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Original article

Common bacterial and fungal infections as a challenging condition in cancer patients : Single centre based study

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ABSTRACT

Background: Cancer patients are at an increasing risk of developing infections that increase morbidity and mortality. The present study aimed to identify different pathogens isolated from infected cancer patients with evaluating the anti-microbial susceptibility pattern of bacterial isolates. **Methods:** 228 samples were collected from infected cancer patients. Bacteriological and fungal examinations were performed using standard methods. Bactec FX40 system was used for blood samples. Antimicrobial susceptibility tests were conducted according to Clinical and Laboratory Standards Institute (CLSI) guidelines. **Results:** The majority of samples revealed single pathogens with a predominance of Gram-negative bacteria (46%). *Escherichia coli (E. coli) spp.* was the most frequently isolated pathogen, followed by *Klebsiella pneumoniae* (*K. pneumoniae*) and *Staphylococcus aureus (Staph. aureus). Candida albicans* isolated from the majority of fungal infections. About 62.7% of bacterial isolates were multidrug-resistant with predominance of *E. coli spp., K. pneumoniae* and *Staph*ylococcus *aureus*. About 40% of isolated Gram-negative bacteria were carbapenem-resistant (CR) with predominance of CR *K. pneumoniae*. 74.2% of *Staphylococcus aureus* were MRSA, 13% were VRSA and 40% of *Enterococci* were VRE. *Escherichia coli spp., K. pneumoniae and Staphylococcus aureus* represented the majority of MDROs with 22.5%, 21.6% and 20.7% respectively, while *K. pneumoniae* represented the majority of PDROs with 44.4%. Patient hospitalization and the presence of medical devices were risk factors with positive culture results. **Conclusions:** High rate of infection was detected among cancer patients with a predominance of MDROs. The regular revision of the antimicrobial policy based on microbiological data can reduce MDRO in cancer patients.

Introduction

Cancer is a pathological disease which is characterized by stepwise deregulation of cell apoptosis and proliferation, with significant morbidity and mortality globally [1]. In 2022, the incidence of cancer was about 20 million cases with about 9.7 million deaths related to cancer all over the world [2]. In Egypt, the estimated cancer cases in 2018 were 134,632 with 89,042 deaths [3].

Cancer patients are immune compromised by many factors including chemotherapy, surgery, malnutrition and radiation. As a result, they are more susceptible to bacterial and fungal infections [4]. In cancer patients, the mortality rate of fatal infections

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was nearly three times the general population [5]. Among adults, mortality on top of infections caused by hematological and solid tumors is about 60% and 50% respectively [6]. Bloodstream infections represent most infections in cancer patients, followed by respiratory tract infections (RTIs), urinary tract infections (UTIs), skin infections (SIs) and gastrointestinal tract (GIT) infections [5].

Because of suppressed immunity in cancer patients, they are more susceptible to colonization with anaerobes. Anaerobes are mostly isolated from GIT infections and surgical site infections [7]. *Clostridium* bacteremia is associated with hematological and gastrointestinal malignancies causing severe and fatal infections [7].

Regarding fungal infections, *Aspergillus species (spp.)* and *Candida albicans* are the most common fungi causing invasive infections, but *non-Candida albicans* and other organisms like *Mucorales*, and *Fusarium spp.* are found infrequently [8].

In oncologic patients, both surgical intervention and ICU admission represent major risk factors for developing healthcare-associated infections with multidrug-resistant organisms (MDROs). Healthcare-associated infections result in prolonged hospitalization, treatment delays and/or interruption, chemotherapy/radiotherapy (RT) dose reduction which result in cancer recurrence and increase the mortality rate [9].

Although the usage of empirical antimicrobials has decreased the mortality rate in cancer patients, it has also led to the emergence of multidrug-resistant bacteria [10]. The prevalence of MDROs steadily increased from 10.3% during 2003–2007 to 39.7% during 2018–2022 [11]. In Egypt, a study among cancer patients in the ICU showed that 62.7% of isolates were MDROs [12]. Extended-spectrum β-lactamase-producing *Enterobacteriaceae* (ESBL-PE), multidrug-resistant (MDR) *Pseudomonas aeruginosa*, carbapenem-resistant *Enterobacteriaceae* (CRE*), Acinetobacter baumannii* and *methicillin-resistant Staphylococcus aureus (MRSA)* have been increasingly identified as the predominant causative pathogens in cancer patients due to the phenomenon of antibiotics misuse [13].

The objectives of this study are to identify different pathogens isolated from infected cancer patients, assess the anti-microbial susceptibility pattern of bacterial isolates, together with correlation between types of infection with the underlying cancer disease and type of treatment.

Material and Methods

Study design

This cross-sectional study was carried out in the Medical Microbiology and Immunology Department and Clinical Oncology Department of Tanta University Hospitals from January 2023 to January 2024. The study was approved by the Institutional Review Board of the Faculty of Medicine, Tanta University, Egypt (approval code 36223/12/22). The study was conducted in accordance with the Declaration of Helsinki guidelines.

Sample size

The sample size for cancer patients was calculated using Open-Epi. The minimal sample size calculated was 228

Study subjects

Adult cancer patients (more than 18 years old) admitted to clinical oncology department with clinical symptoms and signs of infection, either community-acquired, or healthcare-associated infections (infections that developed after 48 hours of admission) were included in this study. Patients' medical history was recorded, including name, age, gender, admission date, associated comorbidity, type and duration of cancer, type, duration of treatment received and clinical outcome. Patients refused to participate or children below 18 years were excluded.

