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ORIGINAL ARTICLE

High frequency of SCC*mec* type IV and multidrug-resistant SCC*mec* type I among hospital acquired methicillin-resistant *Staphylococcus aureus* isolates in Birjand Imam Reza Hospital, Iran

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ABSTRACT

Background and Objectives: The ever-increasing of antibiotic resistance in methicillin-resistant *Staphylococcus aureus* (MRSA) has become a major threat to public health worldwide. Molecular typing is used to determine the source of MRSA infections as well as to control and prevent the spread of these pathogens. The present study aimed to investigate the characteristics of staphylococcal cassette chromosome *mec* (SCC*mec*) types and antibiotic resistance of community- acquired (CA-) and hospital acquired (HA-) MRSA isolates.

Materials and Methods: In this cross-sectional study, the antibiotic susceptibility patterns of 109 clinical *S. aureus* isolates were determined by the Kirby-Bauer disk-diffusion and microdilution broth methods. MRSA isolates were confirmed using the polymerase chain reaction (PCR) method for the detection of the *mec*A gene. SCC*mec* typing was performed by a multiplex PCR assay among MRSA isolates.

Results: The prevalence of MRSA isolates was 39.4%. Linezolid, vancomycin, and ceftaroline were the most effective agents against MRSA isolates. The incidence of multidrug-resistant (MDR) and resistance to most antibiotics were significantly higher in MRSA than methicillin-susceptible *S. aureus* (MSSA) isolates ($P<0.05$). SCC*mec* types I, III, and IV were identified in 27.9%, 23.3%, and 37.2% of MRSA isolates, respectively. SCC*mec* type I and IV were the most prevalent SCC*mec* types in HA-MRSA isolates (each was 32.4%). While SCC*mec* type IV (66.7%) was the most frequently SCC*mec* type associated with CA-MRSA isolates.

Conclusion: Our findings demonstrated a high rate of MDR among MRSA isolates. The high existence of SCC*mec* type IV was reported among the HA-MRSA isolates, which can indicate the spread of MRSA community isolates to hospital settings. Therefore, appropriate antibiotic stewardship plans and microbiological surveillance initiatives must be implemented in healthcare facilities to monitor and limit the spread of these resistant bugs.

Keywords: Methicillin-resistant *Staphylococcus aureus*; Drug resistance; Multidrug-resistant; *mec*A gene; Molecular typing; Polymerase chain reaction

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INTRODUCTION

Staphylococcus aureus is one of the most frequent pathogens in community and health care facilities and is considered as a serious threat to human health. This pathogen is responsible for a wide range of diseases from folliculitis to food poisoning, as well as causing life-threatening infections such as bacteremia, endocarditis, necrotizing pneumonitis, and osteomyelitis (1, 2).

The emergence of methicillin-resistant *S. aureus* (MRSA) strains has become an increasing health concern worldwide. The potential for genetic adaptation and the remarkable ability of MRSA strains to acquire resistance to multiple antimicrobials complicated the treatment of related infections. Therefore, a major public health concern still remains with respect to the high morbidity and mortality of infections caused by MRSA, along with increased hospitalization and health care costs (3, 4).

Although MRSA infections were originally acquired only from hospital settings (HA-MRSA), outbreaks of infection in the community were first reported in the 1990s. However, CA-MRSA infections are now increasingly spreading in hospital settings and are replacing traditional HA-MRSA strains (2, 5). Since antibiotic management and virulence properties of CA-MRSA strains are different from HA-MRSA, it can be important to identify and differentiate the bacteria to reduce unnecessary suffering, the length of hospital stay, and healthcare costs for affected patients (6, 7).

The staphylococcal cassette chromosome *mec* (SCC*mec*) mobile element carries both the *mec*A or *mec*C genes that mediate resistance to methicillin in *S. aureus* (8, 9). To date, thirteen different types of SCC*mec* elements (SCC*mec* I-XIII) have been identified based on structural organization and genetic content, and each SCC*mec* type has individual characteristics (4, 10). Noteworthy, SCC*mec* types I, II, and III are the most seen types found in hospital acquired MRSA (HA-MRSA), whereas types IV and V are prominent SCC*mec* types among community-acquired MRSA (CA-MRSA) strains (11, 12).

