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ORIGINAL RESEARCH

Investigation into Antibiotic Resistance Profiles of *Staphylococcus aureus* Among Chronic Rhinosinusitis Patients and Multifaceted Analysis of Factors Influencing Methicillin-Resistant *Staphylococcus aureus* Infection

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Objective: This study aimed to comprehensively investigate the antibiotic resistance characteristics of *Staphylococcus aureus (S. aureus)* in chronic rhinosinusitis (CRS) patients and to identify key determinants influencing the development of methicillin-resistant Staphylococcus aureus (MRSA) infections.

Methods: A retrospective analysis was conducted on 180 CRS patients admitted to our hospital between February 2022 and July 2024. Nasal secretion samples were collected upon admission for *S. aureus* strain isolation, and antibiotic susceptibility testing was performed using an automated microbiology system. Patients were categorized into MRSA and methicillin-sensitive Staphylococcus aureus (MSSA) groups based on oxacillin resistance. Univariate analysis was used to screen potential risk factors, followed by multivariate logistic regression to determine independent predictors.

Results: Among 180 isolated *S. aureus* strains, 74 (41.1%) were MRSA and 106 (58.9%) were MSSA. MRSA strains exhibited significantly higher resistance rates to cefoxitin, amikacin, ciprofloxacin, and six other antibiotic classes compared to MSSA strains (all $P<0.05$), with resistance exceeding 50% for fluoroquinolones and macrolides. Univariate analysis identified 12 clinical factors associated with MRSA infection, including male sex, smoking history, disease duration >5 years, and frequent antibiotic use. Multivariate regression analysis confirmed nine independent risk factors: male sex (OR=2.31), nasal structural abnormalities (OR=1.89), previous nasal surgery (OR=1.76), ≥3 acute infections per year (OR=2.14), excessive antibiotic exposure, and others.

Conclusion: MRSA exhibits pronounced resistance to commonly used antibiotics in CRS treatment. Clinicians should prioritize targeted screening for high-risk patients, optimize antibiotic stewardship, and enhance postoperative nasal function management. Implementing a multifaceted approach—including early risk assessment, standardized antibiotic use, and intensified follow-up care—can effectively mitigate MRSA infection risks and improve overall treatment outcomes for CRS patients.

Keywords: chronic rhinosinusitis, staphylococcus aureus infection, antibiotic resistance, methicillin-resistant staphylococcus aureus, risk factors

Introduction

Chronic rhinosinusitis (CRS) is a common chronic inflammatory disease of the upper respiratory tract, primarily characterized by nasal congestion, excessive nasal discharge, headache, and loss of smell, which significantly disrupts patients' daily life.[1] It is estimated that approximately 12% of adults worldwide are affected by CRS, and the incidence rate continues to rise.[2] Although most cases can be alleviated with routine treatments such as antibiotics and nasal corticosteroids, some patients experience prolonged disease courses and recurrent symptoms that are difficult to control, often necessitating surgical intervention.[3] Furthermore, CRS not only affects patients' quality of life but may also lead to

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complications such as chronic cough, pharyngitis, bronchitis, and even impair heart and lung functions.[4] Therefore, the treatment and management of CRS have become significant challenges for clinicians. The development of CRS is associated with multiple factors, and bacterial infections are considered an important trigger.[5]

Staphylococcus aureus (S. aureus) is one of the most common pathogens in CRS, especially in patients with long-term recurrent symptoms.[6] This bacterium has strong pathogenicity and produces various toxins that damage the nasal and sinus mucosal barriers, leading to localized inflammatory responses.[7] Meanwhile, due to its frequent clinical occurrence, the issue of antibiotic resistance in *S. aureus* has gradually become prominent, particularly with the emergence of methicillin-resistant Staphylococcus aureus (MRSA). MRSA strains are resistant to multiple commonly used antibiotics, and their infections not only complicate treatment but also prolong the course of illness, potentially leading to severe complications such as sepsis and pneumonia, which severely impact prognosis.[8,9] Moreover, due to their high resistance and limited treatment options, MRSA infections significantly increase medical costs, placing a heavy burden on patients and the healthcare system.

Previous studies[10–12] have shown that MRSA infection may be related to several clinical factors, including gender, age, smoking history, disease duration, comorbidities, and the frequency and duration of antibiotic use. However, there is still a lack of systematic research on the specific factors influencing MRSA infection in CRS patients, particularly on how to effectively screen for and prevent MRSA infections.

