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Antibiotic susceptibility patterns of *Staphylococcus aureus* isolated from various clinical cases in Al-Ramadi Teaching Hospital

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ABSTRACT

Background: One of the most common and potentially fatal pathogens is resistant *Staphylococcus aureus.* When choosing an effective medication for the management of staphylococcal infections, knowledge of the regional isolates' pattern of antimicrobial sensitivity is fundamental. *Aim:* Our study aimed at identifying the antibiotic susceptibility patterns of *S. aureus* based on samples collected at an Iraqi teaching hospital. *Methodology: S. aureus* isolates from various clinical cases presented at the Al-Ramadi Teaching Hospital were identified by using standard microbiological methods. Antimicrobial susceptibility tests through the use of the Kirby-Bauer disc diffusion tests and minimum inhibitory concentrations were also undertaken on an automated VITEK 2 Compact system (bioMérieux). *Results:* A total of 20 antimicrobial agents were used in this study, while a total of 100 *S. aureus* samples have been collected from various clinical cases. These samples were isolated in most cases from wounds (37.5%) and skin swabs (25%). As far as the patterns of antimicrobial resistance are concerned, *S. aureus* was found to be susceptible to gentamicin (68%), tetracycline (80%), rifampicin (85%), erythromycin (68%), ciprofloxacin (85%), and imipenem (90%). A total of 86% of the *S. aureus* isolates were found to be methicillin-resistant, while 35% of the isolates were identified as being trimethoprim-resistant. Moreover, 100% of the *S. aureus* isolates were found to be resistant to benzylpenicillin, and only 3% of the isolates were identified as resistant to vancomycin. *Conclusion:* The knowledge of the antibiotic susceptibility patterns of the *S. aureus* isolates from the various clinical cases presented at Al-Ramadi Teaching Hospital will prove useful in their targeted treatment with antibiotics.

KEYWORDS

Staphylococcus aureus, antimicrobial susceptibility test, antimicrobial resistance, MRSA, antibiotics

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1. INTRODUCTION

Staphylococcus aureus is a major cause of nosocomial bacteremia, surgical site, prosthetic joint, and cardiovascular infections, in addition to pneumonia and various respiratory tract infections. *S. aureus* is estimated to cause a number of simple skin infections that are difficult to determine, along

with hundreds of thousands to millions of more serious, invasive infections around the world [1]. Furuncles, abscesses, and wound infections are examples of other moderately severe *S. aureus* infections that can be extremely painful; although these infections are usually not fatal, their prevalence makes them a substantial public health burden. However, they can sometimes become fatal; for example, in cases of lung infections caused by viral diseases (such as the flu), when the final cause of death is often attributed to a subsequent *S. aureus* infection [2].

Multiple factors have been reported to add to the pathogenicity of *S. aureus*: toxins, immune evasion factors, exoenzymes, and antimicrobial resistance determinants [3]. Antibiotic resistance complicates the treatment of *S. aureus* infections, and there is currently no reliable vaccination against the pathogen. Furthermore, *S. aureus* isolates frequently exhibit antibiotic resistance, with the methicillin-resistant *S. aureus* (MRSA) being the most important clinical isolate. Antibiotic resistance provides a further level of challenge for the treatment of *S. aureus* infections. In such cases, the *S. aureus* isolate could be described by the use of several terms, such as “multidrug-resistant” when the isolate is non-susceptible to at least one agent in three or more antimicrobial agent categories, “extensively drug-resistant” when the isolate is non-susceptible to at least one agent in all but one or two antimicrobial agent categories, and “pandrug-resistant” when the isolate is non-susceptible to all agents in all antimicrobial agent categories [4].

The aim of this study was to identify the antibiotic susceptibility patterns of *S. aureus* based on samples collected at an Iraqi teaching hospital.

2. METHODOLOGY

2.1. Study design

One hundred samples were collected from different clinical sources, including skin swabs, wounds, urine, burns, abscesses, ear swabs, and nasal swabs. The patients were from both rural and urban residential areas, while their age, sex, and complications were recorded. All samples for the present study were collected after obtaining ethical clearance from the ethics committee of the University of Anbar (reference: #9; date: 18-Jan-2024). The study was conducted in accordance with the ethical principles that have their origin in the Declaration of Helsinki, and it was carried out with the patients’ consent. All research participants, including patients and their parents (where applicable), provided signed informed consent.

