Original Article

Staphylococcus aureus Nasal Carriage among Medical Students at Damascus University, Syria

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Abstract

Background: Some healthcare workers, including medical students, are carriers of nasal *Staphylococcus aureus* and could pose as a nasal source of transmission. **Objectives:** The aims of the study are to determine the rate of nasal carriers of *S. aureus* among medical students in the different stages of the study (preclinical stage and clinical stage) and to determine the susceptibility pattern of isolated strains of *S. aureus* to some commonly used antibiotics. **Materials and Methods:** Nasal swabs were collected from 370 medical students. The antimicrobial susceptibility for commonly used antibiotics was determined for all positive isolates. **Results:** Nasal carriage among medical students in all stages was (21%), with a significant difference between the groups of preclinical and clinical stags. The high carriage rate of *S. aureus* was found in smoking and older students. The overall methicillin-resistant *S. aureus* (MRSA) carriage rate among all students was 8.3%. MRSA carriage had a high rate among *S. aureus* carrier students (39.7% of positive isolates were MRSA). A high rate of MRSA carriage was found in students of the clinical stage in comparison to premedical students. MRSA strains were highly resistant for most commonly used antibiotics: penicillin (100%), ampicillin (93.6%), amoxicillin/clavulanate (84%), erythromycin (74.2%), clindamycin (71%), and ceftriaxone (47%), while a moderate or low resistance rate was against ciprofloxacin and gentamycin (49.4%). **Conclusion:** The difference in the carriage rates of *S. aureus* among preclinical and clinical medical students was statistically insignificant. High rates of MRSA carriage were also detected among students of the clinical stage. MRSA strains in our study were highly resistant to most commonly used antibiotics.

Keywords: Medical students, MRSA, nasal carriage, *S. aureus*

Introduction

Staphylococcus aureus (*S. aureus*) is a widespread bacterium in the human environment, and it can be part of the normal bacterial flora in some parts of the human body. These bacteria also constitute an important cause of various human infections, whether they are community-acquired infections, such as skin or respiratory infections, or hospital-acquired (nosocomial infections).[1-3] The importance of nosocomial infections that are caused by *S. aureus* is increased by the fact that some strains isolated from nosocomial infections are resistant to most antibiotics, in addition to the seriousness of the infections caused by this bacterium inside the hospital, such as postoperative infections, burn infections, osteomyelitis, pneumonia, and septicemia.[4-6]

Many studies have shown that *S. aureus* constitutes about 15%–25% of bacteria isolated from nosocomial infections.[6] Some of these studies also showed that isolated strains that are resistant to many antibiotics, including methicillin, constitute about 30%–40% of these isolates,[6-8] which is a serious and real challenge for medical staff in the hospitals, especially since recent research studies indicate a continuous increase in the rates of multi-resistant strains of *S. aureus* in hospitals.[9,10]

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S. aureus forms part of the normal flora of some areas of the body in a large percentage of people as it can be encountered on the skin, especially in the skin folds and moist areas of the skin, in addition to the intestines sometimes, but it can be most commonly encountered in the nostrils. Numerous studies conducted to detect *S. aureus* in the nostrils of large groups of people indicate that these bacteria are found at the entrance of the nose in about 10%–40% of people.[11,12]

Studies have also indicated that the percentage of nasal strains resistant to antibiotics, especially methicillin, ranges between 5% and 10% of the total isolated strains.[12] People who carry these bacteria in their nostrils are called nasal carriers of *S. aureus*. The rates of nasal carriage of *S. aureus* increases, especially with age, and a high rate of *S. aureus* nasal carriage has been observed among members of the medical staff, such as doctors, nurses, medical students, and other healthcare workers.[13-15] Other studies indicate that the nasal carriage of *S. aureus* is an important source for the spread of these bacteria and the occurrence of their infections, as they can distribute from their location in the nostrils of the same person to another place in their body to cause autoinfection. Autoinfection is responsible for the occurrence of many skin infections such as impetigo, boils, wound infections, or respiratory infections including pneumonia. The nasal carriers also could be a source of spread and transmission of *S. aureus* to others and causing many dangerous infections among them, especially if the infection was transmitted inside hospitals or the strains that were transmitted were resistant to methicillin or other antibiotics.[16] Such infections may be dangerous and sometimes fatal.[17]

The increase in the incidence of nosocomial infections caused by *S. aureus*, particularly resistant strains, places high medical importance on the nasal carriers of this bacterium, especially among clinical workers as they can be an important source of transmission of *S. aureus* in hospitals or other medical institutions where they work and even in the community.[16-18]

