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# Bacteriology of chronic maxillary sinusitis in Jeddah, Saudi Arabia

**Hassan El-Banna* and Asif Jiman-Fatani**

Department of Medical Microbiology and Parasitology, Faculty of Medicine, King Abdulaziz University, Jeddah, Kingdom of Saudi Arabia.

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**The objective of the present study was studying the prevailing bacterial etiology of Chronic Maxillary Sinusitis (CMS) in different age groups, to evaluate the impact predisposing factors to chronicity and to estimate the susceptibility of the isolated microorganisms to commonly used antimicrobial agents. This study was carried out on 103 patients (60 males and 43 females) in age ranged from (12 to 67 years) who were diagnosed clinically and radiologically to have CMS. Culturing of sinus aspirates from all patients on an appropriate media to isolate aerobic and anaerobic bacteria was done. The isolates were identified by conventional methods and their sensitivities against commonly used antimicrobial agents were tested. The present study revealed that CMS was higher in 40 males (66.67%) than in 25 females (58.14%) of group II and it was more frequent in adults than in children. Positive cultures were detected in 97 (94.2%) cases of which pure aerobic bacteria were isolated in 11 cases (10.7%) and pure obligate anaerobes were isolated in 9 (8.7 %), while mixed of both were found in 77 cases (74.8%). Our study showed a strong association between CMS and predisposing factors as allergic rhinitis, septal deviation and nasal polyposis, but it showed a poor association with aspirin sensitivity. High susceptibility of all aerobic isolates to vancoymycin, cefotaxime, cefaclor, clarithromycin was detected while, anaerobic isolates showed high susceptibility to moxifloxacin, cefotaxime and meropenem.**

**Key words:** Chronic maxillary sinusitis (CMS), aerobic isolates, antimicrobial agents.

## INTRODUCTION

Chronic Sinusitis (CS) is a widespread health problem that affects approximately 15% of the human population (Fokkens et al., 2007). Inflammation of maxillary sinus mucosa that lasts for more than 12 weeks leads to an impairment of the quality of life of the affected people and causes a high financial burden to society (De Muri and Wald, 2012). Chronic sinusitis is suspected of being caused by impaired paranasal sinus ventilation and drainage disorders due to a blockage of the ostiomeatal complex in the middle nasal meatus (Lund, 2007). Chronic maxillary sinusitis (CMS) is one of the most common CS infections. CMS is a polymicrobial bacterial infection among adults consisting of aerobic and anaerobic bacteria where the recovery rate of anaerobic bacteria varied in some studies from 25 to 56% (Su et al., 1983; Brook et al., 1994). When adequate methods of isolation are used, anaerobes can be recovered in more than half of all cases (Nord, 1995). *Streptococcus pneumoniae*, *Haemophilus influenzae* and *Moraxella catarrhalis* have been the predominant aerobic pathogens recovered in patients with acute maxillary sinusitis. When sinusitis becomes chronic, however, these organisms are replaced by a wider variety of both aerobes and anaerobes, but anaerobes play a significant role in such infection. Special tech-

*Corresponding author. E-mail: misheikh1@hotmail.com. Tel: 09660500098846, 096626332388, +96626400000 Ext: 21033. Fax: +96626400000 Ext: 20742.

niques are required for specimen collection and transport and for cultivation of anaerobes (Finegold, 2000). Anaerobic streptococci, *Fusobacterium* and *Prevotella spp* have been identified as the predominant anaerobic isolates in previous studies of sinusitis (Wald, 1998; Biel at al., 1998). Detailed bacteriologic data would permit targeted empiric therapy, for example, if *Pseudomonas aeruginosa* or *Staphylococcus aureus* were found in the initial specimen, specific coverage would likely be important (Finegold at al., 2002).

Therapy should be adequate to cover β-lactamase–producing anaerobes. To our knowledge, there is no data available on the types of causative microorganisms for acute and CMS and their susceptibility to antimicrobial agents in Jeddah. Therefore, the present study was designed to assess bacterial etiology of CMS in different age groups, predisposing factors and the efficacy of antimicrobial agents used for treatment.