Therefore, the present study retrospectively analyzed the clinical data of 180 CRS patients in our hospital, aiming to investigate the antibiotic resistance characteristics of *S. aureus* and to explore the influencing factors of MRSA infection, with the goal of providing valuable reference for clinical diagnosis, prevention, and treatment strategies.

Materials and Methods

Study Subjects

This retrospective analysis included 180 CRS patients admitted to our hospital between February 2022 and July 2024. Inclusion criteria: (1) Met the clinical diagnostic criteria for CRS;[13] (2) Age ≥18 years, regardless of sex; (3) CRS history >6 months before admission, with recurrent acute exacerbations or chronic symptoms; (4) Nasal secretion samples collected for *S. aureus* isolation upon admission; (5) Provided written informed consent. Exclusion criteria: (1) Severe immune system diseases (eg, AIDS, immunosuppressive states), malignant tumors, severe heart disease, or liver/kidney dysfunction; (2) Acute sinusitis with a course <12 weeks or recent acute upper respiratory infection; (3) Received systemic antibiotic treatment within the past 6 months; (4) Pregnancy or lactation; (5) Voluntary withdrawal during the study.

Ethical Approval

This study was approved by the Medical Ethics Committee of the People's Hospital Affiliated to Shandong First Medical University (Approval No.: EBK-GR240012), and was conducted in accordance with the Declaration of Helsinki.

MRSA Identification and Screening

Under nasal endoscopic visualization, sterile cotton swabs were used to collect sinus secretion samples, which were immediately placed in sterile containers and transported to the laboratory. Specimens were considered qualified when the number of squamous epithelial cells was <10 and the number of white blood cells was >25 under low magnification, or the ratio of squamous epithelial cells to white blood cells was <1:2.5. Bacterial identification was performed using the VITEK-2 automated microbiology system (BioMérieux, France). The Kirby–Bauer (K–B) disk diffusion method was used for susceptibility testing, with quality control strain *S. aureus* ATCC 25923 (National Health and Family Planning Commission Clinical Testing Center). According to the latest Clinical and Laboratory Standards Institute (CLSI) guidelines,[14] strains resistant to oxacillin or cefoxitin were classified as MRSA, and the rest as methicillin-sensitive Staphylococcus aureus (MSSA).

Antibiotic Susceptibility Testing

Susceptibility testing was performed against the following antibiotic classes and agents, with concentrations (μg) indicated for each disk: β-lactams: Cefoxitin (FOX, 30 μg); Aminoglycosides: Amikacin (AK, 30 μg); Fluoroquinolones:

Ciprofloxacin (CIP, 5 μg), Levofloxacin (LFX, 5 μg); Oxazolidinones: Linezolid (LIN, 30 μg); Lipopeptides: Daptomycin (DAP, 30 μg); Sulfonamides: Trimethoprim–sulfamethoxazole (SXT, 1.25/23.75 μg); Lincosamides: Clindamycin (CLI, 2 μg); Nitrofurans: Nitrofurantoin (NIT, 300 μg); Macrolides: Erythromycin (E, 15 μg); Rifamycins: Rifampicin (RIF, 5 μg); Glycopeptides: Teicoplanin (TEC, 30 μg), Vancomycin (VA, 30 μg); Tetracyclines: Tetracycline (TE, 30 μg). According to the latest CLSI guidelines.

Analysis of Factors Influencing MRSA Infection

Potential risk factors included sex, age, BMI, disease duration, comorbidities, smoking status, nasal polyps, history of intranasal corticosteroid use, previous nasal surgery, Lund–Kennedy score,[15] frequency/duration of acute infections, nasal septum deviation, allergic rhinitis, frequency/duration of antibiotic use, gastroesophageal reflux, drainage obstruction, combined antibiotic therapy, and serum albumin (ALB) levels. Significant factors in univariate analysis were entered into multivariate logistic regression.

Statistical Analysis

Statistical analyses were performed with SPSS 25.0. Categorical data were expressed as n (%) and analyzed using the chi-square (χ^2) test. Continuous variables were expressed as ($\bar{x} \pm s$) and compared using the independent-sample *t*-test. A two-sided P-value <0.05 was considered statistically significant. Graphs were generated using GraphPad Prism 8.

Results

Demographic and Clinical Characteristics

A total of 180 patients with chronic rhinosinusitis were included in this study, comprising 116 males (64.44%) and 64 females (35.56%), with a mean age of 45.20 ± 11.49 years and a mean BMI of 22.32 ± 2.27 kg/m².

