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Research Article

Bacterial Prevalence in Sinonasal Aspirates of Chronic Rhinosinusitis Subtypes

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Abstract

Introduction: Bacteria and their products can act as disease modifiers in Chronic Rhinosinusitis (CRS) subtypes. However, studies related to the role of microbes in CRS subtypes are limited.

Objective: The purpose of the present retrospective study was to find and compare the prevalence of bacteria in sinonasal aspirates of CRS subtypes of allergy, asthma, nasal polyps and otitis media.

Patients and Methods: In the present study, microbial culture reports of 253 nasal aspirates and 449 sinus aspirates of CRS subjects who visited MAA ENT Hospitals, Hyderabad, South India from 2009 to 2019 were analyzed.

Results: Of the total CRS subjects 45.3% (n = 228) were affected by allergic rhinitis, 38.2% (27.3%) with nasal polyps, 26.6% (n = 134) with otitis media, 13.1% (n = 66%) with asthma. Bacterial positivity was seen in 48.4% of the cultures. Bacterial positivity increased significantly in sinus aspirates when compared to nasal secretions collected at first visit in CRS subjects with allergy (38.2% vs 22.8%), asthma (12.2% vs 9.4%), nasal polyp's (grade >2) (17.6% vs 3.9%), otitis media (22.9% vs 14.1)) and hearing loss (30.6% vs 3.1). *Staphylococcus aureus* was found in 70% of sinus specimens of CRS subjects with asthma when compared to nonasthmatics (54.4%). *Pseudomonas aeruginosa* was mostly seen in nasal secretions at their first visit while *klebsiella* was seen in sinonasal aspirates of CRS subjects undergoing revision endoscopic surgery.

Conclusion: Our results find that bacterial prevalence varies with CRS subtypes and their severity. Comprehensive management of bacteria at an early stage might prevent the exacerbation of CRS and decrease its burden.

Keywords: Allergy; Asthma; Adenoids; Nasal Polyps; Otitis Media; Hearing Loss

Introduction

Chronic rhinosinusitis (CRS) is a complex and multifactorial inflammatory disorder of the paranasal sinuses with increasing global prevalence and societal burden. The aetiopathogenesis of CRS is complex and factors such as anatomical variants, microbial infections or inflammatory conditions are responsible for its onset

[1]. The mucosal bacterium has a strong effect on the immune system and plays an important role in the exacerbation and perpetuation of inflammation of CRS [2-4]. Bacteria also have a possible role in subtypes of CRS with allergy, nasal polyps and asthma but disparity exists in the prevalence of bacteria identified in the global studies [3]. Chronic infections of the sinuses influence the lower and upper respiratory tract that includes middle ear and mastoid as the nose, paranasal sinuses, eustachian tube and middle ear cleft is lined by a continuous respiratory epithelium [5,6]. Further, the middle ear acquire respiratory pathogens from the nasopharynx and otitis media (OM) is usually caused by the same bacterial pathogens that cause sinusitis [3,5,6]. Despite the evidence that exists for the role of bacteria in the middle ear, mastoid and external auditory canal in CSOM patients, a very few studies have compared bacteriology between the nasopharynx and middle ear in CSOM adult patients [3]. Moreover, regional variation, disease severity, sampling source, the methodology applied, and antimicrobial usage can lead to disparity in organism profiles between studies [7,8]. However, only a few studies on the prevalence of microbes in sinuses of adult CRS patients and its potential relationship to the manifestation of different subtypes or comorbidities of CRS are reported [7]. Hence, the present study aimed to determine the prevalence of the microbes in subtypes of CRS in a South Indian Population.