## MATERIALS AND METHODS

### Patients

The study included 103 CMS patients; 60(58.3%) men and 43 (41.7%) women. They were selected from ENT out patient's clinic of different hospitals in Jeddah city including King Abdulaziz University Hospital, Kingdom of Saudi Arabia. Their ages ranged from 12 to 67 years with mean age of 34 years and they were divided into 3 groups:

Group I included: 26 (24.4%) patients aged less than 20 years;
Group II included: 65 (63.11%) patients aged from 21 to 60 years;
Group III included: 12 (11.65%) patients aged more than 60 years.

Patients were exposed to complete history taking thorough clinical examination and they had complaints from at least one of the following symptoms: facial pain, frontal headache, purulent nasal discharge, fever or malaise. All patients had tenderness over the maxillary sinus. CMS was defined based on clinical records as an infection of at least 12 weeks duration and was judged to be present if the roentgen graphic studies showed mucosal thickening and either an air-fluid level or complete opacity of the maxillary sinus.

### Specimens

Aspirated specimens were obtained by antral puncture of the canine fossa after thorough disinfection of the oral cavity or through the lateral nasal cavity wall. After locally anesthetizing the patient, the nasal cavity was thoroughly flushed with sterile saline solution; cotton pads soaked in a 1:10000 vasoconstriction solution were then introduced in the nasal cavity and left there for 10 min and specimens were aspirated by the use of a sterile syringe, with instillation of non bacteriostatic saline done if necessary. The time between the collection of specimens and their inoculation did not exceed 30 min.

### Aerobic and anaerobic microorganisms

Specimens were inoculated onto plates of blood agar, chocolate agar, MacConkey's agar, mannitol salt agar and the chocolate agar was supplemented with extra Haemophilus test medium supplement and deoxyribonulease test medium for aerobic and anaerobic organisms (Murray et al., 1999; Summanen, 1995).

### Aerobic organisms

Plates were incubated at 37°C aerobically (MacConkey's and mannitol salt agar) or under 5% carbon dioxides (chocolate agar) and examined after 24 and 48 h. The colonies were subjected to Gram's stain and conventional identification tests. Susceptibility testing of the isolates to cefaclor, cefotaxime, cefuroxime, vancomycin, erythromycin, clarithromycin, penicillin, amoxicillin-clavulante, ciprofloxacin and clindamycin, moxifloxacin, pipercillin and meropenem was done by the use of disc diffusion method (Murray et al., 1999).

### Anaerobic organisms

For anaerobes, the specimens were plated onto pre-reduced vitamin K1-enriched brucella blood agar, an anaerobic blood agar plate containing kanamycin sulfate and vancomycin hydrochloride, an anaerobic blood plate containing colistin sulfate and nalidixic acid, and an enriched thioglycolate broth (containing haemin and vitamin K1) (Summanen et al., 1995). The anaerobic plates and thioglycolate broth were incubated in jars (GasPak) and examined after 48 and 96 h. Anaerobes were identified by their microscopic appearance, characteristic colonial morphology and pigment production. Their susceptibility pattern to the commonly used antimicrobial agents and the conventional tests were performed according to techniques described by Summanen et al. (1995).

### Statistical analysis

They were performed using SPSS 20.0 for windows (SPSS Inc, Chicago. IL, USA) and $\chi^2$ analysis was used to compare categorical data.

## RESULTS

Table 1 showed the number and the percentage of the studied 103 CMS patients by age (12 to 67 years) and sex. They were divided according to age into 3 groups; group I: young age are less than 20 years; 26 patients (25.24%), group II: adults aged from 21 to 60 years; 65 patients (63.11%) and group III: elderly aged more than 60 years; 12 patients (11.65%). By sex, they were 60 (58.25%) males and 43 (41.75%) female patients. Differences in sex distribution among different age groups were statistically non significant ($P > 0.05$). In both sexes, age group II showed more infection (63.11%) with CMS than age group I (25.24%) and age group III (11.65%). From medical history taking, clinical examination and laboratory investigations, our elderly patients have intact immunity and they did not take any medication that affected their immunity. Table 2 showed that the most common predisposing factor for CMS found in our patients was nasal polyposis (allergic or non-allergic) 14 (13.6%) followed by bronchial asthma 11 (10.76) then allergic rhinitis 10 (9.7%); while, the least ones were aspirin