2.2. *S. aureus* isolation and identification

Each sample was cultivated on MacConkey agar and 5% human blood agar. After that, it was incubated for 24 h at 37ºC in aerobic conditions. Following the transfer of the blood agar colonies to the mannitol salt agar, the indicator (phenol red) became yellow rather than pink. The colonies were then viewed under a microscope after being stained with Gram stain, followed by tests using coagulase and catalase. Only isolates that were coagulase-positive and mannitol-fermenting were selected; otherwise, they were disregarded [5]. Subsequently, the samples were diagnosed using an automated VITEK 2 Compact system (bioMérieux), which facilitates the identification of microorganisms and the determination of their antibiotic susceptibility in order to provide rapid and accurate results. The manual Kirby-Bauer method and the disk diffusion method on Mueller-Hinton agar plates were also used in order to confirm the findings of VITEK 2; they both are standardized methods for determining bacterial resistance to antimicrobial agents. Finally, the guidelines set by the Clinical Laboratory Standards Institute were followed in the analysis and interpretation of the collected data [5].

2.3. Statistical analysis

The data were analyzed by using chi-square in order to identify the extent of the differences between the observed and expected values. We used the statistical program SPSS in our data analysis, as well as the Excel software in order to display the results.

3. RESULTS

Most samples derived from female patients (62.5%). Samples were obtained from skin swabs (25%), wounds (37.5%), urine (12.5%), burns (10%), abscesses (7.5%), ear swabs (5%), and nasal swabs (2.5%). Based on the *S. aureus* samples’ pattern of antibiotic susceptibility, the antibiotic resistance ratio was as follows: 100% for benzylpenicillin, 86% for cefoxitin, 86% for oxacillin, 78% for amoxicillin, 16% for linezolid, 25% for gentamicin, 7% for tobramycin, 10% for moxifloxacin, 10% for ciprofloxacin, 32% for erythromycin, 33% for clindamycin, 3% for vancomycin, 20% for tetracycline, 17% for tigecycline, 37% for fusidic acid, 15% for rifampicin, 35% for azithromycin, 7% for imipenem, 18% for nitrofurantoin, and 35% for trimethoprim (Table 1).

Table 1. Overview of the obtained antibiotic susceptibility patterns of *S. aureus* isolates from the samples of the study.

Antibiotics tested	Resistant isolates	Sensitive isolates	Intermediately susceptible isolates
Benzylpenicillin	100%	0%	0%
Cefoxitin	86%	14%	4%
Oxacillin	86%	14%	4%
Amoxicillin	78%	14%	4%
Linezolid	16%	84%	0%
Gentamicin	25%	68%	7%
Tobramycin	7%	93%	0%
Moxifloxacin	10%	87%	3%
Ciprofloxacin	10%	85%	5%
Erythromycin	32%	68%	0%
Clindamycin	33%	63%	0%
Vancomycin	3%	95%	2%
Tetracycline	20%	80%	0%
Tigecycline	17%	83%	0%
Fusidic acid	37%	63%	0%
Rifampicin	15%	85%	0%
Azithromycin	35%	55%	10%
Imipenem	7%	90%	3%
Nitrofurantoin	18%	77%	5%
Trimethoprim	35%	65%	0%

4. DISCUSSION

Due to the fact that *S. aureus* bacteria can be fatal in some medical situations, continuous monitoring of this organism is important. It has been estimated that 20,000 deaths per year occur in the United States as a result of *S. aureus* bacteremia [6]. Studies have shown that the *S. aureus* bacteremia is more common as a cause of death than tuberculosis, AIDS, and viral hepatitis all together [7].

In this study, the women had a greater *S. aureus* isolation rate than men. The relationship between the sex and the infection of *S. aureus* types was not clear. No significant difference between the patient sexes was found, which is in agreement with a study by Dilnessa and Bitew [8].

