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Coagulase-negative *staphylococcus* culture in chronic rhinosinusitis

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Abstract

Objective—Coagulase-negative staphylococcus (CoNS) is commonly isolated from patients with chronic rhinosinusitis (CRS). However, the role of CoNS in CRS remains controversial. We aimed to determine the associations between positive CoNS culture at functional endoscopic sinus surgery (FESS) and CRS severity.

Methods—Adult CRS patients who underwent FESS between 10/1/2007 to 12/31/2011 were recruited. Patient demographics, disease characteristics, medication use, Lund-Mackay CT scores, and SNOT-22 scores were collected at baseline before FESS. Intraoperative cultures were obtained in a standard manner. Patients were placed into two groups based on culture findings: patients with CoNS as the sole positive culture result and patients with all other positive culture results, including CoNS, as part of a polymicrobial culture.

Results—376 CRS patients met the criteria. 106 patients (28%) had CoNS as their only isolate, 260 (69%) had other positive cultures, and 10 (3%) had no bacterial growth. Compared to patients with other positive cultures, patients with the sole result of CoNS were significantly less likely to have a history of FESS (52% versus 65%, $p=0.019$), nasal polyps (50% versus 65%, $p=0.006$), and had a better Lund-Mackay CT score (11.95 versus 14.18, $p=0.020$). After adjusting for all factors in the multiple logistic regression model, CoNS as the sole positive culture result was independently associated with having no history of FESS (OR=0.45, 95% CI, 0.22–0.94, $p=0.034$).

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Conclusion—Positive intraoperative CoNS cultures alone do not result in increased CRS disease burden by objective or subjective measures as compared to patients with other bacterial or polymicrobial culture isolates.

Keywords

chronic rhinosinusitis; infection; *Coagulase-negative staphylococcus*

Introduction

Chronic rhinosinusitis (CRS) is defined as a group of disorders characterized by inflammation of the mucosa of the nose and paranasal sinuses lasting for at least a 12-week duration. It is estimated to affect 14–16% of the population in the United States¹. The mainstay of medical therapy for CRS is the combination of long-term antibiotic therapy and nasal steroids². However, the role of bacterial infection in CRS remains controversial, especially *Coagulase-negative staphylococcus* (CoNS), one of the most commonly isolated bacteria in CRS. CoNS are part of the normal flora of human skin but can cause clinically significant infection when foreign bodies or immune compromise present. The treatment of CoNS infections is challenging because of the high antimicrobial resistance. It has been reported that more than 80% of CoNS isolates were resistant to methicillin and semisynthetic penicillins³. However, because CoNS is almost always present on human skin, it is unclear whether CoNS isolation in CRS is due to contamination without proper sterile technique during culture acquisition. Araujo et al. found that 56% of healthy patients had CoNS in the middle meatus compared with 20% of CRS patients, indicating that CoNS may be a contaminant.⁴ However, recent molecular genetic studies have shown the pathologic ability of CoNS, specifically *Staphylococcus epidermidis*, to be dependent on genes associated with biofilm formation that were only found in certain strains.⁵ Considering the controversy of the role of CoNS in CRS, the aim of our study was to determine the association between positive CoNS culture at the time of functional endoscopic sinus surgery (FESS) and CRS severity. An additional aim of our study was to evaluate whether CRS patients with certain comorbidities were more likely to have CoNS.

Methods

Study design and study population

Institutional review board approval was obtained from the University of Pennsylvania and all participants provided written consent. This is a retrospective cohort study. Adult CRS patients (≥ 18 years old) who were scheduled to have FESS at the Department of Otorhinolaryngology–Head and Neck Surgery at the Hospital of the University of Pennsylvania were screened between 2007 and 2011, and those with Sino-nasal outcome test (SNOT-22) score measures prior to FESS were enrolled. The inclusion criteria were patients who met the objective and subjective guidelines for the diagnosis of CRS⁶. According to the recommendation of guidelines for the studies of CRS,^{7,8} patients with the following diseases were excluded: cystic fibrosis, congenital or acquired immunodeficiency, congenital mucociliary, non-invasive fungal balls and invasive fungal disease, systemic vasculitis and granulomatous diseases, cocaine abuse, or neoplasia.

