BACTERIAL INFECTIONS IN CANCER PATIENTS AT BENGHAZI MEDICAL CENTER, LIBYA: EPIDEMIOLOGY AND ANTIMICROBIAL RESISTANCE

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Abstract

Background: Cancer patients are highly susceptible to bacterial infections due to immunosuppression from malignancy and treatment, which significantly increases morbidity, mortality, and hospital stays.

Methods: A retrospective observational study was conducted at Benghazi Medical Center, Libya, between January 2023 and December 2024. Clinical specimens from 188 cancer patients with confirmed infections were processed using the VITEK 2 system, and antimicrobial susceptibility was interpreted according to CLSI standards.

Results: A total of 227 bacterial isolates were recovered: 159 (70.0%) Gram-negative and 68 (30.0%) Gram-positive. The most common Gram-negative pathogens were *Klebsiella spp.* (31.4%), *Pseudomonas aeruginosa* (25.2%), and *Escherichia coli* (23.9%), while *Staphylococcus aureus* constituted 48.5% of Gram-positive isolates. Bloodstream infections were the most frequent (36.7%), followed by respiratory tract infections (27.1%) and urinary tract infections (17.6%). Solid tumor patients had more bloodstream infections (38.9%), while respiratory infections were slightly more common in hematologic malignancy patients (27.0%). ESBL production was observed in 52.0% of *Klebsiella spp.* and 50.0% of *E. coli*. Methicillin-resistant *S. aureus* (MRSA) accounted for 39.4% of isolates, with all Gram-positive isolates remaining susceptible to vancomycin. The overall mortality was 40.0%, with Neutropenia significantly associated with poor outcomes.

Conclusion: Multidrug-resistant bacterial infections, particularly ESBL-producing Gram-negative organisms and MRSA, are prevalent among cancer patients in Libya. Strengthened infection control, antimicrobial stewardship, and targeted empirical therapy are crucial to reduce morbidity and mortality.

Keywords: bacterial infections; antimicrobial resistance; cancer patients; Libya; VITEK 2; multidrug resistance

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1. Introduction

Patients in cancer wards are more vulnerable to infections. Both the immediate impacts of cancer and its treatment make these people more susceptible [1]. Cancer patients often have infections, which can result in treatment disruptions, extended hospital stays, higher medical expenses, and worse survival rates. Bacteria and fungi are the most prevalent pathogens linked to infection-related mortality, even if total mortality has decreased recently. Infection is still a major or contributing cause of death [2].

Appropriate empirical antibiotic treatment and ongoing knowledge of the prevalent infections and their patterns of antimicrobial sensitivity are essential for effective infection control. Gram-negative bacteria still predominate in oncology settings, despite previous reports suggesting an increase in gram-positive infections over the past few decades [3]. *Klebsiella pneumoniae*, *Escherichia coli*, and *Pseudomonas aeruginosa* are frequently isolated in bloodstream and hospital-acquired infections among cancer patients. The growth and spread of multidrug-resistant (MDR) gram-negative pathogens presently pose a significant therapeutic problem, despite the fact that empirical antibiotic treatment has helped to lower mortality [4].

A thorough grasp of the changing microbial spectrum is crucial for efficient prevention, diagnosis, and treatment because immunocompromised people, such as cancer patients, are more frequently exposed to MDR pathogens. With the increased burden of antibiotic resistance seen during the COVID-19 period, managing these infections has emerged as one of the biggest difficulties in contemporary oncology therapy [5].

The current study is to determine the bacterial pathogens causing the infections, examine their antibiotic susceptibility profiles, and determine the incidence of infections among cancer patients undergoing various treatment regimens [6]. This information will help lower medical expenses, enhance prognosis, and provide more customised treatment choices. Additionally, Benghazi Medical Center's findings will help Libya implement evidence-based antimicrobial stewardship and infection control measures [7].

2. Aims and Objectives

The study was undertaken to determine the range of bacterial infections in cancer patients undergoing radiation, chemotherapy, or surgery, to identify the antimicrobial susceptibility profiles of the bacterial pathogens causing the illnesses, and to look for correlations between the kind of infection, the type of malignancy, the mode of therapy, and the clinical results [8].

3. Materials and Methods

3.1 Study Design and Setting

All cancer patients who contracted bacterial infections between January 1, 2023, and December 31, 2024, were included in a retrospective observational study carried out in the oncology department of Benghazi Medical Centre in Libya [9].