Patients and Methods

The study was performed on CRS patients (n = 702) who visited MAA ENT Hospital, Somajiguda, Hyderabad from 2009 to 2019. Chronic Rhinosinusitis and nasal polyps were diagnosed on the criteria established by the European Position Paper on Chronic Rhinosinusitis and Nasal Polyps [9]. The presence and grading of polyps was confirmed by nasal endoscopy, computed tomography scans, and intraoperative findings. Polyps were scored as grade 1 if restricted to the middle meatus; grade 2 if extending beyond the middle turbinate, and grade 3 if the nasal cavity is filled or extended to or beyond the inferior turbinate; grade 4 if massive nasal polyposis filling the entire nasal cavity and spheno-ethmoid region [10]. Diagnosis of allergy was confirmed by ENT specialist by GA2LEN guidelines and asthma by pulmonology specialists as per the guidelines of Gold., *et al*. 2013 [11,12]. IgE levels estimated by ELISA were recorded, and a test reaction with a mean IgE value >0.35kU/l was assigned as a allergic subject. Cases with Otitis media (OM) were diagnosed with the presence of fluid behind the tympanic membrane, without acute onset or signs of inflammation or infection [13]. All these patients had a detailed medical otoscopic examination report that includes tympanometry and puretone test audiometric test for evaluating hearing loss at 0.5,1,2,4 and 8 kHz frequencies. CRS subjects with age less than 18 years, immune-compromised conditions, cystic fibrosis, and nosocomial infections were excluded from the study. The study was performed after obtaining institutional ethics committee approval.

Details of study participants such as demographic and medical history data including age, gender, and history of prior sinus surgery, asthma, allergy, nasal polyps and otitis media were recorded. At the first visit of the subjects if the purulent discharge was present in the middle meatus or from other intranasal mucosal secretions the nasal secretion samples were collected. Sinus aspirates were collected at the surgery from patients using nasal endoscopic guidance by otolaryngologists when the discharge was not seen in the middle meatus due to blockage of sinus openings. All the samples were taken in a sterile container with NaCl 0.9% solution and then aseptically transferred to the laboratory for culture in less than one hour. The specimens were examined macroscopically for appearance; color and bloodstain and then inoculated within 4 hours of the collection into Nutrient agar, Chocolate agar, and MacConkey agar for aerobic bacteria identification. Identification of the microbes was performed by the conventional and VITEK-2 methods [14,15].

Data related to detailed case history, clinical examination, endoscopic findings, computed tomography scanning, and microbiological assessments were recorded in special case proforma. Chi-square test and multinomial logistic regression were used to determine statistical differences between the age, sex, co-morbidities, and type of microbial pathogens. All the statistical analyses were performed using SPSS software version 21 (SPSS Institute, Chicago, USA).

Results

Among a total of 702 CRS subjects, 36.3% were females (n = 255) and 63.7% were males (n = 447). The mean age of the subjects was 38.67 ± 14.28 yrs and the age of onset was 34.39 ± 14.23 yrs. The mean age of onset of CRS subjects who underwent sinus surgery for the first time was 35.74 ± 13.44 yrs and subjects

who underwent revision sinus surgery had a mean age of onset 31.1 ± 13.18 years. Of the total CRS subjects 45.3% (n = 228) were affected by allergic rhinitis, 38.2% (27.3%) with nasal polyps, 26.6% (n = 134) with otitis media, 13.1% (n = 66%) with asthma. 2.2.% (n = 16) of the total CRS subjects had diabetes, and 15% (n = 106) had hypertension. Nasal block (79%, n = 554), Postnasal drip (64.4%, n = 452) and anosmia (16%, n = 16%) were the most common symptoms found in the CRS subjects. Further, anosmia/hyposmia (21%) was the most commonly seen in subjects undergoing revision endoscopic surgery. Patient with nasal polyps (15.6%, n =) and otitis media (11.2%) had underwent revised surgical interventions more frequently when compared to CRS with asthma (9.1%, n = 6). The distribution of demographic factors, clinical symptoms, and co-morbidities with respect to severity is represented in Table 1.