**Table 1.** Number and percentage of (103) CMS patients by age and sex.

| Sex | Male | | Female | | Total | | $\chi^2$ | P |
|---|---|---|---|---|---|---|---|---|
| | 60 (58.251%) | | 43 (41.754%) | | 103 (100%) | | | |
| Age (years) | Number | % | Number | % | Number | % | | |
| Group I: <20 year (young) | 13 | 21.66 | 13 | 30.23 | 26 | 25.24 | | |
| Group II: 21- 60 year (adult) | 40 | 66.67 | 25 | 58.14 | 65 | 63.11 | 1.02 | (NS) * |
| Group III: > 60 year (elderly) | 7 | 11.67 | 5 | 11.63 | 12 | 11.65 | | |
| Total | 60 | 100 | 43 | 100 | 103 | 100 | | |

(NS) * Non significant P > 0.05.

**Table 2.** Numbers and percentage of cases in relation to predisposing factors for CMS in different age groups.

| Predisposing factor | Group I (26) | | Group II (65) | | Group III (12) | | Total (103) | | $\chi^2$ | P |
|---|---|---|---|---|---|---|---|---|---|---|
| | Number | % | Number | % | Number | % | Number | % | | |
| Allergic rhinitis | 3 | 2.9 | 6 | 5.9 | 1 | 0.9 | 10 | 9.7 | 0.14 | (NS) * |
| Septal deviation | 3 | 2.9 | 3 | 2.9 | 2 | 1.9 | 8 | 7.7 | 2.74 | (NS) * |
| Bronchial asthma | 3 | 2.9 | 7 | 5.9 | 1 | 0.9 | 11 | 10.7 | 1.76 | (NS) * |
| Nasal Polyposis | 5 | 4.9 | 7 | 6.8 | 2 | 1.9 | 14* | 13.6 | 1.24 | (NS) * |
| Aspirin sensitivity | - | 0 | 1 | 0.9 | - | 0 | 1 | 0.9 | 0.03 | (NS) * |
| Ig A deficiency | - | 0 | 2 | 3.07 | 1 | 8.3 | 3 | 2.9 | 0.5 | (NS) * |
| $\chi^2$ | 15.03 | | | | | | | | | |
| p | < 0.001 (S) ** | | | | | | | | | |

(NS) * Non significant P > 0.05.

**Table 3.** Culture results of sinus aspirates from 103 CMS patients.

| Culture result | Number of cases (103) | Percentage (%) |
|---|---|---|
| Total positive culture | 97 | 94.2 |
| Positive cases for aerobes only | 11 | 10.7 |
| Positive cases for anaerobes only | 9 | 8.7 |
| Positive cases for mixed infection | 77 | 74.8 |
| Negative cases | 6 | 5.8 |

sensitivity 1 (0.9%) and IgA deficiency (2.9%). The statistical difference between the most common predisposing factors and the least one (aspirin sensitivity) was found to be significant (P<0.001), while, statistical differences in relation to different age groups were non-significant for the all encountered predisposing conditions.

Table 3 showed that 97 out of 103 cases (94.2%) had positive bacteriological cultures. Eleven cases (10.7%) were positive for aerobes only. Nine cases (8.7%) were positive for anaerobes only, while 77 cases (74.8%) had mixed aerobic and anaerobic organisms. Six cases (5.8%) showed no growth. Table 4 showed that the longer the duration of illness is the higher the prevalence of anaerobes and the lower the prevalence of aerobes. In group III with the longest duration of illness, the prevalence of anaerobes which was (60.47%) higher than that of group II (48.44%) and group I (47.57%). While the prevalence of aerobic bacteria in group III was (39.55) lower than that of group II (51.56%) and group I (52.43%). This difference was not statistically significant (P> 0.05). Table 5 showed the different aerobic Gram-positive and Gram-negative isolates recovered in bacteriological cultures and their percentage in relation to the total number of aerobic isolates. *S. pneumoniae* represented the most frequently isolated organism (19.3%) among the aerobic bacteria. The next most common organisms were Coagulase-negative staphylococci (17.1%) followed by Viridans streptococci (12.4%), *H. influenzae* (11.2%) and *S. aureus* (10.7%). Gram-positive bacteria were much commoner 127 (68%) than Gram-negative isolates; 60 (32%).