Given the importance of global surveillance studies on resistance profiles and epidemiological types of MRSA strains, along with the current challenges in the treatment of infections caused by these pathogens, the present study aimed to investigate the characteristics of SCC*mec* types and antibiotic resistance of CA- and HA-MRSA isolates in Birjand Imam Reza hospital, Iran.

MATERIALS AND METHODS

Study design and bacterial isolation. This cross-sectional study was conducted on a total of 109 non-duplicate clinical *S. aureus* isolates collected from out-patients and in-patients (hospital stay >48 hours at the time of specimen collection) referred to Birjand Imam Reza Hospital in Iran from Mar 2018 to Feb 2019. The clinical samples contained urine, joint fluids, lung secretions, wound swab, ear secretions, ascetic fluid, and other samples. The study was approved by the ethics committee of Birjand University of Medical Sciences (IR.BUMS.REC.1396.110).

S. aureus isolates were identified using conventional microbiological methods, such as evaluation of colony morphology on sheep blood agar, Gram-staining, catalase activity, production of coagulase, DNase test (Merck, Germany), and mannitol fermentation on mannitol salt agar (Merck, Germany).

Antibiotic susceptibility testing (AST). The antibiotic resistance profile of the isolates was determined according to the Clinical and Laboratory Standards Institute (CLSI) guidelines (13). The Kirby-Bauer disk-diffusion method was used for susceptibility testing to erythromycin (15 μg), clindamycin (2 μg), doxycycline (30 μg), gentamicin (10 μg), tetracycline (30 μg), ciprofloxacin (5 μg), rifampin (5 μg), trimethoprim /sulfamethoxazole (1.25/23.75 μg), ceftaroline (30 μg), linezolid (30 μg) and quinupristin/dalfopristin (15 μg) (MAST, UK). Furthermore, the minimum inhibitory concentration (MIC) value of vancomycin (Sigma-Aldrich, USA) against the isolates was determined by the microdilution broth method. *S. aureus* ATCC 25923 and *S. aureus* ATCC 29213 were used for quality control of antibiotic susceptibility testing.

Screening of methicillin-resistant *S. aureus* (MRSA). MRSA strains were identified phenotypically using the cefoxitin disk diffusion method (30 μg; MAST, UK) according to the CLSI guidelines (13). *S. aureus* isolates with an inhibition zone diameter of ≤21mm around the cefoxitin disk were confirmed as MRSA strain.

Detection of *mec*A gene. The existence of the *mec*A gene in all MRSA isolates was determined employing PCR assay with specific primers described in Table 1. Genomic DNA was extracted from pure cultures of the isolates using a High Pure PCR Template Preparation Kit (Roche, Germany) according to the manufacturer's instructions. The PCR amplification for the *mec*A gene was carried out as described previously (14). The amplified products were electrophoresed on 1% agarose gel containing 1× RedSafe DNA stain (Intron, USA).

SCC*mec* typing. In this study, a multiplex PCR assay with specific primers (Table 1) described by Boye and colleagues (15) was developed to SCC*mec* typing (SCC*mec* type I-V) among MRSA isolates harboring the *mec*A gene. Amplification of SCC*mec* genes was performed in a final volume of 25 mL consisting of 12.5 µl of 2× Hot Star Taq Master Mix (Amplicon, Denmark), 3 µl of the DNA template, an optimized amount of each primer with a concentration of 10 pmol/µL (0.5 µl of each β, α3, ccrCF, and ccrCR; 0.3 µl of each 1272F1, 1272R1, 5R*mec*A, and 5R431), and 6.3 µl of ddH2O. DNA amplification was performed in a thermocycler (PEQLAB, Erlangen, Germany) with an initial denaturation step at 94°C for 4 minutes; 30 amplification cycles each for 45 seconds at 94°C, 30 seconds at 55°C, and 1 minute at 72°C; and followed by an additional extension step of 5 minutes at 72°C. The amplified products were electrophoresed on 1.5% agarose gel containing 1× RedSafe DNA stain (Intron, USA). Noteworthy, the SCC*mec* types were determined based upon the results of the obtained band pattern comparing to ATCC 10442 (SCC*mec* type I), N315 (SCC*mec* type II), 85/2082 (SCC*mec* type III), MW2 (SCC*mec* type IVa), and WIS (SCC*mec* type V), as reference strains. Isolates with no visible bands, or with a band pattern that was not in agreement with one of the five predicted band patterns, were classified as non-typeable (NT).