Characteristic	Total n (n%)	Nasal aspirates at primary Visit n (n%)	Sinus aspirates at first surgery n (n%)	Sinus aspirates at revision endoscopic surgery n (n%)	p-value
Total	702	253 (36)	397 (56)	52 (7.4)	
Sex					
Male	447 (63.7)	156 (61.7)	254 (64)	37 (71.2)	0.424
Female	255 (36.3)	97 (38.3	143 (36.0)	15 (28.8)	
Age					
<20 yrs	82 (11.6)	34 (13.4)	47 (11.8)	1 (1.9)	0.035*
20-40 yrs	331 (47.2)	111 (43.9)	199 (50.1)	21 (40.4)	
40-60 yrs	228 (32.5)	89 (35.2)	114 (28.7)	25 (48.1)	
>60 yrs	61 (8.7)	19 (7.5)	37 (9.3)	5 (9.6)	
Symptoms					
Anosmia/Hyposmia	143 (16.9)	21 (14.7)	92 (64.3)	30 (21)	0.025*
Nasal Block/Nasal Discharge	554 (79.0)	127 (22.9)	357 (64.4)	70 (12.7)	<0.0001***
Post nasal drip	452 (64.4)	121 (26.7)	283 (62.6)	48 (10.7)	0.087
Subtypes					
Nasal Polyps	192 (27.3)	45 (23.4)	117 (60.9)	30 (15.6)	0.009**
Asthma	66 (13.1)	11 (16.7)	49 (74.2)	6 (9.1)	0.215
Allergy	228 (45.3)	55 (24.1)	151 (66.2)	22 (9.6)	0.846
Otitis Media	134 (26.6)	22 (16.4)	97 (72.4)	15 (11.2)	0.035*

Table 1: Distribution of demographic factors associated with CRS severity.

Values in parenthesis are percentages.

* p-value significance obtained at 0.05% level of significance and using Pearsons Chi-square test.

**p-value significance obtained at 0.01% level of significance and using Pearsons Chi-square test.

Microbial culture reports were collected from nasal secretion of CRS subjects at their first visit (36% n = 253) and sinus secretions from CRS subjects who underwent primary endoscopic sinus surgery (56%, n = 397) and underwent revised endoscopic sinus surgery (FESS) (7%, n = 52). Bacterial positivity was seen in 48.4% of the cultures that included 32.9% of positive cocci, 15.6% of negative bacilli, and 0.004% of positive bacilli. Bacterial positivity increased significantly at ESS when compared to first visit in CRS subjects with allergy (38.2% vs 22.8%), asthma (12.2% vs 9.4%), nasal polyp's (grade >2) (17.6% vs 3.9%), otitis media (22.9% vs 14.1)) and hearing loss (30.6% vs 3.1), Polybacterial cultures were detected in 2.4% (n = 20) of the CRS subjects. Among the polymicrobial cultures, *S. aureus* was seen in 57% (n = 11) samples.

In 31.8% CRS subjects with asthma of *S. aureus* was found, 50% (n = 4) of *Enterobacter* (n = 8) in nasal polyps, and 60% (n = 4) of *Alpha Haemolytic Staphylococcus* (n = 7) was seen in otitis media. *Staphylococcus aureus* was found in 70% of sinus specimens of CRS subjects with asthma when compared to nonasthmatics (54.4%). *Staphylococcus aureus, Pseudomonas aeruginosa, Klebsiella* species and Enterobacter species were the most common bacteria found in CRS adults but their frequencies varied with CRS subtypes and severity. The prevalence of *S. aureus* increased in the sinus aspirates when compared to nasal aspirates. Further, the prevalence of *Staphylococcus aureus* was significantly increased in comorbidities such as asthma and nasal polyps more specifically in subjects undergoing surgery. However, this was not noticed in subjects with otitis media, and allergy. Increase in prevalence of gram negative bacteria, *Pseudomonas aeruginosa* was mostly seen in nasal secretions at their first visit while *klebsiella* was seen in sinonasal aspirates of CRS subjects undergoing revision endoscopic surgery. The prevalence of the bacteria obtained from the cultures with respect to severity, and subtypes are given in Table 2 and Figure 1.