Endoscopically guided bacterial culture

Bacterial cultures were obtained during the FESS, and a standard method was used to collect sinus culture in order to minimize contaminant bacteria and represent sinus infection.⁹ After opening the blocked ostium, endoscopically guided cultures were taken by microbial swabs from the sinus secretions or diseased mucous membrane in the sinus. The aerobic cultures were collected from each patient with the BBL Culture Swab Collection & Transport System (Copan for Becton, Dickinson and Company, in Sparks MD). The samples were immediately sent to the hospital microbiology laboratory for standard microbiological speciation. Sheep blood (5%), chocolate, and MacConkey agar plates for aerobes were inoculated at 37°C aerobically (MacConkey) and under 5% carbon dioxide (blood and chocolate) and examined at 24 and 48 hours.¹⁰ Aerobes were identified using standard methods.¹⁰ For anaerobes, the samples were plated on a Brucella agar supplemented with 5% sheep blood, Vitamin K and Hemin. Plates were then incubated anaerobically for 4 days then examined after 24 hours, 48 hours and after 4 days. If growth was present, then aero-tolerance testing was done. If anaerobic growth was present, standard methods were then used to identify the anaerobes.¹¹

CoNS groups

In order to assess the association between the isolation of CoNS at the time of FESS and CRS severity, patients with bacterial isolates were placed into two groups based on culture findings: patients with CoNS as the sole positive culture results, and patients with all other positive culture results, including CoNS, as part of a polymicrobial culture. Patients with no bacterial growth were considered to be a separate group.

Objective and subjective measures of CRS severity and comorbidities

Preoperative SNOT-22 scores and Lund-Mackay CT scores were collected at the most recent preoperative clinical visits. Patients' medical records were reviewed to determine whether the patients had prior FESS for CRS and this was dichotomized into yes or no categories. Comorbidities that are often considered as risk factors for CRS or have been associated with refractory CRS, such as asthma, nasal polyps, allergic rhinitis, sleep apnea, diabetes, smoking, gastroesophageal reflux disease (GERD), and Samter's triad were collected from patients' medical records.

Potential confounding factors

Basic demographic data including age, sex and race were collected from patients' medical record prior to FESS. Oral antibiotics, oral steroids, nasal steroid spray, and nasal irrigations administered in the month prior to each sample collection were also collected, and dichotomized into yes or no categories. Since medication use in the month prior to sample collection may affect the culture results, we adjusted them in the logistic regression model. At our institute, preoperative topical antimicrobial irrigations and intravenous antibiotics and steroids were not routinely used in CRS patients. Due to the fact that many patients are referred to our institute for FESS after failing maximum medical therapy elsewhere, we did not have a standard way to collect the patients' maximum courses of medical therapy to use as the severity measure of CRS disease burden.

Statistical Analysis

Odds ratio (OR) is the output of logistic regression. It is a measure of association between an exposure and an outcome, and, by definition, the OR of the outcome is equal to the OR of the exposure. Regardless we chose patient characteristics as the outcomes or CoNS groups as the outcome, the statistical models would give the same results. However, using one primary outcome, i.e. CoNS groups, instead of many different outcomes, i.e. patient characteristics, in statistical analysis can avoid the risk of multiple comparisons. In addition, using patient characteristics as the outcomes require different statistical models, for example, linear regression is required for continuous outcomes, such as SNOT-22 scores, multinomial logistic regression is required for outcomes with more than one category, such as smoking status, and logistic regression is required for outcomes with two categories, such as asthma. Using different statistical models increases the difficulty of results interpretation, when no causal relationship was investigated or can be calculated from any of the statistical models. Thus, we chose CoNS groups as the primary outcome to simplify statistical analysis and make the results interpretable and understandable. In addition, in our sensitivity analysis, we used patient characteristics as the outcomes and applied various statistical models to confirm the results were the same regardless whether we chose CoNS groups as the outcome using logistic regression or patient characteristics as the outcomes using various statistical models.

X^2 tests and student's t-tests were used in univariable analyses. Logistic regression was used to evaluate the unadjusted association between CoNS groups and CRS severity measures one by one, and then all variables were entered into the multivariable logistic regression model to evaluate the main effects and adjust for the confounding effects of covariates. Both unadjusted and adjusted odds ratios (ORs) and 95% confidence intervals (95% CIs) were calculated. In our sub-analysis, we further compared the CRS severity measures between patients with CoNS as the sole positive culture result and patients with no bacterial growth. In addition, we tested if nasal polyps and prior FESS were effect modifiers, because the exposure-disease relationship is different within different levels of effect modifier, and it would be more accurate to stratify our final results by nasal polyps and prior FESS instead of presenting the combined results if nasal polyps and prior FESS were effect modifiers. Significance was based on $\alpha < 0.05$ and all hypothesis tests were 2-sided. All analyses were performed using Stata version 11.0 (Stata Corp, College Station, Texas).