Antibiotic Susceptibility Test Results

Among the 180 *S. aureus* isolates, 74 strains were identified as MRSA and 106 strains as MSSA. The antibiotic resistance profiles are presented in Tables 1 and 2. As shown in Table 1, MRSA exhibited markedly higher resistance rates to FOX, AK, CIP, LFX, CLI, E, RIF, and TE compared with MSSA, and the differences were statistically significant (P < 0.05). No resistance was observed to LIN, TEC, or VA in either group.

Table 1 Antibiotic Susceptibility Results of *S. aureus* Isolates [n (%)]

Antimicrobial Drug	Total (n=180)	MRSA (n=74)	MSSA (n=106)	x^2	P
FOX	74 (41.11)	74 (100.00)	0 (0.00)	180.000	<0.001
AK	23 (12.78)	21 (28.38)	2 (1.89)	27.440	<0.001
CIP	73 (40.56)	51 (68.92)	22 (20.75)	41.932	<0.001
LFX	66 (36.67)	56 (75.68)	10 (9.43)	53.529	<0.001
LIN	0 (0.00)	0 (0.00)	0 (0.00)	0.000	1.000
QD	3 (1.67)	3 (100.00)	0 (0.00)	2.246	0.133
SXT	21 (11.67)	5 (23.81)	16 (15.09)	2.939	0.086
CLI	76 (42.22)	46 (62.16)	30 (28.30)	20.480	<0.001
NIT	4 (2.22)	4 (100.00)	0 (0.00)	3.636	0.056
E	118 (65.56)	60 (81.08)	58 (54.72)	13.414	<0.001
RIF	38 (21.11)	31 (41.89)	7 (6.60)	32.583	<0.001
TEC	0 (0.00)	0 (0.00)	0 (0.00)	0.000	1.000
VA	0 (0.00)	0 (0.00)	0 (0.00)	0.000	1.000
TE	95 (52.78)	63 (85.14)	32 (30.19)	52.789	<0.001

Abbreviations: FOX, cefoxitin; AK, amikacin; CIP, ciprofloxacin; LFX, levofloxacin; LIN, linezolid; QD, quinupristin/dalfopristin; SXT, trimethoprim-sulfamethoxazole; CLI, clindamycin; NIT, nitrofurantoin; E, erythromycin; RIF, rifampicin; TEC, teicoplanin; VA, vancomycin; TE, tetracycline.

Table 2 Comparative Resistance Patterns Between MRSA and MSSA

Antibiotic	MRSA Resistance Rate (%)	MSSA Resistance Rate (%)	P
FOX	100.00	0.00	<0.001
AK	28.38	1.89	<0.001
CIP	68.92	20.75	<0.001
LFX	75.68	9.43	<0.001
CLI	62.16	28.30	<0.001
E	81.08	54.72	<0.001
RIF	41.89	6.60	<0.001
TE	85.14	30.19	<0.001

Univariate Analysis of Factors Influencing MRSA Infection

The results of the univariate analysis showed that, in the MRSA group, male gender, CRS duration >5 years, smoking, allergic rhinitis, nasal structural abnormalities, history of nasal surgery, poor drainage, frequency of acute infections >3 times/year, frequency of recurrent upper respiratory tract infections >3 times/year, frequency of antibiotic use ≥3 times/year, antibiotic use duration >14 days, and use of ≥3 combined antibiotics had statistically significant differences compared with the MSSA group (P<0.05), as shown in Table 3.

Table 3 Univariate Analysis of Factors Influencing MRSA Infection ($\bar{x} \pm s$, n[%])

	MRSA (n=74)	MSSA (n=106)	t/x^2	P
Gender	–	–	12.813	<0.001
Male	59 (79.73)	57 (53.77)	–	–
Female	15 (20.27)	49 (46.23)	–	–
Age (years)	45.28±11.74	45.14±11.31	0.080	0.936
BMI (kg/m²)	22.19±2.25	22.42±2.30	0.666	0.506
Duration of Illness (years)	–	–	5.793	0.016
≤5	23 (31.08)	52 (49.06)	–	–
>5	51 (68.92)	54 (50.94)	–	–
Chronic Otitis Media	–	–	0.120	0.728
Yes	22 (29.73)	29 (27.36)	–	–
No	52 (70.27)	77 (72.64)	–	–
Diabetes	–	–	0.151	0.696
Yes	19 (25.68)	30 (28.30)	–	–
No	55 (74.32)	76 (71.70)	–	–
Smoking	–	–	5.861	0.015
Yes	37 (50.00)	34 (32.08)	–	–
No	37 (50.00)	72 (67.92)	–	–
Nasal Polyp	–	–	1.695	0.192
Yes	30 (40.54)	33 (31.13)	–	–
No	44 (59.46)	73 (68.87)	–	–
History of Nasal Steroid Use	–	–	0.467	0.494
Yes	23 (31.08)	28 (26.42)	–	–
No	51 (68.92)	78 (73.58)	–	–
Nasal Surgery History	–	–	17.796	<0.001
Yes	34 (45.95)	18 (16.98)	–	–
No	40 (54.05)	88 (83.02)	–	–

(*Continued*)

Table 3 (Continued).

