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Research Article

Analysis of Gram-Negative Bacterial Prevalence and Antibiotic Susceptibility in Infected Burn Wounds Among Stable Burn Patients

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ABSTRACT
Background: Burn wounds are highly susceptible to infection, with Gram-negative bacteria being the predominant pathogens due to their adaptability and resistance mechanisms. These infections contribute significantly to morbidity and mortality in burn patients, highlighting the need for regular surveillance of bacterial prevalence and resistance patterns.
Objective: To analyze the prevalence of Gram-negative bacteria in infected burn wounds and evaluate their antibiotic susceptibility patterns among stable burn patients.
Study Design and Setting: A cross-sectional study was conducted at Shaikh Zayed Hospital Lahore over six months.
Methodology: A total of 120 stable burn patients with second- and third-degree burns showing clinical signs of infection were included. Wound swabs were collected and processed to identify bacterial isolates using standard microbiological techniques. Antibiotic susceptibility testing was performed using the Kirby-Bauer disk diffusion method, and results were interpreted based on Clinical and Laboratory Standards Institute (CLSI) guidelines.
Results: The most prevalent Gram-negative bacteria were *Pseudomonas aeruginosa* (40%), followed by *Klebsiella pneumoniae* (30%), *Escherichia coli* (20%), and *Acinetobacter baumannii* (10%). *Pseudomonas aeruginosa* exhibited the highest resistance (59.6%), with only 40.4% sensitivity to tested antibiotics. Overall, 30% of patients experienced complications, while 70% had uncomplicated outcomes.
Conclusion: Gram-negative bacteria, particularly *Pseudomonas aeruginosa*, are the dominant pathogens in burn wound infections and show significant antibiotic resistance. Regular surveillance and tailored antimicrobial therapy are essential to optimize treatment and improve patient outcomes.

Keywords: Antibiotic resistance, Burn wounds, Gram-negative bacteria, Infection, Pseudomonas aeruginosa, Prevalence, Susceptibility.

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INTRODUCTION

Burn wounds are among the most common and devastating types of injuries, often resulting in significant morbidity and mortality worldwide. These wounds are not only a source of physical trauma but also create an environment conducive to microbial colonization and infection.[1,2] Burn patients are particularly susceptible to infections due to the loss of skin integrity, immunosuppression, and prolonged hospital stays, which increase their exposure to multidrug-resistant organisms. Infections in burn wounds are a major cause of delayed healing, graft failure, and septic complications, ultimately affecting patient outcomes.[3,4]

Gram-negative bacteria, including species such as Pseudomonas aeruginosa, Klebsiella pneumoniae, Escherichia coli, and Acinetobacter baumannii, are known for their ability to thrive in moist and nutrient-rich burn environments.[4] These pathogens often exhibit intrinsic and acquired resistance mechanisms, making treatment with standard antibiotics increasingly difficult. The emergence of multidrug-resistant Gram-negative bacteria has become a global concern, particularly in burn care units, where the overuse and misuse of antibiotics have contributed to the spread of resistant strains.[5]

Antibiotic susceptibility testing is crucial in guiding the appropriate use of antimicrobials for infected burn wounds. It helps clinicians select effective treatment regimens, reduce the risk of therapeutic failure, and prevent the further development of resistance.[6,7] Surveillance of bacterial prevalence and resistance patterns is also essential to inform hospital infection control policies and to address the specific challenges posed by Gram-negative pathogens in burn patients.[8,9]

Previous research has emphasized the dominance of Gram-negative bacteria in burn wound infections, with varying susceptibility profiles across different regions and healthcare settings. For instance, Pseudomonas aeruginosa has been consistently reported as the leading pathogen, often exhibiting resistance to commonly used antibiotics such as beta-lactams, aminoglycosides, and fluoroquinolones.[10] Similarly, Klebsiella pneumoniae and Acinetobacter baumannii have shown alarming resistance rates to carbapenems, a class of antibiotics often considered the last resort for treating multidrug-resistant infections. These trends underscore the importance of localized studies to identify specific resistance patterns and tailor interventions accordingly.[11]

By addressing the prevalence and susceptibility of Gram-negative bacteria in infected burn wounds, this study aims to contribute to the growing body of knowledge in burn care and antimicrobial stewardship. The findings will help bridge gaps in current understanding, provide data-driven insights for clinical decision-making, and promote better infection control practices. Ultimately, the goal is to reduce the burden of burn wound infections, enhance patient recovery, and combat the global threat of antibiotic resistance in healthcare settings.

