

Original Article

Investigating the antibiotic resistance pattern of *Staphylococcus aureus* isolated from clinical samples of patients hospitalized in the special care departments of Ahvaz teaching hospitals



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ABSTRACT

One of the most significant harmful microorganisms is *Staphylococcus aureus*. Due to the rise in the resistance of this bacteria to antibiotics and the lengthening of hospitalized patients' treatments, one of the causes of infection and mortality among patients hospitalized in special care units of hospitals. In this cross-sectional descriptive study, samples of 113 *S. aureus* isolates were taken from patients who had spent 4 months in the special care units of Ahvaz teaching hospitals. These samples were then tested using antibiograms for oxacillin, cefoxitin, linezolid, ciprofloxacin, clindamycin, trimethoprim sulfamethoxazole, vancomycin, penicillin, and Antibiotic resistance was discovered, and the findings were evaluated against those of previous investigations. 51 (57.63%) of the 113 patient-isolated samples were female, while 62 (70.1%) were male. The oldest person was 89 years old and the youngest was 4 years old. Linezolid antibiotics were effective against every tested strain, although they were ineffective against 6 tested strains (6.31%), 4 tested strains (3.54%), and 1 tested strain (88%) isolated from wound urine. Vancomycin-resistant bacteria have been found. The findings of this study demonstrate that hospital strains of *S. aureus* are resistant to many antibiotics. Therefore, it is important to avoid prescribing and using available antibiotics unnecessarily. It is also advised to look at the evolution of antibiotic resistance in hospital infection management in order to stop the development of resistance to these antibiotics.

1. Introduction

The most significant genus in the medically significant Micrococcaceae family is *Staphylococcus*. *Staphylococcus* is a grape

cluster-shaped, facultatively anaerobic, gram-positive cocci [1-4]. *Staphylococcus* is connected to 80% of purulent infections and is the second leading cause of hospital

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infection among patients after *Escherichia coli*. The surface of a mammal's body and its surroundings are where staphylococcus is primarily found. An infection is brought on by this bacteria, an opportunistic and invasive pathogen, penetrating the tissue if the host's body's protective barrier is compromised by an injury. Without treatment, the infection spreads throughout the body, causing septicemia, acute endocarditis, bacteremia, and extensive skin infections [2, 3, 5, 6].

Catalase, coagulase, and hyaluronidase are a few of the microorganism's enzymes that have been successful in the pathogenesis of surgical wound infections, venous catheter site infections, soft tissue infections, endocarditis, joint infections, toxic shock syndrome, and bacteremia, among other conditions [7, 8].

The presence of venous catheters and tracheostomies, as well as regular contact with healthcare facilities like hospitals, are all factors in the colonization of MRSA infection. *S. aureus* strains have become more resistant as a result of prolonged hospitalization, patient surgery, and the indiscriminate use of antibiotics, which has led to an increase in the number of hospital infections brought on by this bacterium in recent years as compared to earlier years. The past has brought up [9, 10].

Due to frailty, a weakened immune system, and vascular manipulations, patients in special care units are more likely to develop invasive *S. aureus* infections than patients in other departments. In this situation, the patients are a source of infection for the staff who provide care and other individuals [11, 12]. In the current study, the prevalence of *S. aureus* resistance to the antibiotics oxacillin, cefoxitin, ciprofloxacin, erythromycin, clindamycin, trimethoprim, sulfamethoxazole, linezolid, penicillin, and vancomycin in hospitalized patients was investigated. This was done in an effort to stop the spread of infection and ensure proper hospital infection treatment by taking the necessary steps every patient is essential and crucial. This study was carried out to look at the *S. aureus* resistance trend in Ahvaz teaching hospitals.