Sample collection

All types of samples from adult cancer patients were collected in sterile containers under complete aseptic techniques. In order to ensure participant privacy and data confidentiality, each sample was assigned a code number and transferred as soon as possible to the Microbiology and Immunology Department laboratory.

Identification of bacterial isolates

All samples were cultured aerobically on nutrient agar, MacConkey, blood agar, Sabaroud dextrose agar (Oxoid, Basingstoke, UK). Then all cultivated plates were incubated at 37°c for 24-48 hrs. Also, all samples were cultivated anaerobically on Robertson cooked meat broth and incubated for 48 hours. Then, Gram stain smears were made, followed by anaerobic incubation using an anaerobic gas pack system for 72 hrs on selective media as blood agar with neomycin for isolation of

Clostridia species. A quantitative culture was done to urine and broncho-alveolar lavage samples using calibrated loops to differentiate between colonization and infection [14].

BACTEC FX40 system was used for the cultivation of blood samples aerobically and anaerobically by automated blood culture vials (bioMérieux ®) [15]. Phenotypic detection of the isolated pathogens was based primarily on standard microbiological procedures such as colony morphology, Gram staining reaction, and biochemical reactions [14]. Render MA120 (Render Biotech Co., China) was used to confirm bacterial isolates and identification of pathogens that could not be identified using routine conventional methods. The Render MA120 principle is colorimetry for identification and turbidimetry for susceptibility testing [16].

Antimicrobial susceptibility testing

All identified pathogens were subjected to antimicrobial susceptibility testing using the Kirby disc diffusion method on Mueller-Hinton agar plates (Oxoid, UK). By Clinical and Laboratory Standards Institute 2023 (CLSI) standards the used antibiotics varied according to type of the organism and the isolates were categorized into susceptible, intermediate or resistant [17]. An organism is considered MDR when it shows in vitro resistance to at least one agent in three or more antimicrobial classes [18]. Pan drug resistance (PDR) means bacteria are resistant to all antimicrobial agents [19]. Render MA120 was used to confirm the presence of multi-drug resistance and to detect PDR and the MIC for vancomycin and colistin among isolates (Render Biotech Co., China).

According to the Clinical and Laboratory Standards Institute (CLSI) 2023, cefoxitin disk 30µg was used for methicillin-resistant *Staphylococcus aureus (MRSA)* detection. Vancomycin-resistant *Staphylococcus aureus (VRSA)* and vancomycin-resistant Enterococci were confirmed using Render MA 120. Carbapenem-resistant (CR) Gram-negative bacteria were considered when they were intermediate or resistant to at least one carbapenem (imipenem, meropenem, and ertapenem). In this study meropenem was used to test CR in isolated Gram-negative bacteria [17].

Statistical analysis

Sorting and analysis of data were performed by using IBM SPSS Statistics for Windows, Version 25.0, (IBM Corporation, 2017). Numbers and percentages were used to represent categorical data. To compare categorical data, the Chi-square test was employed. Using Epi Info software, the Crude Odds Ratio (COR) and 95% confidence interval were computed. A forward Wald binary logistic regression analysis was used to identify significant independent predictors, Adjusted Odds Ratios (AOR), and 95% confidence intervals based on significant univariate factors associated with non-survival and growth.

Results

Out of 228 samples isolated from cancer patients, bacterial and fungal infections were recovered from 143 samples. The age, sex and type of samples are listed in **(table 1).**

In urine samples, the majority of isolated organisms were *Escherichia coli (E. coli*) spp. While in blood samples, *Staphylococcus aureus* was the most commonly detected organism. *Klebsiella pneumoniae* (11 isolates) followed by fungal isolates were predominantly isolated from the respiratory samples. These results are well demonstrated in **(table 2).**

All Gram-negative isolates were resistant to ampicillin and amoxicillin-clavulanic. Most isolated *E. coli* was sensitive to colistin 92.3% followed by meropenem 84.6%. While 79.2% were resistant to trimethoprim/sulfamethoxazole. Most of the isolated *Klebsiella spp.* were sensitive to colistin and amikacin 83.3%. While 77.8% were resistant to trimethoprim/sulfamethoxazole followed by aztreonam 72.2%. *Acinetobacter* isolates were sensitive to colistin 90.9%. While 81.1% were resistant to ampicillin/sulbactam and cefotaxime. All *Pseudomonas* isolates were sensitive to colistin 100% followed by piperacillin/tazobactam 57.1%. While 85.7% were resistant to ceftazidime followed by ciprofloxacin (71.4%). About 40% of isolated Gram-negative bacteria were carbapenem-resistant (CR). *Klebsiella pneumoniae* represented the majority of CR among Gram-negative isolates 15.8% followed by Pseudomonas spp. and Acinetobacter spp. with 8.3% and 6.7% respectively. **(figure 1).**

All Gram-positive isolated strains were resistant to penicillin (100%) whereas the least resistance rate was against linezolid as all *Coagulase negative Staphylococci* (*CONS)* and *Enterococci spp.* strains were sensitive and 3.2% of *Staphylococcus aureus* was resistant to it. While 74.2% of *Staphylococcus aureus* was resistant to cefoxitin representing MRSA. Regarding

vancomycin, 13% and 40% of *Staphylococcus aureus* (VRSA) and *Enterococci* (VRE) were resistant respectively **(figure 2).**

Escherichia coli was the most predominate isolate showing MDR followed by *K. pneumoniae and Staphylococcus aureus* (22.5%, 21.6% and 20.7% respectively). While *K. pneumoniae* represented the majority of PDROs with 44.4% **(Figure 3)**.

