listed in Table III.

For each of the organisms cultured, possible associations with the gender, the (non)-smoking habits or site of employment of the test subjects were investigated. No such associations were present (all p-values >0.05; chi-square tests). Furthermore, the retrieved species seemed to be present independently from each other (here too, all p-values >0.05 for the Chi-squared tests).

Discussion

There is more than one reason to explore the middle meatal microbiology in healthy subjects: knowledge of this flora can help to improve our understanding of rhinosinusitis, to determine pathways of sinus colonization, and to monitor trends in antimicrobial

TABLE II
NUMBER OF ORGANISMS CULTURED PER TEST SUBJECT

Number of subjects	n	(%)
With sterile culture	13	25
With 1 organism	26	50
With 2 organisms	9	17
With 3 organisms	4	8

TABLE III
CULTURED ORGANISMS

Organisms	Number of adults	(%)
Coagulase-negative staphylococci	18	35
Corynebacterium sp.	12	23
Staphylococcus aureus	4	8
Streptococcus viridans	2	4
Haemophilus parahaemolyticus	1	2
Proteus mirabilis	1	2
Streptococcus pneumoniae	1	2
Micrococcus sp.	1	2
Propionibacterium sp.	14	27
Peptostreptococcus sp.	1	2
Penicillium sp.	1	2

resistance. The most recent publications[2,3] that focus on the middle meatal flora or healthy adults do so in the hope of bridging the obvious gap in our knowledge that arises when interpreting cultures obtained near the sinus ostia from patients with chronic sinusitis.[7,8] Some of the more obvious reasons why it is attempted to substitute the 'gold standard' of direct puncture of the maxillary sinuses by less invasive sampling methods are listed by Nadel *et al.*[3] puncture can be a quite unpleasant procedure for the patient, even by skilled hands, and carries a small risk of injury. Moreover, pathogens from the other paranasal sinuses may be missed. Especially in children, the situation is even more complex. In unusually apprehensive children or children too young to cooperate, sedation or general anaesthesia may be required.[9] Studies of the normal sinus flora in children are therefore seriously hampered. It is indeed difficult to justify puncture of normal sinuses. Even among children with chronic rhinosinusitis, convincing evidence is lacking that antral aspiration and lavage are an effective treatment.[10,11] Meanwhile, the debate whether middle meatal cultures can be a substitute for sinus punctures in children remains unsettled.[12]

Nevertheless, the main purpose of the present paper is neither to compare the flora of healthy subjects with sinus patients nor to advocate a substitute for antral punctures. The incentive for our investigation rather arises from the impressive omnipresence of potential pathogens in the middle meatus of children.[4,5] We therefore wondered – with application of the same methodology – how much different the flora among adults would be.

Comparison with other data from adults

Apart from a paper about acute sinusitis which included 10 healthy subjects as a control group,[13] only one paper,[2] was entirely devoted to the bacteriology of the middle meatus in healthy adults at the time the present study was started. Very recently, a second study was published.[3] Among 10 control subjects, Chow *et al.*[13] found only coagulase-negative staphylococci, *Corynebacterium* sp. and four sterile cultures. The most relevant data from the three larger studies are given in Table IV. In this table, percentages refer to the number of subjects in whom a particular organism was cultured with

https://doi.org/10.1258/0022215001905292 Published online by Cambridge University Press

TABLE IV
BACTERIOLOGICAL FINDINGS ACCORDING TO DIFFERENT AUTHORS

Authors	Klossek *et al*.[2]	Nadel *el al*.[3]		Gordts *et al*.[4,5]
Sample site	MM	MM	SE	MM
Number of test subjects	139	25	25	52
Percentage of test subjects with a positive culture	81	68	68	75
Organisms (%)				
Coagulase-negative staphylococci	53	32	40	35
Corynebacterium sp.	24	20	20	23
Straphylococcus aureus	14	24	16	8
Enterobacteria	6	4	4	2
Streptococcus viridans	4	0	0	4
Propriobacterium sp.	14	12	12	27
Peptostreptococcus sp.	5	8	4	2

MM = middle meatus; SE = sphenoethmoid recess.

respect to the total number of subjects. For the data that stem from the work of Nadel *et al*.,[3] percentages had to be extrapolated separately for the middle meatus and sphenoethmoid recess. There is no obvious difference between these two sampling sites.