3.2 Microbiological Procedures

Gram-stained specimens were cultivated for 24 hours at 37°C on blood agar, chocolate agar, and MacConkey agar. The TDR-X030 Automatic Blood Culture System was used to process blood cultures [10]. The VITEK 2 automated system (bioMérieux, France) was used to subculture and identify positive cultures. The CLSI recommendations were followed in the interpretation of minimum inhibitory concentrations (MICs) [11].

3.3 Antimicrobial Susceptibility Testing

Amikacin, amoxicillin-clavulanic acid, ampicillin, cefixime, ceftazidime, ceftriaxone, ciprofloxacin, ertapenem, imipenem, meropenem, gentamicin, piperacillin–tazobactam, and trimethoprim–sulfamethoxazole are examples of gram-negative bacteria [12]. Cefoxitin, cephalothin, cefoperazone, gentamicin, erythromycin, clindamycin, chloramphenicol, rifampicin, netilmicin, linezolid, teicoplanin, and vancomycin are all considered gram-positive bacteria [13].

3.4 Data Collection

Medical records were used to collect demographic and clinical information, such as age, gender, cancer type, treatment mode, infection location, bacterial isolates, comorbidities, haematological parameters, and therapeutic treatments.

3.5 Statistical Analysis

Microsoft Excel was used to evaluate the data. Microbiological and demographic traits were gathered using descriptive statistics. Chi-square tests and odds ratios (OR) were used to evaluate associations; $p < 0.05$ was deemed significant.

4. Results.

1567 patients were admitted to the Oncology Department at Benghazi Medical Center during the study period. 512 patients were diagnosed with infections, of whom 188 cancer patients with confirmed bacterial infections were included. Male: 51.6%, Female: 48.4%.

The age and sex distribution of the patients are shown in Figures 1 and 2, respectively. The mean age of patients with solid tumors 45 years (range 18–80), hematologic malignancies 30 years (range 20–72).

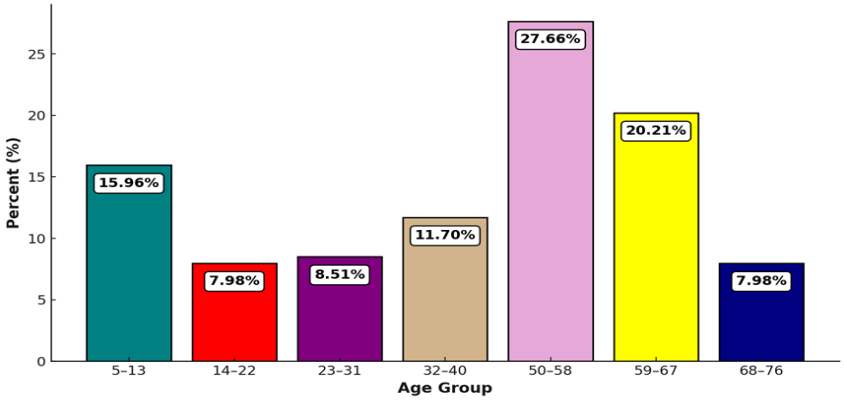

Figure 1: Age-wise distribution of infected patients

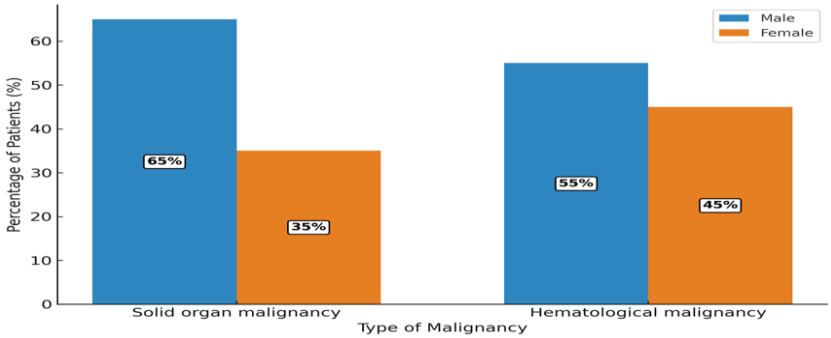

Figure 2: Gender-wise distribution of infected patients

Bloodstream infections were more common among those with solid tumours 38.9%, while Respiratory infections 27.0% were more frequently observed in patients with haematological malignancies (Table 1).