Statistical analysis. The data were analyzed with the Pearson chi-square and Fisher's exact tests, using SPSS software (version 21), to evaluate the statistical significance of associations between potential variables. P-values of less than 0.05 were regarded as statistically significant.

RESULTS

Out of the total 109 *S. aureus* isolates isolated from different clinical samples, the majority of the isolates were originated from wound swabs (33 isolates, 36%), followed by lung secretions (27 isolates, 24.8%), urine (25 isolates, 22.9%), ear secretions (10 isolates, 9.2%), ascetic fluid (Two isolates, 1.8%), and joint fluids (One isolate, 0.9%).

Among the 109 isolates obtained, 67 (61.5%) were from males and 42 (38.5%) were from females. The mean age of patients was 32.12 ± 16.51 years old (range of 1-78 years), of which 72 (66.1%) were hospitalized and 37 (33.9%) were out-patients.

Antibiotic resistance characteristics. The results of the antimicrobial resistance determinations of *S. aureus* isolates are reported in Table 2. The findings showed a high susceptibility of the isolates to linezolid (100%), vancomycin (100%), ceftaroline (99.1%), and quinupristin/dalfopristin (88.1%). In the present study, 48 *S. aureus* isolates (44%, 48/109) were identified as multidrug-resistant (MDR) that these MDR

Table 1. Target genes and their primers used in this study.

	Primers	Sequence (5′-3′)	Products sizes (bp)	Annealing (°C)	Ref.
	*mec*A	Fw- TGGCTATCGTGTCACAATCG	304	58	(14)
		Rv- CTGGAACTTGTTGAGCAGAG			
	β	ATTGCCTTGATAATAGCCYTCT	937		
	α3	TAAAGGCATCAATGCACAAACACT			
SCC*mec* Typing	ccrCF	CGTCTATTACAAGATGTTAAGGATAAT	518	55	(15)
	ccrCR	CCTTTATAGACTGGATTATTCAAAATAT			
	1272F1	GCCACTCATAACATATGGAA	415		
	1272R1	CATCCGAGTGAAACCCAAA			
	5R*mec*A	TATACCAAACCCGACAACTAC	359		
	5R431	CGGCTACAGTGATAACATCC			

S. aureus isolates (52.8% vs. 27%, P=0.01) were significantly more common in hospitalized patients than in out-patients.

In the present study, the prevalence of methicillin-susceptible *S. aureus* (MSSA) and MRSA isolates was 60.6% (66/109) and 39.4% (43/109), respectively. Statistical analysis indicated that resistance to most antibiotics such as erythromycin (44.2% vs. 16.7%, P=0.003), rifampin (39.5% vs. 10.6%, P=0.001), quinupristin/dalfopristin (25.6% vs. 3%, P=0.001), clindamycin (55.8% vs. 4.5%, P=0.0001), doxycycline (20.9% vs. 7.6%, P=0.015), gentamicin (30.2% vs. 10.6%, P=0.017), tetracycline (58.1% vs. 25.8%, P=0.001), and ciprofloxacin (39.5% vs. 15.2%, P=0.016) was significantly higher in MRSA than MSSA isolates. Noteworthy, the incidence of MDR in MRSA isolates was significantly (P<0.001) higher than MSSA isolates, 81.4% vs. 19.7%, respectively.

