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ORIGINAL: Nasal Carriage Frequency and Antibiotic Resistance Pattern of Methicillin-Resistant Staphylococcus aureus Isolates from Operating Room Personnel of Valieasr Hospital, Qaemshahr, Iran

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ABSTRACT

Introduction: *Staphylococcus aureus* is recognized as a significant pathogenic agent in human diseases. Nasal carriage of Staphylococcus aureus is an independent risk factor for hospital-acquired infections, particularly surgical site infections. This study aimed to investigate the frequency and antibiotic resistance pattern of S. aureus strain isolates from the nasal carriage of operating room personnel in a referral hospital in Qaemshahr.

Material and Methods: This study was conducted on 65 personnel in the surgical and operating room departments (morning, evening, and night shifts) in 2022. The sampling method was census-based, and a checklist containing demographic information, underlying diseases, work history, history of antibiotic use, etc., was employed.

Results: The result of nasal swab culture in 10 individuals (15.4%) was positive. Also, the results showed a higher carrier frequency in the age group over 40 years (21.7%), among males (22.6%), in the nursing profession (15.56%), in personnel with more than 10 years of experience in the surgical department (24%), and with a work history in the hospital exceeding 13 years (25%). Furthermore, the results indicated higher sensitivity to rifampin and cefazolin in this descriptive study. Regarding clindamycin and oxacillin, relative sensitivity was observed.

Conclusion: In general, the results indicated that antibiotic resistance to ciprofloxacin, trimethoprim-sulfamethoxazole, erythromycin, clindamycin, and oxacillin was higher in Staphylococcus aureus infections. Therefore, it is suggested to investigate the causes of antibiotic resistance to these drugs to prevent further resistance compared to other antibiotics.

Introduction

Bacterial infections resulting from resistant pathogenic factors continue to pose a growing threat to public health (1). Currently, it is estimated that over 70% of bacteria causing hospital-acquired infections are at least resistant to one of the

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commonly used drugs for treatment. It is projected that by the year 2050, bacterial resistance issues will intensify significantly, causing the annual death of several million people (2, 3).

Staphylococcus aureus has always been recognized as a significant pathogenic agent in human diseases and is the most common strain causing hospital-acquired infections. The ability of Staphylococcus aureus to colonize the nasal passages and other areas of the body makes it a major risk factor for infection. This bacterium may exist as part of the normal flora of the skin or nose (4). It is estimated that around 20% of people may be carriers of the bacterium for an extended period. The rate of nasal carriage of Staphylococcus aureus in adults is approximately 20-40%. The carriage rate may be higher in certain conditions; for example, in patients with insulin-dependent diabetes, individuals with asthma, some skin conditions, and patients with permanent intravenous catheters (5).

Staphylococcus aureus resistant to methicillin is a strain that exhibits resistance to beta-lactam antibiotics, posing therapeutic challenges and leading to increased complications and mortality. Since the 1990s, methicillin-resistant Staphylococcus aureus (MRSA) has been epidemiologically categorized into two groups related to healthcare-associated and community-associated settings. Penicillin was introduced in the 1940s for the treatment of staphylococcal infections. However, in 1945, Staphylococcus aureus strains demonstrated resistance to it. Later, methicillin was introduced in 1959, but in 1961, Staphylococcus aureus isolates also showed resistance to methicillin. MRSA generally exhibits high resistance to almost all beta-lactams, often accompanied by resistance to other classes of antibiotics (6, 7).

There are various options for treating infections associated with MRSA, including macrolides, lincosamides, and streptogramin B with clindamycin as a suitable alternative, especially for skin and soft tissue infections, and as a substitute for patients allergic to penicillin (8). Several studies worldwide have reported nasal carriage rates of Staphylococcus aureus strains ranging from 6.8% to 90% (9, 10). In Iran, various studies have been conducted to investigate the antibiotic resistance pattern of Staphylococcus aureus. For instance, the study by Noorbakhsh et al (2015) reported the prevalence of MRSA strains as 90.2%, erythromycin-resistant strains as 89.7% and gentamicin-resistant strains as 75.8% (11).

