

<https://doi.org/10.48047/AFJBS.6.15.2024.7320-7330>



African Journal of Biological Sciences

Journal homepage: <http://www.afjbs.com>



Research Paper

Open Access

Antibiotic Resistance pattern of *Staphylococcus aureus* strains isolated from medical devices in Khenchela Algeria.

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Volume 6, Issue 15, Sep 2024

Received: 15 July 2024

Accepted: 25 Aug 2024

Published: 05 Sep 2024

doi: [10.48047/AFJBS.6.15.2024.7320-7330](https://doi.org/10.48047/AFJBS.6.15.2024.7320-7330)

Abstract

Microbial biofilms pose a significant danger to individuals needing medical devices (MDs). Extended durations of implantation present an elevated possibility of device-related infections (DRIs). *Staphylococcus* bacteria are frequently detected in nosocomial infections related to medical devices due to their ability to adhere to the surface of biomaterials. This study aimed to assess the presence of *Staphylococcus aureus* in urinary, nasogastric, and peripheral venous catheters. Furthermore, this study examined the antibiotic resistance of *Staphylococcus aureus* isolated from MDs. Over six months, 62 samples were gathered from hospital devices in Khenchela, Algeria. *S. aureus* was identified using morphological and biochemical characteristics. Antibiotic resistance was assessed via disc diffusion following 30 isolates. Vancomycin was the most effective against *S. aureus*. The findings revealed a significant prevalence of multidrug-resistant bacteria in samples from biomaterial surfaces, which highlights the urgent need for advancements in hospital sterilization systems to curb the spread of the most resilient strains of *S. aureus*, thereby reducing the risk of device-related infections.

Key words: Algeria, médical devices , multidrug-resistant , nosocomial infections, *S. aureus*.

Introduction

Biofilms, a key facilitator in the adhesion of microorganisms to implanted medical devices (IMDs) such as central venous catheters, peritoneal dialysis catheters, urine catheters, and intravascular catheters, pose a significant threat to antibiotic-resistant pathogens for patients using these devices (Assefa *et al.*, 2022). These biofilms are a critical factor in developing nosocomial infections, which are frequently associated with the use of medical devices and can lead to complications that extend hospital stays and raise patient morbidity and mortality rates (Folliero *et al.*, 2021; Hoceini *et al.*, 2023). Similarly, extended use of medical devices in hospitalized patients increases the risk of developing device-related infections (DRIs) (Folliero *et al.*, 2021). Furthermore, these infections have implications for individual patients and the community due to their association with multidrug-resistant infections (Benmoumou *et al.*, 2023). Antibacterial drugs are commonly employed in clinical practice due to bacterial infections' intricate and widespread nature (Lerminiaux & Cameron, 2019). However, antibiotic resistance has developed due to excessive usage and improper prescription (Mann *et al.*, 2021). Likewise, antimicrobial resistance (AMR) is a significant risk to worldwide public health and leads to high treatment costs (Liu *et al.*, 2022). Gram-positive bacteria, such as *S. aureus*, play a significant role in mortality linked to antibiotic resistance (An *et al.*, 2024). *S. aureus*, causing nosocomial infection, is a highly adaptable bacteria that quickly spreads in hospitals and can lead to various disorders (Mahmood *et al.*, 2010). *Staphylococcus aureus* is a common human pathogen that causes infections in hospitals and the general population, including skin and soft tissue infections and other diseases. Its ability to make different toxins and adhesion factors is a major cause of widespread and devastating health problems (Joseph Omololu, 2017; Mahmood *et al.*, 2010). It can also adhere to and form a biofilm on tissues or medical indwelling devices (Neopane *et al.*, 2018). Hence, *S. aureus*, particularly methicillin-resistant *S. aureus* (MRSA), is notably prominent as a primary source of healthcare-associated infections (Dayan *et al.*, 2016; An *et al.*, 2024). Interacting with an infected person or surface and eating contaminated food are frequent transmission causes. Furthermore, the main risk factors include open skin wounds, common illnesses, implanted devices, and extended hospitalization (Ondusko and Nolt, 2018; Buonsenso *et al.*, 2023).

This study aimed to identify the frequency of *S. aureus* from medical devices, including central venous catheters, and their antibiotic susceptibility patterns, thereby aiding in providing appropriate antibiotics.

Materials and Methods

Inclusion criteria

The patients included in this study have a severe condition requiring the placement of a venous catheter, which is essential for the administration of antibiotic therapy, blood products, and parenteral nutrition. The catheter tips were collected aseptically. The reasons for the removal of the catheter are as follows: malfunction, signs of infection at the insertion site (redness at the injection point, pain, induration, hematoma), or due to accidental removal (Gominet et al., 2017). The inclusion criteria of the catheter are as follows: - Brand new venous catheter maintained for more than 48 hours, - Placed in surgical aseptic conditions, - any new bladder catheter maintained for more than 48 hours and placed under aseptic conditions, - Any new nasogastric tube maintained for more than 48 hours and placed under aseptic conditions.

