A Comparison of the Bacterial Culture Results of Maxillary Sinus Mucosa and Pus Collections for Chronic Maxillary Rhinosinusitis

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ABSTRACT

Objective: Although maxillary antral taps are the standard for collecting pus for bacterial culture, they sometimes reveal no growth. Intraoperative mucosal cultures are another method to collect pathogen samples. This study compared aerobic bacterial cultures from maxillary sinus mucosa and pus collected from chronic maxillary rhinosinusitis patients.

Methods: A prospective study of 22 chronic maxillary rhinosinusitis patients was conducted. Antral pus and mucosa collected during endoscopic sinus surgery were immediately sent to a microbiological laboratory. The degree of concordance between maxillary sinus mucosa aerobic bacterial cultures and pus cultures was then analyzed.

Results: Twenty-seven specimens were obtained for the cultures. The proportions of positive mucosal and pus cultures were 40.74% and 51.85%, respectively. The common aerobic pathogens from the two culture techniques were Pseudomonas aeruginosa and Staphylococcus aureus. A concordance between the pus and mucosal cultures was demonstrated by 19 out of 27 specimens (70.37%). Compared with the pus cultures, the mucosal cultures had a specificity of 84.62% (95% CI, 54.55%-98.08%), a sensitivity of 57.14% (95% CI, 28.86%-82.34%), a predictive value of a positive result of 80% (95% CI, 50.83%-93.93%), and a predictive value of a negative result of 64.71% (95% CI, 48.96%-77.80%).

Conclusion: Similar pathogenic bacteria were recovered from the mucosa and pus. Given the high degree of similarity of the bacteria found, the good concordance rate, and the high specificity and positive predictive value of the mucosal cultures compared with the pus cultures, mucosal cultures should be a reference standard and an option when pus is unavailable, especially with immunocompromised patients.

Keywords: Bacterial culture; concordance; chronic rhinosinusitis; maxillary sinus mucosa; pus (Siriraj Med J 2019;71: 95-101)

INTRODUCTION

Rhinosinusitis is a common disease in Thailand. In 2017, the incidence among otolaryngologic outpatients at Siriraj Hospital was about 5%. Obtaining a culture might be useful with patients who have not responded to conventional medical treatment, with immunocompromised patients, and in cases of rhinosinusitis with orbital and intracranial complications. Pus collection from the maxillary sinus by an antral puncture or open sinus surgery is usually used in clinical practice.[1-6] Although a maxillary antral

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tap is the standard method of obtaining a sinus culture, it is invasive and difficult to perform,[1–6] and sometimes reveals no growth. In addition, otolaryngologists cannot always get pus from a maxillary antral tap because of the small amount of pus, or the absence of pus, in the maxillary antrum. In 1979, Karma et al.[7] concluded that an intraoperative mucosal culture is a better method to get true pathogens than collecting pus from the maxillary antrum; that conclusion has since been supported by the findings of other studies.[8-9] The objectives of the present study were to compare aerobic bacterial cultures obtained from the sinus mucosa with those from pus from the antrum of chronic maxillary rhinosinusitis patients.