Results

376 CRS patients who met inclusion criteria were enrolled. The mean age was 48 (95% CI, 47-50) years. 42% of the patients were female (n=153) and 90% were white (n=323). Table 1 shows the culture results. 10 patients had no bacterial growth (3%), 106 patients had CoNS isolates alone (28%) and the other 260 patients had polymicrobial or other bacterial isolates including anaerobes (69%). Other than CoNS, *Staphylococcus aureus*, *Pseudomonas spp.*, *Corynebacterium spp.*, *Streptococcus pneumonia*, other *Streptococcus*, *Haemophilus spp.*, *Moraxella catarrhalis*, *Enterobacteriaceae spp.*, *Propionibacterium acnes*, non-sporulating gram-positive bacilli other than *P. acnes*, *Peptostreptococcus spp.* are the most common bacterial isolates.

Table 2 shows patients' characteristics and the differences between CoNS groups. There were no statistical differences in CRS severity measures, co-morbidities and demographics between patients with CoNS as the sole positive culture result and patients with no bacterial growth, so the p-values are not listed for any of these associations in Table 2. In the univariable analysis, compared to patients with all other positive culture results, CRS patients with CoNS as the sole positive culture results were significantly more likely to have nasal polyps (65.39% vs. 50.00%, $p=0.006$), be an active smoker (19.81% vs. 10.77%, $p=0.034$), and have preoperative antibiotics (30.48% vs. 12.74%, $p<0.001$). However, they were significantly less likely to have nasal rinse (26.67% vs. 39.53%, $p=0.040$), prior FESS (51.89% vs. 65.12%, $p=0.019$), as well as significantly better Lund-Mackay CT scores (12 vs. 14, $p=0.020$).

In Table 3, we further calculated ORs and 95% CIs from the logistic regression models to show the magnitudes of the associations. After adjusting for all the clinical factors in the multiple logistic regression model, compared to patients with all other positive culture results, CRS patients with CoNS were significantly more likely to have preoperative antibiotics (OR=3.29, 95% CI (1.18, 9.16), $p=0.023$) but significantly less likely to have preoperative oral steroids (OR=0.36, 95% CI (0.13, 0.99), $p=0.047$) and a history of FESS (OR=0.45, 95% CI (0.22, 0.94), $p=0.034$). Multiple logistic regression model can help to identify independent associations while holding other potential confounding factors constant in the model, though the causal role of CoNS was not evaluated in our study.

We tested if nasal polyps and prior FESS were effect modifiers for the association between each clinical factor and CoNS groups, but none of the tests were statistically significant. Thus, nasal polyps and prior FESS were not effect modifiers for the associations between clinical factors and CoNS groups. Therefore, the combined analysis in Tables 2 and 3 remains to be our primary one. However, because patients with nasal polyps may have different disease etiology and it is well documented that culture results are different in the post-ESS patient, we attempted to sub-classify the CRS patients, and stratified our analysis by nasal polyps in Table 4, and by FESS history in Table 5. However, due to the small sample size in the subgroup analysis, none of the results were significant when stratifying the analysis by nasal polyps, and only the association between preoperative antibiotic use and CoNS groups were significant when stratifying the analysis by FESS history.

Table 6 shows the results of our sensitivity analysis using patient characteristics as the outcomes to quality the associations between patient characteristics and CoNS groups using various statistical models. The ORs from logistic regression and relative risk ratios (RRR) from multinomial logistic regression are the same as the results in Table 3. However, the β -coefficients from linear regression represent the mean changes of age, SNOT-22 scores and Lund-Mackay CT scores comparing patients with CoNS as the sole positive culture results to patients with all other positive culture results, and thus they are not ratios, however, the p-values barely changed as compared to the p-values in Table 3.