MATERIALS AND METHODS

This was a cross-sectional study. The study was carried out at Shaikh Zayed Hospital Lahore over six months from February 2024 to July 2024. A total of 120 stable burn patients with clinical signs of wound infection were included in the study. Patients of all ages and genders with second or third-degree burns and clinical evidence of infection, such as purulent discharge, redness, swelling, or delayed healing, were included. Patients who had received systemic antibiotics within the past seven days or those with comorbidities compromising the immune system, such as diabetes or cancer, were excluded. Ethical approval was obtained from the institutional review board, and informed consent was obtained from all participants or their legal guardians.

Wound swabs were collected aseptically from the infected sites using sterile cotton-tipped applicators. The samples were transported immediately to the microbiology laboratory in sterile transport media for processing. The samples were inoculated onto blood agar, MacConkey agar, and nutrient agar plates and incubated at 37°C for 24-48 hours. Isolated bacterial colonies were identified using standard biochemical tests, including Gram staining, oxidase test, catalase test, and other confirmatory assays as per established guidelines.

Antibiotic susceptibility testing was performed using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar. The antibiotics tested included beta-lactams, cephalosporins, aminoglycosides, fluoroquinolones, carbapenems, and polymyxins. The selection of antibiotics was based on clinical relevance and local prescribing practices. The results were interpreted according to the Clinical and Laboratory Standards Institute (CLSI) guidelines.

Data on patient demographics, burn severity, bacterial isolates, and their susceptibility patterns were recorded in a pre-designed proforma. Statistical analysis was performed using SPSS version 25. Descriptive statistics, such as frequencies and percentages, were used to summarize categorical variables, while mean and standard deviation were calculated for continuous variables. The prevalence of Gram-negative bacteria and their susceptibility profiles were analyzed, and results were compared between different demographic and clinical subgroups.

RESULTS

The study included 120 patients, with a mean age of 33.4 ± 15.6 years. Males comprised the majority of the sample, accounting for 84 patients (70.0%), while females constituted 36 patients (30.0%). Regarding burn severity, second-degree burns were more prevalent, affecting 72 patients (60.0%), compared to 48 patients (40.0%) with third-degree burns as given in table 1

Table 1: Demographic Characteristics of Patients

Variable	Value
Total Patients	120
Age (Mean ± SD)	33.4 ± 15.6 years
Gender (n, %)	Male: 84 (70.0%)
	Female: 36 (30.0%)
Burn Severity (n, %)	Second Degree: 72 (60.0%)
	Third Degree: 48 (40.0%)

Among the bacterial isolates, Pseudomonas aeruginosa was the most common, identified in 48 cases (40%). This was followed by Klebsiella pneumoniae in 36 cases (30%), Escherichia coli in 24 cases (20%), and Acinetobacter baumannii in 12 cases (10%). This highlights the dominance of Pseudomonas aeruginosa as a leading pathogen in infected burn wounds as given in table 2.

Table 2: Prevalence of Gram-Negative Bacterial Isolates

Bacterial Isolate	n (%)
Pseudomonas aeruginosa	48 (40%)
Klebsiella pneumoniae	36 (30%)
Escherichia coli	24 (20%)
Acinetobacter baumannii	12 (10%)

Antibiotic resistance varied across bacterial isolates. Pseudomonas aeruginosa showed the highest resistance, with 29 cases (59.6%) resistant and 19 cases (40.4%) sensitive. Klebsiella pneumoniae had a nearly equal distribution, with 17 cases (48.6%) resistant and 19 cases (51.4%) sensitive. Similarly, Escherichia coli exhibited 13 cases (56.5%) resistant and 10 cases (43.5%) sensitive. Acinetobacter baumannii showed 7 cases (53.8%) resistant and 6 cases (46.2%) sensitive. These findings emphasize the growing challenge of antimicrobial resistance, particularly in Pseudomonas aeruginosa as given in table 3.

Table 3: Antibiotic Resistance Summary by Bacterial Isolates

Bacterial Isolate	Sensitive (n, %)	Resistant (n, %)
Pseudomonas aeruginosa	19 (40.4%)	29 (59.6%)
Klebsiella pneumoniae	19 (51.4%)	17 (48.6%)
Escherichia coli	10 (43.5%)	13 (56.5%)
Acinetobacter baumannii	6 (46.2%)	7 (53.8%)

Complications were reported in 36 patients (30%), whereas 84 patients (70%) experienced no complications. This relatively low rate of complications suggests effective initial wound management, though the 30% affected highlights the need for continued vigilance in preventing and managing infections in burn patients as given in table 4.