Table 6 showed the different anaerobic isolates recovered in bacteriological cultures and their percentage in relation to total number of anaerobic isolates *P. niger* re-

**Table 4.** Comparison between number and percentage of aerobic and anaerobic isolates regarding duration of illness in different age groups.

| Group | Duration of illness (months) | Aerobes | | Anaerobes | | | | $\chi^2$ | p |
|---|---|---|---|---|---|---|---|---|---|
| | | Number | % | Number | % | Number | % | | |
| Group I | (2-4) | 54/103 | 52.43 | 49/103 | 47.57 | 103 | 100 | 2.32 | (NS)* |
| Group II | (2-48) | 116/225 | 51.56 | 109/225 | 48.44 | 225 | 100 | | |
| Group III | (12-60) | 17/43 | 39.55 | 26/43 | 60.47 | 43 | 100 | | |

(NS) * Non significant P > 0.05.

**Table 5.** Aerobic isolates from sinus aspirates of CMS patients.

| Bacteria | Number of isolates | Percentage (%) |
|---|---|---|
| **Gram- positive** | **(127)** | **(68)** |
| *S. pneumoniae* | 36 | 19.3 |
| Coagulase-negative staphylococci | 32 | 17.1 |
| Viridans streptococci | 23 | 12.4 |
| *S.aureus* | 20 | 10.7 |
| *S. pyogenes* | 9 | 4.8 |
| Diphtheroids | 7 | 3.7 |
| **Gram- negative** | **(60)** | **(32)** |
| *H. influenzae* | 21 | 11.2 |
| *M. catarrahlis* | 9 | 4.8 |
| *Klebsiella spp* | 9 | 4.8 |
| *Proteus spp* | 7 | 3.7 |
| *Neisseria spp* | 5 | 2.7 |
| *E coli* | 4 | 2.1 |
| *Citrobacter* | 3 | 1.6 |
| *Pseudomonas aeruginosa* | 2 | 1.1 |
| **Total** | **187** | **100** |

represented the most frequently isolated organism (24.5%) followed by *Bacteroides fragilis* (17.4%). The next most common was *F. necrophorum* (13%), then *P. micros* (12%), *Prevotella spp.* (10.3%), *F. nucleatum* (7.6%) and *Veillonella* (4.4%).

## DISCUSSION

Chronic sinusitis (CS) is a very common illness with a substantial health care impact (Hamilos, 2000). Bacteriology of chronic maxillary sinusitis (CMS) has been studied extensively; however, the results obtained from different reports are extremely diverse (Wood and Weir, 1997; Jiang et al., 1998). Moreover, the study of the bacteriology of CMS has suffered from many variables that increase difficulty in comparing various studies. The increasing resistance to antimicrobial agents of organisms from sinus infection has made the management of this infection more complex (Brook et al., 1997) and medical "treatment failures" often become surgical (Hamilos, 2000). The present study revealed that CMS in group II was more prevalent in males compared to females; a result in basic agreement with that of Brook et al. (1997) and Hanna et al. (1994). Such finding may be due to increase risk of exposure to irritant agents such as air pollution or tobacco smoking habit which is more common in males. Furthermore, Brook and Hausfeld (2011) found that acute and chronic sinusitis was more prevalent in smoker patients than non-smoker patients (Lieu and Feinstein, 2000). Differences in sex distribution among patients were statistically non-significant (p> 0.05). Almost all of our patients were adults except four of them were children and this finding confirmed the report of Neu (1995) who stated that sinusitis is more frequent in adults than children because adults are more exposed to air pollution than children.