As regards the clinical variables in patients with a positive culture, Urinary tract infection was statistically significant in patients who did not receive any cancer treatment, hospitalized patients and patients without inserted medical devices *p* value (≤ 0.05). Solid tumors, patients receiving cancer treatment, hospitalized patients and patients with inserted medical devices were correlated significantly with wound and surgical site infections *p* value (≤ 0.05). Patients with other types of infections were statistically significant with the presence of other comorbidities *p* value (≤ 0.05) as illustrated in **table (3).**

Figure 3 illustrates MDROs and Pan Drug Resistant Organisms (PDROS) among bacterial isolates. From the total 111 MDROs, *E. coli spp., K. pneumoniae* and *Staphylococcus aureus* represented the majority of isolates with 22.5%, 21.6% and 20.7% respectively, while *K. pneumoniae* represented the majority of PDROs with 44.4%.

Table 1. Characteristics of patients infected by isolated microorganisms.

Characteristics		**N =143**
Age	18-40	31(21.7%)
	41-60	64(44.8%)
	>60	48(33.5%)
Gender	Male	69(48.3%)
	Female	74(51.7%)
Sample type	Urine (71)	46(32.2%)
	Blood (59)	37(25.8%)
	Sputum (36)	21(14.7%)
	BAL (12)	6(4.2%)
	Endotracheal tube (6)	2(1.4%)
	Surgical wound swab (20)	16(11.2%)
	Bedsore (6)	5(3.5%)
	Rectal swab (2)	2(1.4%)
	Pus (10)	6(4.2%)
	Ascetic fluid (4)	1(0.7%)
	Portacath (1)	0
	CSF (1)	1(0.7%)

Table 2. Distribution of different bacterial and fungal organisms isolated from clinical samples studied.

Organisms		Urine	Blood	Respiratory samples			Swabs			Others				Total
				Sputum	BAL	ETT	Surgical wound swab	Bedsore	Rectal swab	Pus	Ascetic fluid	Portacath	CSF	
		N (%)												
Gram-positive cocci	***Staph aureus***	3(5.6)	16(34)	3(11.6)	1(12.5)	0	1(5)	4(50)	1(50)	1(14.3)	0	0	1(100)	31(11.8)
	Coagulase negative staph.	3(5.6)	0	0	0	0	0	0	0	0	0	0	0	3(1.2)
	Enterococcal spp.	2(3.7)	1(2.1)	1(3.8)	0	0	0	0	0	1(14.3)	0	0	0	5(1.9)
Gram-positive bacilli	***Clostridium perfringens***	0	1(2.1)	0	0	0	0	1(12.5)	0	0	0	0	0	2(0.8)
Gram-negative bacteria	***E.coli spp.***	25(46.4)	4(8.5)	3(11.6)	1(12.5)	0	3(15)	1(12.5)	0	2(28.5)	0	0	0	39(14.9)
	K. pneumonia	8(14.8)	13(27.8)	7(27)	3(37.5)	1(33.3)	4(20)	0	0	0	0	0	0	36(13.7)
	Enterobacter spp.	3(5.6)	1(2.1)	0	0	1(33.3)	4(20)	0	0	0	0	0	0	9(3.4)
	Proteus mirabilis	2(3.7)	1(2.1)	0	0	0	0	0	0	1(14.3)	0	0	0	4(1.5)
	Providenitia spp.	0	0	0	0	0	0	0	0	1(14.3)	0	0	0	1(0.4)
	Salmonella para b	1(1.7)	0	0	0	0	0	0	1(50)	0	0	0	0	2(0.8)
	Acinetobacter spp.	3(5.6)	3(6.4)	2(7.7)	1(12.5)	0	0	0	0	1(14.3)	1(100)	0	0	11(4.2)
	Pseudomonas	0	5(10.7)	1(3.8)	0	0	7(35)	1(12.5)	0	0	0	0	0	14(5.3)
	Klyvera ascrobata	1(1.7)	0	1(3.8)	0	0	0	0	0	0	0	0	0	2(0.8)
	Burkorderia cepecae	0	0	2(7.7)	0	0	0	0	0	0	0	0	0	2(0.8)
Fungi	***Candida albicans***	3(5.6)	1(2.1)	2(7.7)	0	1(33.3)	1(5)	1(12.5)	0	0	0	0	0	9(3.4)
	Candida non albicans	0	1(2.1)	1(3.8)	0	0	0	0	0	0	0	0	0	2(0.8)
	Aspergillus spp.	0	0	1(3.8)	2(25)	0	0	0	0	0	0	0	0	3(1.1)
	Cryptococcus spp.	0	0	2(7.7)	0	0	0	0	0	0	0	0	0	2(0.8)
Total		54	47	26	8	3	20	8	2	7	1	0	1	177

*: data are not mutually exclusive (Multiple organism) (BAL: Bronchoalveolar lavage, ETT: Endotracheal tube).

