Original Article

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Microbiology Section

Microbiological Profile and Antibiotic Resistance of Bloodstream Infections among Cancer Patients at a Tertiary Care Cancer Centre in North Kerala, India

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ABSTRACT

Introduction: Bacterial infections, especially Bloodstream Infections (BSI) are among the most frequent complications in immunosuppressed patients with cancer, and are associated with considerable morbidity and mortality and high economic costs. Patients with chemotherapy induced neutropenia, especially haematological patients with malignancies in whom the neutropenia is often profound and prolonged, and those undergoing Haematopoietic Stem Cell Transplantation (HSCT) are at higher risk for BSI.

Aim: To analyse the microbiological profile of Bloodstream Infections and their antibiotic resistance pattern among the clinically diagnosed cases of sepsis in cancer patients.

Materials and Methods: This retrospective study was conducted at a Microbiology Division, Department of Clinical Laboratory Services and Translational Research, Malabar Cancer Centre, Kannur, Kerala, India during the period from July 2020 to December 2020. Data of January 2016 to December 2017 on all microbial cultures from blood samples were analysed. All blood cultures during the study period were processed by Bactec 9050 Blood Culture System (Becton Dickinson Microbiology Systems, Sparks, MD, USA. After performing culture, bacterial identification and susceptibility was done by using automated culture system (VITEK 2 Compact system). Simple descriptive analysis of data was done and results presented in frequencies and percentages.

Results: Total 385 (9.2%) were identified to be culture positive from 4154 blood cultures screened. Out of 385 positive cultures, 354 (92%) showed bacterial growth, gram negative were 245 (64%) and gram positive were 109 (28.3%) and fungal species were 31 (8%). Among the Gram negative bacteria (GNB), *Klebsiella pneumoniae* was found to be the most frequent species (n=83), followed by *Escherichia coli* (n=75). In gram positive bacteria, Coagulase-negative Staphylococci (CoNS) were the most common species (n=48). High prevalence of antimicrobial resistance was observed among *E.coli, K.pneumoniae, Acinetobacter baumannii*. Among the 48 isolates of CoNS and 26 isolates of *S.aureus* in which 30 (62.5%) isolates and 14 (54%) isolates respectively were found to be methicillin resistant.

Conclusion: A proper antimicrobial stewardship should be followed in all healthcare centres especially cancer treating hospitals as the patients are immunocompromised. This current study on regular reporting of antibiogram with clinical guidelines will help in judicious use of antibiotics, as drug resistance is on the rise globally.

Keywords: Antibiotic susceptibility, Bacterial infection, Bloodstream infections, Malignancy

INTRODUCTION

According to the World Health Organisation (WHO) World Cancer Study 2014, cancer is the leading cause of mortality and morbidity worldwide, with nearly 14 million new diagnoses and 8.2 million cancer-related deaths in 2012. The number of new cases is projected to increase by 70% over the next two decades [1]. Bacterial infections, especially Bloodstream Infections (BSI), are among the most common complications in immunocompromised cancer patients. Their prolonged hospital stays, are associated with significant morbidity and mortality, and raises the cost of patient care [2-4]. The most significant risk factors for infection in cancer patients have been identified as frequent hospitalisations, exposure to invasive procedures, use of broad spectrum antibiotics, and chemotherapy. Chemotherapy causes neutropenia in cancer patients, making them more vulnerable to potentially fatal BSI [5-8].

In cancer patients, the crude mortality rate due to BSI varies from 18% to 42% [8]. Gram positive to gram negative bacteremia has become more common in recent years, according to studies on the epidemiology of BSI [9-11]. Antimicrobial resistance in Gram negative bacteria (GNB) is on the rise and spreading [e.g. cephalosporin- and/or carbapenem-resistant *Enterobacteriaceae*, colistin resistant *Klebsiella pneumoniae*, and Multi-Drug Resistant (MDR) *Pseudomonas aeruginosa*] [2,12].

Among gram positives, Methicillin-resistant *Staphylococcus aureus* (MRSA), Methicillin-resistant coagulase-negative staphylococci (MRCoNS) and vancomycin-resistant enterococci (VRE) are also worrying [13,14]. CoNS have progressed from common contaminants to nosocomial BSI agents in recent years. Invasive fungal infections are often caused by fungal pathogens such as yeasts (mostly *Candida sp.*, *Trichosporon asahii*, and others) [6,15,16].