Table 1. Distribution of infection types among patients with solid tumors and hematological malignancies

Infection Type	Solid Tumours No. (%)	Haematologic Malignancies No. (%)	Total No. (%)
Bloodstream	49 (38.9%)	21 (33.3%)	70 (36.7%)
Respiratory	34 (27.0%)	15 (23.8%)	49 (27.1%)
Urinary tract	27 (21.4%)	11 (17.5%)	38 (17.6%)
Skin and soft tissue	7 (5.6%)	9 (14.3%)	16 (8.5%)
Others (PUO, GI)	9 (7.1%)	6 (9.5%)	15 (7.9%)

From the 188 patients with positive cultures, 227 microorganisms were isolated. Among these, 159 (70.0%) were Gram-negative bacilli, and 68 (30.0%) were Gram-positive cocci (Figure 3)

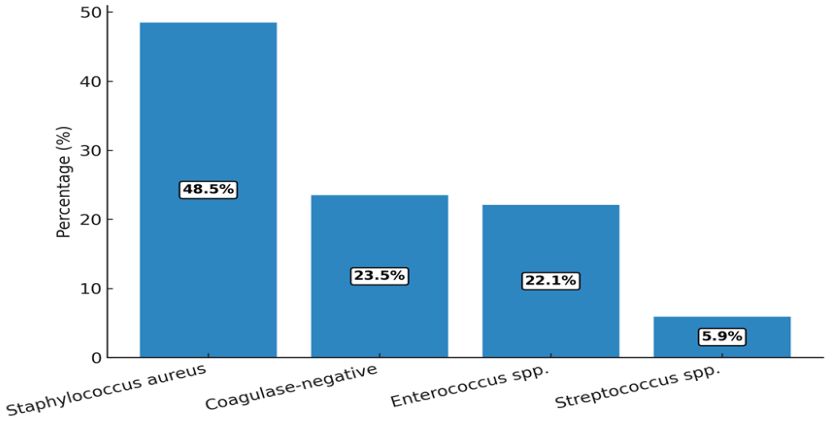

Figure 3: Distribution of Gram-positive isolates among cancer patients.

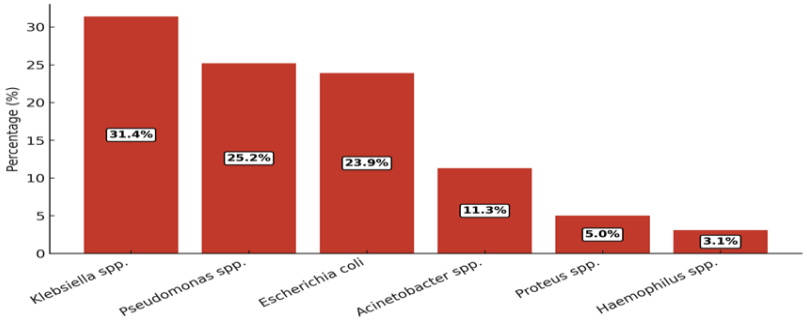

Figure 4: Distribution of Gram-negative isolates among cancer patients.

The most frequently isolated pathogen was *Klebsiella spp*. (18.30%), followed by *Pseudomonas spp.* (15.9%), *Escherichia coli* (14.5%), and *Staphylococcus aureus* (13.7%). Pathogen distribution varied by infection site: *Klebsiella spp*. was predominant in bloodstream infections, *Pseudomonas spp.* in respiratory tract infections, *E. coli* in urinary tract infections, and *S. aureus* in skin and soft tissue infections (Table 2).

Table 2. Predominant Bacterial isolated from infected patients

Gram-Negative	No. (%)	Gram-Positive	No. (%)
Klebsiella spp.	50 (31.4)	***S. aureus***	33 (48.5)
Pseudomonas spp.	40 (25.2)	***CoNS***	16 (23.5)
E. coli	38 (23.9)	***Enterococcus spp.***	11 (16.2)
Acinetobacter spp.	18 (11.3)	***Streptococcus spp.***	8 (11.8)
Proteus spp.	8 (5.0)	—	—
Haemophilus spp.	5 (3.1)	—	—

The antibiotic resistance profiles of Gram-negative and Gram-positive isolates are summarized in Tables 3 and 4, respectively.

Table 3. Antimicrobial resistance among Gram-negative isolates

Bacteria	Quinolone N/Total (%)	Aminoglycoside N/Total (%)	ESBL N/Total (%)	Carbapenem N/Total (%)
Klebsiella spp.	16/50 (32.0)	18/50 (36.0)	26/50 (52.0)	6/50 (12.0)
Pseudomonas spp.	14/40 (35.0)	10/40 (25.0)	7/40 (17.5)	2/40 (5.0)
E. coli	29/38 (76.3)	15/38 (39.5)	19/38 (50.0)	3/38 (7.9)
Acinetobacter spp.	12/18 (66.7)	10/18 (55.6)	13/18 (72.2)	1/18 (5.6)
Proteus spp.	5/8 (62.5)	6/8 (75.0)	4/8 (50.0)	1/8 (12.5)
Haemophilus spp.	3/5 (60.0)	3/5 (60.0)	2/5 (40.0)	1/5 (20.0)