Skin cracks, abrasions, wounds, burns, surgical incisions, and intravenous catheters, from deep-seated infections to localized skin lesions like folliculitis and abscesses – these infections can cause a wide range of complications. In our study, 37.5% of the *S. aureus* samples were isolated from wound infections. From skin swabs, a second set of isolates was collected due to contamination of the collected samples with normal skin flora. *S. aureus* is an uncommon urinary tract infection; nevertheless, several studies have found that patients with urinary tract infection exhibit a greater rate of this pathogen isolation. In our study, 12.5% of the isolates came from urine sampling.

Table 1 shows the variable susceptibility of the *S. aureus* isolates to antimicrobial drugs. Interestingly, 84% of the isolates have been identified as MRSA based on the cefoxitin disk diffusion of the cefoxitin-resistant *S. aureus*. According to studies, the mecA gene complex, which encodes the penicillin-binding protein 2a with a low affinity for binding β-lactam antibiotics like penicillin and cephalosporin, is the cause of the high rates of methicillin resistance [9]. The MRSA group is unique. In addition to exhibiting multidrug resistance, *S. aureus* has the unmatched capacity to quickly adopt a resistance mechanism in response

to each new antibiotic. Oral antibiotics are common, which reduces their absorption through the blood, as excessive intake of oral antibiotics can cause the development of resistant bacteria.

Erythromycin and azithromycin are macrolide antibiotics that inhibit protein synthesis. Treatment for both mild and severe staphylococcal infections has led to the widespread use of these medicines. Furthermore, because erythromycin resistance has been reported in most countries of the world, its use in empirical treatment is further limited. In the current study, 32% of the isolates were found to be resistant to erythromycin and 35% of the isolates were found to be resistant to azithromycin. However, the resistance ratio to azithromycin was 62% in a study conducted in the same hospital three years ago [10].

Ciprofloxacin is considered a strong antibiotic that can effectively treat staphylococcal infections. Following the widespread use of ciprofloxacin, there was a notable increase in the incidence of fluoroquinolone-resistant *Staphylococcus* species among the clinical isolates; in a previous study, the resistance ratio was 31%, and 10% of the *S. aureus* samples exhibited resistance to ciprofloxacin [10].

Only 3% of the isolates were found to not be susceptible to vancomycin, which is still the antibiotic of last choice for MRSA infections. Despite being detected, highly vancomycin-resistant strains have not proliferated, most likely because the vancomycin resistance genes impose a much greater fitness cost [11]. A suitable replacement for vancomycin in the treatment of staphylococcal illnesses is trimethoprim / sulfamethoxazole (TMP/SMZ). In fact, TMP/SMZ has shown effectiveness against most MRSA strains. However, as numerous studies have reported, MRSA has been shown to develop resistance to this drug, which may be due to the misuse of this antibiotic for numerous other infections and the widespread availability of over-the-counter antibiotics in developing countries. In this study the resistance ratio to TMP/SMZ was 35%.

The susceptibility of *S. aureus* isolates to gentamicin was higher than that of previous studies; in our study, only 25% of the isolates were found to be resistant to gentamicin. By comparison, the United States (35.5%), Latin America (91.2%), Europe (71.2%), and the Western Pacific region (74%) have reported much higher resistance ratios for *S. aureus* [12]. Another drug that proved effective in treating *S. aureus* was imipenem; in the present study, 7% of the *S. aureus* isolates were found to be resistant to imipenem, as compared to 10% reported in a previous study [10] for the same area.

Finally, linezolid and fusidic acid function as inhibitors of protein synthesis. A significant percentage of our isolates were found to be sensitive to linezolid and fusidic acid: 84% and 63%, respectively.

5. CONCLUSION

Antimicrobial susceptibility tests are essential for managing *S. aureus* infections due to their ability to identify antibiotic resistance, guide treatment decisions, monitor resistance patterns, and improve patient results. The knowledge of the antibiotic susceptibility patterns of the *S. aureus* isolates from the various clinical cases presented at Al-Ramadi Teaching Hospital will prove useful in their targeted treatment with antibiotics.

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CONFLICT OF INTEREST STATEMENT
The authors declare no conflicts of interest.

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