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The Bacterial Causes of Infections in Burned Patients and Antibiotic Resistance: A study conducted at Baquba Teaching Hospital, Diyala Province-Iraq

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Abstract

Background: Burn injuries serve as sites with the potential for colonization by pathogens from both within and outside the body. Proper diagnostic and treatment protocols depend on a thorough understanding of burn pathophysiology and the relationship between pathogens and infection types. Resistant bacteria have a longer survival in hospital environments and reflect their easy spread and cause epidemics. Thus, this study aimed to identify the bacterial causes of burn infections and their antibiotic sensitivity test.

Methods: A total of 100 burn patients were collected, including males (52) and females (48), with a mean age of 39.17 years, ranging from 15 to 65 years. These patients were admitted to the burn unit at Baquba Teaching Hospital for this study, conducted from November 2022 to November 2023. The mean total surface area burned was 18%, with a range of 12% to 83%.

Results: *Staphylococcus aureus* exhibited the highest sensitivity to vancomycin (75.25%), whereas most of the isolated Gram-negative bacterial strains displayed multidrug resistance. *S. aureus* has been demonstrated to be resistant to ciprofloxacin at 40% and erythromycin at 84%, with all strains sensitive to vancomycin and ciprofloxacin in a minority of cases. Furthermore, 40% of the *Staphylococcus* isolated from samples were Methicillin-resistant *Staphylococcus aureus* (MRSA).

Conclusion: The study showed an increased rates of resistance bacteria among the burn patients and need urgent intervention from the health authorities.

Keywords: Antibiotic resistant, Burns, Bacterial infection

INTRODUCTION

Invasive burn wound infection is a critical issue characterized by the infiltration of microorganisms into burn wounds, potentially leading to pus formation and severe complications. The occurrence of invasive burn infections has significantly reduced over time. These advancements have not only altered the types of microorganisms involved but also extended the time from injury to infection onset, reducing the mortality rate associated with burn injuries caused by thermal energy. Prior to the introduction of topical antibacterial chemotherapeutic agents in the mid-1960s, invasive burn wound infection posed a significant threat, often resulting in fatal outcomes. The progress in managing invasive burn wound infections is commendable and has undoubtedly improved patient outcomes in burn care [1]. The severity of the burns, depending on the rate of separation of burn infections, is also determined by the age of the patient and the level of the burn. In partial-thickness wounds invasive burn infections occur rarely; occurrence was frequent in children, most frequent in the elders and a decrease in young adults (15 to 40 years old) [2]. The presence of coagulant proteins and microbial nutrients in the wound increases the susceptibility to infection stems on the burned surfaces. Additionally, the transportation of humoral factors, immune-active cells, and antibiotics necessary for combating infections is hindered by the avascular nature of the scab. This compromised delivery system contributes to the