Table 4: Frequency of Complications in Patients

Complication	n (%)
Yes	36 (30%)
No	84 (70%)

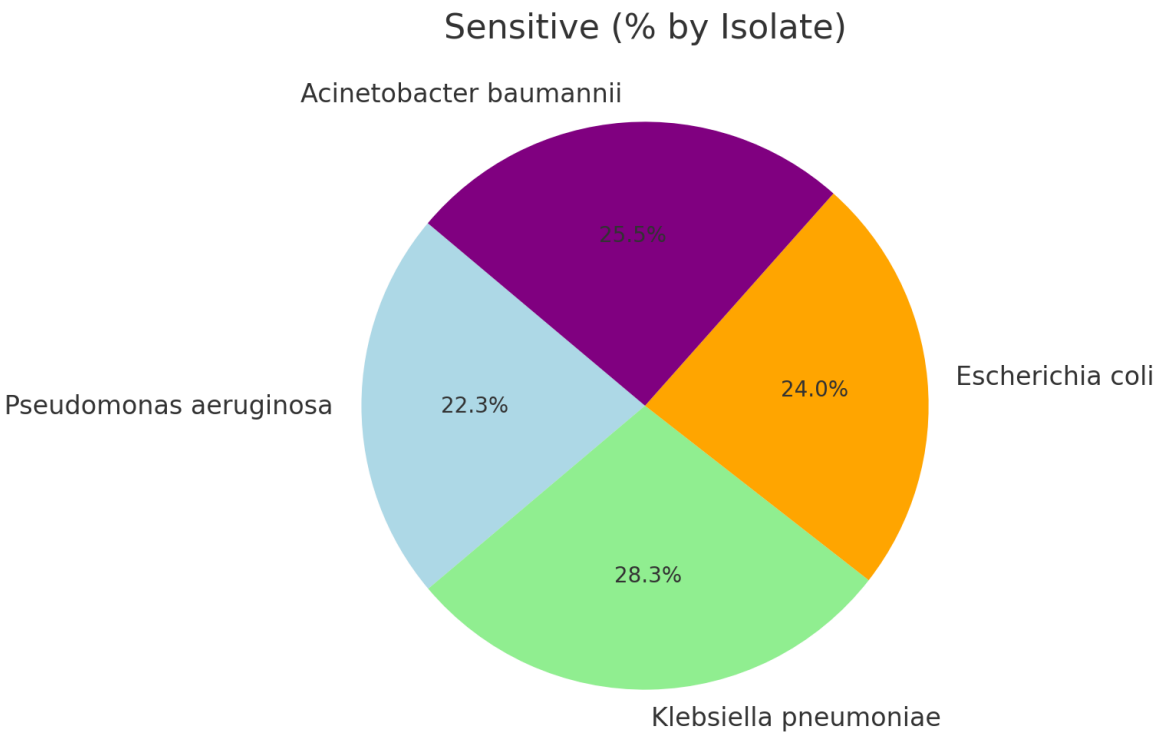

Figure 1: Antibiotic Sensitive distribution by Bacterial Isolates

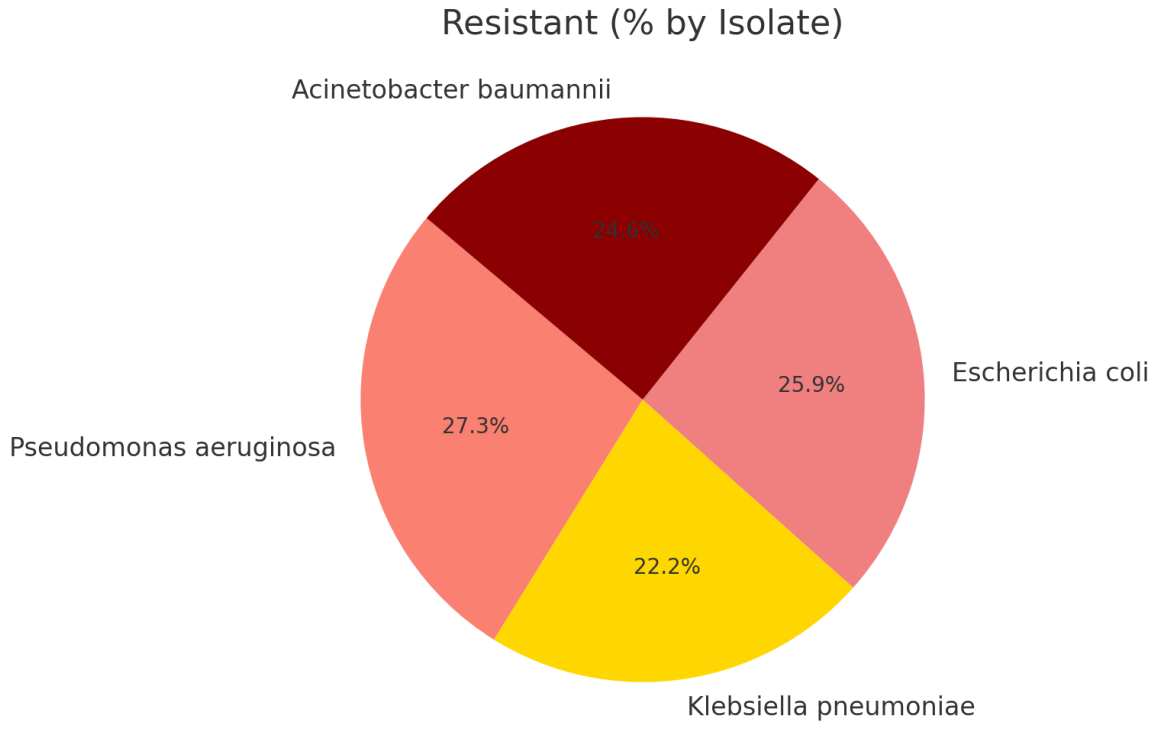

Figure II: Antibiotic Resistance distribution by Bacterial Isolates

DISCUSSION

Burn wounds are a significant cause of morbidity and mortality worldwide, particularly due to the high risk of infection resulting from skin barrier loss and immunosuppression. Among the pathogens causing these infections, Gram-negative bacteria, such as Pseudomonas aeruginosa, Klebsiella pneumoniae, and Escherichia coli, are highly prevalent due to their ability to thrive in the moist and nutrient-rich burn environment. These bacteria are often resistant to multiple antibiotics, complicating treatment and prolonging recovery. The emergence of multidrug-resistant strains has become a major global concern, especially in healthcare settings where antibiotic

misuse is common. Surveillance of bacterial prevalence and resistance patterns is essential to guide empirical antibiotic therapy and infection control measures. This study aims to analyze the prevalence of Gram-negative bacteria in infected burn wounds and evaluate their antibiotic susceptibility patterns among stable burn patients. Understanding these trends can help optimize treatment regimens and improve patient outcomes.

In our study, *Pseudomonas aeruginosa* was the most prevalent isolate (40%), followed by *Klebsiella pneumoniae* (30%), *Escherichia coli* (20%), and *Acinetobacter baumannii* (10%). These results are consistent with Hassan (2021), who reported *Pseudomonas aeruginosa* as the leading pathogen (30%), followed by *Proteus spp.* (25.3%).[15] Similarly, Saaiq et al. (2015) found *Pseudomonas aeruginosa* in 35.29% of cases, making it the most common Gram-negative isolate.[16] Irshad et al. (2017) highlighted the predominance of Gram-negative bacteria, with *Klebsiella pneumoniae* (21.2%) and *Pseudomonas aeruginosa* (19.16%) being the most frequent isolates. These findings reinforce the dominance of Gram-negative pathogens, particularly *Pseudomonas aeruginosa*, in burn wound infections.[17]