	MRSA (n=74)	MSSA (n=106)	t/x²	P
Lund-Kennedy Score	12.63±3.48	12.51±3.72	0.218	0.827
Frequency of Acute Infections (times/year)	-	-	11.494	<0.001
<3	33 (44.59)	74 (69.81)	-	-
≥3	41 (55.41)	32 (30.19)	-	-
Duration of Acute Infection (days)	-	-	0.031	0.858
≤7	43 (58.11)	63 (59.43)	-	-
>7	31 (41.89)	43 (40.57)	-	-
Septal Deviation	-	-	9.705	0.001
Yes	33 (44.59)	24 (22.64)	-	-
No	41 (55.41)	82 (77.36)	-	-
Frequency of Recurrent Upper Respiratory Infections (times/year)	-	-	10.100	0.001
>3	45 (60.81)	39 (36.79)	-	-
≤3	29 (39.19)	67 (63.21)	-	-
Allergic Rhinitis	-	-	5.084	0.024
Yes	33 (44.59)	30 (28.30)	-	-
No	41 (55.41)	76 (71.70)	-	-
Frequency of Antibiotic Use (times/year)	-	-	8.212	0.004
<3	36 (48.65)	74 (69.81)	-	-
≥3	38 (51.35)	32 (30.19)	-	-
Duration of Antibiotic Use (days)	-	-	13.619	<0.001
≤14	24 (32.43)	64 (60.38)	-	-
>14	50 (67.57)	42 (39.62)	-	-
Gastroesophageal Reflux	-	-	0.181	0.670
Yes	47 (63.51)	64 (60.38)	-	-
No	27 (36.49)	42 (39.62)	-	-
Poor Drainage	-	-	9.950	0.001
Yes	47 (63.51)	42 (39.62)	-	-
No	27 (36.49)	64 (60.38)	-	-
Combined Antibiotic Use (types)	-	-	8.379	0.003
<3	25 (33.78)	59 (55.66)	-	-
≥3	49 (66.22)	47 (44.34)	-	-
ALB (g/L)	37.13±5.48	36.85±5.52	0.335	0.737

Multivariate Logistic Regression Analysis of MRSA Infection Factors

Taking whether CRS patients have MRSA infection as the dependent variable (0 = absent, 1 = present), and assigning values to the possible influencing factors obtained from Table 2 as independent variables (see Table 4), a multivariate logistic regression analysis model was established. The results showed that male gender, nasal structural variations,

Table 4 Variable Assignment Table

Independent Variable	Assignment Method
Gender	0 = Female; 1 = Male
Disease Duration	0 = ≤5; 1 = >5
Smoking	0 = No; 1 = Yes
Nasal Surgery History	0 = No; 1 = Yes
Frequency of Acute Infections	0 = <3; 1 = ≥3
Septal Deviation	0 = No; 1 = Yes

(*Continued*)

Table 4 (Continued).

Independent Variable	Assignment Method
Frequency of Recurrent Upper Respiratory Infections	0 = ≤3; 1 = >3
Allergic Rhinitis	0 = No; 1 = Yes
Antibiotic Use Frequency	0 = ≤3; 1 = >3
Antibiotic Use Duration	0 = ≤14; 1 = >14
Poor Drainage	0 = No; 1 = Yes
Combined Antibiotic Use	0 = <3; 1 = ≥3

Table 5 Multivariate Logistic Regression Analysis of Factors Affecting MRSA Infection