Many factors are associated with CMS such as allergy, septal deviation, nasal polyposis, aspirin sensitivity, duration of illness, bronchial asthma and Ig A deficiency. The present study showed that (9.7%) of CMS cases has allergic rhinitis. On the other hand, higher incidence (56%) was reported by Mcnally et al. (1997). Several authors

**Table 6.** Anaerobic isolates from 103 sinus aspirates of CMS patients.

| Bacteria | Number of isolates | Percentage (%) |
|---|---|---|
| ***Peptostreptococcus spp*** | **(79)** | **(43)** |
| *P. niger* | 45 | 24.5 |
| *P. micros* | 22 | 12 |
| *P. saccharolyticus* | 7 | 3.8 |
| *P. magnus* | 5 | 2.7 |
| ***Fusobacterium spp.*** | **(38)** | **(20.6)** |
| *F. necrophorum* | 24 | 13 |
| *F. nucleatum* | 14 | 7.6 |
| ***Prevotella spp*** | **(19)** | **(10.3)** |
| *P. melaningenica* | 1 | 0.5 |
| *Other Prevotella spp.* | 18 | 9.8 |
| ***Bacteroides fragilis*** | **(32)** | **(17.4)** |
| ***Veillonella spp*** | **(8)** | **(4.4)** |
| ***Porphyromonas spp*** | **(3)** | **(1.6)** |
| ***Propionobacterium*** | **(3)** | **(1.6)** |
| ***Eubacteria*** | **(2)** | **(1.1)** |
| Total | 184 | 100 |

indicated that allergic rhinitis increased susceptibility to CMS by playing role in the pathogenesis of CMS (Suzuki et al., 1999; Bertrand et al., 1997) as allergic rhinitis may make sinuses vulnerable to bacterial infection. In our study, the association between CMS and bronchial asthma was reported in (10.7%) of patients and similar result was obtained by Slavin (1992), Polmar (1992) and Ferrante et al. (1998) found that CMS is more prevalent in asthmatic patients than normal persons. Medical or and surgical treatment of CMS improve attack of bronchial asthma (Kaliner et al., 1997). Septal deviation was observed in (7.7%) of our patients which was in basic agreement with results reported by Kaliner (1998). A higher incidence (23%) of septal deviation among CMS patients was reported by Danese et al. (1997) and McNally et al. (1997). However, Kim et al. (2006) did not find any significant relationship between septal deviation and CMS. Our study showed that 14 (13.6%) of our patients had nasal polyposis (ten of them were allergic and four were non allergic). Such finding was confirmed by work of Niederfuhr et al. (2009). Our study also indicated a poor association between CMS and aspirin sensitivity (0.96%). However, Hamilos (2000) found a valuable association between CMS and aspirin sensitivity. These associations between the previously predisposing factors and age groups were not found in our work.

The present study showed that 3 (2.9%) out of 103 patients have Ig A deficiency which was in agreement with the work of Armenaka et al. (1994) who found that Ig A deficiency was presented in 2 out of 60 patients (3%). Collection of specimens was done by antral puncture which provided an optimal culture material for determination of the bacteriology of sinusitis (Brook et al., 1997). Mucosal specimens have been claimed to reflect the real bacteriology of maxillary sinusitis more accurately. However, it was found that the size of mucosal specimen collected was too small to reflect the real bacteriology of maxillary sinus, so some authors concluded that mucosal specimens did not give more accurate results (Brook et al., 1997; Jiang et al., 1998). Our study was unique in that it provided quantitation of bacteriologic data analysis of likely pathogenic organisms, identification of anaerobic and aerobic and/or facultative organisms involved in bacteriology of CMS. Previous studies that have evaluated sinus puncture aspirates obtained from patients with CMS have yielded mixed findings varying from an absence of anaerobes to anaerobes constituting 56% of all the pathogens isolated (Brook, 2004; Mantovani et al., 2010a). In studies of Drettner and Lindholm (1970) and Kremer et al. (2001) who have used good anaerobic techniques, the anaerobic bacteria reached up to 25 to 56% of isolates. Our results indicated that 97 cases out of 103 (94.2%) were positive for bacteriological cultures. The anaerobic bacteria alone presented in 9 cases (8.7%) while aerobic or facultative bacteria presented in 11 cases (10.7) and mixed aerobic and anaerobic bacteria were detected in 77 cases (74.8%). This finding was not consistent with other studies.