The Hospital Infection Control (HIC) team monitors BSI rates on a regular basis, which helps them to evaluate antimicrobial treatment methods and their effectiveness in reducing nosocomial infections. The microbiological spectrum and antimicrobial susceptibility of pathogens causing BSI in patients with cancer vary widely between geographic regions [16,17]. In Southern India, epidemiological data on pathogens that cause BSI in cancer patients is scarce and the present study was the continuation of author's previous study [6,18]. As a result, the current research was conducted in a tertiary care cancer centre to analyse the microbiological profile and antibiotic resistance pattern of pathogens that cause BSI from various cancer patients.

MATERIALS AND METHODS

This retrospective study was conducted at a Microbiology Division, Department of Clinical Laboratory Services and Translational Research, Malabar Cancer Centre, Kannur, Kerala, India during the period from July 2020 to December 2020. Data was collected from January 2016 to December 2017 on all microbial cultures from blood samples were analysed. This study was approved by Institutional Review Board (IRB) (1616/IRB-SRC/13/MCC/23-1-2018/8).

Inclusion criteria: Patients who had BSI according to the diagnostic or clinical criteria confirmed by clinical signs and symptoms and pathogenic bacteriological examination were included.

Exclusion criteria: Patients who had multiple hospitalisations and repeated BSI during the study were excluded.

Laboratory Assessment Method for Positive Blood Cultures

Microbial and its antibiotic resistant profile of the blood culture samples were retrieved from the microbiology laboratory data register. For patients with suspected sepsis, local guidelines recommended the inoculation of 1-3 mL (for paediatric patients) and 8-10 mL (for adults) directly into Bactec culture vials and loaded in Bactec 9050 Blood Culture System (Becton Dickinson Microbiology Systems, Sparks, MD, USA) according to manufacturer's instructions. When bacterial growth was detected in blood culture vials, it was removed from the blood culture machine and immediately gram stain was performed.

Based on gram stain results, the positive blood cultures were immediately inoculated into appropriate sterile culture-media namely blood agar, MacConkey agar, chocolate agar and Sabouraud Dextrose Agar (SDA). Two sets of SDA were inoculated for each sample, one incubated at 37°C and the other at room temperature. Authors incubated bacterial cultures aerobically at 37°C for upto 24-48 hours and the SDA for 2 weeks. The chocolate agar plates were incubated in 5% to 10% carbon dioxide for the growth of fastidious microorganisms.

Bacterial identification and Antibiotic susceptibility testing: The colony characteristics of the bacteria were observed manually from the grown culture plate. These colonies were taken from the plate and suspension was made and compared with the MacFarland standard before inoculating into the identification panel kits. Bacterial identification and susceptibility was performed by using BD PhoenixTM (Becton Dickinson) instrument from January 2016 to October 2017 and thereafter by using VITEK 2 Compact system (Biomerieux, France).

The bacterial suspensions were added to the respective gram positive and gram negative panel kits and loaded into the automated bacterial identification system for organism identification and antibiotic susceptibility testing. Post evaluation of all positive blood cultures were analysed in the laboratory to categorise isolates as contaminants or true pathogens. Patients with significant bacteremia due to CoNS were included in this study. Significant bacteremia due to CoNS is defined as the isolation of the same CoNS species from 2 or more blood culture samples within a 5-day period was considered significant. In cases where only one blood sample were available, in addition to the positive blood culture, the presence of atleast two clinical parameters constituted significance. The clinical parameters included were: body temperature >38°C or <36°C, systolic blood pressure of <90 mmHg, total leucocyte count of >12,000/µL or <2000/µL and presence of >10% immature neutrophil granulocytes [19].

An organism was considered resistant, if it showed resistance to the institution's empiric antibiotic regimen for the patients. Organisms like Micrococcus species, Bacillus species and Diphtheroids were classified as contaminants. *S. aureus* ATCC 25923, *E. coli* ATCC 25922 and *Pseudomonas aeruginosa (P.aeruginosa)* ATCC 27853 were used as controls.