Discussion

Despite the high prevalence of CoNS in CRS, the effect of CoNS in CRS remains unclear. Our study demonstrates that CoNS as the sole positive culture result at the time of FESS did not result in increased CRS disease burden by objective or subjective measures as compared to other positive culture results, and the CoNS presence was independently associated with no history of FESS after adjusting for all clinical factors in the multiple logistic regression models. In addition, no CRS disease severity measures were found to be statistically significant between CRS patients with CoNS as the sole positive culture result and no bacterial growth. Araujo et al found 20% of the CRS patients had CoNS, while 56% healthy individuals had CoNS from the middle meatus secretion samples.⁴ But with recent studies of biofilms in CRS, certain strains of CoNS have been associated with biofilm formation.⁵ Although we did not test for the causal role of CoNS in CRS, to our knowledge, this appears to be the first study to evaluate the associations between CoNS and CRS disease severity

We found that CRS patients with CoNS as the sole positive culture result were significantly less likely to have a history of FESS as compared to patients with other positive culture results. Several published studies looked at the presence of bacteria in postoperative sinus using endoscopically directed cultures,¹²⁻¹⁵ and found that CoNS was one of the most common bacterial isolates in postoperative CRS patients.¹²⁻¹⁵ In our study, 106 patients had CoNS as the sole positive culture result and 111 patients had CoNS as part of polymicrobial isolation, and thus, CoNS was also the most common bacterial isolate. The novelty of our study is that we analyzed the group of CRS patients with CoNS as the sole positive culture result separately. Findings showed that CRS patients with CoNS as the sole positive culture result were significantly less likely to have a history of FESS as compared to CRS patients with other positive culture results. Moreover, after adjusting for all the clinical factors and potential confounders, the magnitude of the association between history of prior FESS and CoNS groups became even stronger (OR=0.45, 95% CI (0.22, 0.94), p=0.034) as compared to the unadjusted association (OR=0.58, 95% CI (0.37, 0.91), p=0.019) as shown in Table 3, which further demonstrated that this association was independent of all the other clinical factors and potential confounders. Our finding indicates that CoNS may not be associated with the refractory nature of CRS, and it is possible that FESS actually decreases the colonization of CoNS, and thus alters the microbiome of the sinuses.

In order to better understand if the associations between CoNS groups and CRS severity differ in subgroups of CRS, such as patients with versus patients without nasal polyps, as well as patients with versus patients without a history of FESS, we further tested if nasal polyps and a history of FESS were effect modifications for each of the associations between CoNS groups and the clinical factors, and none of the tests were statistically significant. This may be because CoNS is not only the most common bacterial isolate in CRS in general, but also in subgroups of CRS, such as patients with a history of FESS.¹²⁻¹⁵ Thus, the associations between the clinical factors and CoNS groups did not differ depending on the presence of nasal polyps or history of prior FESS. Therefore, it is appropriate to report combined results in Tables 2 and 3. We further reported the stratified results by nasal polyps and history of prior FESS in Tables 4 and 5 to show the percentage differences in sub-

groups of CRS, however, we did not have enough sample size to detect the statistical significance of similar associations in the sub-analyses.

We adjusted for the preoperative antibiotic use in the month prior to sample collection because antibiotic use in this time period may affect the culture results. We found that CRS patients with CoNS as the sole positive culture result were significantly more likely to have preoperative antibiotic use than patients with other positive culture results. Our previous study found that preoperative antibiotic use decreased the odds of positive culture results by 44%.¹⁶ The high CoNS isolation rates in patients with preoperative antibiotic use may suggest that CoNS rapidly repopulates the microbial voids created by antibiotic therapy. Another potential explanation for this finding is the high antibiotic resistance in CoNS isolated from the CRS patients. Resistance to methicillin and semisynthetic penicillin has been observed in more than 80% of CoNS isolates.³ Such isolates are often resistant to multiple classes of antibiotics in addition to beta-lactams.

In our unadjusted analysis, CRS patients with CoNS as the sole positive culture result were significantly less likely to have nasal polyps but this association went away in the multiple logistic regression model after adjusting for other factors. In contrast, preoperative oral steroids as a potential confounding factor was not significantly associated with CoNS as the sole positive culture result in the unadjusted analysis, but in our adjusted logistic regression model, CRS patients with CoNS as the sole positive culture result were associated with significantly less use of preoperative oral steroids. It is possible that the association between nasal polyps and CoNS were confounded by preoperative oral steroid use in the month prior to FESS. Another potential explanation of these findings is the correlation between oral steroids and nasal polyps.¹⁷ CRS patients with nasal polyps often receive oral steroids. When two factors are highly correlated in the multiple logistic regression model, the coefficient estimates may change. However, this does not reduce the predictive power or reliability of the model as a whole and it only affects calculations regarding individual predictors.¹⁸