Microbe Identified	Total n (n%)	Nasal aspirates at primary Visit n (n%)	Sinus aspirates at first surgery n (n%)	Sinus aspirates at revision endoscopic surgery n (n%)
Total bacterial positives	303	121	158	24
Actinomycetes	3 (1.0)	2 (1.7)	1 (0.6)	0 (0.0)
Acid Fast Bacilli	3 (1.0)	0 (0.0)	3 (0.6)	0 (0.0)
Alpha Haemolytic Streptococcus	7 (2.3)	2 (1.7)	3 (1.9)	2 (8.3)
Beta Haemolytic Streptococcus	3 (1.0)	2 (1.7)	1 (0.6)	0 (0.0)
Coagulase Negative Staphylococcus	3 (1.0)	3 (2.5)	0 (0.0)	0 (0.0)
Enterobacter sps	8 (2.7)	3 (2.5)	5 (3.2)	0 (0.0)
MRSA	2 (0.7)	1 (0.8)	0 (0.0)	1 (4.2)
Moraxella sps	3 (1.0)	1 (0.8)	2 (1.3)	0 (0.0)
Staphylococcus aureus	152 (50.2)	62 (51.2)	80 (50.6)	10 (41.7)
Klebsiella sps	25 (8.3)	6 (5)	15 (9.6)	4 (16.7)
Pseudomonas aeruginosa	79 (26.2)	31 (25.6)	41 (26.3)	7 (29.2)
Streptococcus pneumoniae	11 (3.7)	8 (6.6)	3 (1.9)	0 (0.0)
Non-sporulating anaerobes	3 (1.0)	0 (0.0)	3 (1.9)	0 (0.0)
Proteus vulgaris	1 (0.3)	0 (0.0)	1 (0.6)	0 (0.0)

Table 2: Frequency of bacteria identified in CRS subjects with respect to severity.

Values in parenthesis are percentages.

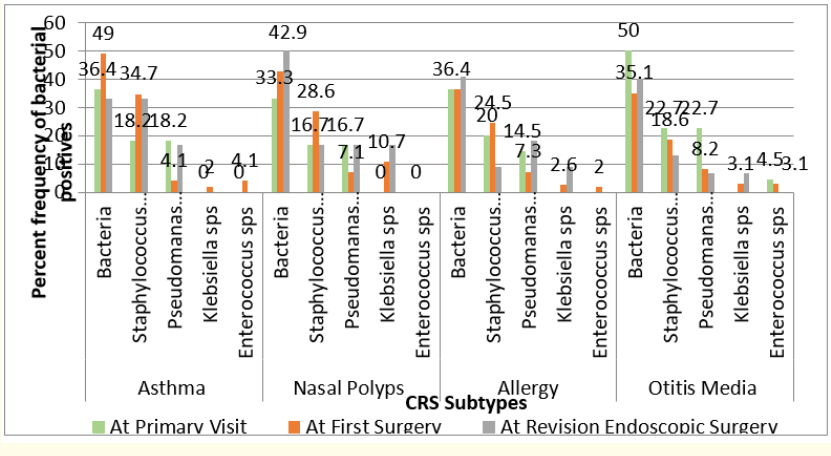

Figure 1: Prevalence of bacteria with respect to severity in CRS subtypes.