The infection rate of MRSA isolates (51.4% vs. 16.2%, P=0.0001) was shown to be significantly higher in in-patients (HA) compared with out-patients (CA). Comparison of resistance pattern of HA-MRSA and CA-MRSA strains to antimicrobial agents is shown in Table 2. The findings revealed that resistance to quinupristin/dalfopristin (29.7% vs. 0%, P=0.018), and clindamycin (62.2% vs. 16.7%, P=0.037) was considerably higher in HA-MRSA compared to CA-MRSA strains. Finally, among CA- and HA-MRSA, 66.7 percent (4/6) and 81.1 percent (30/37) were found to be MDR, respectively (P=0.369).

SCC*mec* typing patterns. In the present study, the *mec*A gene was found in all MRSA isolates. Out of 43 *mec*A positive isolates, SCC*mec* types I, III, and IV were identified in 12 (27.9%), 10 (23.3%), and 16 (37.2%) of MRSA isolates, respectively, and five (11.6%) isolates were not typeable. The PCR amplification of products obtained from SCC*mec* typing of MRSA isolates is shown in Fig. 1. Noteworthy, SCC*mec* type I and IV were the most prevalent SCC*mec* types in HA-MRSA isolates (each was 32.4%). While SCC*mec* type IV (66.7%) was the most frequently SCC*mec* type associated with CA-MRSA isolates (Table 3). In this study, statistical analysis did not show a significant difference in the frequency of SCC*mec* types between HA-MRSA and CA-MRSA isolates (P>0.05).

The antimicrobial resistance patterns of MRSA isolates grouped by SCC*mec* types are summarized in Table 4. The findings showed high resistance to most

Table 2. Resistance pattern of *S. aureus* and MRSA isolates to different antimicrobial agents.

Antimicrobial Agents	*S. aureus*	Methicillin-resistant Status			MRSA isolates		
	isolates (%)	MRSA (%)	MSSA (%)	P-value	HA-MRSA (%)	CA-MRSA (%)	P-value
Erythromycin		(n=43)	(n=66)		(n=37)	(n=6)	
Ceftaroline	30 (27.5)	19 (44.2)	11 (16.7)	0.003	18 (48.6)	1 (16.7)	0.341
Rifampin	1 (0.9)	1 (2.3)	0 (0)	0.394	1 (2.7)	0 (0)	0.860
Trimethoprim/sulfamethoxazole	23 (21.1)	17 (39.5)	7 (10.6)	0.001			
Quinupristin	20 (18.3)	11 (25.6)	9 (13.6)	0.243	10 (27)	1 (16.7)	0.696
/dalfopristin	13 (11.9)	11 (25.6)	2 (3)	0.001	11 (29.7)	0 (0)	0.018
Clindamycin	27 (24.8)	24 (55.8)	3 (4.5)	0.0001	23 (62.2)	1 (16.7)	0.037
Doxycycline	14 (12.8)	9 (20.9)	5 (7.6)	0.015	8 (21.6)	1 (16.7)	0.64
Gentamicin	20 (18.3)	13 (30.2)	7 (10.6)	0.017	12 (32.4)	1 (16.7)	0.274
Tetracycline	42 (38.5)	25 (58.1)	17 (25.8)	0.001	23 (62.2)	2 (33.3)	0.344
Ciprofloxacin	27 (24.8)	17 (39.5)	10 (15.2)	0.016	14 (37.8)	3 (50)	0.224
Cefoxitin	43 (39.4)	66 (100)	0 (0)	NA	NA	NA	NA
Linezolid	0 (0)	0 (0)	0 (0)	NA	0 (0)	0 (0)	NA
Vancomycin	0 (0)	0 (0)	0 (0)	NA	0 (0)	0 (0)	NA
MDR Status							
Yes	48 (44)	35 (81.4)	13 (19.7)	<0.001	30 (81.1)	4 (66.7)	0.369
No	61 (56)	8 (18.6)	53 (80.3)		7 (18.9)	2 (33.3)	

MDR: Multidrug-resistant, MRSA: Methicillin-resistant *S. aureus*, MSSA: Methicillin-susceptible *S. aureus*, HA-MRSA: Hospital-acquired MRSA, CA-MRSA: Community-acquired MRSA, NA: Not applicable.