STATISTICAL ANALYSIS

The organisms isolated and antibiotic sensitivity patterns were analysed using WHONET 5.6 software (World Health Organisation Collaborating Centre for Surveillance of Antimicrobial Resistance). Categorical variables were represented as frequency and percentages.

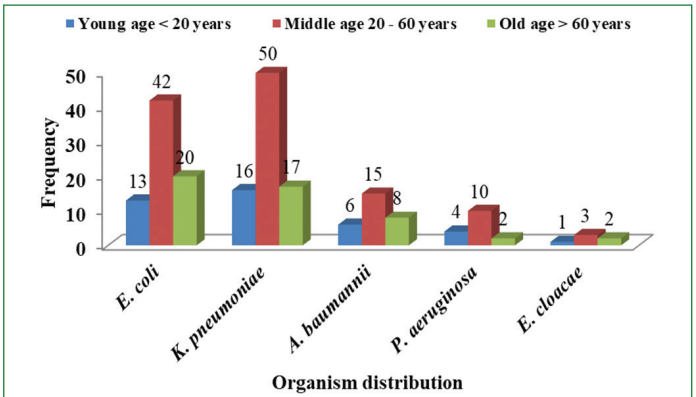
RESULTS

During the study period, a total of 4154 blood cultures were analysed with young age group less than 20 years (n=416), middle aged 20-60 years (n=2695) and old aged more than 60 years (n=1043). Gender wise distribution of blood culture positivity rate was found to be higher in male (n=212) when compared to female (n=173). Culture positivity was seen in 385 (9.2%) samples with young age group less than 20 years in 79 (20.5%) patients, middle age 20-60 years in 260 (67.5%) and old age more than 60 years in 46 (11.9%) patients, respectively [Table/Fig-1].

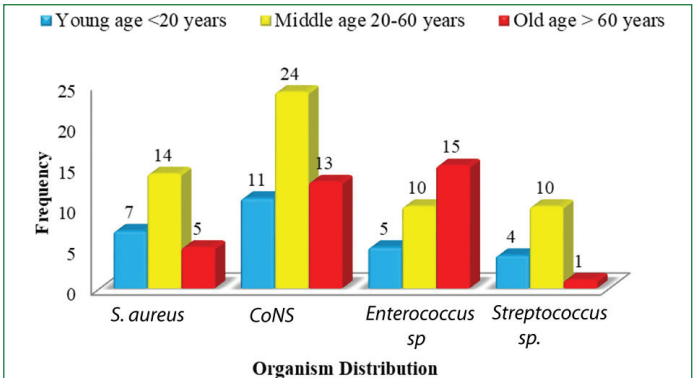
Age group (in years)	Patients tested	Number of patients with BSI		
	n	n (%)	Male	Female
Young age (<20)	416	79 (19)	47	32
Middle age (20-60)	2695	260 (10)	136	124
Old age (>60)	1043	46 (4.4)	29	17
Total	4154	385 (9.2)	212	173

[Table/Fig-1]: Descriptive data of bloodstream infection among cancer patients (n=385).

Gram negative bacilli isolates (n=120) was seen more in 20-60 age group and also higher number of Gram Positive Bacteria (GPB) isolates (n=58) was observed among the 20-60 age group [Table/Fig-2,3]. Contaminants like Micrococcus species, Bacillus species and Diphtheroids were grown in 135 (3.2%) blood cultures and there was no microbial growth in 3634 (87.5%) blood culture samples. Among 385 positive cultures, 354 (92%) showed bacterial growth, which 245 (63.6%) were GNB, 109 (28.3%) were GPB and 31 (8%) were fungal organisms. The overall distribution of microbial pathogens causing BSI illustrated in [Table/Fig-4].



[Table/Fig-2]: Distribution of predominant Gram Negative Bacterial (GNB) pathogens among the three age groups.