Results from different reports were extremely diverse with broad range of prevalence of anaerobes which varied from as high as (80 to 100%) in some studies and (0 to 25%) in other studies (Kremer et al., 2001; Brook and Frazier, 2005). These variations in results may be due to different methods of taking samples from patients

and to other environmental factors. Also, the frequent involvement of anaerobes in CMS is probably related to the poor drainage and the increased intranasal pressure that develops during inflammation (Drettner and Lindholm, 1970). These changes can reduce the oxygen tension in the inflamed sinus (Carenfelt and Lundberg, 1977) by decreasing the mucosal blood flow (Aust et al., 1976) and depressing ciliary action. The lowering of the oxygen content and of the pH of the sinus cavity support the growth of anaerobic organisms by providing them with an optimal oxidation–reduction potential. As regar-ding the prevalence of aerobic bacteria in aspirates cultures, it varied from one study to another. Our study revealed that the longer duration of illness, increased the prevalence of anaerobe and decreased the prevalence of aerobes. Group II in our series showed highest preva-lence of aerobes and anaerobes compared to group I and III. Increased chronicity in group II than in group III may be explained on the following basis; presence of small number of patients in group III compared to the other groups, or exposure of this group to more antibiotics rather than other groups when chronicity develops, aero-bic and facultative species are gradually replaced by strictly anaerobic bacteria due to development of condi-tions appropriate for the growth of anaerobic bacteria which include the reduction in oxygen tension, increase acidity, mucus stasis and sinus ostial obstructions (Brook et al., 1996; Wood and Weir, 1997).

In the present study, we founded a large number of positive cultures for Gram-positive bacteria (68%) and the most frequently isolated microorganism was *S. pneumoniae* followed by coagulase-negative *staphylococci*, Viridans streptococci, *S. aureaus*, *S. pyogenes* and Diphtheroids. We found 39 cultures with Gram-negative bacterial growth, in which the most frequently micro-organisms found were: *H*. *influenzae* followed by *M*. *catarrhalis* and *Klebsiella spp.,* then *Proteus spp*, *Neisseria spp, E. coli*, *Citrobacter spp*. and finally *Pseudomonas aeruginosa*. Two studies conducted decades ago involving maxillary sinus aspiration in children presenting with sinus symp-toms of 10 to 30 days' duration identified *S. pneumoniae* as the predominant bacterium (detected in 40% of all isolates), followed by non-typable *H. influenzae* and *M*. *catarrhalis* (each detected in 20% of all isolates) and less frequently other bacteria (group A streptococcus, group C streptococcus, *Eikenella corrodens*, *Peptostreptococcus spp* and alpha-hemolytic streptococcus) (Wald et al., 1981, 1984). Orobello et al. (1991) isolated Coagulase–negative staphylococci, Viridans streptococci, *Neisseria spp*, *S. pneumoniae*, group A Streptococcus, *E. coli*, *Pseudomonas aeruginosa* and *Klebsiella spp* from CMS patients in rate of 5 and 46%. Brook et al. (1997) revealed that the predominant aerobic organisms were *Staphylococcus spp* (55.50%), Viridans streptococci, *H. influenzae*(22.2%),*S.pneumoniae*(22.2%)and*S.pyogenes* (13.3%). Biel et al. (1998) revealed that coagulase-negative staphylococci were the most common isolates followed by *S*. *aureus*, Viridians streptococci and *Corynebacterium spp*. Brook (2005) found the commonest aerobic bacteria in 22 children patients with CMS was *H. influenzae*, followed by *S. pneumoniae*, *S. aureus* and *M. catarhalis.* Most recent study by Chow et al. (2012) showed that *S. aureus* is a potential pathogen in sinusitis. We may conclude that Coagulase–negative staphylococci might be pathogenic in the disease process; although, they are not considered true pathogens and sensitivity should be obtained for these isolates for evaluation and possible treatment (Dellamonica, 1998). However, some other investigators found their role as pathogens, is less clear and uncertain (Wood and Weir, 1997; Kalliner et al., 1997).