Many studies conducted to detect cases of nasal carriage of *S. aureus* have focused on workers in the medical field, such as doctors, nurses, and laboratory workers, because these are more likely to become carriers, and if they are, they will be the most likely source of transmission of this important bacterium in the surrounding environment, especially inside the hospitals where they work. These studies also showed an increase in the percentage of strains that are multi-drug-resistant, including strains that are resistant to methicillin-resistant *S. aureus* (MRSA) among healthcare workers.[18]

Some studies have shown a moderate or high rate of nasal carriage of *S. aureus* among medical college students, especially clinical-stage students. This may indicate that the attendance of medical students with clinical stage of disease in hospitals and their daily contact with patients, medical workers, and exposure to hospital environment may be an important factor in increasing the nasal carriage rate among them.[19,20] The nasal carriage of *S. aureus* among medical college students is important in spreading the infection in hospitals or in the community.[21] Although medical students and trainees are part of healthcare workers collectively, they constitute a commonly forgotten part among healthcare workers because they are often not as well informed as other healthcare personnel about standard infection control measures.[20-22]

Given the great potential medical importance of the case of nasal carriage of *S. aureus* among medical students, this study was conducted, and it aims to determine the rate of transmission of nasal carriers of *S. aureus* among medical college students in the different stages of the study (preclinical stage and clinical stage) and to determine the susceptibility pattern of isolated strains of *S. aureus* to some commonly used antibiotics, in particular determining the percentage of strains resistant to methicillin and comparing it between the two study groups.

Materials and Methods

Study design, period, and population

This study is a cross-sectional study that was conducted from February 2023 to March 2023. A total of 370 medical students (Faculty of Medicine, Medical Technical Institute/Damascus University) were included. The students were distributed over the years of study as follows: 178 students from the first, second, and third years (preclinical stage) (106 males and 72 females) and 192 students from the fourth, fifth, and sixth years (clinical stage) (111 males and 81 females). All participants were requested to complete a written survey about age, gender, stage of study, smoking habits, and hygiene habits. Students with antibiotic use in the last 3 weeks prior to sample collection were excluded.

Research methods

Samples were collected in the form of nasal swabs from the anterior nares using sterile nasal cotton swabs moistened with sterile physiological saline. The number of samples taken and examined was 370 samples from 370 students (one sample from each student).

After taking the samples, the samples were inoculated directly on mannitol salt agar as a *Staphylococcus* selective medium in order to isolate the mannitol-fermenting *S. aureus*. The results were read after 20–48 h of incubation in an aerobic environment at 37°C.

Fermented colonies of mannitol were isolated from the surface of the agar and were sub-cultured on blood agar medium and incubated for 24 h at 37°C to grow. After that, slides were prepared from the colonies that grew on blood agar, Gram-stained, and examined microscopically. Catalase and coagulase tests were also conducted for all isolates that grew on mannitol salt agar.

All colonies that grew on mannitol salt agar and fermented mannitol (golden-yellow colonies) showed consistent results of a positive reaction for Gram stain, catalase test-positive, and the tube coagulase test-positive at the same time were considered indicative of *S. aureus*.

Susceptibility testing was performed for all positive isolates using the disk diffusion method, which showed the sensitivity of the positive isolates to some commonly used antibiotics. The antibiotics used were penicillin G (10 units) ampicillin (10 µg), amoxicillin/clavulanic acid (15 µg) erythromycin (15 µg), ceftriaxone (30 µg) ciprofloxacin (5 µg), clindamycin (2 µg), gentamicin (10 µg), vancomycin (10 µg), and cefoxitin (30 µg). Moreover, isolates with a zone of inhibition of ≤21 mm to cefoxitin (30 µg) were phenotypically considered to be MRSA. All methods were performed as recommended by the Clinical and Laboratory Standards Institute.[23-25]

According to the objectives of the study, results were exported to SPSS software for analysis and analyzed to compare the significance of differences in the distribution by using the chi square test. The difference in distribution was considered significant if *P* value was less than 0.05.

Table 1: Distribution of positive cases for *S. aureus* and their percentages in regard to the stage of the study

	Number of samples	Number of positive samples	%
Preclinical stage	178	30	16.8
Clinical stage	192	48	25
Total	370	78	21

Results

The study showed nasal carriage of *S. aureus* in 78 students out of 370 students from whom samples were taken for bacterial examination (the percentage of positive samples was 21% of the total samples). The cases of the nasal carriage of *S. aureus* were distributed according to the stage of study among the students as follows: 30 cases for the preclinical stage students (16.8%), (18 males and 13 females), and 48 cases for the clinical stage students (23.4%) (29 males and 16 females) [Table 1].

Table 2 shows the distribution of positive cases and their percentages in regard to the stage of the medical study and gender.

The number of culture-positive cases among smoking students was 46 (59%), and the number of culture-positive cases among nonsmoking students was 32 (41%).