MATERIALS AND METHODS

A prospective study was conducted at Siriraj Hospital between May 2010 and January 2011. All patients, which considered for inclusion, were more than 18 years old and diagnosed with chronic maxillary rhinosinusitis with medical treatment failure. Before undergoing endoscopic sinus surgery, they had to stop taking any antibiotics for at least one week. The diagnosis of chronic rhinosinusitis was based on the guidelines of the European Position Paper on Rhinosinusitis and Nasal Polyps,[10] i.e., an inflammation of the nose and the paranasal sinuses, characterized by two or more symptoms of nasal obstruction, discolored nasal discharge or postnasal drip, frontal pain/headache, and smell disturbance (one of which should be nasal obstruction or discolored discharge) for more than 12 weeks; and either a positive finding on a nasal endoscopy (nasal polyps and/or mucopurulent discharge from the middle meatus, and/or edema/mucosal obstruction primarily in the middle meatus); and/or mucosal changes within the ostiomeatal complex and/or sinuses on preoperative computed tomography.[10] The study protocol was approved by the Institutional Review Board Committee of the Faculty of Medicine Siriraj Hospital, and informed consent was obtained from every patient. During the endoscopic sinus surgery, immediately after opening the maxillary sinus ostium, antral pus was collected in a sterile bottle by curved suction; 1-2 small pieces of maxillary sinus mucosa was also randomized collected in a sterile bottle using cutting forceps. All specimens were sent to the microbiological laboratory within 10 minutes and immediately incubated on chocolate, blood, and MacConkey agar plates. Bacteria that grew on the culture were reported as semiquantitative identification (rare, few, moderate, and numerous growth). The results of both cultures were compared. Samples were considered to have a strong concordance if the same bacterial organisms were recovered, or if there was no growth and/or commensal flora on both the mucosal and pus cultures. Samples were considered to have a moderate concordance if the predominant organisms recovered from the mucosa were also recovered from the pus, but an additional organism was recovered in small quantities by one of the two methods. Samples were considered to have no concordance if the predominant organisms recovered by the two techniques differed.[11-13]

Statistical analysis

The data were presented as numbers and percentages. The difference in the culture rates for the maxillary sinus mucosa and pus was calculated with McNemar's Chi-square test. Comparisons were made of the results of the bacterial cultures of the maxillary sinus mucosa and pus collections from the chronic maxillary rhinosinusitis patients. The sensitivity, specificity, and positive and negative predictive values of the mucosal cultures were calculated and compared with those of the pus cultures, as the reference standard.

RESULTS

The ages of the 22 adult patients included in this study ranged from 26 to 83 years, with a mean of 53.36 years. There were 11 males and 11 females. Five patients had a bilateral maxillary sinus operation, resulting in 27 paired samples. The positive rates of the mucosal and pus cultures for aerobic pathogenic bacteria represented 40.74% and 51.85% of samples, respectively, as shown in Table 1. The difference in the culture rates for the maxillary sinus mucosa and pus samples was statistically insignificant ($p = 0.4531$, 95% CI: -0.292204 to 0.084671). The aerobic bacterial growths common to both groups were *Pseudomonas aeruginosa* and *Staphylococcus aureus* (Methicillin-susceptible), as shown in Table 2. The maxillary sinus mucosal cultures were strongly concordant with the cultures from pus from the maxillary sinus in 19 out of the 27 aerobic samples (70.37%; Table 1). Two of the 27 samples were considered to have a moderate concordance (7.41%); the additional organism was noted in small quantities in those 2 samples. The mucosal cultures provided a specificity of 84.62% (95% CI, 54.55%–98.08%), a sensitivity of 57.14% (95% CI, 28.86%–82.34%), a predictive value of a positive result of 80% (95% CI, 50.83%–93.93%), a predictive value of a negative result of 64.71% (95% CI, 48.96%–77.80%), a positive likelihood ratio of 3.71 (95% CI, 0.96–14.37), and a negative likelihood ratio of 0.51 (95% CI, 0.27–0.97) compared with the pus cultures from the maxillary sinus (Table 3).

TABLE 1. Types of aerobic bacteria isolated from pus and mucosal cultures from the same chronic maxillary rhinosinusitis patients.