Table 3. Infection type according to demographic and clinical variables among samples with growth (N=143).

Variable	Total N	Urinary N (%)	*p*- value	Respiratory N (%)	*p*- value	Surgical N (%)	*p* value	Blood N (%)	*p*- value	Others** N (%)	*p* value
Overall	143	46(32.2)	-	29(20.3)	-	27(18.9)	-	37(25.9)	-	4(2.8)	-
Age											
18-40	31	9(29)	0.9	6(19.4)	0.6	7(22.6)	0.8	7(22.6)	0.8	2(6.5)	0.4
41-60	64	22(34.4)		11(17.2)		12(18.8)		18(28.1)		1(1.6)	
>60	48	15(31.3)		12(25)		8(16.7)		12(25)		1(2.1)	
Sex											
Male	69	22(31.9)	0.9	17(24.6)	0.2	10(14.5)	0.2	19(27.5)	0.7	1(1.4)	0.3
Female	74	24(32.4)		12(16.2)		17(23)		18(24.3)		3(4.1)	
Cancer type											
Solid	80	21(26.3)	0.09	17(21.3)	0.8	23(28.7)	0.001*	18(22.5)	0.3	1(1.3)	0.2
Hematological	63	25(39.7)		12(19)		4(6.3)		19(30.2)		3(4.8)	
Treatment #											
No	19	12(63.2)	0.003*	2(10.5)	0.3	0	0.02*	5(26.3)	0.9	0	0.4
Yes	124	34(27.4)		27(21.8)		27(21.8)		32(25.8)		4(3.2)	
Hospital admission	59	25(42.4)	0.003*	14(23.7)	0.3	4(6.8)	<0.001 *	15(25.4)	0.6	1(1.7)	0.2
Outpatient											
In patient	38	15(39.5)		9(23.7)		5(13.2)		9(23.7)		0	
≤ 2 days	46	6(13)		6(13)		18(39.1)		13(28.3)		3(6.5)	
>2 days											
Metastasis											
No	91	31(34.1)	0.5	16(17.6)	0.3	18(19.8)	0.7	24(26.4)	0.9	2(2.2)	0.6
Yes	52	15(28.8)		13(25)		9(17.3)		13(25)		2(3.8)	
Inserted device											
No	79	34(43)	0.002*	16(20.3)	0.9	6(7.6)	<0.001 *	22(27.8)	0.5	1(1.3)	0.3
Yes	64	12(18.8)		13(20.3)		21(32.8)		15(23.4)		3(4.7)	
Comorbidities											
No	75	27(36)	0.3	13(17.3)	0.4	16(21.3)	0.4	19(25.3)	0.9	0	0.05*
Yes	68	19(27.9)		16(23.5)		11(16.2)		18(26.5)		4(5.9)	

#: include chemotherapy, radiotherapy, surgical intervention, palliative. Others**: include gastrointestinal, CSF, and portacath .samples
*Significant

Figure 1. Antibiotics resistant profile of isolated Gram-negative bacteria

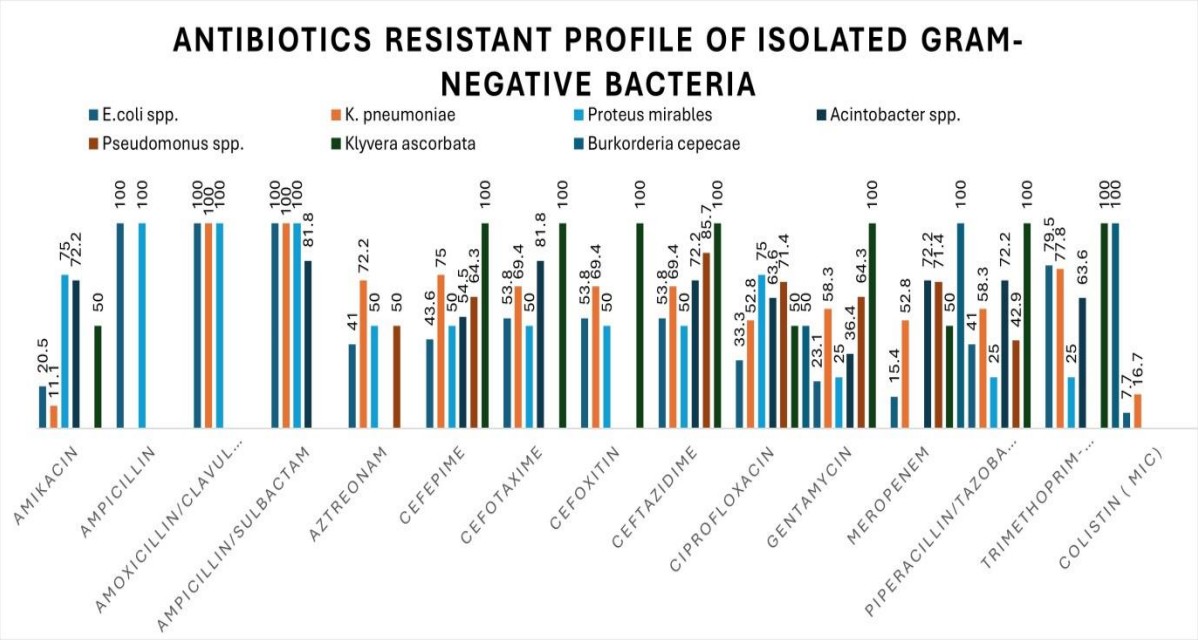


Figure 2. Antibiotics resistant profile of isolated Gram-positive bacteria.