CRS patients with CoNS as the sole positive culture result also had significantly better Lund-MacKay CT scores in our unadjusted analysis, but this association went away in the multiple regression model. This may be because Lund-MacKay CT scores did not add any additional information to the model after adjusting for all the other clinical factors. Moreover, the mean difference in Lund-MacKay CT scores was 2, which may not be clinically important, because the mean Lund-Mackay score in patients who undergo imaging for nonrhinologic symptoms has been found to be 4.3.¹⁹ In addition, active smoking was also significantly associated with higher isolation rates of CoNS alone as compared to non-smoking in the unadjusted analysis, but the association disappeared in the adjusted multiple Logistic regression model, and thus, there was no independent association between CoNS as the sole positive culture result and smoking.

A limitation of our study is that not all CRS patients who underwent FESS had pre-operative measures of SNOT-22 scores and thus, only patients with complete information on all the variables for the study were included in the analysis. In addition, all the clinical variables were collected retrospectively from patients' medical records. Finally, the standard culture

results used in our study may be different from results from microbial assays or other molecular microbiology methods, and future studies using molecular microbiology methods can help to verify our findings.

In conclusion, despite the high prevalence of CoNS in CRS and their controversial effect on CRS, our findings indicate that CoNS as the sole positive culture result did not result in increased CRS disease burden by objective or subjective measures as compared to other positive culture results, and presence of CoNS alone was independently associated with no history of prior FESS. Moreover, there was no significant difference in CRS disease severity between patients with CoNS as the sole positive culture result and no bacterial growth. Future studies with increased sample size can further evaluate if the effect of CoNS differs in sub-groups of CRS.

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Table 1
Bacteria isolated from all patients (N=376)

Culture results	No. of isolates
No growth	10
Only Coagulase-negative <i>staphylococcus</i>	106
Polymicrobial or other bacterial isolates	260
Mixed Coagulase-negative <i>staphylococcus</i>	111
<i>Staphylococcus aureus</i>	104
<i>Pseudomonas spp.</i>	32
<i>Corynebacterium spp.</i>	46
<i>Haemophilus spp.</i>	18
<i>Streptococcus pneumoniae</i>	17
Other <i>Streptococcus</i>	39
<i>Moraxella catarrhalis</i>	7
Enterobacteriaceae spp.	35
Anaerobes (n=224)	
<i>Propionibacterium acnes</i>	82
Non-sporulating gram-positive bacilli other than <i>P. acnes</i>	26
<i>Peptostreptococcus spp.</i>	24
Others	14

Table 2

Patients' characteristics by culture results

Characteristics	Total	No growth	Culture	Results	p-value
n(%) or mean ± SD			Only CoNS	Others	
Age	48(47, 50)	49(35, 63)	48(46, 51)	48(47, 50)	0.889
Sex					0.662
Female	153(42.03)	6(60.00)	46(43.81)	107(41.31)	
Male	211(57.97)	4(40.00)	59(56.19)	152(58.69)	
Race					0.771
White	323(89.72)	7(77.78)	92(88.46)	231(90.23)	
Black	28(7.78)	1(11.11)	10(9.62)	18(7.03)	
Asian	6(1.67)	1(11.11)	1(0.96)	5(1.95)	
Hispanic	3(0.83)	0(0.00)	1(0.96)	2(0.78)	
Asthma	202(55.19)	3(30.00)	59(55.66)	143(55.00)	0.908
Nasal polyps	223(60.93)	3(30.00)	53(50.00)	170(65.39)	0.006
Allergic rhinitis	242(66.12)	6(60.00)	70(66.04)	172(66.15)	0.983
Sleep apnea	17(4.65)	0(0.00)	5(4.72)	12(4.62)	0.967
Diabetes	26(7.10)	0(0.00)	6(5.66)	20(7.69)	0.492
Smoking					0.034
Nonsmoker	243(66.39)	7(70.00)	61(57.55)	182(70.00)	
Former	74(20.22)	1(10.00)	24(22.64)	50(19.23)	
Current	49(13.39)	2(20.00)	21(19.81)	28(10.77)	
GERD	94(25.75)	2(20.00)	26(24.53)	68(26.26)	0.732
Samter's triad	29(7.92)	1(10.00)	9(8.49)	20(7.69)	0.798
Preoperative antibiotics	65(17.86)	2(20.00)	32(30.48)	33(12.74)	<0.001
Nasal rinse					0.040
None	233(64.19)	9(90.00)	77(73.33)	156(60.47)	
Saline	122(33.61)	1(10.00)	25(23.81)	97(37.60)	
With Medications	8(2.20)	0(0.00)	3(2.857)	5(1.94)	
Steroid use					0.586
None	153(42.15)	5(50.00)	45(43.27)	108(41.70)	