Discussion

Bacterial infections play a major role in worsening of CRS disease with allergy, asthma, nasal polyps and otitis media and unmanageable CRS post-sinus surgery. Region specific variations in causative bacteria further cause difficulty in diagnosis and treatment [4-8]. Thanasumpun., *et al*. (2015) in a metanalysis study reported *Coagulase Negative Staphylococcus* followed by *Staphylococcus aureus* as the common CRS pathogen while Nadel., *et al*. (1998) found prevalence of Gram-negative rods in 27% and *Pseudomonas* spp in 16% of adult CRS [16,17]. In the present study *Staphylococcus aureus* was the most common pathogen found in the nasal secretion and sinus aspirates in CRS and its endotypes which is in agreement with the earlier studies in allergic rhinitis, asthmatics, CRS and CRS with nasal polyps in Europe, US and Asia (Refaat., *et al*. 2011; Chin., *et al*. 2014; Ramakrishna., *et al*. (2002), Refaat*., et al.* (2008), Redinbo., *et al*. (2014) and Earl., *et al*. (2012) [18-22]. *S. aureus* is reported to be present in 27% of CRS subjects with nasal polyps in the Middle East population while the frequency was 63% in the European population [23,24]. In the present study on the South Indian population, the culture rate was found to be 44.8% in CRS adult subjects with nasal polyps. Further, S.aureus was found to be 28.4% in sinus aspirates at first surgery which is in accordance with the Middle East population. Moreover, there was a significant increase in the prevalence of *S. aureus* obtained at surgery in CRS subjects with ≥ grade 2 nasal polyps (17.4% sinus aspirates vs 3% in nasal aspirates). However, Stern., *et al*. in 2016 reported Gram-negative species to be more significantly prevalent in the CRSwNP group regardless of disease severity [25].

Persistent inflammation in the nasal cavity, nasopharynx, and middle ear canal allows bacteria to exists even after medical and surgical interventions [3]. Paranasal sinuses and middle ear acquire respiratory pathogens from the nasopharynx and hence sinusitis is usually caused by the same bacterial pathogens that cause OM [5,6]. Irreversible changes in the middle and inner ear can be caused by chronic OM and result in varying degree of hearing loss in children and adults [2,26-28]. In agreement with the earlier studies, the present study also finds *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Streptococcus* spp as the common aerobic organism identified in adults with CRS and OM [3,4]. However the prevalence of bacteria in CRS with Otitis media varied with other CRS subtypes. Further, the bacterial positivity increased in CRS with otitis media and hearing loss which suggests role of bacteria in sinuses with severity of OM in CRS adults. The prevalence of the bacteria obtained from the nasal and sinus aspirates with respect to severity has been represented in Table 2 and Figure.

Staphylococcus *aureus* was also found to be the most common pathogens in nasal (52%) and endoscopically derived sinus aspirates (50.6%) at first sinus surgery and sinus aspirates (41.7%) at revised sinus surgery in aCRS adults which is in agreement with an earlier report on the microbiology of recurrent rhinosinusitis, gram-positive cocci mainly *S. aureus* was predominately present [28]. Also, Significant increase in bacterial positivity at revision endoscopic sinus surgery was observed in CRS and its endotypes of nasal polyps, asthma and allergy. Zhang., *et al*. 2015, reported that *Pseudomonas aeruginosa* to be more common in CRS subjects with prior FESS history [29]. In contrast, another studies, *Pseudomonas aeruginosa*, *Klebsiella* sps*, Enterobacter* sps, *Alpha Haemolytic Streptococcus* sps, were the most common microbes promoting recalcitrance CRS [30,31]. In the present study, *P. aeruginosa* (26.2%) In agreement with the above studies, the present study also finds the predominance of *Pseudomonas aeruginosa in the nasal secretions at the first visit*. However, the revision FESS cultures of the present study demonstrated a higher frequency of gram-negative bacteria, *Klebsiella sps* compared to the primary FESS cultures. The comparative analysis in the present study indicated a varied prevalence of bacteria with CRS subtypes and severity indicates a difference in the microbial contribution towards phenotypes of CRS. A better understanding of the role of bacteria in CRS subtypes may help to improve the quality of life of CRS patients.

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Conflicts of Interest

The authors declare no conflict of interest.

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