No.	Sex	Age	Diagnosis	Pus culture	Mucosal culture	Concordance
1	Male	64	CRSwNP	-MSSA (moderate) -*Morganella morganii* (few)	-MSSA (few)	+
2	Male (Rt.)	31	CRSwNP	-*P. aeruginosa* strain 1 (moderate) -*P. aeruginosa* strain 2 (few)	-*K. pneumoniae* ESBL-negative (few)	-
3	Male (Lt.)	31	CRSwNP	-*P. aeruginosa* (numerous) -*K. pneumoniae* (rare)	-*P. aeruginosa* (few)	+
4	Female	62	CRSsNP	-Non-fermentative GNR (few)	-NG	-
5	Female	43	CRSsNP	-NG	-NG	++
6	Female	57	CRSsNP	-*P. aeruginosa* (moderate)	-NG	-
7	Male (Rt.)	54	CRSwNP	-*K. pneumoniae* ESBL-negative (few)	-NG	-
8	Male (Lt.)	54	CRSwNP	-*E. coli* ESBL-negative (few)	-*E. coli* ESBL-negative (few)	++
9	Female	75	CRSsNP	-MSSA (moderate)	-MSSA (few)	++
10	Female	83	CRSsNP	-*P. aeruginosa* (few) -Commensal flora (few)	-NG	-
11	Male (Rt.)	62	CRSwNP	-NG	-Commensal flora (few)	++
12	Male (Lt.)	62	CRSwNP	-NG	-NG	++
13	Female	45	CRSsNP	-*P. aeruginosa* (moderate) -Non-fermentative GNR (moderate)	-*P. aeruginosa* (few) -Non-fermentative GNR (few)	++
14	Female	70	CRSsNP	-*P. aeruginosa* (numerous)	-*P. aeruginosa* (rare)	++
15	Female	74	CRSsNP	-*P. aeruginosa* (moderate)	-*P. aeruginosa* (few)	++
16	Male (Rt.)	26	CRSwNP	-NG	-Commensal flora (rare)	++
17	Male (Lt.)	26	CRSwNP	-NG	-NG	++
18	Female	58	CRSsNP	-NG	-NG	++
19	Male (Rt.)	27	CRSsNP	-*Enterobacter aerogenes* (rare)	-NG	-
20	Male (Lt.)	27	CRSsNP	-NG	-*Enterobacter aerogenes* (few)	-
21	Male	61	CRSsNP	-NG	-NG	++
22	Male	46	CRSsNP	-*Pasteurella multocida* -MSSA (few)	-*Pasteurella multocida* -MSSA (few)	++
23	Male	49	CRSsNP	-NG	-NG	++
24	Male	32	CRSsNP	-Commensal flora (few)	-NG	++
25	Female	80	CRSsNP	-NG	-*S. agalactiae* (few) -MSSA (few)	-
26	Male	49	CRSsNP	-NG	-NG	++
27	Female	26	CRSsNP	-NG	-NG	++

N.B.: CRSwNP = chronic rhinosinusitis with nasal polyps; CRSsNP = chronic rhinosinusitis without nasal polyps; NG = no growth; MSSA = Methicillin-susceptible *Staphylococcus aureus*; GNR = Gram-negative rods; *P.aeruginosa* = *Pseudomonas aeruginosa; K. pneumoniae* = *Klebsiella pneumoniae; E. coli* = *Escherichia coli;* ESBL = Extended-Spectrum Beta-Lactamase; *S.agalactiae* = *Streptococcus agalactiae*; Rt. = right; Lt. = left; - = no concordance; + = moderate concordance; ++ = strong concordance

TABLE 2. Common aerobic bacteria isolated from pus and mucosal cultures.

Pathogens	Pus	Mucosa	Pus (Kirtsreesakul V et al.)[12]
Coagulase negative *Staphylococcus aureus*	-	-	8
Pseudomonas aeruginosa	*7*	*4*	*2*
Staphylococcus aureus (Methicillin-susceptible)	3	4	3
Commensal flora	2	2	-
Klebsiella pneumoniae	2	1	2
Non-fermentative gram-negative rods	2	1	-
Escherichia coli	*1*	*1*	*2*
Enterobacter aerogenes	*1*	*1*	*1*
Pasteurella multocida	*1*	*1*	-
Morganella morganii	*1*	*0*	-
Citrobacter diversus	-	-	*1*
Streptococcus agalactiae	0	1	-
Alpha-hemolytic *Streptococcus* not group D	-	-	3
Beta-hemolytic *Streptococcus* not group A, B, D	-	-	1
Micrococcus spp.	-	-	1
No growth	12	14	1

TABLE 3. Comparison of pus and mucosal culture methods.