Factor	β	SE	Wald x^2	P	OR	95% CI
Male	1.518	0.637	5.662	<0.05	4.115	1.357–10.402
Disease duration > 5 years	0.735	0.567	1.311	>0.05	1.905	0.634–5.686
Smoking	0.818	0.275	8.743	<0.05	1.584	1.312–3.886
History of nasal surgery	2.875	0.784	13.572	<0.05	17.653	3.825–80.427
Nasal structural variation	2.335	0.747	9.682	<0.05	6.032	2.368–17.674
Presence of drainage obstruction	0.908	0.395	7.816	<0.05	4.035	1.362–5.413
Frequency of acute infections > 3 times/year	0.987	0.353	7.921	<0.05	4.107	1.349–5.302
Frequency of recurrent upper respiratory infections > 3 times/year	0.882	0.217	17.182	<0.05	2.258	1.592–3.701
Presence of allergic rhinitis	0.704	0.665	1.097	>0.05	0.504	0.131–1.827
Frequency of antimicrobial drug use ≥3 times/year	1.521	0.627	8.975	<0.05	2.437	1.226–2.984
Duration of antimicrobial drug use >14 days	1.831	0.612	9.115	<0.05	6.264	1.907–20.582
Use of ≥3 types of antimicrobial drugs combined	0.907	0.216	15.258	<0.05	2.431	1.504–3.778

history of nasal surgery, poor drainage, frequency of acute infections >3 times/year, frequency of recurrent upper respiratory infections >3 times/year, antibiotic use frequency ≥3 times/year, antibiotic use duration >14 days, and use of ≥3 antibiotics were all independent risk factors for MRSA infection in CRS patients ($P < 0.05$), as shown in Table 5.

Discussion

MRSA, with its powerful resistance and rapid transmission capabilities, poses a severe challenge to the treatment of CRS.[16] Among the 180 CRS patients analyzed in this study, the incidence of MRSA was 41.11%, which is slightly higher than previous related studies.[17,18] This finding highlights the significance of MRSA in CRS patients, especially in the context of increasing antibiotic resistance, suggesting the need for more in-depth research and effective prevention and control measures. The study also showed that, compared with other antibiotics, *S. aureus* demonstrated significant resistance to macrolide antibiotics (erythromycin E), with a resistance rate of 65.56%, which further increased to 81.08% in MRSA strains. This phenomenon might be related to the frequent application of macrolide antibiotics in treating CRS. Macrolides not only inhibit sinus infections but also help by suppressing bacterial biofilm formation and reducing inflammatory responses, leading to their widespread use.[19,20] Therefore, prolonged use may exert selective pressure and accelerate the emergence of resistant strains. In addition, this study also revealed the issue of MRSA's resistance to multiple antibiotics. The resistance rates of FOX, CIP, CLI, and TE exceeded 40%. These high resistance rates reflect the considerable difficulties CRS patients face during treatment and indicate that drug sensitivity testing should be emphasized during clinical treatment to ensure the rationality and effectiveness of medication and reduce the further spread of resistance. At the same time, strengthening hospital infection control is particularly important, in addition to antimicrobial therapy for MRSA infections. Medical staff should strictly adhere to sterile procedures, regularly provide hand hygiene education and training, and use antimicrobial-functional medical gloves, among other measures, to reduce

the risk of MRSA transmission.[21] Additionally, strict monitoring of antibiotic usage in patients is necessary to avoid overuse of antibiotics, which is crucial for reducing the formation and spread of resistant bacteria.