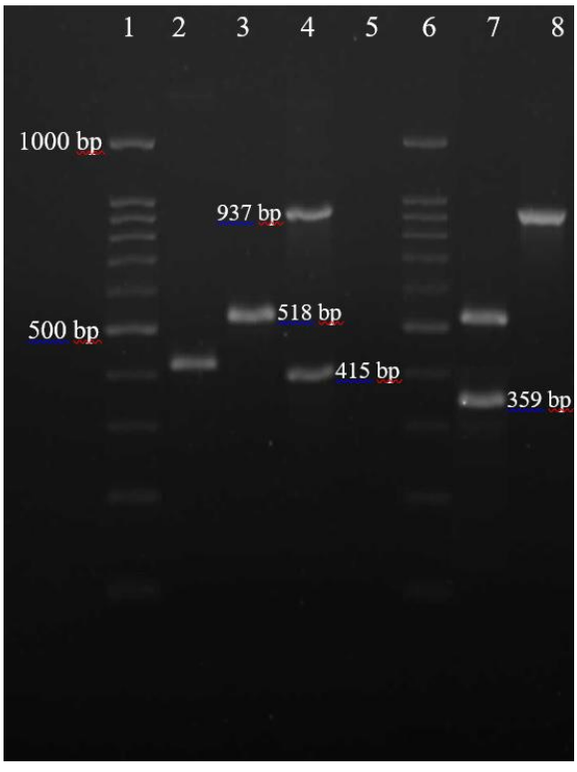

Fig. 1. PCR amplification of products obtained from SCC*mec* typing of MRSA isolates. Lane 1 and 6, DNA marker (100 bp); Lane 2, Clinical MRSA SCC*mec* type I strain (415 bp); Lane 3, Clinical MRSA SCC*mec* type III strain (518 bp); Lane 4, Clinical MRSA SCC*mec* type IV strain (415 and 937 bp); Lane 5, Negative control; Lane 7, *S. aureus* WIS 173 (SCC*mec* type V); Lane 8, *S. aureus* N315 strain (SCC*mec* type II).

antibiotics in MRSA with type III SCC*mec*. So that, the MRSA SCC*mec* type III strains were significantly more resistant to rifampin (P=0.025), gentamicin (P=0.007), tetracycline (P=0.043), and ciprofloxacin (P=0.01) than strains with other types of SCC*mec*. Furthermore, all MRSA SCC*mec* type III strains were identified as MDR (100%). In contrast, compared with SCC*mec* I/III MRSA strains, a greater proportion of SCC*mec* IV strains were susceptible to most antibiotics tested. The results indicated that the MRSA SCC*mec* type IV strains were more multidrug-susceptible compared to the other SCC*mec* types.

DISCUSSION

Today, the emergence of MRSA isolates has become a major challenge in public health. MRSA isolates are commonly MDR strains, and this issue can lead to limited therapeutic options for the control of infections, causing high morbidity and mortality, especially in hospitalized patients (3, 10).

Table 3. Distribution of SCC*mec* types among CA- and HA-MRSA isolates.

SCC*mec* Types	MRSA isolates		P-value
	HA-MRSA (%) (n=37)	CA-MRSA (%) (n=6)	
I	12 (32.4)	0 (0)	0.121
III	9 (24.3)	1 (16.7)	0.571
IV	12 (32.4)	4 (66.7)	0.125
NT	4 (10.8)	1 (16.7)	0.547

MRSA: Methicillin-resistant *S. aureus*, HA-MRSA: Hospital-acquired MRSA,
CA-MRSA: Community- acquired MRS, NT: Non-typeable.