2. Materials and Methods

In this cross-sectional analytical procedure, patient samples from their blood, urine, and wound cultures were cultivated on blood agar and EMB as soon as they entered the microbiology lab, and were then incubated at 37 degrees for 24 hours and then read if positive. In order to conduct phenotypic tests for warm color, catalase, mannitol salt agar, DNase, and tubular coagulase, the creamy-white, gray-colored colonies were removed from the culture media after cultivation. Following the identification of *S. aureus*, 113 samples were isolated and kept at -70°C and glycerol in a TSB medium for 4 months.

The research period was from the beginning of September to the end of November 2020, and it was based on 113 samples of *S. aureus* isolated from patients hospitalized in the special care departments of Ahvaz teaching hospitals (Imam, Razi, Sina, Bagai, Taleghani, Abu Zoro, Golestan). Labs for microbiology received the samples. With 113 samples, the appropriate sample volume was obtained using the agar disk diffusion technique, and Oxacillin (30 micrograms) was used to isolate the methicillin-resistant *S. aureus* strain based on CLSI for cefoxetine antibiotics. The antibiograms were carried out (Figure 1) on Hilton Muller Agar medium using sterile tweezers to retrieve and culture a sterile swab or loop of turbidity comparable to the normal turbidity of half McFarland (108 × 1.5 bacterium cells per milliliter).

The environment's surface was covered with antibiogram disks, which were incubated for 24 hours at 37°C with halo formation and classified by Kirby-Bauer as sensitive, semi-sensitive, and resistant. All MRSA isolates were tested for resistance to antibiotics after being given the desired MRSA, including vancomycin (30 micrograms), linezolid (30 micrograms), ciprofloxacin (5 micrograms), clindamycin (2 micrograms), trimethoprim sulfamethoxazole (1 microgram), penicillin (10 micrograms), and erythromycin (15 micrograms). Patten Teb Company was then cultured on Muller's medium. This procedure was the same as the one described above for these antibiograms in that it was placed on Hilton Muller Agar medium with a sterile swab or sterile loop of turbidity equivalent to

the standard turbidity of half McFarland (1.5 x 10⁸ bacterial cells per ml), cultured, and using AntibioGram disks were placed on the surface of the medium with sterile forceps and incubated for 24 hours at 37°C.

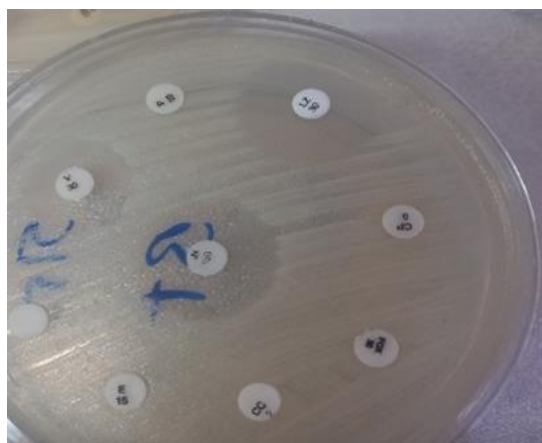


Fig. 1. AntibioGrams performed

3. Results

Out of 113 samples of *S. aureus* that were isolated, the study's findings revealed that

males had the highest prevalence of the bacteria (54.86%), and males over the age of 45 had the highest prevalence (32.25%), while males between the ages of 31 and 45 had the lowest prevalence (19.6%) (Table 1).

According to the findings, Golestan Hospital had the highest frequency of *S. aureus* (21.23%) (Table 2). In blood culture samples, penicillin had a 100% success rate, clindamycin had an 88.9% success rate, ciprofloxacin had an 81.81% success rate, erythromycin had an 80.7% success rate, and trimethoprim had a 73.52% success rate in inhibiting MRSA growth. Periodic exams should include blood since it is crucial.

According to the findings (Table 3), *S. aureus* was most prevalent in blood samples (49.55%) and least prevalent in urine samples (32.12%). If 90% of MRSA detected in blood samples were responsive to the antibiotic vancomycin, then all strains of *S. aureus* tested positive for linezolid sensitivity (Table 4 and 5).