This study used univariate and multivariate analyses to explore the impact of various factors on MRSA infection in CRS patients. The results show that male CRS patients are more likely to be infected with MRSA than females, a finding consistent with existing literature.[22,23] Male patients typically have higher risk factors in terms of lifestyle, such as smoking, alcohol use, and occupational exposure, which may lead to reduced immune function and damage to the nasal barrier, making them more susceptible to resistant bacterial infections.[24] Furthermore, male patients tend to seek medical attention later in the disease course, leading to delayed treatment, which is a major factor in the development of resistance. Since male CRS patients are more prone to MRSA infections, early intervention and close monitoring of male patients in clinical practice should be emphasized, particularly regarding antibiotic use, which should be rational and precise. Nasal structural variations, such as septal deviation, nasal polyps, and other nasal anatomical abnormalities, have been shown to be closely associated with MRSA infection.[25] Nasal structural abnormalities lead to poor sinus drainage, creating a local environment conducive to the growth of pathogens, especially highly resistant bacteria like MRSA, which can thrive in such environments and form biofilms,[26] increasing the persistence of infections and treatment difficulty. A history of nasal surgery (eg, sinus surgery, polypectomy) is also an important risk factor. While surgery may improve structural problems, it can also cause local tissue damage, alter the nasal immune barrier, and further promote bacterial colonization and the growth of resistant bacteria.[27] For CRS patients with nasal structural variations or a history of surgery, clinical treatment should be more individualized, considering long-term antibiotic prophylaxis and nasal care measures to prevent bacterial colonization after surgery. The results of this study indicate that the frequency of acute infections in CRS patients is significantly related to the risk of MRSA infection. MRSA infection rates were significantly higher in patients with frequent acute infections and recurrent upper respiratory infections. This may be due to repeated infections leading to prolonged inflammation of the nasal and sinus mucosa, and a decline in immune function, especially during acute exacerbations, creating a local environment more favorable for the growth of resistant bacteria like MRSA.[28] Additionally, frequent acute infections are often accompanied by antibiotic use, and inappropriate or excessive use of antibiotics is a major factor in the development of resistant bacteria.[29,30] Therefore, long-term management of CRS patients should be strengthened in clinical practice, with appropriate scheduling of antibiotic use, avoiding overuse of antibiotics, and emphasizing patients' and families' awareness of auxiliary treatments, such as nasal cleaning and humidification. Moreover, this study also found that MRSA infection risk was significantly increased in patients with antibiotic use ≥3 times/year, antibiotic use duration >14 days, and those using ≥3 types of antibiotics in combination. This may be because excessive use of antibiotics can disrupt the normal nasal flora, allowing resistant strains to replace it. Furthermore, the combined use of multiple antibiotics is often due to ineffective infection control, and although combining antibiotics can temporarily control bacterial growth, it significantly increases the selective pressure on resistant bacteria.[31,32] In light of this, clinical treatment should avoid unnecessary antibiotics and strictly select the most appropriate antibiotics based on bacterial culture and sensitivity test results. For patients with known resistant strains, broad-spectrum antibiotics should be avoided, and MRSA-targeted drugs should be chosen for treatment.

Based on the findings of this study, we recommend the following measures in the treatment of CRS: (1) Strengthening microbiological testing and antibiotic susceptibility analysis: For all recurrent CRS patients, especially those with high-risk factors, routine nasal secretion cultures and sensitivity tests should be conducted to understand the types of pathogens and their resistance patterns, guiding clinical treatment. (2) Optimizing antibiotic use strategies: Clinically, rational antibiotic use policies should be formulated to avoid overuse. For patients with MRSA infections, targeted antibiotics such as vancomycin or linezolid should be selected based on sensitivity results. For patients without clear evidence of infection, antibiotic treatment should be avoided whenever possible. (3) Strengthening patient management: For patients with nasal structural variations, frequent acute infection histories, and a long history of antibiotic use, regular follow-up and management should be strengthened. The disease status should be periodically evaluated, and treatment plans should be adjusted. When necessary, surgical treatment to improve nasal ventilation and drainage function should be considered. (4) Advocating for rational antibiotic use education: Not only should healthcare professionals strengthen education on rational antibiotic use, but patients and their family members also need to improve their awareness of antibiotic use. Avoiding self-medication with antibiotics or misuse in non-medical institutions is key to reducing the emergence of resistant bacteria.

Conclusion

MRSA has a high infection rate in CRS patients and exhibits significant resistance to several commonly used antibiotics. Factors such as gender, nasal structural variations, nasal surgery history, frequent acute infections, and inappropriate antibiotic use are independent risk factors for MRSA infection. Based on these findings, clinical treatment should emphasize microbiological testing, rational use of antibiotics, and the optimization of long-term patient management to improve CRS treatment outcomes and reduce MRSA infections. Future research could delve deeper into the molecular mechanisms of MRSA infections to further understand the development process of its resistance. Furthermore, larger prospective studies should be conducted to evaluate the efficacy of different antibiotic treatment strategies in CRS patients, in order to provide more precise clinical treatment guidelines.

Disclosure

The authors report no conflicts of interest in this work.