[Table/Fig-3]: Distribution of predominant Gram Positive Bacterial (GPB) pathogens among the three age groups.
CoNS: Coagulase-negative Staphylococci

Overall distribution of isolated microorganisms	n (%)
Bacterial isolates	354 (92)
Gram positive bacteria	109 (28.3)
S. aureus	26 (23.9)
Coagulase-negative Staphylococci	48 (44)
Enterococcus sp.	20 (18.3)
Streptococcus sp.	15 (13.8)
Gram negative bacteria	245 (63.6)
Fermentative gram negative bacilli	
Escherichia coli	75 (30.6)
Klebsiella pneumoniae	83 (34)
Enterobacter sp.	8 (3.2)
Rare bacterial isolates*	9 (3.6)
Total	175
Non-fermentative gram-negative bacilli	
Acinetobacter baumannii	29 (12)
Pseudomonas aeruginosa	16 (6.5)
Burkholderia cepacia complex	5 (2.0)
Stenotrophomonas maltophila	4 (1.6)
Rare bacterial isolates*	16 (6.5)
Total	70
Fungi	
Candida albicans	5 (16.1)
Non C. albicans	17 (54.8)
Trichosporon asahii	6 (19.4)
Cryptococcus neoformans	3 (9.7)
Total	31

[Table/Fig-4]: Distribution of bacterial and fungal pathogens causing BSI (n=385).
**E. meningoseptica, S. plymuthica, S. multivorum, S. paucimobilis, S. maltophila, B. gladioli, C. farmerii, P. agglomerans*

Blood culture isolates of both GNB and GPB were observed high among the leukaemic cancer patients followed by patients with lymphoma [Table/Fig-5]. Among the GNB, *K. pneumoniae* was found to be the most frequent species (n=83). There were also fungal pathogens isolated (n=31), in which *Candida* species (n=22) was the predominant species.

Polymicrobial infections were found in ten samples (2.6%) namely, *K. pneumoniae+Enterococcus sp.*, *K. pneumoniae+Enterococcus sp., K. pneumoniae+E. coli+Enterococcus sp., K. pneumoniae+E. coli, K. pneumoniae+CoNS, K. pneumoniae+E. coli, A. baumannii+CoNS, A. baumannii+Enterococcus sp., P. aeruginosa+Streptococcus sp.* and *E. coli+Streptococcus sp.* Polymicrobial bacteraemia is defined as the isolation of more than one microorganism during a single bacteraemic episode.

K. pneumoniae isolated from all the age groups was found to be MDR. Much resistance was observed in piperacillin-tazobactum (86%), ciprofloxacin (83%) and cefepime (83%). *E. coli* showed resistance for fluoroquinolones (79%), cephalosporins (69%) and high susceptibility was observed in amikacin (91%), meropenem (92%).

K. pneumoniae had carbapenem resistance rate of (65%) followed by *A. baumannii* (48%) and *P. aeruginosa* (12%) in all the age groups analysed. Similarly, 25% and 17% of *K. pneumoniae* and *A. baumannii* were found to be resistant for colistin. *E. coli* and *P. aeruginosa* isolates were found be susceptible to colistin [Table/Fig-6].

The resistant rates to methicillin were, 14 (54%) and 30 (62.5%) isolates of *S. aureus* and CoNS, respectively [Table/Fig-7]. Four (15%) and eight (17%) isolates of *S. aureus* and CoNS were inducible clindamycin resistance (iMLSB) [Table/Fig-8]. Six isolates (*S. aureus*- 3; CoNS- 3) were resistant to linezolid. All the *Staphylococci*, *Enterococcus* species and *Streptococcus* species isolates were found to be vancomycin and teicoplanin susceptible.

DISCUSSION

Bloodstream Infections (BSI) are an important cause of morbidity and mortality in cancer patients. In this retrospective analysis, 354 (92%) of the samples tested positive for bacterial growth. The most common species isolated in this study were *K. pneumoniae* (n=83) in GNB and CoNS (n=48) in GPB. When compared to the geriatric age group, middle age groups 20 years to 60 years were found to be positive for blood cultures, which was consistent with the pan India research report in which positive blood cultures were more observed in middle age group [20]. The prevalence, incidence, and general trends of