In more recent study, Mantovani et al. (2010b) stated that in 29 studied patients, *Pseudomonas aeruginosa* was the most commonly prevailing microorganism followed by *S*. *aureus* and *S. epidermidis* (4: 13.9%) for each, *S. pneumonia*e was found in 3 cases (10.4%) and then *Proteus mirabilis* in 2 cases (6.9%), *Klebsiella pneumoniae, E. coli,* viridans streptococcus *Enterobacter cloacae, Enterobacter aerogenes, Haemophilus spp, H. influenzae* and one (3.4%) un-identified Gram-negative rod were found for each and *Cryptococcus neoformans* was found in only one case. Moreover, Brook and Hausfeld (2011) illustrated a greater frequency of isolation of *S. aureus* in patients with acute and chronic sinusitis. It seems likely that these bacterial infections have a role in the disease, but it is not clear whether they participate in the basic process initiating the chronic sinus disease (Kalliner et al., 1997). Increasing interest in the role of *M.catarhalis* has been shown recently that the organism may act as primary pathogen or facilitate the pathogenecity of other organisms (Wood and Weir, 1997). Our data confirm that anaerobic bacteria predominated in CMS. Anaerobic bacteria may deserve more attention in the aetiopathogenesis of CMS where *Peptostrptococcu spp* represented the most frequently isolated organisms of anaerobic bacteria and the next most common anaerobic organism encountered was *Viridans streptococci, Fusobacteria spp* followed by *B*. *fragilis* and *Prevotella spp*, the least ones were *Veillonella spp*, *Porphyromonas spp* and anaerobic diphtheroid and finally *Eubacterium spp*. (Brook and Frazier, 2005; Brook, 2009). Puglisi et al. (2011) found that the predominant anaerobic organisms were *Peptostreptococcus spp*., *Prevotella spp*., *Porphyromonas saccharolyticus* and *Fusobacterium spp*, while, Hanna et al. (1994) reported that pigmented Bacteroides represented the most frequently isolated organism, followed by *B*. *fragilis* and finally *Fusobacterium spp*. and *Peptostreptococci*.

This variation in the results, besides the real difference in bacterial flora, may be due to the difference in the methods of obtaining the sinus specimens, the type of transport media, the interval between sinus aspirate and culturing it and the difference in bacteriologic culturing techniques. Also, the variation may be due to the difference

ference in the chronicity of the disease, and prior or concurrent antibiotic use. Factors that may allow organisms to survive antimicrobial therapy within the inflamed sinuses are: inadequate penetration of antimicrobial agents into the sinus cavity, a high protein content that can bind antimicrobial agents, a high content of antimicrobial inactivating enzymes as β lactamase that protects penicillin susceptible isolates, decreased multiplication rate of the organisms in sinus cavity that can interfere acidity within the sinus cavity that reduces the efficacy of some antimicrobial agents as aminoglycosides and quinolones. Moreover, resistant strains isolated from sinus infection are increasing in prevalence (Wood and Weir, 1997; Kalliner et al., 1997).

In the present study, a wide scale of commonly used antimicrobial agents was investigated against the isolated microorganisms to test their susceptibility toward these agents. Over all, in the present study, the aerobic isolates were susceptible to amoxicillin-clavulante (augmentin), vancoymycin, cefotaxime, cefaclor and clarithromycin. As regard aerobic Gram-positive bacterial isolates; *S. pneumoniae* was highly susceptible to amoxicillin-clavulante, clindamycin, cefaclor, vancomycin, erythromycin, clarithromycin and amoxicillin, respectively. Vancomycin is the best antibiotic to which *S. pneumoniae* was sensitive, while 28 to 52.8% of *S. pneumoniae* were resistant to cefotaxime, cefuroxime, ciprofloxacin and penicillin, respectively. Coagulase – negative staphylococci were susceptible to ciprofloxacin (93.8%) and amoxicillin-clavulante (87.5%) than other antibiotics and 68.8% of this group of organisms was resistant to clindamycin. All Viridans streptococci (100%) were highly susceptible to clarithromycin, penicillin and amoxicillin-clavulante. *S. aureus* was highly susceptible to vancomycin (100%) and cefaclor (89%); while only 5% of which was sensitive to penicillin. No isolates of methicillin-resistant *S. aureus* (MRSA) were detected. Both *S. pyogenes* and diphtheroids were sensitive to the most antibiotics tested. As concern aerobic Gram-negative bacterial isolates: *H. influenzae*, *M. catarrhalis* and *Neisseria spp* were highly susceptible to amoxicillin-clavulante (100% for each), while they showed resistance to amoxicillin in (42.9), (11.1) and (40%), respectively. *Klebsiella spp* and *Proteus spp* were highly susceptible to gentamicin (90 and 96%, respectively), while they were resistant to amoxicillin in (100) and (42.9%), respectively.