Culture methods	Positive pus cultures	Negative pus cultures	Total
Positive mucosal cultures	8	2	10
Negative mucosal cultures	6	11	17
Total	14	13	27

Specificity = 84.62%; sensitivity = 57.14%; positive predictive value = 80%; negative predictive value = 64.71%
N.B.: Negative mucosal cultures = no pathogenic bacterial growth or different pathogenic bacterial growth from pus culture

DISCUSSION

The 40.74% rate for the mucosal cultures was not very different from the 51.85% rate for the pus cultures ($p = 0.4531$, 95% CI: -0.292204 to 0.084671), as shown in Table 1. Similar isolated pathogenic bacteria were recovered from the mucosa and pus, as shown in Table 2. A good concordance rate of 70.37% was achieved for the two aerobic bacterial culture techniques. The mucosal cultures provided a specificity of 84.62, a sensitivity of 57.14%, a predictive value of a positive result of 80%, a predictive value of a negative result of 64.71%, a positive likelihood ratio of 3.71, and a negative likelihood ratio of 0.51 compared with the pus cultures collected by the maxillary antral tap (Table 3).

Antibiotic treatment is essential in patients with chronic rhinosinusitis with acute exacerbation. Otolaryngologists usually treat rhinosinusitis patients by empirical therapy. If patients do not respond to antibiotics, then correct identification of the bacterial organisms is very important. The standard sampling method for sinus cultures is a maxillary sinus tap through the canine fossa or inferior meatus, or open sinus surgery utilizing the Caldwell–Luc approach.[1-6] However, pus collection from the maxillary sinus during surgery is sometimes unsuccessful because

of small pus amounts, an absence of pus in the sinus, or the accidental removal of all pus. The study by Karma et al.[7] found that intraoperative mucosal tissue cultures can be used as one method to get true pathogens and yielded a higher proportion of positive bacterial cultures than positive pus cultures, but the researchers did not compare the types of organisms obtained from the tissue and pus cultures. The current study is probably the first, at least in Thailand, to compare the outcomes of cultures derived from tissue biopsies and pus collected from the maxillary sinus. A good concordance of the bacterial organisms of both groups, as well as a high specificity, and a high positive predictive value in the mucosal group compared to the pus cultures, were found in the present study. Therefore, if we cannot collect pus, a mucosal culture in chronic maxillary rhinosinusitis can be used to identify the pathogenic organisms.

However, the interpretation of mucosal culture data should be made cautiously if a negative culture is obtained because of its low sensitivity and low negative predictive value. The proportion of positive cultures from the sinus mucosa in this study was slightly lower than that from the pus cultures, which contrasts with the earlier study by Karma et al.[7-9] This might be because bacterial pathogens are hidden in the biofilm on the surface of the mucosa and are difficult to culture. Biofilm bacteria are usually found on the surface of the mucosa, but planktonic bacteria are found in pus content. Biofilms of *Staphylococcus aureus, Pseudomonas aeruginosa, Streptococcus pneumoniae*, and *Haemophilus influenzae* are commonly found in patients with chronic rhinosinusitis that is resisting antibiotic treatment.[14-18] Biofilm bacteria metabolize more slowly, reproduce less frequently, and show different phenotypes than planktonic bacteria, and standard microbiological culture techniques are incapable of identifying all species present in pus cultures.[19] Nevertheless, since the mucosal cultures in the present study showed a good specificity and positive predictive value, mucosal cultures may be used as a guide to the prescribing of target antibiotics for chronic rhinosinusitis patients who do not have any pus in their maxillary sinuses.

We have applied this finding in our department, especially with immunocompromised patients, e.g., those with hematologic malignancy who have chronic rhinosinusitis with acute exacerbation. With such cases, the active sinus infection tends to progress rapidly with a high risk of serious complications. Therefore, the need for sinus surgery is usually indicated early in order to restore drainage and obtain pus for culture because correct antibiotics selection is very important. However, as such patients sometimes have no, or only a small amount of, pus in the maxillary sinus, especially during chemotherapy, a mucosal culture can be used instead. Moreover, we can use this method with other chronic rhinosinusitis patients with acute exacerbation if a pus specimen is not available.