Given that this bacterium possesses multiple virulence factors, it can cause infections both on external surfaces and internal organs of the human body. Additionally, due to its high capability to adhere to surfaces, attributed to various adhesin factors, this bacterium is considered one of the most significant bacteriological factors causing hospital-acquired infections. Its presence in various hospital departments, especially in critical areas such as surgery and operating rooms, poses a serious threat to the health of hospitalized patients. Therefore, the investigation of the presence of this bacterium on inanimate surfaces as well as in the tissues and cavities of personnel working in these departments, and determining its antibiotic resistance pattern, is of paramount importance. It can help mitigate the adverse consequences resulting from the contamination of relevant patients.

Methods

Sampling

The present research was a descriptive-cross-sectional study with an applied objective in terms of methodology. The target population of this study included personnel from the surgical and operating room departments of Valiasr Hospital in Qaemshahr city (including physicians, nurses, operating room technicians, and support staff). In this study, all positive samples taken from the personnel of the surgical and operating room departments of Valiasr Hospital were collected through a census method, and ultimately, the antibiotics present were examined on 10 patients, and their data were

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collected. This study was approved with the ethics code IR.IAU.SARI.REC.1401.055.

Data Collection Tools

In this study, a checklist was used to collect data. The checklist included patient information such as age, gender, position, work history, and duration of employment in the surgical and operating room department, obtained through interviews and then added to the checklist.

Procedure

Individuals with positive samples of Staphylococcus aureus were included in this study. The samples were cultured on blood agar and mannitol salt agar using the streak method. After an overnight incubation, catalase, coagulase, and deoxyribonuclease (DNase) tests were used to identify Staphylococcus aureus. If the tests were positive and the bacteria grew on mannitol salt agar with a color change to yellow and beta-hemolysis in blood agar, the presence of Staphylococcus aureus was confirmed. Then, the bacterial sample was evaluated for antibiotic sensitivity according to the Clinical and Laboratory Standards Institute (CLSI) guidelines (2021). The disk diffusion method was used for this evaluation, where a microbial suspension of Staphylococcus aureus was prepared, and its turbidity was compared with a McFarland tube. If the turbidities were equal, a swab was placed in the microbial suspension, and then it was streaked on Mueller-Hinton agar. This process was performed in three directions. After one day of incubation, the results were observed, and based on the formation or absence of zones of inhibition and the measurement of their diameters, the level of sensitivity or resistance was determined.

Results

Frequency of Staphylococcus aureus Carriers in the Nasal Passages of Surgical and Operating Room Personnel

In this descriptive study, a total of 65 personnel from the surgical and operating room departments of Valiasr Hospital in Qaemshahr were examined. The individuals had an age range of 24 to 63 years with a mean age of 38.3 ±8.7 years. Demographic information of the personnel is presented in ***Table 1***. The majority of the study population consisted of female personnel (52.3%) in nursing (49.2%) and operating room technician (30.8%) occupations. Underlying diseases were present in 18.5% of individuals. The average duration of employment in the hospital was 13.6 ± 6.8 years (ranging from 1 to 28 years), and the average duration of employment in the surgical and operating room department was 9.9 ± 7.5 years (ranging from 1 to 28 years). The history of antibiotic use was observed in 18.5% of individuals, with azithromycin and co-amoxiclav being the most commonly used antibiotics in 4.6% of cases each. Nasal swab cultures were positive in 15.4% of the personnel (***Table 2***).

Table 1. Demographic information of the personnel of the surgical departments and operating rooms of the hospital (n=65)

Variables		Frequency	Percentage
Age	< 30	13	20.0
	30-40	29	44.6
	> 40	23	35.4
Sex	Female	34	52.3
	Male	31	47.7
Job Category	Surgery specialist	5	7.7
	Nurse	32	49.2
	Services	5	7.7
	Operating Room Technician	20	30.8
	Anesthesiologist	2	3.1
	Others	1	1.5
Underlying disease	No	53	81.5
	Yes	12	18.5
Type of Disease	Diabetes	2	3.1
	Malignancy	0	0
	Immunosuppression	0	0
	Others	10	15.4