Table 4. Gram-positive isolates' pattern of antibiotic resistance

Bacteria	Methicillin N/Total (%)	Vancomycin N/Total (%)	Macrolide N/Total (%)	Aminoglycoside N/Total (%)
Staphylococcus aureus	13/33 (39.4%)	0/33 (0.0%)	13/33 (39.4%)	3/33 (9.1%)
CoNS	11/16 (68.8%)	0/16 (0.0%)	5/16 (31.3%)	3/16 (18.8%)
Enterococcus spp.	—	3/11 (27.3%)	1/11 (9.1%)	4/11 (36.4%)
Streptococcus spp.	—	0/8 (0.0%)	2/8 (25.0%)	0/8 (0.0%)

The association between Neutropenia and outcome is presented in Table 5. Since the p-value exceeded 0.05, there was no statistically significant association between leukopenia and mortality. The odds ratio for mortality in leukopenic patients was 1.224, indicating a 1.22-fold higher risk compared with non- Neutropenia patients. The distribution of infection sites in neutropenic and non-neutropenic patients is depicted in Figure 4.

Table 5. Neutropenia and clinical outcomes

Outcome	Neutropenia NO. (%)	Non- Neutropenia NO. (%)	χ^2	p-value
Dead	38 (61.3%)	67 (53.2%)	0.83	0.36
Stable	24 (38.7%)	59 (46.8%)	—	—

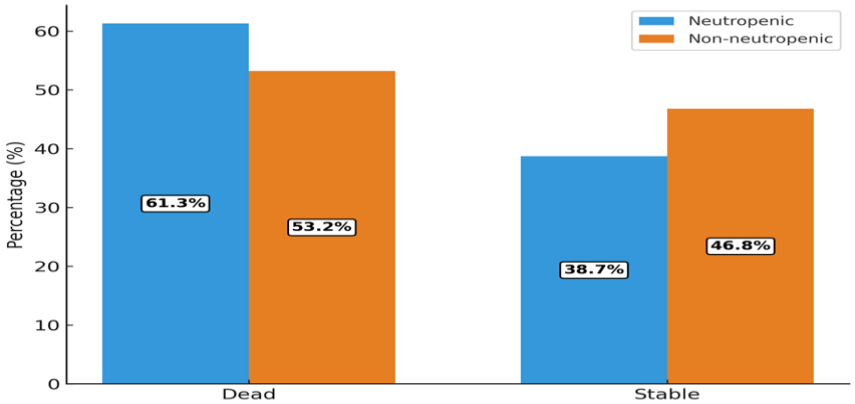

Figure 5: Infection site distribution by neutropenia status

Among the 188 cancer patients with documented infections, 80% were receiving chemotherapy, 27.9% underwent radiotherapy, and 21.4% had surgical procedures. The overall mortality rate among infected cancer patients was 40%.

5. Discussion

Among cancer patients, infections continue to be a major source of morbidity and death. 40% of the 188 patients in the current research who had microbiologically confirmed infections died from the disease, which is in line with findings from throughout the world that show infection-related mortality in cancer patients ranges from 30% to 40% [14]. The main causes of mortality were severe infections, including pneumonia and bloodstream infections (BSIs), whereas other patients had problems that lengthened hospital stays and raised medical expenses [15].

Gram-negative infections predominated among the 227 bacterial isolates found, with 159 (70.0%) being Gram-negative and 68 (30.0%) being Gram-positive. In contrast, Gram-positive bacteria are responsible for around 70% of illnesses in high-income countries (8), although this is consistent with trends seen in underdeveloped countries [16]. This disparity is probably explained by variations in indwelling medical device usage, antibiotic prophylaxis, and infection control procedures. Gram-negative bacteria historically dominated oncology infections in the 1960s and 1970s, then by Gram-positive bacteria in the 1980s. In the last 20 years, however, Gram-negative bacilli such *Klebsiella spp*., *Pseudomonas spp*., and *Acinetobacter spp*. have returned as the main pathogens [17].