Type of cancer	*K. pneumoniae* n=83	*E. coli* n=75	*A. baumannii* n=29	*P. aeruginosa* n=16	*S. aureus* n=26	Coagulase-negative staphylococci n=48	*Enterococcus* sp. n=20	*Streptococcus* sp. n=15
Leukaemia (n=86)	23	20	8	3	7	14	5	6
Lymphoma (n=49)	14	16	3	1	3	8	2	2
Genitourinary cancer (n=34)	8	6	3	2	3	5	6	1
Colorectal cancer (n=32)	9	5	4	1	4	4	4	1
Head and neck cancer (n=20)	5	5	1	2	0	2	2	3
Sarcoma (n=12)	3	5	1	2	0	0	1	0
Breast cancer (n=40)	9	11	2	3	8	7	0	0
Gastric cancer (n=15)	4	2	3	0	1	3	0	2
Lung cancer (n=7)	3	2	1	0	0	1	0	0
Pancreatic cancer (n=2)	2	0	0	0	0	0	0	0
Thyroid cancer (n=7)	3	1	2	0	0	1	0	0
Others (n=6)*	0	0	1	2	0	3	0	0

[Table/Fig-5]: Microbial pathogens isolated in different cancer patients with sepsis.
*Skin cancer (n=3), Bone cancer (n=2), Retinoblastoma (n=1).

Organisms	Antibiotics (% resistant isolates) n (%)								
	AMC	AK	CPM	CIP	COLISTIN	IPM	LEV	MRP	PIT
E. coli (n=75)	49 (65)	7 (9)	52 (69)	58 (77)	0	4 (5)	59 (79)	6 (8)	35 (47)
K. pneumoniae (n=83)	66 (79)	55 (66)	69 (83)	69 (83)	21 (25)	54 (65)	67 (81)	54 (65)	71 (86)
A. baumannii (n=29)	---	11 (38)	14 (48)	15 (52)	5 (17)	14 (48)	13 (45)	14 (48)	15 (52)
P. aeruginosa (n=16)	---	2 (12)	1 (6)	10 (62)	0	2 (12)	10 (62)	2 (12)	6 (37)

[Table/Fig-6]: Antimicrobial resistance rate of predominant Gram negative isolates among cancer patients (n=245).
AMC: Amoxicillin-clavulanic acid; AK: Amikacin; CPM: Cefepime; CIP: Ciprofloxacin; IPM: Imipenem; LEV: Levofloxacin; MRP: Meropenem; PIT: Piperacillin-tazobactum

Organisms	Antibiotics (% resistant isolates)									
	FOX	CLI	COT	ERY	GEN	GEN (HIGH-LEVEL)	LEV	LIN	RIF	TET
S. aureus (n=26)	14 (54)	7 (27)	15 (58)	19 (73)	12 (46)	---	12 (46)	3 (11)		7 (27)
Coagulase-negative Staphylococci (n=48)	30 (62)	15 (31)	30 (62)	29 (60)	28 (58)	---	19 (40)	3 (6)	6 (12)	12 (25)
Enteroc-occus species (n=20)	---	9 (45)	10 (50)	8 (40)	---	12 (60)	11 (55)	---	---	8 (40)

[Table/Fig-7]: Antimicrobial resistance rate of predominant Gram positive isolates among cancer patients (n=109).
FOX: Cefoxitin, CLI: Clindamycin; COT: Cotrimoxazole, ERY: Erythromycin; GEN: Gentamicin; LEV: Levofloxacin; LIN: Linezolid; RIF: Rifampicin; TET: Tetracycline; VAN: Vancomycin

Gram positive bacteria	iMLSB n (%)	cMLSB n (%)
S. aureus (n=26)	4 (15)	3 (11)
Coagulase negative *staphylococci* (n=48)	8 (17)	5 (10)

[Table/Fig-8]: Prevalence of inducible and constitutive clindamycin resistance among *S.aureus* and CoNS, respectively.

microbial aetiology of BSI among cancer patients are influenced by a variety of factors. Being neutropenic is an independent risk factor for BSI. Neutrophils are the first line of defence against invading microbes, especially bacterial pathogens. The most dangerous haematological toxicity is a reduction in their number (neutropenia), which is often seen in cancer patients undergoing chemotherapy. Present study also revealed that leukaemic patients had the highest number of bacterial isolates [10]. When analysed for the antibiotic sensitivity pattern of the microbial isolates, much of resistance was seen in *K. pneumoniae* followed by *E. coli* in gram negative isolates. Similarly in gram positive isolates, 54% were found to be MRSA and 62.5% were MR CoNS.

Since the emergence of drug resistant bacteria to multiple antibiotics in the cancer population leads to treatment delays, hospital expenses due to extended stays, and mortality, routine monitoring for MDR pathogens is critical in the hospital setting.