vulnerability of the wound to ulcer disease [3]. The presence of flora in a burn area significantly impacts infection risk and invasiveness. Initially, post-burn wounds exhibit a low microbial population, primarily consisting of Gram-positive bacteria surviving in the skin adnexa. As time progresses, Gram-negative bacteria colonize the scab, becoming the predominant type in the burn wound after approximately one week. This transition underscores the importance of monitoring and managing microbial flora in burn injuries to mitigate infection risks effectively. [4]. A hemolytic streptococcus-β was the most common cause of burns and dangerous systemic infections, but after the discovery of antibiotics, treatment with penicillin essentially eliminated the mortality rate [5]. After treatment with penicillin, *Staphylococcus aureus* was identified as the most frequently encountered early Gram-positive pathogen in burn wounds [6]. Pathogens have the capability to invaginate the squamous layer and infiltrate unburned subcutaneous tissue, forming multiple abscesses of varying sizes. While *S. aureus* typically does not cross tissue planes and can lead to the development of thickened abscess walls, compromising the efficacy of both host defenses and antibiotic treatments [7]. Purplish discoloration dark-brown or present on the wound may vary in localization, appearing as a singular spot, scattered areas, or spreading throughout the entire system. This alteration could signal a shift from a partial-thickness injury to complete tissue necrosis [8]. Patients commonly present with specific symptoms such as redness, swelling, and sensitivity of the no burned skin surrounding the burn or wound site can be observed [9]. Without intervention, these symptoms may progressively spread, with some cases involving lymphatic involvement. An escalation in clear fluid discharge from the wound may be noted, and in instances where β-hemolytic streptococcal infection affects the skin graft. The graft could be rapidly compromised or sometimes deteriorating overnight [10]. The higher concentrations of bacteria at an appropriate depth of the burn wound causes suppurative separation of the eschar or graft loss and finally invasive infection. In cases where sensitivity testing and culture assessments are unavailable, broad-spectrum antibiotics are typically employed to address cellulitis. Warm water baths are recommended for managing areas affected by cellulite. Additionally, applying "Mafenide Acetate Burn Cream" twice a day on the donor surface until the infection was under control. If the donor skin site remains unhealed, full-thickness lesions can undergo grafting, while biological dressings can be used for partial-thickness lesions to promote optimal conditions for bandage removal [11]. The important indicator of an invasiveness of the burn is the presence of a localized, multi localized, or generalized dark brown area and after while wound turns black or purple [12]. Skin exfoliation may be the first sign of midface mucositis, and its presence suggests retrobulbar fat biopsy [13]. Heals vesicular lesions or heals second-degree burns as well as the presence of tooth edges and partial thickness crusts. Facial burns, especially nasolabial area, were indicative of burn infections caused by herpes simplex virus type-1 [14]. Given that similar alterations in the wound can stem from various causes like wound desiccation, necrosis, pressure-induced necrosis, or hemorrhage (local trauma), an infection diagnosis should be made carefully. Surface cultures, which serve as another confirming method, prove valuable in identifying organisms present on the burn as well as the prevalent bacterial species in the burn area. However, even quantitative culture methods may not differentiate between burn colonization and infection [15]. The lower bacterial count generally indicates the absence of burn infection, but a quantitative count ≥10 organisms/ gram of tissue is often associated with histological signs pointing towards invasive infection, observed in less than half of samples [16]. Histological examination of a burn biopsy is the golden tool and an important way to confirm the diagnosis of infected burned patients more than culture examination and its limitations. In cases of viral infection due to burns, diagnosis can also be diagnosed with histological test of scratches resulting in skin lesions. Using antibiotics for systemic prophylaxis is common in burn patients [17]. Resistant bacteria with intrinsic antibiotic resistance, longer survival in hospital environments, and contact transmission of bacteria causes their rapid and easy spread to cause epidemics [18]. Extensively drug-resistant (XDR) and pan-drug-resistant (PDR) strains classified as non-susceptible to at least one agent in all. Two or fewer classes of antibiotics, and strains were non-susceptible to all antibiotics according to ECDC and CDC respectively [19]. Therefore, this study aimed to investigate the causes of burns infection and antibiotics resistance.

MATERIALS AND METHODS

All medical records of burn patients hospitalized to the Burn Unit; Baquba Teaching Hospital, Diyala government hospital (Iraq), were examined from November 2022 to November 2023 retrospectively. Data on patient age, gender, and infection outcomes were documented. Treatment protocols for burns aligned with established international standards, encompassing antibiotic, daily wound care involving topical antibiotic like sulfadiazine, fluid resuscitation, nutritional support, resuscitation procedures, and surgical interventions such as resection and pressure grafting for ulcers. Fundamental measures within the burn unit aimed at burn care and infection prevention encompass practices like staff hygiene, room isolation, periodic ward area cultures, and visitor restrictions. During wound exchanges, samples were directly inoculated onto 5% blood agar and Eosin methylene blue (EMB) agar. The incubation of agar plates at 35±2°C for 18-24 hours under aerobic conditions [20]. Any observed bacterial growth patterns were meticulously documented, and the isolated bacteria were subsequently identified using conventional techniques. Among 100 burn patients with positive culture included 52 males and 48 females with mean age 39.17 years (15 -65 years) were selected for this study during the period.

Mean total surface burned area was 18% and range from 12% to 83%.