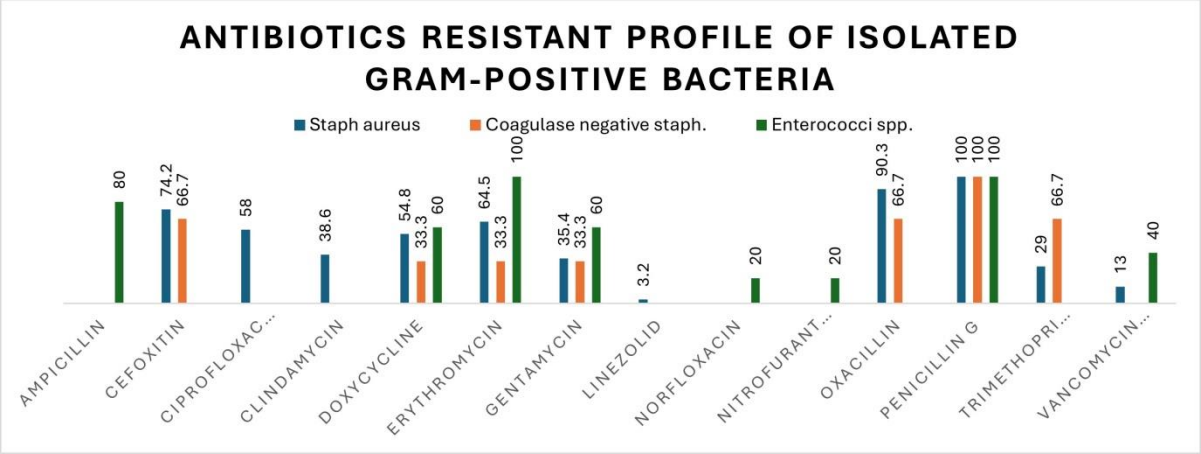
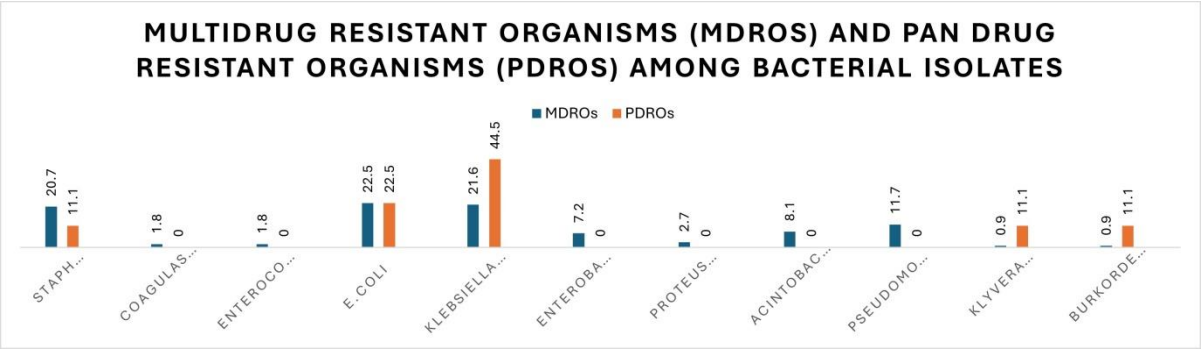


Figure 3 . Multidrug resistant organisms and pan drug resistant organisms among bacterial isolate



Discussion

Cancer increases the risk of getting a serious infection. Despite the advances in medical science in cancer treatment, infections are still a major cause of morbidity and mortality in cancer patients [6]. Many factors contributed to the increase of (MDROs in cancer patients, including neutropenia, inappropriate antibiotics usage, chemotherapy, metastasis and prolonged hospital stay [18].

In the current study, female patients were more predominant than males which aligns with **Jiang AM et al. 2020** study as females represented 54.5% of studied patients, but their average age was 59.6 ± 11.5 years [13].

Regarding the site of infections, urinary tract infections represented (32.2%), followed by bloodstream infections (25.8%) and respiratory tract infections (20.3%), which were consistent with **Jiang et al. 2020** and **Mohamed et al. 2023** in which urinary tract infections represented the leading cause of infection [13, 18]. In contrast, a study conducted by **Chathuranga et al. 2021** revealed that respiratory infections were the most frequent infections followed by urinary tract infections as in their study they selected patients with lower respiratory tract infections, skin infections and urinary tract infections unlike the present study where different samples were collected [20].

In the current study, urinary tract infection was statistically significant with patients not receiving cancer therapy, hospitalized patients and patients without inserted medical devices. In contrast to the study performed by **Tolani, 2020** which showed that the presence of an indwelling catheter in the urinary bladder was an independent predictor of urinary tract infection [21]. **Sime 2020** detected no relation between bacteriuria with demographic and clinical features of the cancer patients [22].

In addition, wound and surgical site infections were significantly correlated with the presence of solid tumors and cancer treatment, which is similar to **Fentie et al. 2018 and**

Varughese, 2018 who found an association between solid tumors with the use of antitumor regimens and the development of serious infections [23, 24]. In the present cohort, urine samples showed predominance of *Escherichia coli* (*E. coli)* (46.4%) followed by *Klebsiella pneumonia (K. pneumonia)* (14.8%). These findings are in line with **Mahmoud et al 2020, Chathuranga et al. 2021 and Mohamed et al. 2023** which showed that *E.coli* represented the majority of positive urine cultures [25,20,18].