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Table 1 Continue

Blood type	O-	7	10.8
	O+	19	29.2
	AB-	1	1.5
	AB+	8	12.3
	B-	0	0
	B+	16	24.6
	A-	1	1.5
	A+	13	20.0
Work experience	<13	37	56.9
	>13	28	43.1
Duration of employment in the surgery department or operating room	<10	40	61.5
	>10	25	38.5
Antibiotic consumption	No	53	81.5
	Yes	12	18.5
Antibiotic type	Amx, Mtr	1	1.5
	AZ	3	4.6
	CA	3	4.6
	CF	1	1.5
	Cfx	2	3.1
	Cp, Mtr	1	1.5
	Crx	1	1.5
	PV	1	1.5

Table 2. The prevalence of Staphylococcus aureus carriers in the noses of surgical and operating room personnel

Variables		Positive*	Negative*	P-value**
Total		**10(15.4)**	**55(84.6)**	
Age	< 30	1(7.7)	12(92.3)	0.612
	30-40	4(13.8)	25(86.2)	
	> 40	5(21.7)	18(78.3)	
Sex	Female	3(8.8)	31(91.2)	0.117
	Male	7(22.6)	24(77.4)	
Job Category	Surgery specialist	1(20.0)	4(80.0)	0.547
	Nurse	5(15.6)	27(84.4)	
	Services	1(20.0)	4(80.0)	
	Operating Room	2(10.0)	18(90.0)	
	Anesthesiologist	1(50.0)	1(50.0)	
	Others	0.0	1(100.0)	
Underlying disease	No	6(11.3)	47(88.7)	0.078
	Yes	4(33.3)	8(66.7)	
Blood type	O-	1(14.3)	6(85.7)	0.585
	O+	5(26.3)	14(73.7)	
	AB-	0.0	1(100.0)	
	AB+	2(25.0)	6(75.0)	
	B-	0.0	0.0	
	B+	1(6.2)	15(93.8)	
	A-	0.0	1(100.0)	
	A+	1(7.7)	12(92.3)	
Work experience	<13	3(8.1)	34(91.9)	0.086
	>13	7(25.0)	21(75.0)	
Duration of employment in the surgery department or operating room	<10	4(10.0)	36(90.0)	0.165
	>10	6(24.0)	19(76.0)	
Antibiotic consumption	No	7(13.2)	46(86.8)	0.376
	Yes	3(25.0)	9(75.0)	

* Reported according to frequency (percentage)
** Significance according to the chi-square test

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Antibiotic Resistance Pattern in Staphylococcus aureus Carriers in the Nasal Passages of Surgical and Operating Room Personnel

A total of 10 personnel from the surgical and operating room departments of Valiasr Hospital, who were carriers of Staphylococcus aureus, were selected. These 10 individuals had an age range of 27 to 63 years with a mean age of 42.6 ± 11.8 years. The antibiotic resistance pattern was determined for erythromycin, clindamycin, rifampin, cefazolin, ciprofloxacin, oxacillin, and trimethoprim-sulfamethoxazole in the nasal carriers of Staphylococcus aureus among personnel in the surgical and operating room departments of the hospital. The results are presented in ***Table 3***. Higher sensitivity was observed towards rifampin, cefazolin, and oxacillin. Relative sensitivity was observed for clindamycin and oxacillin. Antibiotic resistance was present for ciprofloxacin, trimethoprim-sulfamethoxazole,
rythromycin, clindamycin, and oxacillin, with oxacillin showing the highest resistance. The antibiotic resistance pattern based on age, gender, occupation, work history in the surgical department, and duration of employment in the hospital is presented in ***Table 4***.

Table 3. Frequency of sensitivity/relative sensitivity/antibiotic resistance according to the type of drug in transport personnel (10 individuals)

Drug type	Sensitive		Semi-sensitive		Resistance	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Rifampin	10	100	-	-	-	-
Ciprofloxacin	6	60	-	-	4	40
Trimethoprim-Sulfamethoxazole	7	70	-	-	3	30
Cefazolin	10	100	-	-	-	
Erythromycin	6	60	-	-	4	40
Clindamycin	5	50	2	20	3	30
Oxacillin	-	-	1	10	9	90

Table 4. The frequency of resistance patterns to some antibiotics in nasal carriers of Staphylococcus aureus in surgical departments and operating room personnel (10 individuals)