Table 1. Relationship between gender and age of patients in the spread of *S. aureus*

Gender	Age				Total
	>45	31-45	16-30	0-15	
female	14(27.45%)	10(60.19%)	15(41.29%)	12(23.52%)	51(45.31%)
male	20(32.25%)	15(24.19%)	11(17.74%)	16(25.8%)	62(54.86%)
total	34(30.08%)	25(22.12%)	26(23%)	28(24.77%)	113(100%)

Table 2. The number of samples and hospitals where *S. aureus* was isolated

Sample	Hospital							Total
	Sina	Baghaee	Taleghani	Golestan	Abouzar	Razi	Emam	
Wound	2(25%)	-	13(72.22%)	5(20.83%)	1(9.09%)	8(36.36%)	3(10%)	32(28.31%)
Urine	2(25%)	4(40%)	-	6(25%)	2(18.18%)	5(22.72%)	6(20%)	25(22.12%)
Blood	4(50%)	6(60%)	5(27.77%)	13(54.16%)	8(72.72%)	9(40.90%)	11(36.66%)	56(49.55%)
Total	8(7.08%)	10(8.85%)	18(15.92%)	24(21.23%)	11(9.37%)	22(19.46%)	1(1.77%)	113(100%)

Table 3. Status of antibiotics examined in blood, urine and wound samples

Antibiotic	Sample								
	Urine			Wound			Blood		
	R*	SS*	S*	R*	SS*	S*	R*	SS*	S*
Vanco Mycine	2(10%)	-	18(90%)	2(6.06%)	1(3.03%)	30(90.9%)	3(10%)	-	27(90%)
Clindamycine	16(80%)	4(20%)	-	26(96.3%)	1(3.7%)	-	32(88.9%)	4(11.1%)	-
Erythromycin	18(81.8%)	2(9.09%)	2(9.09%)	30(85.7%)	3(8.57%)	2(5.71%)	21(80.7%)	1(3.8%)	4(15.3%)
Ciprofloxacin	20(95.23%)	-	1(4.76%)	28(93.33%)	-	1(3.33%)	27(81.81%)	2(6.06%)	4(12.12%)
Trimethoprim	13(68.42%)	3(15.78%)	3(17.78%)	22(73.33%)	2(6.66%)	6(20%)	25(73.52%)	3(8.82%)	6(17.64%)
Sulfamethoxazole									
Penicillin	83(100%)	-	-	83(100%)	-	-	83(100%)	-	-
Linezolid	-	-	83(100%)	-	-	83(100%)	-	-	83(100%)

*R: Resistance; SS: Semi Sensitive; S: Sensitive

Table 4. Identification of MRSA by disk diffusion method

Antibiotic	Situation		
	Resistant	Semi-Sensitive	Sensitive
Cefoxetone	83 (73.45%)	18(15.92%)	12(10.61%)
Oxacillin	83(73.45%)	18(15.92%)	12(10.61%)

Table 5. Antibiotic resistance pattern of methicillin-resistant *S. aureus* (MRSA) compared to the studied antibiotics

Antibiotics	situation		
	Resistant	Semi sensitive	sensitive
Ciprofloxacin	75(9.36%)	2(2.21%)	6(7.22%)
Clindamycin	74(86.15%)	9(10.84%)	-
Vancomycin	7(8.43%)	1(1.20%)	75(90.36%)
Trimethoprim Sulfamethoxazole	60(7.22%)	8(9.63%)	15(13.27%)
Penicillin	83(100%)	-	-
Erythromycin	69(83.13%)	6(7.22%)	8(9.62%)
Linezolid	-	-	83(100%)

4. Discussion

Out of 113 *S. aureus* isolates from patients hospitalized in ICU wards, 83 (73.45%) were methicillin-resistant strains, and all of these isolates were 100% sensitive to linezolid antibiotic. In contrast, all penicillin antibiotics showed 100% resistance, while vancomycin antibiotic showed 90.36% sensitivity, ciprofloxacin antibiotic showed 90.36% resistance, and clindamycin antibiotic showed 86.15% resistance.