There were no major differences in methodology between the studies mentioned, except that the sampling in the present study was done without endoscopes in order to be able to compare the present adult data with those previously obtained in children without the use of endoscopes.[4,5] Poole[14] showed that in patients with sinusitis, cultures taken directly from the stream of purulence were positive for the typical acute sinusitis pathogens, whereas cultures taken from the adjacent mucosa of the turbinates, septum and nasopharynx were negative. These authors claim that the endoscope is necessary to recover pathogens. In contrast with these observations, in a group of children requiring adenotonsillectomy we cultured the typical sinusitis pathogens as frequently in children with and without purulent nasal secretions: *Haemophilus influenzae* 63 versus 62 per cent. *Moraxella catarrhalis* 55 versus 52 per cent and *Streptococcus pneumoniae* 53 versus 43 per cent.[4]

Sample contamination by the nasal flora is the main drawback of all endonasally collected nasosinus secretions. Once more, the endoscope is credited with the merit of minimal contamination.[3] However, if coagulase-negative staphylococci stand as a testimony for contamination, our culture results score at least as good[3] if not better[2] than the endoscopic studies. This probably reflects our strict adherence to the exclusion criteria that demanded a view of the middle meatus unobstructed by any septal or other anatomical deformity. Of course, in a non-experimental setting with sinusitis patients, the value of the endoscope cannot be overestimated.

TABLE V
ADULT VERSUS PAEDIATRIC FLORA

Organism	% of adults (n = 52)	% of children (n = 50)*	
Coagulase-negative staphylococci	35	30	N.S.
Corynebacterium sp.	23	52	$p = 0.004$
Staphylococcus aureus	8	20	N.S
Haemophilus influenzae	0	40	$p<0.001$
Moraxella catarrhalis	0	34	$p<0.001$
Streptococcus pneumoniae	2	50	$p<0.001$
Streptococcus viridans	4	30	$p = 0.001$
Neisseria sp.	0	14	$p = 0.017$

p-values for χ^2-test with continuity correction.
N.S. = difference not statistically significant ($p>0.05$).
(Gordts *et al*.[5])*

Nevertheless we achieve results strikingly similar to the endoscopically-obtained samples (Table IV). *Staphylococcus aureus*, coagulase-negative staphylococci, and *Corynebacterium* sp. (diphteroids) were the most prevalent aerobes in the middle meatus. *Propriobacterium* spp. were the predominant anaerobes.

In order to provide a more reliable interpretation of culture results, some authors advise to perform bacterial colony count and/or leukocyte count on a Gram stain preparation.[9] A high bacterial colony count is more likely to reflect actual infection, and bacteria present in a low colony count are usually not seen on a smear with Gram staining. Here too, the three studies are in accordance with each other: although positive cultures ranged from 68 to 81 per cent of the subjects, Gram staining, leukocyte count and/or semiquantification all demonstrated poor growth: more than 95 per cent of the samples collected by Klossek *et al*.[2] contained few or no white blood cells 'confirming the normality of the population'. Out of the 50 samples gathered in the study of Nadel *et al*.,[3] 68 per cent had no leukocytes. Only two of the 50 Gram stains revealed bacteria. Furthermore growth (of diphteroids) was 'moderate' in only one of the cultures. In all other aerobic cultures, growth was quantified as 'few' or 'rare'.[3] In the present paper, organisms were only detected after enrichment in 86 per cent of the cultures.

As mentioned above, the role of coagulase-negative staphylocci and *Staphylococcus-aureus* as true pathogens remains controversial. Especially coagulase-negative staphylococci are part of the ubiquitous skin flora and well known to be a frequent contaminant in cultures from other locations. Nevertheless, the role of coagulase-negative staphylococci as a pathogen in other body sites has been well documented and reviewed by Hsu *et al*.:[15]

https://doi.org/10.1258/0022215001905292 Published online by Cambridge University Press

neonatal sepsis, neutropenic sepsis, infections of indwelling catheters, urinary tract infections, and burn patients.