The present study findings were consistent with previous studies conducted throughout the world which has clearly mentioned that GNB were the most predominant organisms namely *K. pneumoniae*, *E. coli* in the BSI [6,12,16,17]. *K. pneumoniae* (n=83) was the most common species among GNB, followed by *E. coli* (n=75) and *A. baumannii* (n=29), which was consistent with previous study [21]. Among GPB, CoNS (n=48) was the predominant bacteria followed by *S. aureus* (n=26) and *Enterococcus species* (n=20). In the current study, Polymicrobial BSI (PBSI) was found to be 2.6% (n=10). Study conducted by Santoro A et al., reported 9% of PBSI which is not consistent with the current study, the reason being large sample size [22]. Clinical presentation, microbiology and outcomes can vary in infections caused by single pathogen compared to PBSI caused by multiple organisms. The accessible literatures regarding such PBSI are very limited. Also, the lack of consistent PBSI definitions and the heterogeneity of populations in the earlier studies makes it very difficult to understand the true relevance of PBSI [22,23].

Owing to patient and procedure related improvements, CoNS is now one of the most common nosocomial pathogens, with *Staphylococcus haemolyticus* and *Staphylococcus epidermidis* being the most common species [24]. CoNS are particularly associated with the indwelling or implanted foreign bodies, which are indispensable in modern medicine. The higher prevalence of the CoNS in this study may be attributed to BSI caused by foreign bodies. Catheter-related BSI (CRBSI) account for the majority of Foreign Body Related BSI. Various studies have demonstrated that CoNS adheres to the catheter surface and produces slime, which are risk factors for BSI [8,24,25]. Yeasts (mostly *Candida* sp.) are the main causes of invasive fungal infection (8%) which was in agreement with other study [10].

There are also growing concerns about BSI due to Methicillin-Resistant Staphylococci (MRS) as they are resistant to commonly used antibiotics. High incidence of 14 (54%) and 30 (62.5%) isolates were found to be MRSA and MRCoNS respectively in our study. The prevalence of MRSA is high as compared to previous study reports which reported 15% and 32%, respectively [6,19]. Further, *Enterococcus species* isolated in the present study was comparatively few but majority of the isolates were MDR. Clindamycin is a member of the Macrolide-Lincosamide Streptogramin B (MLSB) family of antibiotics that can be used to treat both methicillin-resistant and susceptible staphylococci.

As compared to the previous study, the overall prevalence of cMLSB {(11%), (10 %)} and iMLSB {(15%), (17%)} among *S. aureus* and CoNS was found to be very low in our study [26]. Clindamycin resistance in the form of iMLSB and cMLSB limits the therapeutic options for MRS to the antibiotics like linezolid and vancomycin. In the current study, among gram positive organisms, six isolates (*S. aureus*-3; CoNS-3) were found to be linezolid resistant. The ease of oral administration of linezolid can be easily exploited in clinical practice, especially its use in treating staphylococcal infection in the community settings. So, there is a need to emphasise the rational antibiotic use and keep linezolid as a reserve. All GPB were 100% sensitive to vancomycin and teicoplanin.

The high prevalence of MRS and few clindamycin and linezolid resistant isolates in our study, emphasises the urge to improve our healthcare practices and to formulate new policy for the control of MRS infections.

Gram Negative Bacteria (GNB) with MDR, especially carbapenem resistance, has become a major public health concern in recent years. The high prevalence of antimicrobial resistance in gram negative isolates, especially MDR *K. pneumoniae* in all three age groups, is concerning in this study. Resistance to β-lactam antibiotics in GNB is often linked to the development of hydrolytic enzymes, such as Extended Spectrum Lactamases (ESBLs), class C cephalosporinase (AmpC), and carbapenemases (including Metallo-beta-lactamases). In this study, high levels of cephalosporin (69%) and carbapenem resistance were found (65%), which is higher than the previous reports [2,17,27,28]. With the exception of colistin, Babu KG et al., found that amikacin and ciprofloxacin had higher overall activity against gram negative isolates than most other antibiotics in South India [6].

Amikacin was found to be effective against more than 80% of *E. coli*, *P. aeruginosa*, and 38% of *A. baumannii* isolates in the current study. The highest resistance was noted in the *K. pneumoniae* (66%) in all the three age groups. Furthermore, ciprofloxacin resistance was found in 70% of GNB isolates.