The findings of Khazaei et al.'s study, *S. aureus* resistance to vancomycin: a six-year study 1385–1390, revealed that 5736 staphylococcus samples were isolated from all the samples that were delivered to the lab. 3987 of them (69.5%) had staphylococcus coagulase positive cases. According to the study, 3897 instances (68.1%) of *S. aureus*-positive cases were found in urine samples, 966 cases (16.9%) in blood samples, and the remaining cases were found in samples from wounds, throats, and sputum. Vancomycin's antibiotic pattern analysis revealed 4.8% resistance [13]. With regard to antibiotic resistance to vancomycin, this is consistent with the current study.

A phenotypic and molecular analysis of vancomycin-resistant *S. aureus* clinical isolates collected from Rasht hospitals during a six-month period (Feb. 1994, Jul. 1995) has been done. There are 67 different strains of *S. aureus*. Chloramphenicol 10.5%, gentamicin 25.37%, tetracycline 37.32%, vancomycin 38.80%, oxacillin 44.70%, and penicillin 100% had the highest rates of antibiotic resistance in the disk diffusion technique test. 22.4% of the samples used in the broth macrodilution technique had vancomycin resistance. VanA gene PCR results showed no VanA gene band [14]. This research found a

100% penicillin resistance rate, which is consistent with the current study.

Research has been done to identify the pattern of antibiotic sensitivity in *S. aureus* strains obtained from human clinical infections and to monitor genes expressing antibiotic resistance. The phenotypic analysis of the antibiotic resistance pattern of *S. aureus* strains revealed that the antibiotics penicillin (90%), tetracycline (76%), methicillin (64%) and ampicillin (55%) have the highest levels of resistance, while nitrofurantoin (8%) and vancomycin (14%) have the lowest levels. The strains had 89% of the tetM gene, according to molecular analyses. Following that, the presence of the genes mecA (58%), ermA (40%), msrA (36%), aacA-D (24%) and tetK (13%) was associated with the greatest frequencies [15]. This study's findings were comparable to those of this one.

Phenotypic techniques have been used to identify methicillin-resistant *S. aureus* and bacteria that produce ESBL after investigating the antibiotic sensitivity pattern of microorganisms isolated from patients hospitalized in PICU. *Escherichia coli* (24 instances), *Pseudomonas aeruginosa* (3 cases), and *S. aureus* (8 cases) were found to be the most frequently isolated microorganisms from all clinical samples given to the lab, according to the findings. Seven (65%) of the eight *S. aureus* strains that were found in the various clinical samples that they were isolated from were MRSA. 52 isolates of Gram-negative bacteria included 5 (3.7%) ESBL strains [16]. In terms of the proportion of methicillin-resistant *S. aureus* isolates, this study is compatible with the previous research [16].

Its goal is to look into the prevalence and distribution of MRSA strains that are resistant to antibiotics at the Imam Reza (AS) Mashhad

Hospital. The findings of this investigation revealed that 925 (12.6%) strains of *S. aureus* were found in the patients out of a total of 7335 germs isolated from patients hospitalized in Imam Reza Hospital, Mashhad. There were 382 (41.7%) instances of MRSA. Blood and wound culture samples were used to isolate the majority of MRSA isolates. Adalatian, Internal Affairs, Burns, and Cardiology emergency departments had the highest MRSA prevalence rates [17]. The proportion of methicillin-resistant *S. aureus* strains in blood and wound samples is consistent and aligned when compared to the current investigation.

Ayat Alleh Mousavi Hospital in Zanjan patients' clinical samples of *S. aureus* were examined for antibiotic resistance patterns. The findings revealed that out of 66 samples obtained, every single sample was vancomycin sensitive. Cotrimoxazole was 90.9% sensitive, cefazolin was 4.86% sensitive, clindamycin was 81.8% sensitive, cloxacillin was 2.71% sensitive, and the D-test was positive in 5.5% of samples [5]. This research's level of clindamycin sensitivity was consistent with the current study.