Sample collection

Sixty-two samples from medical devices were collected aseptically at a public hospital establishment in Khenchela. For venous catheters, the catheter must be removed sterilely, and its distal end (the entire inserted part for short catheters, 5 cm for long catheters (Brun-Buisson et al., 1987) should be cut and immersed in 1 ml of saline solution. It is then sent to the laboratory, where it is agitated for 1 minute on the vortex to detach the pathogenic product from the catheter. Then, 10 10 μ l of the prepared suspension was spread onto the culture medium. For the microbiological analysis of urinary catheters and nasogastric tubes, we referred to the Brun-Buisson et al. (1987) technique used for catheters, which we adapted and applied to urinary probes. To this end, the 10 cm of the terminal end of the urinary catheter is placed in 2 ml of sterile physiological saline vortexed for 1 minute. Then, 10 μ l of the preparation was inoculated onto the culture media.

Bacteria Isolation and Identification

All collected samples were cultured on a selective media Chapman and blood agar (BAPs) (Buxton, 2016; Shields & Tsang, 2016). . Take 10 μ l of liquid using a micropipette and place

it on the medium. Using a platinum loop or a Pasteur pipette, inoculate onto agar in a Petri dish to obtain well-isolated colonies. After 18–24 h of incubation (at 37 °C), pure cultures of *Staphylococcus aureus* colonies were first subjected to standard bacteriological techniques (morphology; cocci-shaped and cluster arrangement, Gram stain, catalase, and coagulase tests). Colonies that showed the *staphylococcus aureus* colony morphology on blood agar and Chapman were considered presumptive *S. aureus* and later identified to species level by commercial API staph kits (BioMérieux) (Kloos, 1999; Leyral & Vierling, 2007). Furthermore, we performed successive subcultures alternating between liquid medium (BHIB broth) and selective solid medium (Chapman agar) to confirm the strains' purity.

Antimicrobial Susceptibility

The antibacterial resistance of *S.aureus* strains was determined for 19 antibiotics by the disk diffusion method. The sensitivity to antibacterial drugs was determined according to the guidelines of the Clinical and Laboratory Standard Institute (CLSI, 2020). Pure colonies were suspended in 10 ml of sterilized physiological water from a fresh overnight culture of the isolates. The bacterial suspension density was adjusted to a concentration of 0.5 McFarland. A cotton swab was used to inoculate the agar plate surface, and the procedure was repeated three times by rotation of the plate (60°). The antibiotic disks were placed on the inoculated plates and incubated for 24 h (at 37°C). The following antibiotics were tested: cefoxitin (30µg), gentamicin (10µg), amikacin (30µg), ofloxacin (5µg), ciprofloxacin (5µg), trimethoprim/sulfamethoxazole (1.25/23.75 µg), chloramphenicol (30 µg), Clindamycine (2 µg), Erythromycine (15µg), kanamycine (30µg), Levofloxacin (5µg), Oxacilline (1µg), Pénicilline (10UL), Rifampicine (5µg), Tétracycline (30µg), Teicoplanine (30µg), Vancomycine (30µg), Pristinamycine (15µg), Acide fusidique (10µg).

Results and discussion

A total 30 bacterial specimens were obtained from 62 patients. Mean age of the patients was 52.7 years (range 20-70). Microorganisms' growth was obtained on 30 (48.38%) specimens. Coagulase negative *Staphylococcus* bacteria were the most common bacteria found in 22 (73.33%) specimens followed by *Staphylococcus aureus* 18 (26.77%). *S. aureus*'s pathogenicity has been reported to be associated with the expression of several virulence factors. Furthermore, certain coagulase-negative staphylococci, can induce skin infections and other types of infectious (Socohou et al., 2020). A total of 30 positive strains of *Staphylococcus* were isolated from medical devices in hospitalized patients. 07 strains were

isolated from bladder catheters, nine strains were isolated from nasogastric tubes, and 14 strains were isolated from venous catheters. Central venous catheters are commonly utilized for injectable nourishment and medications, as well as for hemodialysis in patients with kidney failure and hemodynamic surveillance in critically ill patients. They might be linked to numerous technical problems and infections (Hassan *et al.*, 2022).

Table 1: Antibiotic resistance profile of isolated Staphylococcus strains.