Characteristics n(%) or mean ± SD	Total	No growth	Results		p-value
			Only CoNS	Others	
<i>Nasal</i>	64(17.63)	1(10.00)	21(20.19)	43(16.60)	
<i>Oral</i>	115(31.68)	4(40.00)	32(30.77)	83(32.05)	
<i>Both</i>	31(8.54)	0(0.00)	6(5.77)	25(9.65)	
Prior FESS	223(61.26)	4(40.00)	55(51.89)	168(65.12)	0.019
SNOT-22 scores	40(38.43)	29(9.49)	41(37.46)	40(38.43)	0.767
Lund-Mackay CT scores	14(13.14)	11(0.23)	12(10.14)	14(13.15)	0.020
Total (row^a%)	376	10(2.68)	106(28.18)	260(69.14)	

Note: GERD: Gastroesophageal reflux disease

Table 3
Unadjusted and adjusted associations between CoNS as the sole positive culture result and patients' characteristics

Characteristics	Unadjusted		Adjusted	
	OR (95%CI)	p-value	OR (95%CI)	p-value
Age	1.00(0.98, 1.02)	0.888	1.00(0.98, 1.03)	0.580
Sex				
<i>Female</i>	Reference		Reference	
<i>Male</i>	0.90(0.57, 1.43)	0.662	1.09(0.54, 2.24)	0.804
Race				
<i>White</i>	Reference		Reference	
<i>Black</i>	1.39(0.62, 3.14)	0.421	1.37(0.39, 4.81)	0.628
<i>Asian</i>	0.50(0.06, 4.36)	0.532	1.14(0.10, 12.50)	0.917
<i>Hispanic</i>	1.26(0.11, 14.01)	0.853	7.65(0.37, 157.66)	0.188
Asthma	1.03(0.65, 1.62)	0.908	1.91(0.90, 4.05)	0.091
Nasal polyps	0.53(0.33, 0.84)	0.007	0.76(0.35, 1.65)	0.488
Allergic rhinitis	0.99(0.62, 1.60)	0.983	1.08(0.50, 2.31)	0.847
Sleep apnea	1.02(0.35, 2.98)	0.967	0.93(0.22, 4.00)	0.924
Diabetes	0.72(0.28, 1.85)	0.494	1.21(0.35, 4.21)	0.759
Smoking				
<i>Nonsmoker</i>	Reference		Reference	
<i>Former</i>	1.43(0.81, 2.52)	0.214	1.28(0.54, 3.07)	0.574
<i>Current</i>	2.24(1.18, 4.23)	0.013	1.54(0.55, 4.28)	0.408
GERD	0.91(0.54, 1.54)	0.732	0.85(0.39, 1.86)	0.690
Samter's triad	1.11(0.49, 2.53)	0.798	0.41(0.08, 2.16)	0.293
Preoperative antibiotics	3.00(1.73, 5.22)	<0.001	3.29(1.18, 9.16)	0.023
Nasal rinse				
<i>None</i>	Reference		Reference	
<i>Saline</i>	0.52(0.31, 0.88)	0.014	0.99(0.46, 2.11)	0.976
<i>With Medications</i>	1.22(0.28, 5.22)	0.793	4.22(0.39, 45.91)	0.237
Steroid use				
<i>None</i>	Reference		Reference	
<i>Nasal</i>	1.17(0.63, 2.19)	0.620	0.97(0.40, 2.34)	0.944
<i>Oral</i>	0.93(0.54, 1.58)	0.776	0.36(0.13, 0.99)	0.047
<i>Both</i>	0.58(0.22, 1.50)	0.258	1.02(0.27, 3.76)	0.981
Prior FESS	0.58(0.37, 0.91)	0.019	0.45(0.22, 0.94)	0.034
SNOT-22 scores	1.00(0.99, 1.01)	0.766	1.00(0.98, 1.02)	0.876
Lund-Mackay CT scores	0.95(0.90, 0.99)	0.021	0.97(0.91, 1.04)	0.387