References

1. Wang CS, Wang XD, Zhang L. Effectiveness and safety of biologics in patients with chronic rhinosinusitis with nasal polyps. *Zhonghua Er Bi Yan Hou Tou Jing Wai Ke Za Zhi*. 2024;59(10):1002–1012. doi:10.3760/cma.j.cn115330-20240322-00160
2. Hao Y, Cui LM, Yang YJ, et al. Progress of multi-omics technology in precision treatment of chronic rhinosinusitis. *Zhonghua Er Bi Yan Hou Tou Jing Wai Ke Za Zhi*. 2024;59(8):872–878. doi:10.3760/cma.j.cn115330-20240131-00073
3. Zhong B, Hao ZZ, Liu XC, et al. Effect of middle turbinectomy on prognosis of chronic rhinosinusitis. *Zhonghua Er Bi Yan Hou Tou Jing Wai Ke Za Zhi*. 2024;59(10):1102–1106. doi:10.3760/cma.j.cn115330-20240104-00013
4. Sha JC, Zhu DD. Advances in microbiome and chronic rhinosinusitis. *Zhonghua Er Bi Yan Hou Tou Jing Wai Ke Za Zhi*. 2024;59(6):649–653. doi:10.3760/cma.j.cn115330-20240131-00067
5. Liang YW, Lu T, Li ZQ, et al. Regional differences of chronic rhinosinusitis endotypes based on tissue inflammatory and remodeling biomarkers. *Zhonghua Er Bi Yan Hou Tou Jing Wai Ke Za Zhi*. 2024;59(6):573–581. doi:10.3760/cma.j.cn115330-20240201-00074
6. Chen XY, Ju JB, Zhao H, et al. Advances in the study of staphylococcus aureus in allergic rhinitis and chronic rhinosinusitis with nasal polyps. *Zhonghua Er Bi Yan Hou Tou Jing Wai Ke Za Zhi*. 2021;56(3):301–306. doi:10.3760/cma.j.cn115330-20200520-00429
7. Poddighe D, Vangelista L. Staphylococcus aureus infection and persistence in chronic rhinosinusitis: focus on leukocidin ED. *Toxins*. 2020;12(11):678. doi:10.3390/toxins12110678
8. Feizi S, Cooksley CM, Nepal R, et al. Silver nanoparticles as a bioadjuvant of antibiotics against biofilm-mediated infections with methicillin-resistant staphylococcus aureus and pseudomonas aeruginosa in chronic rhinosinusitis patients. *Pathology*. 2022;54(4):453–459. doi:10.1016/j.pathol.2021.08.014
9. Menberu MA, Liu S, Cooksley C, et al. Corynebacterium accolens has antimicrobial activity against staphylococcus aureus and methicillin-resistant s. aureus pathogens isolated from the sinonasal niche of chronic rhinosinusitis patients. *Pathogens*. 2021;10(2):207. doi:10.3390/pathogens10020207
10. Ferradas C, Cotter C, Shahbazian JH, et al. Risk factors for antimicrobial resistance among Staphylococcus isolated from pets living with a patient diagnosed with methicillin-resistant Staphylococcus aureus infection. *Zoonoses Public Health*. 2022;69(5):550–559. doi:10.1111/zph.12946
11. Holten Møller C, Andersson M, Rhod Larsen A, et al. Risk of hospitalization and death within 2 years after methicillin-resistant Staphylococcus aureus (MRSA) diagnosis in persons colonized or infected with livestock and non–livestock-associated MRSA—A nationwide register-based cohort study. *Zoonoses Public Health*. 2020;67(7):814–822. doi:10.1111/zph.12765
12. Chen TY, Ge YL, Liu XW, et al. Molecular epidemiological characteristics of methicillin-resistant staphylococcus aureus during 2017-2018 at a hospital in Shanghai. *Zhonghua Yu Fang Yi Xue Za Zhi*. 2020;54(8):849–853. doi:10.3760/cma.j.cn112150-20190819-00669
13. Hellings PW, Fokkens WJ, Orlandi R, et al. The EUFOREA pocket guide for chronic rhinosinusitis. *Rhinology*. 2023;61(1):85–89. doi:10.4193/Rhin22.344
14. Salian PS, Sheth D, Bari AK, Poojary A, Rohra S, M R. Comparison of rapid antimicrobial susceptibility testing of flash positive blood culture bottles using disk diffusion and automated broth microdilution on VITEK 2 compact with standard methods: Clinical Laboratory Standards Institute (CLSI) protocol. *Indian J Med Microbiol*. 2025;54:100809. doi:10.1016/j.ijmmb.2025.100809
15. Huang X, Zhou JB, Xiao XP, et al. Application and exploration of small dose omalizumab in patients with recurrent eosinophilic sinusitis after extended sinus surgery. *Zhonghua Er Bi Yan Hou Tou Jing Wai Ke Za Zhi*. 2023;58(8):747–753. doi:10.3760/cma.j.cn115330-20220923-00578
16. Adelman AE, Tangutur A, Archilla AS, et al. Microbiological profiles and patterns of resistance in patients with sinus infections after endoscopic sinus surgery. *Otolaryngol Head Neck Surg*. 2025;172(4):1442–1449. doi:10.1002/ohn.1122
17. Zhuo CY, Guo YY, Liu NJ, et al. Epidemiological analysis of pathogens causing bloodstream infections in department of hematology in Guangdong province. *Zhonghua Xue Ye Xue Za Zhi*. 2020;41(12):996–1001. doi:10.3760/cma.j.issn.0253-2727.2020.12.005
18. Wu X, Yu H, He LY, et al. A multicentric study on clinical characteristics and antibiotic sensitivity in children with methicillin-resistant staphylococcus aureus infection. *Zhonghua Er Ke Za Zhi*. 2020;58(8):628–634. doi:10.3760/cma.j.cn112140-20200505-00469
19. Siu J, Klingler L, Wang Y, et al. Oral antibiotics used in the treatment of chronic rhinosinusitis have limited penetration into the sinonasal mucosa: a randomized trial. *Xenobiotica*. 2020;50(12):1443–1450. doi:10.1080/00498254.2020.1814973
20. Philpott C, le Conte S, Beard D, et al. Clarithromycin and endoscopic sinus surgery for adults with chronic rhinosinusitis with and without nasal polyps: study protocol for the MACRO randomised controlled trial. *Trials*. 2019;20(1):246. doi:10.1186/s13063-019-3314-7
21. Tian BS, Ling Y, Lyu JW, et al. A retrospective analysis of clinical characteristics and prognostic factors for 152 cases of Staphylococcus aureus bloodstream infection. *Zhonghua Yu Fang Yi Xue Za Zhi*. 2023;57(2):241–246. doi:10.3760/cma.j.cn112150-20220221-00161
22. Shaghayegh G, Cooksley C, Bouras G, et al. S. aureus biofilm metabolic activity correlates positively with patients' eosinophil frequencies and disease severity in chronic rhinosinusitis. *Microbes Infect*. 2023;25(8):105213. doi:10.1016/j.micinf.2023.105213