RESULTS

The research consisted of 100 participants: 52 males and 48 females, as shown in Table-1 and Figure-1. The age

ranged from 16-65 years, with the majority 46-65 age group as shown in Table-1 and Figure 2. The percentage of body surface area burned ranged from 12% to 83%. In the cultures studied, only one species per culture was studied. A gram-positive spherically shaped bacterium, *Staphylococcus aureus*; a short, rod-shaped gram-negative bacterium, *Acinetobacter baumannii* were found. This research showed the considerable variety of bacteria from the 100 wound swabs collected. The principal species were *S. aureus*, *A. baumannii*, and *Klebsiella spp*. The gram-negative, rod-shaped bacterium, *Pseudomonas aeruginosa*, spherical shaped gram-positive bacterium, *Streptococcus pneumoniae*, or pneumococcus, and rod-shaped coliform bacterium, *Escherichia coli* was isolated with less frequency as showed in Table-3 and Figure-3 and the bacterial isolates were shown. Body surface area of burned patients ranged between 12-83%.

Table 1: Gender of patients

Gender	Patients (%)
Male	52
Female	48

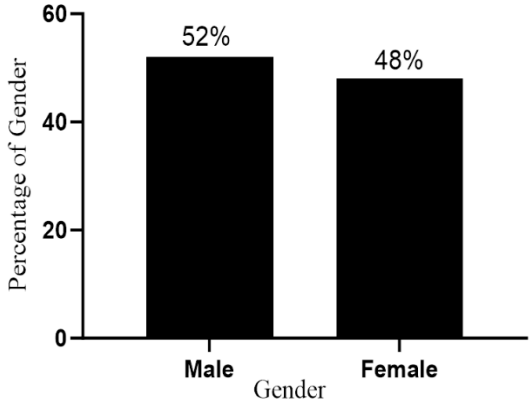

Figure 1: Gender distribution of burn patients

Table 2: Age of patients

Age (years)	Patients (%)
15-25	17
26-35	25
36-45	27
46-65	31

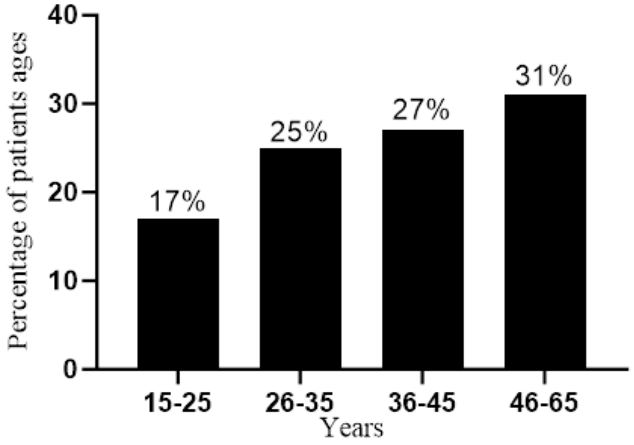

Figure 2: Age distribution of burn patients

Table 3: Type of bacteria present in burns

Bacterial types	Count
A. baumannii	51
Staphylococcus aureus	65
Klebsiella spp	11
Pseudomonas aeruginosa	5
Streptococcus pneumoniae	20
Proteus spp.	6
Escherichia coli	5