Each form of tumour has a different distribution of infections. While respiratory infections were more prevalent in solid tumours (34.9%), BSIs were the most common infections overall (36.7%), especially in haematological malignancies (33.3%) [18]. Skin/soft tissue infections (8.5%) and urinary

tract infections (17.6%) were less common. These results are somewhat consistent with other research that found BSIs in haematologic malignancies and pneumonia as the most frequent infection in solid tumours [19].
The most common bacterial pathogens were *Staphylococcus aureus* (48.5% of Gram-positive isolates), *Escherichia coli* (23.9%), *Pseudomonas spp*. (25.2%), and *Klebsiella spp.* (31.4%). Notable examples of multidrug resistance (MDR) included the production of ESBL in 52% of *Klebsiella species*, 50% of *E. coli*, 72.2% of *Acinetobacter species*, and 50% of *Proteus species*; carbapenem resistance in 12% of *Klebsiella species* and 5% of *Pseudomonas species*; and resistance to aminoglycosides and quinolones in 25% to 76.3% of Gram-negative isolates [20]. All isolates of *S. aureus* and CoNS were vancomycin-sensitive; whereas 39.4% of isolates of Gram-positive bacteria were *methicillin-resistant S. aureus* (MRSA) and 27.3% of isolates of *Enterococcus spp.* were vancomycin-resistant enterococci (VRE) [21]. These resistance patterns are probably a reflection of local antibiotic stewardship policies, as they are lower than those seen in other regional studies [22]. Clinically, there was a substantial correlation between MDR infections and death. MDR pathogen infections, mainly *Klebsiella pneumoniae*, *Acinetobacter baumannii*, and sepsis-related pneumonia, were present in 84% of the 75 patients who passed away [23]. According to earlier research, neutropenia is an independent risk factor for infection-related mortality in cancer patients [24], and it raised the risks of death by 1.22 times.

The retrospective single-center design of the study and the exclusion of culture-negative infections are its primary drawbacks, which may restrict how broadly the findings may be applied [25]. Nevertheless, the results highlight the crucial need for efficient infection control, antimicrobial stewardship, and empirically guided treatment targeting MDR pathogens and offer important insights into the epidemiology and resistance patterns of bacterial infections in Libyan oncology patients.

6. Conclusion

Since infections can result in chemotherapy termination, changed treatment results, higher medical expenses, and greater morbidity, they remain one of the biggest obstacles to cancer patient care. Antibiotic-induced selection pressure has resulted in the emergence of resistant organisms, complicating control tactics. Therefore, effective prevention, diagnosis, and treatment require a thorough grasp of the changing epidemiology of disorders. The types of bacterial infections, related bacterial pathogens, and patterns of antibiotic susceptibility in cancer patients receiving anticancer treatment were assessed in this study. Important conclusions include:
1. Patient Cohort: 182 infection episodes comprised 188 cancer patients with positive cultures and clinically confirmed infections. 227 isolates from 188 patients.
2. The overall infection-related mortality rate among cancer patients was 40%, affecting both solid-tumor and hematological-malignancy patients, with no evidence that mortality was confined to solid tumors .
3. Mortality occurred in 38 - neutropenic patients (61.3%) and 67 non- neutropenic patients (53.2%).The most prevalent illness categories were respiratory tract infections (27.1%) and bloodstream infections (36.7%).
4. Chemotherapy was the most frequently administered treatment, received by 80% of infected cancer patients, followed by radiotherapy (27.9%) and surgical interventions (21.4%).
5. Distribution of Pathogens: *Klebsiella species* was the most often isolated pathogen (18.3%), with gram-positive isolates making up 30.1% and gram-negative isolates 69.9%.
6. Antibiotic Resistance: Of Gram-negative bacteria, 26.92% were resistant to all three classes; 45.13% were resistant to fluoroquinolones, 39.20% to aminoglycosides, and 48.58% to third-generation cephalosporins. ESBL was generated by 48.9% of *E. Coli* isolates and 51.8% of *Klebsiella* isolates. 22.22% of patients had carbapenem resistance, whereas 11.63% of patients had β-lactam/β-lactamase inhibitor combination resistance.
7. Gram-Positive Resistance: While 41% of the *Staphylococcus aureus* isolates showed methicillin resistance, all of them were still sensitive to vancomycin. 8.3% of *Enterococcus species* are resistant to vancomycin.

Strict infection control measures, frequent prospective surveillance of hospital antibiotic susceptibility patterns to inform local treatment guidelines, the development of novel antimicrobial agents, and limiting indiscriminate antibiotic use in clinical practice are all necessary to lower infection incidence and improve outcomes for cancer patients

Study Implications
This study informs local antibiotic policies, supports rational antimicrobial use, and provides a basis for preventive and therapeutic strategies tailored to Libyan oncology units.

Data Availability
All datasets are included in the article and supplementary materials and are available upon reasonable request.

Ethical Approval
Ethical clearance was obtained from the institutional ethics committee of Benghazi Medical Centre, Libya.

Conflict of Interest
The authors declare no conflicts of interest.

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