Table 4
The characteristics of CRS patients with versus without nasal polyps by culture results

Characteristics n(%) or mean±SD	Nasal polyps		Culture results			
	No		Yes		P-value	
	Only CoNS	Others	Only CoNS	Others	P-value	P-value
Age, mean (95%CI)	48(46, 52)	49(44, 52)	48(46, 50)	48(45, 52)	0.700	0.889
Sex					0.400	0.560
<i>Female</i>	28(52.83)	41(45.56)	18(34.62)	66(39.05)		
<i>Male</i>	25(47.17)	49(54.44)	34(65.39)	103(60.95)		
Race					0.735	0.740
<i>White</i>	49(94.23)	80(90.91)	43(82.69)	151(89.88)		
<i>Black</i>	3(5.77)	6(6.82)	7(13.46)	12(7.14)		
<i>Asian</i>	0(0)	1(1.14)	1(1.92)	4(2.38)		
<i>Hispanic</i>	0(0)	1(1.14)	1(1.92)	1(0.60)		
Asthma	24(45.28)	27(30.00)	35(66.04)	116(68.24)	0.065	0.070
Allergic rhinitis	30(56.60)	44(48.89)	40(75.47)	128(75.29)	0.373	0.370
Sleep apnea	2(3.77)	5(5.56)	3(5.66)	7(4.12)	0.633	0.630
Diabetes	1(1.89)	6(6.67)	5(9.43)	14(8.24)	0.201	0.200
Smoking					0.323	0.320
<i>Nonsmoker</i>	30(56.60)	62(68.89)	31(58.49)	120(70.59)		
<i>Former</i>	14(26.42)	18(20.00)	10(18.87)	32(18.82)		
<i>Current</i>	9(16.98)	10(11.11)	12(22.64)	18(10.59)		
GERD	14(26.42)	22(24.72)	12(22.64)	46(27.06)	0.822	0.820
Santer's triad	0(0)	2(2.22)	9(16.98)	18(10.59)	0.274	0.270
Preoperative antibiotics	17(32.08)	15(16.67)	15(28.85)	18(10.65)	0.033	0.030
Nasal rinse					0.086	0.090
<i>None</i>	41(77.39)	64(71.11)	36(69.23)	92(54.76)		
<i>Saline</i>	10(18.87)	26(28.89)	15(28.85)	71(42.26)		
<i>With Medications</i>	2(3.77)	0(0)	1(1.923)	5(2.98)		

Characteristics n(%) or mean±SD	Nasal polyps		Culture results			
	No		Yes			
	Only CoNS	Others	P-value	Only CoNS	Others	P-value
Steroid use			0.248			0.250
<i>None</i>	28(53.85)	56(62.22)		17(32.69)	52(30.77)	
<i>Nasal</i>	8(15.39)	14(15.56)		13(25.00)	29(17.16)	
<i>Oral</i>	16(30.77)	17(18.89)		16(30.77)	66(39.05)	
<i>Both</i>	0(0)	3(3.33)		6(11.54)	22(13.02)	
Prior FESS			0.267			0.270
	22(41.51)	46(51.11)		33(62.26)	122(72.62)	
SNOT-22 scores, mean (95%CI)			0.976			0.488
	39(34, 43)	39(32, 45)		44(38, 45)	41(37, 51)	
Lund-Mackay CT scores, mean (95%CI)			0.644			0.020
	10(8, 11)	9(8, 13)		14(15, 17)	16(11, 16)	
Total (row%)	53(37.06)	90(62.94)		53(23.77)	170(76.23)	

Table 5
The characteristics of CRS patients with versus without prior FESS by culture results