The number of culture-positive cases among students who clean their noses regularly was 33 students (42%), and the number of culture-positive among students who do not clean their noses regularly was 45 students (58%).

Methicillin-resistant *S. aureus* colonization rates

The overall MRSA carriage rate was 8.3% (31/370). Moreover, among *S. aureus* carriers, 39.7% (31/78) were MRSA carriers. The MRSA carriage rate among students in the premedical stage was 6% (11/178) and 10.4% (20/192) among students in the clinical stage [Table 3].

Antibiotic susceptibility pattern

The *in vitro* antibiotic sensitivity pattern of all positive isolates (78 isolates) was as follows: penicillin (9%), ampicillin (15.3%), amoxicillin/clavulanate (24.3%), erythromycin (33.3%), clindamycin (42.3%), ciprofloxacin (69.2%), ceftriaxone (43.5%), gentamicin (73%),

Table 2: Distribution of positive cases and their percentages in regard to the stage of the medical study and gender

Variables	*S. aureus* colonization ($n = 370$)		Total, *n* (%)
	Yes, *n* (%)	No, *n* (%)	
Sex			
Male	49 (22.6%)	168 (77.4%)	217 (100%)
Female	29 (18.9%)	124 (80.1%)	153 (100%)
Age (in years)			
≤21	29 (16.5%)	146 (83.5%)	175 (100%)
≥21	49 (25.1%)	146 (74.9%)	195 (100%)
Category of the students			
Preclinical stage	30 (16.8%)	145 (81.9%)	178 (100%)
Clinical stage	48 (25%)	147 (76.6%)	192 (100%)
Total	78 (21%)	292 (79%)	370 (100.0)

Table 3: Distribution of methicillin-resistant *S. aureus* (MRSA) according to sex, age and category of year among medical students

Characteristics	MRSA colonization		Total, *n* (%)
	Yes (*n* = 31), *n* (%)	No (*n* = 370) *n* (%)	
Sex			
Male	22 (10.1%)	195 (89.9.2%)	217 (100%)
Female	9 (5.9%)	144 (94.1%)	153 (100%)
Age (in years)			
≤21	12 (6.8%)	163 (93.2%)	175 (100%)
≥21	19 (9.7%)	176 (90.3.2%)	195 (100%)
Category of the students			
Preclinical	11 (6%)	167 (95%)	178 (100%)
Clinical	120 (10.4.8%)	175 (91.2%)	192 (100%)

Table 4: The antibiotic susceptibility patterns of all *S. aureus* isolates (MSSA and MRSA)

Antimicrobial	MSSA *n* = 47 (%)		MRSA *n* = 31 (%)		Total *n* = 78 (%)	
	S	R	S	R	S	R
Penicillin	7 (14.8)	40 (85.2)	0 (0)	31 (100)	7 (9)	71 (91)
Ampicillin	10 (21.2)	37 (78.8)	2 (6.4)	29 (93.6)	12 (15.3)	66 (84.7)
Amoxicillin/clavulanate	14 (29.7)	33 (70.3)	5 (16)	26 (84)	19 (24.3)	59 (75.7)
Erythromycin	18 (38.2)	29 (61.8)	8 (25.8)	23 (74.2)	26 (33.3)	52 (66.7)
Clindamycin	24 (51)	23 (49)	9 (29)	22 (71)	33 (42.3)	45 (57.7)
Ciprofloxacin	38 (80.8)	9 (19.2)	16 (51.6)	15 (49.4)	54 (69.2)	24 (30.8)
Ceftriaxone	25 (53)	22 (47)	9 (29)	22 (71)	34 (43.5)	44 (66.5)
Gentamicin	41(87.2)	6 (12.8)	16 (51.6)	15 (49.4)	57 (73)	30 (27)
Vancomycin	47 (100)	0 (0)	31 (100)	0 (0)	78 (100)	0 (0)
Cefoxitin	47 (100)	0 (0)	0 (0)	31 (100)	47 (60.2)	31 (39.8)

S: sensitive, R: resistant, MSSA: methicillin-sensitive *S. aureus*, MRSA: methicillin-resistant *S. aureus*

vancomycin (100%), and cefoxitin (60.2%) [Table 4]. The antibiotic sensitivity pattern of 31 isolates of MRSA and 47 isolates of methicillin-susceptible *S. aureus* (MSSA) is illustrated in Table 4.

Discussion

This study reveals that the prevalence of *S. aureus* nasal carriage among medical students in all stages of studying was moderate (21%), with significant difference between the group of preclinical and clinical stages, as the carrier rate of *S. aureus* was observed higher among the clinical stage student group (25%) in comparison to preclinical stage group (16.8%). This may indicate that the presence of medical students of the clinical stage in hospitals and their daily contact with patients, medical workers, and the exposure to hospital environment may be an important factor in increasing the nasal carriage rate among them.