Variables		Ciprofloxacin	Trimethoprim-Sulfamethoxaz-le	Erythromycin	Clindamycin	Oxacillin
Age	< 40	2	2	2	2	5
	> 40	2	1	2	1	4
Sex	Female	3	2	2	2	3
	Male	1	1	2	1	6
Job Category	Surgery specialist	1	1	1	1	1
	Nurse	2	1	2	1	5
	Services	0	0	0	0	0
	Operating Room Technician	2	1	1	1	2
	Anesthesiologist	0	0	0	0	1
Work experience in the surgery department (in a year)	<14	0	0	1	0	3
	>14	4	3	3	3	6
Work experience in a hospital (in a year)	<17	1	1	2	1	4
	>17	3	2	2	2	5

Discussion

One of the main objectives of this study was to determine the prevalence of Staphylococcus aureus carriers in the nasal passages of personnel in the surgical and operating room departments. The result of nasal swab cultures

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in 10 positive individuals among the personnel was reported, corresponding to a prevalence of 16.6%. Numerous studies have been conducted in this field, including SheikhAl-Islam et al (2018), Raeisi et al (2012), Jazayeri et al (2000), Asif et al (2017), Nabil et al (2017), and Andre et al (2017), reporting Staphylococcus aureus prevalence rates of 25%, 30%, 28.1%, 23%, 31%, and 30%, respectively, among healthcare workers in hospitals, which were higher than the prevalence reported in this study (12-16).

In this study, no significant relationship was observed between the age and gender of individuals and the prevalence of Staphylococcus aureus carriers in the nasal passages. This finding is consistent with the studies of Sheikh al-Islam et al (2018), Raeisi et al (2012), Jazayeri et al (2000), Asif et al (2017), Nabil et al (2017), Andre et al (2017), and Moradi et al (2014) (7,12). Additionally, no significant relationship was found between the prevalence of Staphylococcus aureus carriers in the nose and the workplace of personnel in the surgical and operating room departments of the hospital. These results are in line with the studies of Jazayeri et al (2000) and Andre et al (2017). However, Asif et al (2017) demonstrated, by assessing the prevalence of nasal carriers among healthcare personnel, that physicians were more likely to be carriers of Staphylococcus aureus, which contrasts with the findings of the present study (14). The reason for this difference could be attributed to variations in the work environment, prevalence in the region, and the specific population under study.

Furthermore, this study demonstrated that the work experience in the surgical and operating room departments did not establish a significant correlation with the prevalence of Staphylococcus aureus carriers. These results are consistent with the studies of Jazayeri et al (2000), Asif et al (2017), Andre et al (2017), and Moradi et al (2014) (14, 16, 17). However, in the study by Nabil et al (2017), aiming to investigate the prevalence of nasal carriers of Staphylococcus aureus among healthcare personnel, the findings indicated a statistically significant difference between being a carrier of Staphylococcus aureus and work experience, which contrasts with the results of the present study. The reason for this difference can be attributed to variations in the study samples.

The results of this study indicated that there was a higher sensitivity to rifampin and ceftazidime. Additionally, antibiotic resistance was observed against ciprofloxacin, trimethoprim-sulfamethoxazole, rythromycin, clindamycin, and oxacillin, with the highest resistance observed against oxacillin. In the study conducted by Khan et al (2019) aiming to estimate the prevalence and risk factors of Staphylococcus aureus susceptible to methicillin and nasal carriers of MRSA, the results showed that 21 individuals were carriers of MRSA (18). Moreover, the findings of the study by Sadeghi et al (2012) demonstrated that most examined samples were resistant to penicillin, while no strains resistant to vancomycin and rifampin were observed. The resistance rates to other studied antibiotics were 33%, 19%, and 5% for co-amoxiclav, tetracycline, chloramphenicol, and ceftriaxone, respectively (12,19).