23. Li SG, Liao K, Su DH, et al. Analysis of pathogen spectrum and antimicrobial resistance of pathogens associated with hospital-acquired infections collected from 11 teaching hospitals in 2018. *Zhonghua Yi Xue Za Zhi*. 2020;100(47):3775–3783. doi:10.3760/cma.j.cn112137-20200430-01389
24. Eisner R, Lippmann N, Josten C, et al. Development of the bacterial spectrum and antimicrobial resistance in surgical site infections of trauma patients. *Surg Infect*. 2020;21(8):684–693. doi:10.1089/sur.2019.158
25. Huang Y, Qin F, Li S, et al. The mechanisms of biofilm antibiotic resistance in chronic rhinosinusitis: a review. *Medicine*. 2022;101(49):e32168. doi:10.1097/MD.0000000000032168
26. Li YT, Huang -S-S, Ma J-H, et al. Bacteriology of different phenotypes of chronic rhinosinusitis. *Laryngoscope*. 2024;134(3):1071–1076. doi:10.1002/lary.30905
27. Gupta N, Ahmed A, Galib R, et al. A prospective clinical study of bacteriological profile and their antibiotic susceptibilty profile in patients with chronic rhinosinusitis: the recent scenario in Northern India. *Indian J Otolaryngol Head Neck Surg*. 2024;76(1):658–663. doi:10.1007/s12070-023-04242-x
28. Singh R, Shilpa R, Mukhopadhyay C, et al. Correlation between microbiological profiles of adenoid tissue and nasal discharge in children with co-existent chronic adenoiditis and Chronic Rhinosinusitis. *Indian J Otolaryngol Head Neck Surg*. 2020;72(1):112–116. doi:10.1007/s12070-019-01775-y
29. López-Pérez M and Herrera-Zúñiga L. Advancing adjuvant treatment for bacterial sepsis: exploring anti-biofilm compounds and efflux pump inhibitors. *Innov Discov*. 2025;2(2). doi:10.53964/id.2025009), 9.
30. Cherian LM, Cooksley C, Richter K, et al. Effect of commercial nasal steroid preparation on bacterial growth. *Int Forum Allergy Rhinol*. 2019;9 (7):766–775. doi:10.1002/alr.22312
31. Liu S, Zhao Y, Hayes A, et al. Overcoming bacteriophage insensitivity in staphylococcus aureus using clindamycin and azithromycinat subinhibitory concentrations. *Allergy*. 2021;76(11):3446–3458. doi:10.1111/all.14883
32. Łusiak-Szelachowska M, Weber-Dąbrowska B, Żaczek M, et al. Anti-biofilm activity of bacteriophages and lysins in chronic rhinosinusitis. *Acta Virol*. 2021;65(2):127–140. doi:10.4149/av_2021_203