Tested Antibiotics	<i>S. aureus</i> resistance rate (%)	Coagulase negative staphylococcus resistance rate (%)
Amikacin 30 µg	100	100
Céfoxitin 30 µg	100	43
Chloramphénicol 30 µg	23	00
Clindamycin 2 µg	30	80
Erythromycin 15 µg	80	100
Gentamicin 10 µg	100	100
Kanamycine 30 µg	75	50
Levofloxacin 5 µg	00	18
fluoroquinolones		
Ofloxacin 5 µg	/	00
fluoroquinolon		
Oxacillin 1 µg	100	00
Pénicillin 10 UL	100	43

Rifampicin 5 µg	/	33
Tétracyclin 30 µg	100	00
Teicoplanin 30 µg	/	00
Vancomycin 30 µg	00	50
Fucidic acid 10µg	100	100
Ciprofloxacin 5 µg fluoroquinolones	33	00
trimethoprim/sulfamethoxazole (1.25/23.75 µg)	100	100
Pristinamycin 15µg	100	100

Depending on the source of contamination, the primary microorganisms responsible for the production of biofilms on central venous catheters include, in order of prevalence, coagulase-negative staphylococci, *Staphylococcus aureus*, enteric Gram-negative bacilli, and *Candida* spp. (Gominet et al., 2017). Pichitchaipitak et al. (2018) identified *staphylococcus aureus*, coagulase-negative staphylococci, and fungi as the predominant pathogens responsible for catheter-related bloodstream infections. This study assessed the antibiotic resistance patterns of *S. aureus* (Table 1). The study revealed that the resistance rates for oxacillin, Cefoxitin, and penicillin were 100%, indicating that *S. aureus* is completely evading the effects of β -lactam. Following closely behind is a resistance rate of 75% for Amikacin and Gentamicin. The resistance rates to aminoglycosides and fluoroquinolones were 75% and 50%, respectively. All of the isolates were susceptible to glycopeptides. The observation that the rate of resistance to glycopeptides by *S. aureus* is increasing is crucial. Systematic reviews demonstrated a prevalence of glycopeptide-resistant *S. aureus* strains ranging from 4.68% in 1997 to 7.93% in 2017 (Lambert, 2005; Buonsenso et al., 2023). Vancomycin, a glycopeptide antibiotic that hinders the production of cell walls, continues to be the preferred medication for treating severe MRSA infections. *Staphylococcus aureus* strains display heightened resistance to vancomycin. Based on the results, we decided to prioritize the criteria for employing glycopeptides due to their significance and the potential clinical consequences of a

rise in antibiotic-resistant bacterial strains (Buonsenso et al., 2023). In a study conducted by Gominet et al. (2017), it was found that coagulase-negative staphylococcus bacteria were the primary cause of nosocomial infections in patients with central venous catheters, despite the implementation of all necessary aseptic procedures after catheter placement. These bacteria adhere to the tip of a catheter and spread the infection, often necessitating early removal of the catheter due to the severity of the infection. Likewise, the lowest resistance after vancomycin of *S. aureus* was recorded with chloramphenicol (23%) and Clindamycin (30%). Considering the coagulase-negative staphylococci, there was recorded total sensibility to Chloramphénicol, Ciprofloxacin, Teicoplanin, Oxacillin and Ofloxacin. The, lowest resistance in Coagulase negative staphylococcus was observed with Levofloxacin (17%) (Table 1). Furthermore, they exhibiting more than 60% resistance rate to several tested antibiotics: trimethoprim/sulfamethoxazole, Pristinamycin, Fucidic acid, Clindamycin, Erythromycin, Gentamicin, Kanamycin, Amikacin (Table1). Several studies reported similar conditions in other contexts, highlighting the generalized spread of MDs-related resistances (Folliero, et al., 2021).

It is crucial to monitor the catheter daily to detect any infection promptly. It is also essential to determine the culture and sensitivity pattern of bacterial isolates to effectively eliminate the infection and prevent the development of antibiotic resistance caused by inappropriate antibiotic use (Hassan et al., 2022)

Conclusion

This research was conducted in Algeria and revealed the occurrence of *Staphylococcus aureus* on medical devices and its antibiotic resistance. Staphylococcus species are the primary cause of bloodstream infections associated with catheter use. Vancomycin has been demonstrated to be more effective against these bacteria. Our study showed that antibiotic resistance of *S. aureus* is progressively increasing in our environment. Antimicrobial resistance is a significant public health problem, and more attention should be paid to spreading resistance strains. Measures to minimize the risk of catheter colonization and infection should be used. Furthermore, developing a broader understanding of the biofilm-producing strains obtained from MDs and their associated antibiotic resistance profiles might help establish an approach

to treatment, enhance the enhancer, and encourage the community to explore innovative strategies to counteract this issue.

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