Regarding bloodstream infections, *Staphylococcus aureus (Staph. aureus)* represented the most isolated organism (34%) in the present study. Similarly, **Worku et al. 2022** and **Mohamed et al. 2023** [26,18] documented the same finding. Regarding Gram-negative isolates from blood samples, *K. pneumonia* was the most prominent (27.8%). This does not coincide with a study conducted by **Tawfick et al. 2020** and **Merdad et al. 2023** which showed that the most common Gram-negative organism was *K. pneumonia* with (33.3 % and 58.5%) respectively [27,28]. In contrast, **Moghnieh et al. 2015 and Tang et al. 2021** stated that *E.coli* was the most isolated bacteria from blood cultures [29, 30].

Regarding candidemia, it represented (4.2%) of positive blood cultures. Lower percentage was detected by **Puerta-Alcalde et al. 2019** in which candida spp. isolated from (3.8%) of BSI isolates [31].

In this study, most of the positive respiratory samples' cultures were *K. pneumonia* which agrees with **Chathuranga et al. 2021 who** detected a higher incidence (42.4%) [20].

Aspergillus spp. was isolated from BAL samples and represented (3.7%) of respiratory samples which mainly met the clinical and radiological diagnostic criteria of invasive aspergillosis. This does not agree **Dandachi et al. 2018** study in which Invasive Pulmonary Aspergillosis (IPA) represented 10% [32].

Clostridum perfringens were isolated from cancer patients one from a blood sample and the other from a bed sore represent (1.1% from total isolates). On the contrary, a study by **Gudiol et al. 2013** detected 3 (0.005%) *Clostridum spp* were isolated from BSIs [33].This was mainly attributed to the differnce in the type and number of the samples.

In our study, all Gram-negative isolates were resistant to ampicillin and amoxicillin-clavulanic which is higher than the result by **Wang et al. 2023,** as they had colorectal cancer patients only for sample size [34]. Our study showed (92.3%) of *E.coli* were sensitive to colistin. This is nearly similar to **Amanati et al. 2021** study in which (82%) of the isolated *E. coli* were colistin sensitive [35].

In the current study, 52.8% of isolated *Klebsiella spp.* were resistant to meropenem, similar to **Chathuranga et al. 2021** and **Mohamed et al. 2023** who stated carbapenem resistance among *K. pneumoniae* exceeded (50%) [20,18]. On the other hand, **Amanati et al. 2021** detected that more than 80% of *K. pneumoniae* was sensitive to meropenem [35]. About (72.2%) of *Acinetobacter* isolates were sensitive to meropenem which is slightly less than the results of **Nazer et al. 2015** study which reported (88.2%) *Acinetobacter* isolates were carbapenem-resistant [36].

All *Pseudomonas* isolates were sensitive to colistin (100%) in the current study like the result of **Garg et al. 2019** and **Mohamed et al. 2023** studies [37,18]. In the present study (71.4%) of *Pseudomonas spp.* were resistant to ciprofloxacin. Unlike that reported by **Amanati et al. 2021** as more than 90% of *Pseudomonas spp.* were sensitive [35]. The regional variations of resistance to antibiotics may be explained by different local antibiotic practices. The influence of inappropriate antibiotic use on the event of antibiotic-resistant strains, especially broad-spectrum agents, has been proven through empirical observation [25].

The current study showed that all isolated Gram-positive cocci were resistant to penicillin (100%) whereas the least resistance rate was against linezolid as all *coagulase-negative Staphylococci spp.* (*CONS)* and *Enterococci spp*. strains were sensitive and 3.2% of *Staphylococcus aureus* were resistant to it. The result aligned with that by **Garg et al. 2019** and **Mohamed et al 2023** in which *Staphylococcus* spp. were sensitive to Linezolid and all strains were resistant to penicillin [18, 37].

The present study showed that about 59% of isolated Gram-positive was MRSA, meanwhile the study by **Puerta-Alcalde 2019** showed that MRSA strains only represented 13.8% [31].

Our study showed that Vancomycin-Resistant Enterococcus (VRE) represented 40% of isolated *Enterococci***,** which lies in the same line with **Joudeh et al. 2023** study which showed that 30% of the isolated Enterococcus were VRE [38].

From the total 111 MDROs, *E. coli spp., K. pneumoniae* and *Staphylococcus aureus* represented the majority of isolates with 22.5%, 21.6% and 20.7% respectively. However, a study by **Tawfick et al. 2020** showed higher frequencies of MDR isolates were recorded among *K. pneumoniae* and *E. coli* isolates with frequencies of 98.73% and 96.07%, respectively [27]. Adherence to infection control procedures are required to decrease incidence of MDROs, including surveillance, isolation, specific interventions, and antimicrobial stewardship [11].