In the current study, the prevalence of MRSA isolates was 39.4%, which is almost consistent with some studies in Iran (8, 10, 16, 17), and other countries such as the Philippines (45.76%), India (35.33%), Iraq (42.5%), Pakistan (39%), Africa (53.4%), Nigeria (41.4%), and Brazil (33.3%) (7, 18-22). However, there are reports of much higher rates of MRSA isolates compared with our study from several other studies in Iran (12, 23-25), and Sudan (70%), Sweden (70%), Nepal (75%), USA (75%), and India (93.5%) (26-30). These discrepancies in the prevalence of MRSA isolates could be explained by differences in the studied patients, the clinical samples, the geographic areas, the infection-control policies, and the diagnostic techniques.

The findings revealed that resistance to tetracycline (58.1%), clindamycin (55.8%), erythromycin (44.2%), and ciprofloxacin and rifampin (each was 39.5%) was the most common resistance pattern among MRSA isolates. Moreover, 81.4% of MRSA isolates were identified as MDR. This pattern of antibiotic resistance is in line with the results of many studies. Japoni et al. demonstrated a reduced gradient of MRSA susceptibility to rifampin, co-trimoxazole, clindamycin, tetracycline, ciprofloxacin, and erythromycin (31). In another study, the highest resistance of MRSA isolates was related to levofloxacin, ciprofloxacin, erythromycin, and clindamycin (9). In the study of Rossato and colleagues, the highest levels of resistance among MRSA isolates were reported against erythromycin, ciprofloxacin, and clindamy-

Table 4. Distribution of antimicrobial resistance among MRSA isolates by SCC*mec* types characteristics.

Antimicrobial Agents	SCC*mec* Types				P-value
	I (%) n=12	III (%) n=10	IV (%) n=16	NT (%) n=5	
Erythromycin	4 (33.3)	7 (70)	4 (25)	4 (80)	0.137
Ceftaroline	0 (0)	0 (0)	0 (0)	1 (20)	0.051
Rifampin	3 (25)	8 (80)	4 (25)	2 (40)	0.025
Trimethoprim /sulfamethoxazole	4 (33.3)	1 (10)	4 (25)	2 (40)	0.665
Quinupristin/dalfopristin	3 (25)	3 (30)	3 (18.8)	2 (40)	0.857
Clindamycin	7 (58.3)	8 (80)	5 (31.3)	4 (80)	0.057
Doxycycline	1 (8.3)	3 (30)	3 (18.8)	2 (40)	0.315
Gentamicin	1 (8.3)	7 (70)	2 (12.5)	3 (60)	0.007
Tetracycline	9 (75)	9 (90)	5 (31.3)	2 (40)	0.043
Ciprofloxacin	1 (8.3)	8 (80)	4 (25)	4 (80)	0.01
MDR Status					
Yes	10 (83.3)	10 (100)	10 (62.5)	5 (100)	0.065
No	2 (16.7)	0 (0)	6 (37.5)	0 (0)	

MDR: Multidrug-resistant, NT: Non-typeable.

cin (4). Nevertheless, in many studies in line with our study, vancomycin, linezolid, and ceftaroline were introduced as the most effective antibiotics against MRSA isolates (16, 20, 31-33).

In this study, the rates of antibiotics resistance in MRSA isolates were higher in comparison with MSSA isolates. The results indicated that resistance to most antibiotics such as erythromycin, rifampin, quinupristin/dalfopristin, clindamycin, doxycycline, gentamicin, tetracycline, and ciprofloxacin was significantly higher in MRSA than MSSA isolates. Noteworthy, the incidence of MDR in MRSA isolates was significantly higher than MSSA isolates. Many studies in line with our study have reported high antibiotic resistance of MRSA isolates to MSSA (10, 33-35). Hence, the accurate identification and reporting of MRSA isolates would help select the appropriate antibiotic therapy and, control and minimize the spread of these MDR isolates.