Many published data on nasal carriage of *S. aureus* among medical students and healthcare workers present a carrier rate of 15%–35% and is similar to the present study.[19,20,26,27]

Although the overall nasal carriage rate observed in this study was higher in male students (22.6%) compared to female students (18.9%), no significant difference was found.

A significant difference was found between the group of students of age ≥21 and the group of age ≤21 as a high rate of carriage was observed in students of age ≥21 (25.1%), while the rate of carriage in students of age ≤21 was (8.5%). This can be explained by the fact that students of age ≥21 are mostly students in the clinical study stage. Some other studies observed the high incidence of *S. aureus* carriage among older age students.[26-28]

High carriage rate of *S. aureus* was also found in smoking students (59%), in comparison to the carriage rate among nonsmoking students (32%). This may indicate that smoking may be a factor predisposing to the risk of *S. aureus* nasal carriage.[12,28] The association between smoking and *S. aureus* nasal carriage is a subject of debate. A number of authors have suggested that cigarette smoke extract has bactericidal activity and increases immune activity associated with smoking-induced hypoxia, whereas others have shown that smokers are more frequently colonized than nonsmokers, and cessation from smoking improves the clearance of *S. aureus* in an experimental model.[12,28]

The methicillin-resistant strains of *S. aureus* are important causes of hospital-acquired infections and make the management of patients difficult especially in critical care units and has been associated with higher mortality rates even after using anti-MRSA therapy.[6,8,9,29] In this study, the prevalence of MRSA nasal carriage among the medical students was (8.3%) among all participating students and has a high rate among *S. aureus* carrier students (39.7% of positive isolates were MRSA).

High rates of MRSA carriage and significant differences were found in students of clinical stage (10.4%), in comparison to premedical students (6%). The high rate nasal carriage of MRSA among students at the clinical stage was also observed in other studies.[12,15,26] This may indicate that the longer stay of medical students in the hospital environment during the clinical stage, where they entered into contact with patients on day-to-day basis, is associated with the acquisition of MRSA, and it is known that the prevalence of MRSA strains is usually high in hospitals.

Antimicrobial sensitivity testing for all isolated strains (both MSSA and MRSA) in the current study revealed that all strains were sensitive to vancomycin, but there was high or moderate resistance rate for most other tested antibiotics. High resistance was observed to penicillin (91%), ampicillin (84.7%), amoxicillin/clavulanate (75.7%), erythromycin (66.8%), clindamycin (57.7%), and ceftriaxone (66.5%), while moderate resistance rate was found against ciprofloxacin (30.8%) and gentamycin (27%). The high or moderate resistance rate of most strains of *S. aureus* was observed in the most recent studies.[12,30,31]

Antibiotic resistance among the MSSA isolates in this study showed overall highly sensitive MESSA strains to penicillin (85.2%), ampicillin (78.8%), amoxicillin/clavulanate (70.3%), erythromycin (61.8%), clindamycin (49%), and ceftriaxone (47%), while a moderate or low resistance rate was observed for ciprofloxacin (19.2%) and gentamicin (12.8%).

MRSA strains in our study were highly resistant to most used antibiotics: penicillin (100%), ampicillin (93.6%), amoxicillin/clavulanate (84%), erythromycin (74.2%), clindamycin (71%), and ceftriaxone (47%), while a moderate or low resistance rate was observed against ciprofloxacin and gentamicin (49.4%). The high rate of resistance to most antibiotics among MRSA strains indicates the spread of these strains in the hospital environment and may also reflect the widespread and unwise use of antibiotics in hospitals and the community.

Conclusion

The results of our current study showed a moderate nasal carriage rate of *S. aureus* among medical students, with a significant statistical difference in carriage rates between preclinical and clinical stage students. High rates of MRSA carriage were detected among students of clinical stage, which might support the idea that students in medical stage can be MRSA nasal carriers because of their exposure to hospital environment and daily contact with patients and healthcare workers and may later act as vectors in the transmission of MRSA *S. aureus* strains. The fact that their knowledge of standard infection control measures is poor during this period of clinical practice may increase the possibility of transmission. MRSA strains in our study were highly resistant to most commonly used antibiotics, indicating the spread of these resistant strains in hospitals and perhaps in the community, which calls for urgent measures and adoption of effective policies to reduce the inappropriate use of antibiotics. According to our results, it is necessary to note the importance of training and standard infection control precautions to prevent the increase in MRSA carriage rates among medical students of the clinical stage. Advanced studies are important to monitor carriage rates and effective risk factors.

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Conflicts of interest

There are no conflicts of interest.

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