This study was conducted at a single medical center. These results may not be representative to other health facilities, or other regions with different distributions of MDROs. Furthermore, the small sample size and absence of cancer patients less than 18 years were added more limitation to our study

Conclusion

This study highlights the prevalence of MDROs in different types of infection in cancer patients with the predominance of Gram-negative pathogens especially with prolonged hospitalization or with the usage of different medical devices, which attracted the attention on the importance of rapid microbiological diagnosis and proper antibiotic selection together with routine susceptibility testing for empirical treatments and monitoring MDROs prevalence in oncology settings to improve the outcome in these immunocompromised patients. Further multicentered studies on a large scale of patients are also recommended.

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None.

Conflict of interest

The authors affirm that they have no conflicts of interest.

References

1- **Gong L, Huang D, Shi Y, Liang ZA, Bu H.** Regulated cell death in cancer: from pathogenesis to treatment. Chinese Medical Journal. 2023 Mar 20;136(06):653-65.

2- **Bray F, Laversanne M, Sung H, Ferlay J, Siegel RL, Soerjomataram I, et al.** Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA: a cancer journal for clinicians. 2024 May;74(3):229-63.

3- **Alorabi M, Elghazawy H, Alorabi M, Elghazawy H.** Cancer control in Egypt: Investing in health. The ASCO Post. 2021.

4- **Bhat S, Muthunatarajan S, Mulki SS, Archana Bhat K, Kotian KH.** Bacterial infection among cancer patients: analysis of isolates and antibiotic sensitivity pattern. International journal of microbiology. 2021;2021(1):8883700.

5- **Zheng Y, Chen Y, Yu K, Yang Y, Wang X, Yang X, et al.** Fatal infections among cancer patients: a population-based study in the United States. Infectious diseases and therapy. 2021 Jun;10:871-95.

6- **Zembower TR.** Epidemiology of infections in cancer patients. Infectious complications in cancer patients. 2014:43-89.

7- **Yamamoto Y, Itoh N, Sugiyama T, Kurai H.** Clinical features of Clostridium bacteremia in cancer patients: A case series review. Journal of Infection and Chemotherapy. 2020;26(1):92-4.

8- **Ruhnke M, Behre G, Buchheidt D, Christopeit M, Hamprecht A, Heinz W, et al**. Diagnosis of invasive fungal diseases in haematology and oncology: 2018 update of the recommendations of the infectious diseases working party of the German society for hematology and medical oncology (AGIHO). Mycoses. 2018;61(11):796-813.

9- **Kamboj M, Sepkowitz KA.** Nosocomial infections in patients with cancer. The lancet oncology. 2009;10(6):589-97.

10- **Kumar P, Medhekar A, Ghadyalpatil N, Noronha V, Biswas S, Kurkure P, et al.** The effect of age on the bacteria isolated and the antibiotic-sensitivity pattern in infections

among cancer patients. Indian Journal of Cancer. 2010;47(4):391-6.

11- **Park K-H, Jung YJ, Lee HJ, Kim HJ, Maeng CH, Baek SK, et al.** Impact of multidrug resistance on outcomes in hematologic cancer patients with bacterial bloodstream infections. Scientific Reports. 2024;14(1):15622.

12- **Mohamed N, Ghazal A, Ahmed AAH, Zaki A.** Prevalence and Determinants of Antimicrobials Resistance of Pathogens Among Cancer Patients in Intensive Care Units. 2022.

13- **Jiang A-M, Shi X, Liu N, Gao H, Ren M-D, Zheng X-Q, et al.** Nosocomial infections due to multidrug-resistant bacteria in cancer patients: a six-year retrospective study of an oncology Center in Western China. BMC infectious diseases. 2020;20:1-12.

14- **Cheesbrough M.** District laboratory practice in tropical countries, part 2. Cambridge university press; 2006 Mar 2.

15- **Saher L, Afzal M, Ansari HQF.** Comparative study of manual conventional blood cultures versus automated blood culture system in cases of septicemia. Ind J Microbiol Res. 2021;8:327-32.

16- **Zhang Q, Yan W, Zhu Y, Jing N, Wang S, Yuan Y, et al.** Evaluation of commercial products for colistin and polymyxin B susceptibility testing for mcr-positive and negative Escherichia coli and Klebsiella pneumoniae in China. Infection and Drug Resistance. 2023:1171-81.

17- **CLSI.** Performance Standards for Antimicrobial Susceptibility Testing, 33rd Edition. CLSI supplement M100. Clinical and Laboratory Standards Institute 2023, Wayne, PA.2023.

18- **Mohamed N, Ghazal A, Ahmed AAH, Zaki A.** Prevalence and determinants of antimicrobial resistance of pathogens isolated from cancer patients in an intensive care unit in Alexandria, Egypt. Journal of the Egyptian Public Health Association. 2023;98(1):9.

19- **Magiorakos A-P, Srinivasan A, Carey RB, Carmeli Y, Falagas M, Giske C, et al.** Multidrug-resistant, extensively drug-resistant and pandrug-resistant bacteria: an international expert proposal for interim standard definitions for acquired resistance. Clinical microbiology and infection. 2012;18(3):268-81.

20- **Chathuranga G, Dissanayake T, Fernando N, Wanigatunge C.** Appropriateness of the empirical antibiotics prescribed and their concordance with national guidelines for three selected infections among cancer patients in a tertiary care centre in Sri Lanka. International Journal of Microbiology. 2021;2021(1):7572215.

21- **Tolani MA, Suleiman A, Awaisu M, Abdulaziz MM, Lawal AT, Bello A.** Acute urinary tract infection in patients with underlying benign prostatic hyperplasia and prostate cancer. Pan African Medical Journal. 2020;36(1).