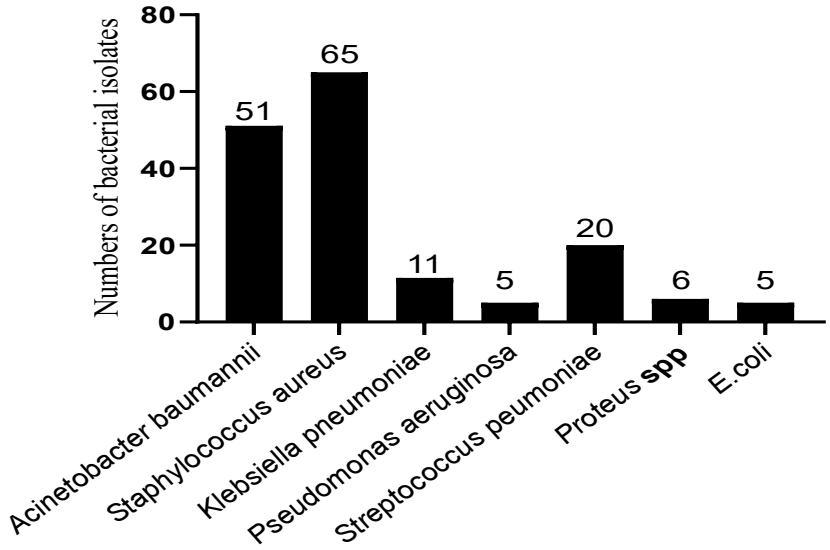

Figure 3: Bacterial types that cause burn infections

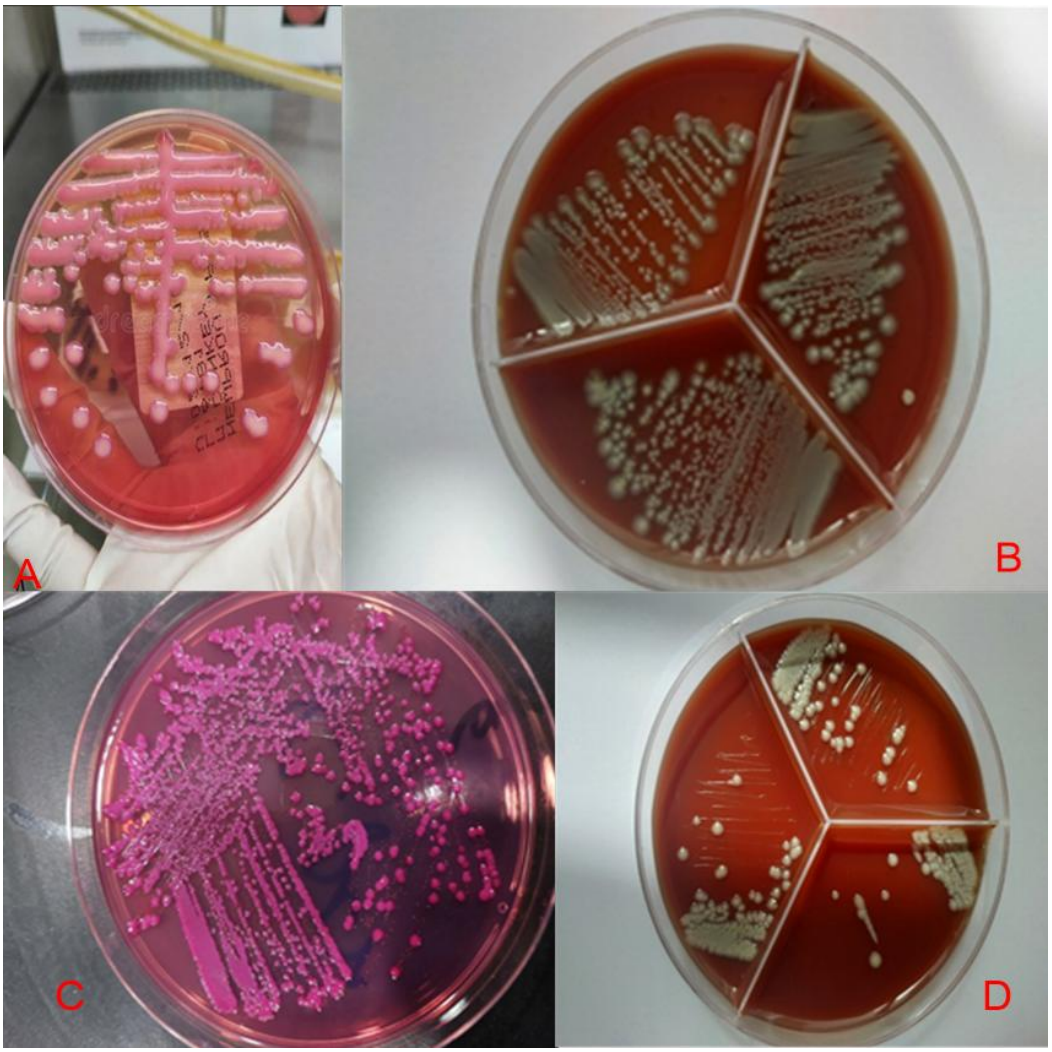

Figure 4: Bacterial isolates, (A) *Klebsiella pneumoniae*, (B) *Staphylococcus aureus*, (C) *E. coli*, (D) *Acinetobacter*

ciprofloxacin and 84% to erythromycin with all strains that were sensitive to vancomycin and ciprofloxacin in a minority of instances. Additionally, 40% of *staphylococci* isolated from samples were determined as MRSA. Figure-5 showed the bacteria responsible for burn infections, along with the antibiotics tested and their corresponding resistance profiles.