*E. coli* showed susceptibility to meropenem (100%), amikacin (95%), and amoxicillin-clavulanate (86%), and less susceptible to trimethoprim-sulfamethoxazole (65%) and ampicillin (58%). *P. aeruginosa* showed susceptibility to amikacin (95%), ceftazidime (90%), ciprofloxacin (90%), meropenem (88%) and gentamicin (86%).

The present study indicated that all aerobic and facultative anaerobic isolates were susceptible to vancoymycin, amoxicillin-clavulanate, cefotaxime, cefaclor and clarithromycin. Similar results were reported by the study of Dellamonica (1998) and Sugita et al. (1999) who demonstrated that penicillin-resistance was evident in (48%) of aerobic and facultative anaerobic isolates and (30% ) of *H. influenzae* was amplicillin-resistant. In the previous study, *S. pneumoniae* was isolated from 38.6% of cases and (62.1%) was penicillin-resistant. Amoxicillin-clavulanate showed superior antimicrobial activity against *S. pneumoniae*, *H. influenzae* and *M. catarralis* (78, 58 and 72.8%) each, respectively. Thornsberry et al. (1999) and Puglisi et al. (2011) reported that 44 to 75% of *S. pneumoniae* isolates were susceptible to penicillin. Therefore, the antimicrobial resistance patterns of *S. peneumoniae* isolates may vary by site of infection, age and geographic source of the isolate. Hoyt et al. (1992) found that penicillin G, erythromycin, tetracycline hydrochloride and to a lesser degree, first generation cephalosporins were found to be inferior to ciprofloxacin, trimethoprim-sulfamethoxazole and cefuroxime when oral antibiotics commonly used in the empiric therapy of CMS were compared. The continuing rise in antimicrobial-resistance of organisms from sinus infection complicates the antibiotic selection process and increases the failure rate of empiric treatment, making culture and sensitivity testing increasingly desirable. Although, judicious selection of antimicrobial agents is essential for the management of sinusitis, surgical intervention for correction of pathology and evacuation of pus may be required (Brook et al., 1996). Also, recurrent courses of antibiotics alone without prior identifying and treating the underlying cause (s), are certainly unhelpful and aiding long term resolution (Hamilos, 2000).

As regard the anaerobic microorganisms, they were highly susceptible to cefotaxime, meropenem and moxifloxacin which were found to be the best antimicrobial agents for treatment of CMS. However, because tuberculosis is common in Saudi Arabia, it has to take in consideration that moxifloxacin is recommended to be saved as a second-line anti-tuberculous agent.

In conclusion, CMS is polymicrobial infection, consisting of aerobic and anaerobic bacteria. CMS is associated with predisposing and precipitating factors such as allergy, septal deviation, nasal polyposis, aspirin sensitivity, duration of illness and IgA deficiency. In the present study, anaerobic bacteria alone were isolated in 8.7% of the cases and aerobic bacteria were present in 10.7% cases, while mixed aerobic and anaerobic bacteria were isolated in 77 cases (74.8%). *Peptostrptococcus spp* represented the most frequently isolated organisms (43%) of anaerobic bacteria, followed by *Fusobacteria ssp* (20.6%). While *S. pneumoniae* was the commonest aerobic isolate (19.3%) followed by coagulase-negative staphylococci (17.1%). Vancoymycin, cefotaxime, cefaclor and clarithromycin are the most effective antibio-tics against all aerobic organisms, while anaerobic isolates were highly sensitive to mexifloxocin, cefotaxime and meropenem.

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