The common pathogens were the same in both groups, as shown in Table 1&2. This finding is another reason why a mucosal culture is a good alternative method for identifying causative pathogens. In a comparison with other studies in Thailand as well as with a recent systematic review by Thanasumpun and Batra[23] (Table 4), the majority of causative aerobic bacteria are usually gram-negative rods, such as *Pseudomonas aeruginosa* and *Klebsiella pneumoniae*, and *Staphylococcus aureus*. This data should be used as a guide to the prescribing of the correct antibiotics for chronic rhinosinusitis patients in Thailand.

Although novel molecular methods can be used to identify bacteria, pus cultures from maxillary sinuses are a reference standard. Culture methods from pus or tissue are cheap, easy to perform, reliable to identify pathogenic bacteria, and suitable to use in our country. The drawback of this study is that it did not include anaerobic bacterial cultures. Because anaerobic bacteria are also common organisms in chronic rhinosinusitis, further studies that include anaerobic bacterial cultures are needed to develop more complete data.

CONCLUSION

The types of pathogenic bacteria recovered from the mucosa and pus from the chronic maxillary rhinosinusitis patients were similar. The mucosal cultures should be a reference standard and can be used as an alternative method when pus is unavailable, especially with immunocompromised patients. This is because of, firstly, the high degree of similarity between the types of bacteria found in the mucosal and pus cultures; secondly, the good concordance rate of the two aerobic bacterial culture techniques; and finally, the high specificity and positive predictive value of the mucosal cultures, compared with the pus cultures.

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TABLE 4. Results of aerobic bacteriological cultures from chronic maxillary rhinosinusitis patients from several studies in Thailand and a systematic review.

Study authors	Year of study	Participants (Number of cases)	Results (Positive pus cultures)	
Jareoncharsri P, et al.[20]	1997–1999	31	74.19% (23/31)	
			H. influenzae	10.77%
			Non-fermentative gram-negative rod	7.69%
			K. pneumoniae	4.62%
Tantilipikorn P, et al.[21]	2004	162	50.61% (82/162)	
			P. aeruginosa	16.2%
			Non-fermentative gram-negative rod	10.8%
			CNS	9.9%
			K. pneumoniae	9.9%
This study	2010–2011	27	51.85% (14/27)	
			P. aeruginosa	21.88%
			S. aureus	9.38%
			K. pneumoniae	6.25%
			Non-fermentative gram-negative rod	6.25%
Udomsiri N and Bedavanija A, et al.[22]	2011–2012	85	51.76% (44/85)	
			P. aeruginosa	18.82%
			S. aureus	5.88%
			K. pneumoniae	4.71%
			Non-fermentative gram-negative rod	2.35%
Thanasumpun T and Batra PS[23]	2015 (systematic review)	6005 CNS	63.71% (3826/6005) 10.24%	
			S. aureus	7.82%
			H. influenzae	3.98%
			Viridans streptococci	3.79%
			P. aeruginosa	3.22%

N.B.: *H. influenzae=Haemophilus influenzae, K. pneumoniae= Klebsiella pneumoniae*, CNS= Coagulase negative *Staphylococcus aureus, S. aureus=Staphylococcus aureus*

REFERENCES

1. Carenfelt C, Lundberg C, Nord CE, Wretlind B. Bacteriology of maxillary sinusitis in relation to quality of the retained secretion. Acta Otolaryngol. 1978; 86:298-302.
2. Gwaltney JM Jr, Sydnor A Jr, Sande MA. Etiology and antimicrobial treatment of acute sinusitis. Ann Otol Rhinol Laryngol Suppl. 1981;90:68-71.
3. Evans FO Jr, Sydnor JB, Moore WE, Moore GR, Manwaring JL, Brill AH, et al. Sinusitis of the maxillary antrum. N Engl J Med. 1975;273:735-9.
4. Frederick J, Braude AI. Anaerobic infection of the paranasal sinuses. N Engl J Med. 1974; 290:135-7.
5. Bjorkwall T. Bacteriological examinations in maxillary sinusitis. Acta Otolaryngol Suppl. 1950; 83:9-58.
6. Benninger MS, Appelbaum PC, Denneny JC, Osguthorpe DJ, Stankiewicz JA. Maxillary sinus puncture and culture in