Various antibiotics were assessed concerning their effectiveness against gram-positive and gram-negative bacteria. The susceptibility of microorganisms to antibiotics varies among different isolates. *Staphylococcus aureus* exhibited the highest sensitivity to vancomycin (75.25%), whereas most of the isolated gram-negative bacterial strains displayed multidrug resistance. Resistance in *S. aureus* was noted at 40% to

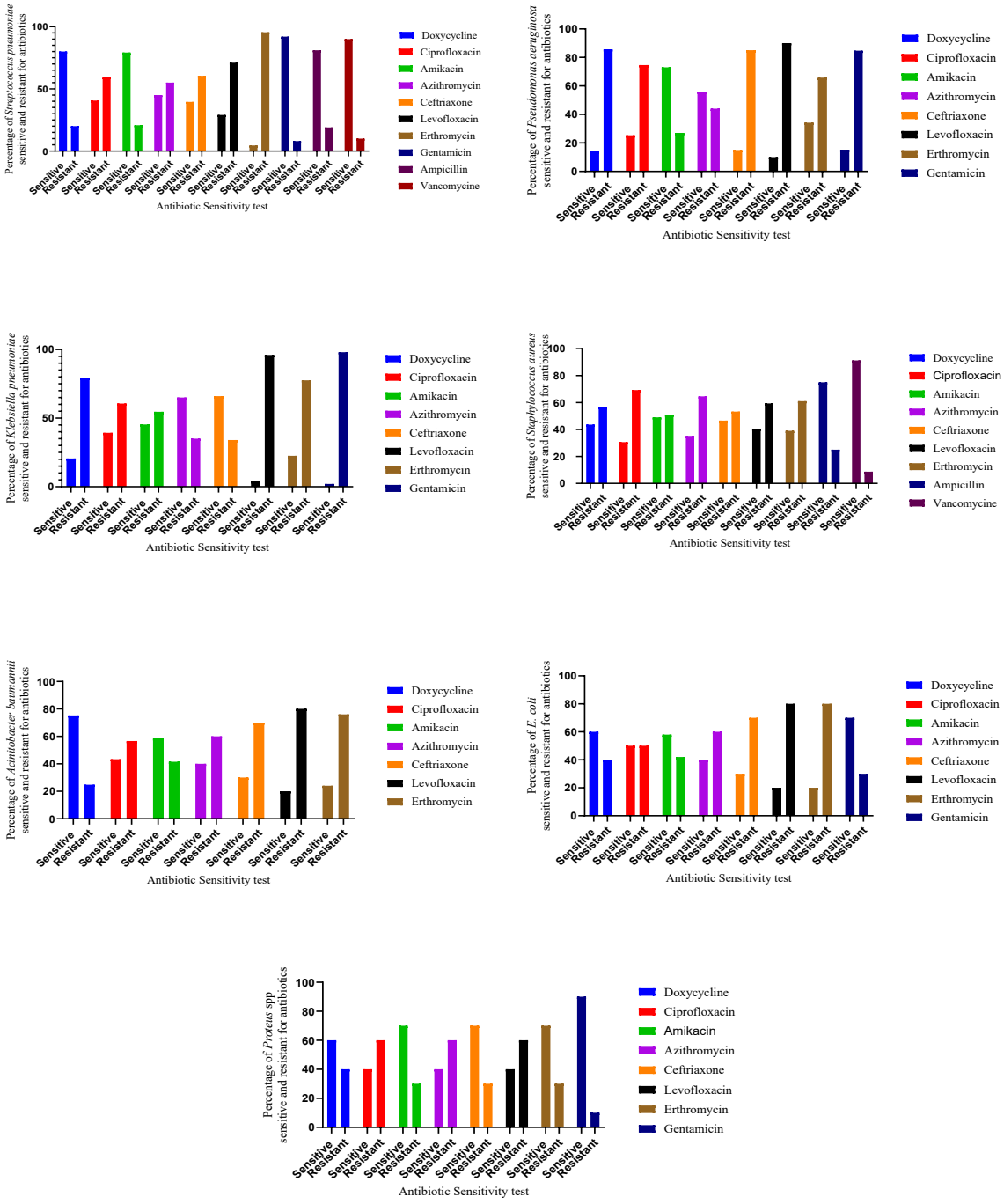

Figure 5: Antibiotic sensitivity test for burn bacterial infections

DISCUSSION

The drug spectrum and drug resistance of pathogenic isolates obtained from severely burned patients admitted in Baquba Teaching Hospital, Diyala government hospital (Iraq), were increased annually. However, better environmental control, use of contact precautions, and strictly enforced surgical care may be the reason for the low infection rate in admitted patients. Although survival after burn injury has improved significantly with improved treatments [21], control of infection remains a challenge. Several studies have sought to identify the most common multidrug-resistant pathogens, but the impact of multidrug-resistant organisms (MDROs) on survival and other outcome parameters remains unclear [22, 23]. Our goal was to shed light on this issue by examining 100 infected burn patients admitted to our burn unit. In 40.3% of cases, gram-positive cocci and in 55.7% gram-negative bacilli were identified. Pseudomonas emerged as the primary pathogen in our study, similar results from other research; however, it contrasts with studies, notably from developed nations, that pinpoint *Staphylococcus aureus* as the main organism. The universality of *Pseudomonas* infections in burn units may be reason to its preference for humid environments [24, 25]. *Staphylococcus aureus* and *A. baumannii* were the most frequently isolated pathogens in burn wounds in our study, followed by *Klebsiella* spp., *Streptococcus*, and *E. coli*. *Proteus* was present in 18.5% of cases, Antibiotic susceptibility profiles revealed widespread resistance to

commonly used antibiotics due to indiscriminate usage over time. *S. aureus* displayed sensitivity to vancomycin and Gemifloxacin, while *Pseudomonas* and *Klebsiella* showed resistance to gentamicin and limited sensitivity to ciprofloxacin. In our research, a second-generation aminoglycoside, amikacin, showed the efficacy against *Pseudomonas* and *Klebsiella* [26, 27].