In humans, bacterial infections from MRSA have been acknowledged for several years as either HA-MRSA or CA-MRSA depending on the source of infection. CA-MRSA strains have been found to have distinctive genetic composition, antimicrobial characteristics, and virulence properties that set them apart from HA-MRSA strains. Clinically, HA-MRSA strains are usually MDR and the infections caused by them are associated with high morbidity and mortality (2, 7, 17). In the present study, the infection rate of MRSA isolates (51.4% vs. 16.2%, P=0.0001) was shown to be significantly higher in in-patients (HA) compared with out-patients (CA). A similar result was reported by Preeja et al. where the prevalence of MRSA among in-patients and out-patients was 96.1% and 55.6%, respectively. Furthermore, a significant difference was observed between the isolation of HA-MRSA and CA-MRSA from the inpatient and outpatient groups (2). In another study, the incidence of HA-MRSA and CA-MRSA infection was reported to be 73% and 37%, respectively (23). In the study of Tsige and colleagues, the frequency of MRSA isolates in in-patients (19.5%) was higher as compared to out-patient (5.4%) (36). It is noteworthy that in our study, the resistance to most antibiotics in HA-MRSA strains was higher than CA-MRSA so that this difference was significant for quinupristin/dalfopristin (29.7% vs. 0%, P=0.018) and clindamycin (62.2% vs. 16.7%, P=0.037). Moreover, among CA- and HA-MRSA, 66.7% and 81.1% were found to be MDR, respectively. These findings are in line with the results of many studies that have reported high antibiotic resistance in HA-MRSA strains compared to CA-MRSA (2, 11, 18, 35). Overall, it should be noted that the high occurrence of MRSA isolates with high rates of resistance to commonly used antimicrobials among hospitalized patients is not surprising due to various hospital-related factors such as long-term hospitalization, the use of various

antibiotics for treatment, and underlying immunodeficiency conditions, which predispose patients to acquire MRSA.

Nowadays, applying a simple, rapid and accurate typing method can help identify the source of antibiotic-resistant infections. SCC*mec* typing provides useful information about antimicrobials resistance, and to determine the epidemiological relationship between various MRSA strains and origin of infection (3, 10). In the current study, the most prevalent SCCmec types among MRSA isolates was SCC*mec* IV (37.2%), followed by SCC*mec* I (27.9%), and SCC*mec* III (23.3%). Similar results in some studies indicate the predominance of type SCC*mec* IV in MRSA isolates (3, 4, 7, 10, 37), which can be explained by the fact that the small size of this SCC*mec* type may facilitate its spread among MRSA isolates collected from hospitals and communities (10, 38). Noteworthy, SCC*mec* type I and IV were the most prevalent SCC*mec* types in HA-MRSA isolates (each was 32.4%) in our study. While, SCC*mec* type IV (66.7%) was the most frequently SCC*mec* type associated with CA-MRSA isolates. In this regard, some studies have shown a high prevalence of SCC*mec* type IV among the HA-MRSA isolates (2, 10, 11, 23), which can indicate that the MRSA community isolates has spread to the hospital settings. Therefore, applying an action plan with appropriate antibiotic stewardship and the implementation of strict aseptic techniques can help control colonization and the spread of CA-MRSA isolates to health care facilities. Finally, the findings of current study showed a high resistance to most antibiotics in MRSA with types I and III SCC*mec*, while a greater proportion of SCC*mec* IV strains were susceptible to most antibiotics. Similar results have been found in many previous studies (4, 16, 17, 39), and this is because SCC*mec* types I and III is often observed in HA-MRSA isolates, which generally has a high antibiotic resistance.

CONCLUSION

Our findings demonstrated a high rate of MDR among MRSA isolates. In this study, linezolid, vancomycin, and ceftaroline were still effective antibiotics to treat MRSA infections. The present results showed the high existence of SCC*mec* type IV among the HA-MRSA isolates, which can indicate the spread of MRSA community isolates to hospital settings. It is imperative that appropriate antibiotic stewardship plans and microbiological surveillance initiatives are implemented in healthcare facilities to monitor and limit the spread of these resistant bugs.

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