Characteristics n(%) or mean (95%CI)	Prior FESS			
	No		Yes	
	Culture results		Culture results	
	CoNS	Other	P-value	P-value
Age, mean (95%CI)	47(43, 51)	47(44, 50)	0.890	0.880
Sex			0.239	0.685
<i>Female</i>	24(48.00)	34(37.78)		72(43.11)
<i>Male</i>	26(52.00)	56(62.22)		95(56.89)
Race			0.679	0.539
<i>White</i>	44(88.00)	75(84.27)		154(93.33)
<i>Black</i>	6(12.00)	13(14.61)		5(3.03)
<i>Asian</i>	0(0)	1(1.12)		4(2.42)
				1(1.85)
				2(1.21)
Asthma	23(45.10)	38(42.22)	0.741	0.636
Nasal polyps	20(39.22)	46(51.11)	0.174	0.078
Allergic rhinitis	33(64.71)	53(58.89)	0.496	0.678
Sleep apnea	2(3.92)	7(7.78)	0.368	0.391
Diabetes	3(5.88)	4(4.44)	0.706	0.348
Smoking			0.058	0.248
<i>Nonsmoker</i>	30(58.82)	70(77.78)		110(65.48)
<i>Former</i>	10(19.61)	9(10.00)		41(24.41)
<i>Current</i>	11(21.57)	11(12.22)		17(10.12)
GERD	10(19.61)	22(24.44)	0.510	0.757
Samter's triad	2(3.92)	3(3.33)	0.856	0.588
Preoperative antibiotics	15(29.41)	6(6.74)	<0.001	0.013
Nasal rinse			0.664	0.112
<i>None</i>	40(78.43)	65(73.03)		90(53.89)
<i>Saline</i>	10(19.61)	23(25.84)		73(43.71)

Characteristics n(%) or mean (95%CI)	Prior FESS		Culture results			
	No		Yes			
	CoNS	Other	P-value	CoNS	Other	P-value
<i>With Medications</i>	1(1.96)	1(1.12)	0.959	2(3.70)	4(2.40)	
Steroid use						0.713
<i>None</i>	25(49.02)	45(50.56)		20(37.74)	62(36.91)	
<i>Nasal</i>	9(17.65)	15(16.85)		12(22.64)	28(16.67)	
<i>Oral</i>	16(31.37)	26(29.21)		16(30.19)	56(33.33)	
<i>Both</i>	1(1.96)	3(3.37)		5(9.43)	22(13.10)	
SNOT-22 scores, mean (95%CI)	41(34, 48)	38(34, 42)	0.493	42(35, 48)	42(38, 45)	0.990
Lund-Mackay CT scores, mean (95%CI)	11(8, 13)	13(11, 15)	0.090	13(11, 16)	15(14, 16)	0.286
Total (row%)	51(36.17)	89(63.83)		53(24.66)	168(75.34)	

Table 6
Unadjusted associations between patients' characteristics and CoNS as the sole positive culture result

Logistic regression	OR (95%CI)	p-value
Sex		
<i>Female</i>	Reference	
<i>Male</i>	0.90(0.57, 1.43)	0.662
Asthma	1.03(0.65, 1.62)	0.908
Nasal polyps	0.53(0.33, 0.84)	0.007
Allergic rhinitis	0.99(0.62, 1.60)	0.983
Sleep apnea	1.02(0.35, 2.98)	0.967
Diabetes	0.72(0.28, 1.85)	0.494
GERD	0.91(0.54, 1.54)	0.732
Samter's triad	1.11(0.49, 2.53)	0.798
Preoperative antibiotics	3.00(1.73, 5.22)	<0.001
Prior FESS	0.58(0.37, 0.91)	0.019
Linear regression	β-coefficient (95%CI)	p-value
Age	-0.22(-3.24, 2.81)	0.889
SNOT-22 scores	0.76(-4.29, 5.81)	0.767
Lund-Mackay CT scores	-2.23(-4.09, -0.36)	0.020
Multinomial Logistic Regression	RRR (95%CI)	p-value
Race		
<i>White</i>	Reference	
<i>Black</i>	1.39(0.62, 3.14)	0.421
<i>Asian</i>	0.50(0.06, 4.36)	0.532
<i>Hispanic</i>	1.26(0.11, 14.01)	0.853
Smoking		
<i>Nonsmoker</i>	Reference	
<i>Former</i>	1.43(0.81, 2.52)	0.214
<i>Current</i>	2.24(1.18, 4.23)	0.013
Nasal rinse		
<i>None</i>	Reference	
<i>Saline</i>	0.52(0.31, 0.88)	0.014
<i>With Medications</i>	1.22(0.28, 5.22)	0.793
Steroid use		
<i>None</i>	Reference	
<i>Nasal</i>	1.17(0.63, 2.19)	0.620
<i>Oral</i>	0.93(0.54, 1.58)	0.776
<i>Both</i>	0.58(0.22, 1.50)	0.258