The sensitivity of multiple pathogens to amikacin has been reported in previous research [28,29,30, 31]. The empiric use of broad-spectrum antibiotics and noncompliance with hospital antibiotic policies may be the reason for an increased rate of multi-drug-resistant isolates. Early discovering isolates is also important to avoid treatment misuse, as the time required to isolate, identify and detect antibiotic susceptibility can take up to 48 hours from the time of infection as it's a sufficient time to allow a sub-clinical infection to become a life-threatening disease [32, 33, 34]. In case of burns, with mixed infections, the potential virulence of one organism can affect another organism may be another factor that increases the complications is multi-drug resistance (MDR). MDR strains can persist for many months, once established in a hospital environment [35, 36, 37].

Therefore, careful and precise microbiological monitoring and *in vitro* testing before starting of antibiotic therapy and a restrictive antibiotic policy can be of great help in the prevention and treatment of MDR isolates [38, 39]. Therefore, careful and precise microbiological monitoring and *in vitro* testing before starting of antibiotic therapy and a restrictive antibiotic policy can help to prevent and treatment MDR isolates [38, 39]. In burn units, overcrowding is a significant cause of cross-infection and can be avoided to control NI [40, 41,42].

CONCLUSION

It was found in this study that the low progression of nosocomial infection (NI) and a reduced rate of isolates resistant to some drugs that are rarely used in hospitals. These results suggest that widespread antibiotic use in burn patients may lead to high rates of infection-resistant pathogens. Therefore, antibacterial drugs must be used with caution, depending on the isolate and its antibiotic profile. *Staphylococcus aureus* is the main pathogen in burn wound infections, and *A. baumannii* is the second most common cause of infection in burned patients.

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Ethical approval: The study was performed as per the guidelines mentioned on the Declaration of Helsinki. The verbal consent and analytical approval of all participants was maintained before specimen collection. All documents related to the study protocol and consent form were reviewed and approved by the Ethical Committee of Baquba Teaching Hospital, Diyala government hospital (Iraq).

Conflict of interests: The authors declare no conflict of interest.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

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