Not only among healthy subjects, but also in patients with sinusitis, coagulase-negative staphylococci and – to a lesser extent – *Staphylococcus aureus* are among the most frequently retrieved organisms, both among children[16,17] and adults.[7,8,18] Nadel *et al.*[8] observed that the difference might be of a semi-quantitative nature. Among patients with chronic sinusitis, coagulase-negative staphylococci were significantly more frequently observed in the cultures with no leukocytes on Gram stain and in the cultures quantified as 'rare, a few or broth-only'. According to these authors, the unusual finding of heavy growth of coagulase-negative staphylococci, or a large number of white blood cells, should alert the clinician to the possibility of a true infection. Otherwise, coagulase-negative staphylococci should be considered as a predominantly saprophytic organism in the sinuses.[8] Similarly, a light growth of *Staphyloccus aureus* would indicate the probability that the organism is saprophytic.[8]

Comparison with data from children

Among children, a middle meatus free of bacterial organisms is virtually non-existent. Only in one child out of the 220 included in two previous studies,[4,5] culture of material collected from the middle meatus on both sides was negative. Among the adults only 75 per cent of the cultures were positive, but – as discussed above – growth was very often too limited to maintain the full semiquantification of our pediatric studies. The nature of the organisms retrieved from children is also very different (Table V).[5] Instead of the presumed commensal adult flora, typical sinusitis pathogens such as *Haemophilus influenzae*, *Moraxella catarrhalis* and *Streptococcus pneumoniae* were the most frequently cultured species. These potential pathogens were observed not only in the ENT-group (children submitted to adenoidectomy or adenotonsillectomy) but also in the control group (children submitted to minor surgical procedures and free from obvious ENT disease). The pathogens were more frequently seen among the ENT children (*Haemophilus influenzae* 68 versus 40 per cent, *Moraxella catarrhalis* 50 versus 34 per cent and *Streptococcus pneumoniae* 60 versus 50 per cent).[5] On semiquantitative analysis (quantification in four categories ranging from negative to rich cultures) the richer cultures were also obtained from the ENT group. However, only for *Haemophilus influenzae* was the difference statistically significant ($p = 0.009$ for the observed frequency difference and $p = 0.003$ for the difference in semiquantification; Chi-squared test with continuity correction).[5] Among adults, hardly any of these pathogens can be discovered. *Streptococcus pneumoniae* was cultured from only one out of our 52 test subjects and from two out of 139 samples.[2] Likewise, out of these 139 samples, two cultures were positive for *Haemophilus influenzae*. Among 25 adults, Nadel *et al.*[3] did not find any member of the 'infernal trio'. Colonization by some of the pathogens is supposed to be inhibited by *Streptococcus viridans* and *Neisseria* sp. In children, both organisms were indeed more frequently cultured in the control than in the ENT group: *Streptococcus viridans* 30 versus 10 per cent ($p = 0.025$; Chi-squared test with continuity correction) and *Neisseria* sp 14 versus two per cent ($p = 0.069$; Chi-squared test with continuity correction).[5]

In adults, however, a significant number of both organisms is lacking: in the present study as well as in the paper by Klossek *et al.*,[2] *Streptococcus viridans* is retrieved in four per cent of the test subjects while absent among the population studied by Nadel *et al.*[3] *Neisseria* sp. were not cultured in any of the three adult studies. It is therefore unlikely – as observed among children – that a shift in the balance between pathogenic and 'protective' bacteria is the sole mechanism responsible for the disappearance of typical sinusitis pathogens in healthy adults.

These striking differences in the middle meatal flora between healthy adults and children give rise to many other questions. What is the exact role of the middle meatal flora? Does a commensal flora prevent invasions by pathogens of the naso(sinus) cavities?[2] If so, are there other factors which protect the sinuses of children against infection with the typical pathogens so abundantly present in their middle meatus? At what age and how do these typical sinusitis bacteria disappear from the child's middle meatus? Or is there rather some ongoing sinus infection, even among 'healthy' children?[19]

Conclusion

The microbiology of the middle meatus seems to be very consistent among healthy adults, whether or not an endoscopic sampling technique is used. The differences with the paediatric middle meatal microbiology are however striking and give rise to several questions that once more illustrate our incomplete understanding of paediatric rhinosinusitis.

Acknowledgement

I would like to thank Professor Peter Deconinck, Chairman of the Department of Paediatric Surgery, whose cooperation enabled us to gather an important part of the paediatric data.

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Address for correspondence:
Frans Gordts, M.D.,
Department of Otorhinolaryngology,
University Hospital V.U.B.,
Laarbeeklaan 101,
1090 Brussels,
Belgium.

Fax: 32 2 477 64 23

https://doi.org/10.1258/0022215001905292 Published online by Cambridge University Press