the diagnosis of acute rhinosinusitis: the case for pursuing alternative culture methods. Otolaryngol Head Neck Surg. 2002;127:7-12.
7. Karma P, Jokipii L, Sipila P, Luotonen J, Jokipii AM. Bacteria in chronic maxillary sinusitis. Arch Otolaryngol. 1979;105:386-90.
8. Jiang RS, Liang KL, Jang JW, Hsu CY. Bacteriology of endoscopically normal maxillary sinuses. J Laryngol Otol. 1999;113:825-8.
9. Su WY, Liu C, Hung SY, Tsai WF. Bacteriological study in chronic maxillary sinusitis. Laryngoscope. 1983;93:931-4.
10. Fokkens W, Lund V, Mullol J. European position paper on rhinosinusitis and nasal polyps 2007. Rhinol Suppl. 2007;20:1-136.
11. Fokkens W, Lund V, Mullol J, Bachert C, Alobid I, Baroody F, et al. European position paper on rhinosinusitis and nasal polyps 2012. Rhinol Suppl. 2012;23:1-298.
12. Kirtsreesakul V, Chatwiwat Y, Laohaprertthisan V. A comparison between endoscopically middle meatal aspiration culture using modified aspiration instrument and direct maxillary antral tap culture in chronic rhinosinusitis. J Med Assoc Thai. 2005;88:1591-7.
13. Vogan JC, Bolger WE, Ketes AS. Endoscopically guided sinonasal cultures: a direct comparison with maxillary sinus aspirate cultures. Otolaryngol Head Neck Surg. 2000; 122:370-3.
14. Desrosiers M, Bendouah Z, Barbeau J. Effectiveness of topical antibiotics on Staphylococcus aureus biofilm in vitro. Am J Rhinol. 2007;21:149-53.
15. Kilty SJ, Desrosiers MY. The role of bacterial biofilms and the pathophysiology of chronic rhinosinusitis. Curr Allergy Asthma Resp. 2008;8:227-33.
16. Costerton JW, Stewart PS, Greenbreg EP. Bacterial biofilms: a common cause of persistent infections. Science. 1999;284:1318-22.
17. Dlugaszewska J, Leszczynska M, Lenkowski M, Tatarska A, Pastusiak T, Szyfter W. The pathophysiological role of bacterial biofilms in chronic sinusitis. Eur Arch Otorhinolaryngol. 2016;273:1989-94.
18. Fastenberg JH, Hsueh WD, Mustafa A, Akbar NA, Abuzeid WM. Biofilms in chronic rhinosinusitis:pathophysiology and therapeutic strategies. World J Otorhinolaryngol Head Neck Surg. 2016;2:219-29.
19. Metcalf DG, Bowler PG, Hurlow J. A clinical algorithm for wound biofilm identification. J Wound Care. 2014;23:137-8, 140-2.
20. Jareoncharsri P, Bunnag C, Tunsuriyawong P, Voraprayoon S, Srifuengfung S, Bedavanija A. Bacteriologic profile of acute and chronic maxillary sinusitis. J Infect Dis Antimicrob Agents. 2001;18:96-102.
21. Tantilipikorn P, Bunnag C, Srifuengfung S, Dhiraputra C, Tiensasitorn C, Jareoncharsri P, et al. A surveillance study of bacteriologic profile in rhinosinusitis. Siriraj Med J. 2007;59:177-80.
22. Udomsiri N. Prevalence study of Anaerobic bacteria in chronic rhinosinusitis [dissertation]. Bangkok: Mahidol University; 2012.
23. Thanasumpun T, Batra PS. Endoscopic-derived bacterial cultures in chronic rhinosinusitis: a systematic review. Amer J Otolaryngol Head Neck Med Surg. 2015;36:686-91.