In Ghafouri's study, the pattern of antibiotic resistance in bacteria isolated from clinical samples of hospitalized patients was examined. During the course of the investigation, 126 patients with nosocomial infections were discovered. *Escherichia coli*, coagulase-negative *Staphylococcus*, *Candida*, coagulase-positive *Staphylococcus*, *Enterobacter*, *Klebsiella*, *Citrobacter*, *Pseudomonas aeruginosa*, *Acinetobacter*, Gram-positive bacillus, *Enterococcus*, and Gram-negative coccobacillus were the most frequently isolated microorganisms (commonly 20). The isolated microbes varied in their antibiotic resistance. In *Acinetobacter*, the greatest level of resistance was noted. *Acinetobacter* was completely resistant to ciprofloxacin, amikacin, and gentamicin in all instances [18].

The incidence of methicillin-resistant *S. aureus* carriers and their pattern of drug resistance among Torbat Heydarieh hospital staff members were examined in 2013. The results showed that 28 out of the 130

individuals examined (21.5%) had *S. aureus* in their nostrils. In comparison to other departments, the women's department had the fewest *S. aureus* carriers while the critical care and laboratory departments had the most. Only the age of the personnel and the *S. aureus* carrier were discovered to have a significant association among the factors under investigation. Penicillin (100 percent), gluxacillin (42.9 percent), and cotrimoxazole (5 percent) had the greatest and lowest rates of resistance, respectively. In this investigation, the oxacillin agar technique revealed methicillin resistance in 14 samples (10.8%) [19]. The degree of penicillin resistance in this investigation was wholly consistent with that in the current study.

The investigation of the *S. aureus* strain's antibiotic resistance pattern revealed resistance to ampicillin (56%), oxacillin (14%), gentamicin (22%), kanamycin (40%), dexacillin (6%) and afaloxin (18%) [20]. It agreed with the current study in terms of erythromycin antibiotic resistance.

Antibiotic resistance in *S. aureus* isolated from Imam Reza Hospital, Kermanshah, including its incidence and patterns. The findings demonstrated that the majority of *S. aureus* cases (43.7%), blood samples (40.1%), and urine samples (23.9%) were isolated from other sources. Erythromycin, penicillin G, ofloxacin, cefoxitin, clindamycin, and piperacillin were the antibiotics with the highest rates of resistance. With sensitivity rates of 93.3 and 81.8%, respectively, vancomycin and teicoplanin were the most effective drugs against *S. aureus* [21]. Regarding sensitivity and resistance to the antibiotics cefoxitin, clindamycin, and vancomycin, this investigation was comparable to the current study.

The infection control committees of each hospital should review the antibiotics used in the hospital in terms of resistance and periodically put them on the chart in the special care departments to prevent the prescription of antibiotics, per the report obtained in the teaching hospitals of Ahvaz. The physicians in the department should use strong opposition to stop it.

5. Conclusion

The findings demonstrated a significant rise in vancomycin antibiotic resistance, which poses a significant concern in the management of infections brought on by resistant strains. Therefore, one should avoid prescribing without a prescription and inappropriate use of accessible antibiotics in order to prevent the development of resistance to the stated antibiotics as well as other common antibiotics. The results of the current study also revealed that there is no connection between antibiotic resistance and the frequency of methicillin-resistant *S. aureus* in the department, sampling site, or hospital; however, when it comes to the relationship with age and gender, the resistance rate was higher in men over 45 years of age than it was in men under 45. According to the judgment of the location of the body sample, more blood samples were taken there than in other research.

Conflict of Interests

All authors declare no conflict of interest.

Ethics approval and consent to participate

No human or animals were used in the present research.

Consent for publications

All authors read and approved the final manuscript for publication.

Informed Consent

The authors declare not used any patients in this research.

Availability of data and material

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Authors' contributions

All authors had equal role in study design, work, statistical analysis and manuscript writing.

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