22- **Sime WT, Biazin H, Zeleke TA, Desalegn Z.** Urinary tract infection in cancer patients and antimicrobial susceptibility of isolates in Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia. PLoS One. 2020;15(12):e0243474.

23- **Fentie A, Wondimeneh Y, Balcha A, Amsalu A, Adankie BT**. Bacterial profile, antibiotic resistance pattern and associated factors among cancer patients at University of Gondar Hospital, Northwest Ethiopia. Infection and drug resistance. 2018:2169-78.

24- **Varughese T, Taur Y, Cohen N, Palomba ML, Seo SK, Hohl TM, et al.** Serious

infections in patients receiving ibrutinib for treatment of lymphoid cancer. Clinical Infectious Diseases. 2018;67(5):687-92.

25- **Mahmoud AT, Salim MT, Ibrahem RA, Gabr A, Halby HM.** Multiple drug resistance patterns in various phylogenetic groups of hospital-acquired uropathogenic E. coli isolated from cancer patients. Antibiotics. 2020;9(3):108.

26- **Worku M, Belay G, Tigabu A**. Bacterial profile and antimicrobial susceptibility patterns in cancer patients. PLoS One. 2022;17(4):e0266919.

27- **Tawfick MM, Alshareef WA, Bendary HA, Elmahalawy H, Abdulall AK.** The emergence of carbapenemase bla NDM genotype among carbapenem-resistant Enterobacteriaceae isolates from Egyptian cancer patients. European Journal of Clinical Microbiology & Infectious Diseases. 2020;39:1251-9.

28- **Merdad R, Alyami A, Basalim A, Alzahrani A, Aldainiy A, Awadh A, et al.** Bloodstream gram-negative bacterial infections in adult patients with leukemia: A retrospective review of medical records in a tertiary care hospital in Western Saudi Arabia. Journal of Infection and Public Health. 2023;16(10):1525-30.

29- **Moghnieh R, Estaitieh N, Mugharbil A, Jisr T, Abdallah DI, Ziade F, et al.** Third generation cephalosporin resistant Enterobacteriaceae and multidrug resistant gram-negative bacteria causing bacteremia in febrile neutropenia adult cancer patients in Lebanon, broad spectrum antibiotics use as a major risk factor, and correlation with poor prognosis. Frontiers in cellular and infection microbiology. 2015;5:11.

30- **Tang Y, Xu C, Xiao H, Wang L, Cheng Q, Li X.** Gram-negative bacteria bloodstream infections in patients with hematological malignancies–the impact of pathogen type and patterns of antibiotic resistance: a Retrospective Cohort Study. Infection and Drug Resistance. 2021:3115-24.

31- **Puerta-Alcalde P, Cardozo C, Suárez-Lledó M, Rodríguez-Núñez O, Morata L, Fehér C, et al.** Current time-to-positivity of blood cultures in febrile neutropenia: a tool to be used in stewardship de-escalation strategies. Clinical microbiology and infection. 2019;25(4):447-53.

32- **Dandachi D, Wilson Dib R, Fernández-Cruz A, Jiang Y, Chaftari A-M, Hachem R, et al.** Invasive pulmonary aspergillosis in patients with solid tumours: risk factors and predictors of clinical outcomes. Annals of medicine. 2018;50(8):713-20.

33- **Gudiol C, Bodro M, Simonetti A, Tubau F, González-Barca E, Cisnal M, et al.** Changing aetiology, clinical features, antimicrobial resistance, and outcomes of bloodstream infection in neutropenic cancer patients. Clinical Microbiology and Infection. 2013;19(5):474-9.

34- **Wang X-t, Lan T-t, Chang X-w, Yang X-f.** Distribution of pathogenic bacteria and analysis of infection risk factors in surgical site infections of colorectal cancer patients. 2023:1214-1217.

35- **Amanati A, Sajedianfard S, Khajeh S, Ghasempour S, Mehrangiz S, Nematolahi S, et al.** Bloodstream infections in adult patients with malignancy, epidemiology, microbiology, and risk factors associated with mortality and multi-drug resistance. BMC infectious diseases. 2021;21:1-14.

36- **Nazer LH, Kharabsheh A, Rimawi D, Mubarak S, Hawari F.** Characteristics and outcomes of Acinetobacter baumannii

infections in critically ill patients with cancer: a matched case–control study. Microbial Drug Resistance. 2015;21(5):556-61.

37- **Garg VK, Mishra S, Gupta N, Garg R, Sachidanand B, Vinod K, et al.** Microbial and antibiotic susceptibility profile among isolates of clinical samples of cancer patients admitted in the intensive care unit at regional tertiary care cancer center: a retrospective observational study. Indian journal of critical care medicine: peer-reviewed, official publication of Indian Society of Critical Care Medicine. 2019;23(2):67.

38- **Joudeh N, Sawafta E, Abu Taha A, Hamed Allah M, Amer R, Odeh RY, et al.** Epidemiology and source of infection in cancer patients with febrile neutropenia: an experience from a developing country. BMC Infectious Diseases. 2023;23(1):106.

BastwesyAR, Ghoname NF, Sabry NM, Mohamed EA. Common bacterial and fungal infections as a challenging condition in cancer patients : Single centre based study. Microbes Infect Dis 2025; 6(2): 603-614.