Another cause for concern around the world is the high resistance rate of GNB to fluoroquinolones (ciprofloxacin and levofloxacin). This high resistance to fluroquinolones in India has also been seen in a large community-based WHO surveillance project [29]. Currently, Infectious Diseases Society of America (IDSA) recommends that fluoroquinolones be used as prophylaxis against bacterial infections in cancer patients [30]. Given India's high level of quinolone resistance, the efficacy of such a prophylactic regimen must be challenged.

According to recent reports from India, 100% of isolates were susceptible to colistin in one study [8], while (5.7%) of isolates were found to be resistant to colistin in another study [2]. The present study data on isolates and their antibiotic resistance is compared with various recent studies conducted in India [Table/Fig-9] [8,16,21,31,32]. Our current research finds a substantial increase in colistin resistance among MDR, *K. pneumoniae* (25%) and *A. baumannii* (17%) isolates, which a major concern is given

the restricted treatment options for gram negative infections. As a result, there is an increasing need for novel antibiotics to combat MDR GNB [2,27].

Various studies/ year	Place	Microbiological profile	Antibiotic resistance in percentage
Singhal T et al., 2016 [16]	Mumbai, India	*E. coli* and *Klebsiella spp.*	Aminoglycosides- 14% β-lactam/β-lactamase inhibitor combinations- 43.5% carbapenems- 30%
Rani DR et al., 2017 [8]	Hyderabad, India	*E. coli* and *Klebsiella spp.*	Aminoglycosides- 14% β-lactam/β-lactamase inhibitor combinations- 45% carbapenems- 39%
Kokkayil P et al., 2018 [21]	New Delhi, India	*K. pneumoniae* and *Enterobacter*	Aminoglycosides- 49% β-lactam/β-lactamase inhibitor combinations- 61% carbapenems- 46%
Paul M et al., 2020 [31]	Uttarakhand, India	Klebsiella spp., *E. coli*, and *Acinetobacter spp.*	Aminoglycosides- 26.6 to 91.7% β-lactam/β-lactamase inhibitor combinations- 8.3% to 86.6% and carbapenems 8.3 to 73.3%
Ghosh S et al., 2021 [32]	Kolkata, India	CoNS, Klebsiella spp and *Pseudomonas*	Aminoglycosides- 66% β-lactam/β-lactamase inhibitor combinations- 85% carbapenems- 72%
Present study	Kerala, India	*K. pneumoniae*, *E. coli* and CoNS	Aminoglycosides- 79% β-lactam/β-lactamase inhibitor combinations- 86% carbapenems- 65% MR CoNS- 62.5%

[Table/Fig-9]: Comparison of present study with other Indian studies [8,16,21,31,32].

To avoid the spread of these multidrug resistant strains, stringent infection management procedures, rational use of available antibiotics, and antibiotic stewardship should be implemented.

In general, antibiotic resistance among isolates in India is higher than in Western countries, a finding that was confirmed in our research. This high level of resistance has been attributed to indiscriminate antibiotic use in the environment, antibiotic use in animals, especially poultry and livestock, and even antibiotic traces in food [33].

Limitation(s)

The clinical specifics of the different cancer types, as well as genotypic research, were not assessed in this report, which may have helped to confirm whether the sepsis was caused by a clinical entity or was acquired in the hospital. Furthermore, the current study findings must be confirmed by a multicentric study as this was a retrospective analysis conducted at a single centre.

CONCLUSION(S)

In this study, it was observed that middle age group was more vulnerable for sepsis with carbapenem resistance being most common, and that GNB appears to be the most common pathogen, especially *K. pneumoniae*, which causes sepsis in patients at this cancer centre. The current study provides information on antibiotic resistance of blood isolates in cancer patients of Northern Kerala which may be a useful guide for physicians initiating empiric therapy. Hospital Infection Control team in every hospital can help in reducing nosocomial BSI by monitoring and reporting of BSI rates. This can be possible only when the antibiogram data from the microbiology laboratory is promptly reported to the clinicians and to the Hospital Infection Control (HIC) team. The effectiveness of major surgery and cancer chemotherapy will be jeopardised without effective antibiotics.

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