In the study by Jazayeri et al (2017), conducted to investigate the prevalence of nasal carriers of MRSA among healthcare workers in teaching hospitals, the results showed that, in terms of antibiotic sensitivity, the isolated strains from healthcare workers were 88.3% sensitive to vancomycin, 83.3% to cotrimoxazole, 83.3% to gentamicin, 70% to erythromycin, and 43.3% to tetracycline. All isolated strains from healthcare workers and the control group were resistant to penicillin and cephalothin. In another study, Noorbakhsh et al (2014) demonstrated that the highest antibiotic resistance was observed against methicillin (90.2%), erythromycin (89.7%), ciprofloxacin (89.5%), penicillin (88%), tetracycline (82.4%), and gentamicin (75.8%), while the lowest resistance was observed against nitrofurantoin (2%) and vancomycin (10.3%)(11). The overall prevalence of nasal carriers of MRSA in the study by Benard Okamo (2013) among preclinical and clinical medical students was

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0.3% (19). The prevalence of carriers among preclinical and clinical students was 9.1% and 3.22%, respectively. Most colonies were resistant to ampicillin (66.5%), while all were sensitive to ciprofloxacin and vancomycin (12). The results of this study showed that the frequency of antibiotic resistance, specifically to oxacillin, was significant in the age group under 40 years. These findings are consistent with the studies by Khan et al. (2019), Sheikh al-Islam et al. (2017), Sadeghi et al. (2012), and Jazayeri et al. (2017), which demonstrated that antibiotic resistance increases with age, and is a significant relationship between age and the pattern of antibiotic resistance (12, 18). However, Noorbakhsh et al. (2014) and Benard Okamo et al. (2013) showed that there is no significant relationship between age and the pattern of antibiotic resistance, which contradicts the results of our study (11, 19).

In examining the pattern of antibiotic resistance based on gender, the frequency of antibiotic resistance, specifically to oxacillin, was higher and significant in male personnel. These results are contrary to the findings of studies by Khan et al. (2019), Sheikh al-Islam et al. (2017), Sadeghi et al. (2012), Noorbakhsh et al. (2014), and Benard Okamo et al. (2013), which demonstrated no difference in gender and antibiotic resistance (11, 12, 19). Additionally, the results obtained showed that the frequency of antibiotic resistance to oxacillin was significant and higher in the nursing profession. In Khan et al.'s study (2019), conducted to estimate the prevalence and risk factors of methicillin-sensitive Staphylococcus aureus and MRSA, the results indicated that the rate of MRSA resistance was higher in physicians, which contradicts the findings of the present study, and the cause may be attributed to differences in the types of collected samples (18).

In examining the pattern of antibiotic resistance based on the duration of employment in the hospital, the results showed that the frequency of antibiotic resistance, specifically to oxacillin, was higher and significant in personnel with more than 17 years of employment. These findings align with the study by Khan et al. (2019) (18), Sadeghi et al. (2012), and Jazayeri et al. (2017), indicating that resistant strains isolated from healthcare workers with longer employment histories are more prevalent. Additionally, in the study by Benard Okamo et al. (2013), which aimed to investigate the prevalence and antimicrobial sensitivity profiles of Staphylococcus aureus nasal carriers among preclinical and clinical medical students, the results showed differences among preclinical and clinical medical students, with higher resistance observed in clinical students (19).

Conclusion

In this study, a total of 65 personnel from the surgical departments and operating rooms of the hospital were investigated. The result of nasal swab cultures showed positivity in 10 individuals, accounting for 15.4% of the personnel. In the examination of carrier prevalence based on demographic factors, the results indicated a higher carrier frequency in the age group over 40 years (21.7%), among male individuals (22.6%), in the nursing profession (15.5%), in personnel with more than 10 years of experience in the surgical department (24%), and with a work history in the hospital exceeding 13 years (25%). Additionally, a higher carrier frequency was observed in personnel with underlying diseases (33.3%), those without antibiotic consumption (13.2%), and individuals with blood type O+ (26.3%). In conclusion, the results of this study showed that antibiotic resistance to ciprofloxacin, trimethoprim-sulfamethoxazole, erythromycin, clindamycin, and oxacillin drugs was higher among the Staphylococcus aureus infections. It is suggested to investigate the causes of antibiotic resistance to these drugs to prevent further resistance in comparison to other antibiotics.

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Conflicts of interest

The authors declare no conflict of interest.

Authors' contributions

All authors were involved in the conception and design, analysis and interpretation of the data, drafting of the manuscript and revising it critically for intellectual content, approved the final version for submission, and agreed to be accountable for all aspects of the work.

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