Our study found that *Pseudomonas aeruginosa* had a high resistance rate (59.6%), consistent with Mujtaba et al. (2023), who noted *Pseudomonas aeruginosa* susceptibility to Polymyxin B at 67.04%. *Klebsiella pneumoniae* showed 48.6% resistance, similar to its susceptibility patterns reported by Mujtaba et al. (61.11% to Polymyxin B).[20] Arooj et al. (2023) also observed *Pseudomonas aeruginosa* and *Escherichia coli* among the resistant isolates, with Tigecycline and Polymyxin B being the most effective antibiotics. This highlights the importance of regularly updating susceptibility testing to guide empirical therapy.[19] Roy et al. (2024) emphasized the role of multidrug-resistant Gram-negative bacteria, including *Acinetobacter baumannii* and *Klebsiella pneumoniae*, in prolonging hospital stays and complicating treatment.[18] The relatively low prevalence of *Acinetobacter baumannii* (10%) in our study contrasts with Roy et al.'s findings, potentially reflecting regional differences in infection control measures. Saaiq et al. (2015) also noted geographic variations, underscoring the need for localized data to address region-specific challenges.[16,18]

Hassan (2021) reported *Pseudomonas aeruginosa* as highly susceptible to imipenem and cefepime, while our study identified considerable resistance.[15] This discrepancy could arise from differences in antibiotic usage policies. Irshad et al. (2017) and Mujtaba et al. (2023) provided broader perspectives on bacterial diversity, but their inclusion of both Gram-positive and Gram-negative isolates may limit direct comparisons to our findings focused exclusively on Gram-negative bacteria.[17,20]

This study's strength lies in its analysis of a substantial sample size with detailed antibiotic susceptibility testing, providing valuable insights into resistance patterns. It highlights a pressing clinical issue with implications for antimicrobial stewardship and patient management. However, its limitations include a single-center setting and the absence of long-term follow-up data, which may affect the generalizability of the findings. Further multicenter studies are recommended to validate these results.

CONCLUSION

Gram-negative bacteria, particularly Pseudomonas aeruginosa, are the predominant pathogens in infected burn wounds, with significant levels of antibiotic resistance. Antibiotic susceptibility testing is crucial to guide effective therapy and prevent resistance escalation. Continued surveillance and stewardship are essential for better infection control and patient care.

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