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Original Research Article.

Comparative Analysis of Carbapenem-Resistant and Carbapenem-Susceptible Klebsiella Isolates: A Microbiological Study

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ABSTRACT

Background: Carbapenem resistance among Klebsiella species has emerged as a major challenge in modern healthcare, particularly in hospital environments where treatment options are increasingly limited. Understanding differences between resistant and susceptible strains is essential for guiding therapy and infection control.

Objectives: To evaluate and compare antimicrobial resistance patterns and microbiological characteristics of carbapenem-resistant and carbapenem-sensitive Klebsiella isolates obtained in a tertiary care hospital.

Methods: A cross-sectional study was conducted over one year at the National Institute of Medical Sciences (NIMS), Jaipur. A total of 150 non-repetitive Klebsiella isolates from clinical samples were analyzed. Identification was carried out using conventional microbiological methods. Antibiotic susceptibility testing was performed using the Kirby–Bauer disk diffusion technique in accordance with CLSI standards. Isolates were grouped as carbapenem-resistant or carbapenem-susceptible, and their resistance profiles were compared.

Results: Out of 150 isolates, 58 (38.7%) were resistant to carbapenems. These resistant isolates exhibited markedly higher resistance to multiple antibiotics and showed a significantly greater prevalence of multidrug resistance compared to susceptible strains ($p < 0.001$).

Conclusion: Carbapenem-resistant Klebsiella isolates demonstrate extensive resistance across antibiotic classes, limiting treatment choices. Continuous monitoring and responsible antibiotic use are critical to controlling the spread of resistance.

Keywords: Klebsiella, Carbapenem Resistance, Antimicrobial Susceptibility, Multidrug Resistance, Nosocomial Infections.

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INTRODUCTION

Klebsiella species are frequently encountered in clinical practice as causative agents of infections involving the respiratory tract, urinary system, bloodstream, and surgical wounds[1]. Their ability to acquire and accumulate resistance determinants has made them a persistent challenge in hospital environments, particularly in settings where antibiotic exposure is high and patient populations are vulnerable[2].

Carbapenems have historically played a crucial role in the management of infections caused by organisms resistant to multiple drug classes[3]. Over time, however, strains of Klebsiella that are no longer susceptible to carbapenems have emerged and spread, reducing the effectiveness of these critical drugs[4]. This shift has altered treatment approaches and increased dependence on a limited number of alternative agents, some of which are associated with toxicity or reduced efficacy.

The development of resistance in Klebsiella is driven by a combination of mechanisms, including enzymatic breakdown of antibiotics, structural changes that limit drug entry, and active removal of antimicrobial agents from the bacterial cell[5]. These mechanisms often occur together, resulting in organisms that are resistant to several unrelated antibiotic groups at the same time[6].

The burden of carbapenem resistance is not uniform and tends to vary between regions and healthcare facilities[7]. In many parts of India, higher resistance rates have been observed, likely influenced by factors such as widespread empirical antibiotic use, limited antimicrobial regulation, and challenges in infection control practices[8,9]. These conditions create an environment that favors the persistence and transmission of resistant strains.

A direct comparison between carbapenem-resistant and carbapenem-susceptible isolates provides useful insight into how

resistance affects broader antimicrobial profiles. Such comparisons are particularly valuable in identifying trends that can inform treatment decisions and hospital policies. Data from specific geographic regions remain essential, as resistance patterns are often shaped by local practices. In this context, the present study was conducted to examine and compare the resistance characteristics of Klebsiella isolates obtained from a tertiary care center.

AIMS AND OBJECTIVES

Aim

To compare carbapenem-resistant and carbapenem-susceptible Klebsiella isolates with respect to their antimicrobial resistance patterns in a tertiary care center.

Objectives

1. To determine the proportion of carbapenem-resistant Klebsiella isolates among clinical samples.
2. To compare antimicrobial susceptibility profiles between carbapenem-resistant and carbapenem-susceptible isolates.
3. To assess the prevalence of multidrug resistance among carbapenem-resistant isolates.
4. To analyze the distribution of isolates across different clinical specimens.

MATERIALS AND METHODS

This hospital-based cross-sectional study was conducted in the Department of Microbiology at the National Institute of Medical Sciences (NIMS), Jaipur, over a period of one year.

A total of 150 non-duplicate Klebsiella isolates obtained from various clinical specimens, including urine, blood, sputum, pus, and endotracheal aspirates, were included in the study. Isolates were identified using standard microbiological techniques based on colony morphology, Gram staining, and biochemical reactions.

Antimicrobial susceptibility testing was performed using the Kirby–Bauer disk diffusion method on Mueller–Hinton agar, and results were interpreted according to Clinical and Laboratory Standards Institute (CLSI) guidelines. Carbapenem resistance was determined using imipenem and meropenem discs.

Based on susceptibility results, isolates were categorized into:

- Carbapenem-resistant Klebsiella (CRK)
- Carbapenem-susceptible Klebsiella (CSK)

Multidrug resistance (MDR) was defined as resistance to three or more classes of antibiotics.

Data were analyzed using SPSS version 25.0. Categorical variables were expressed as percentages and compared using the Chi-square test. A p-value of <0.05 was considered statistically significant.

Ethical Considerations and Consent

The study was approved by the Institutional Ethics Committee of the National Institute of Medical Sciences (NIMS), Jaipur. As the study involved bacterial isolates obtained from routine clinical samples, no additional risk was posed to patients. Relevant clinical data were collected without revealing patient identity, ensuring confidentiality and anonymity. Wherever applicable, informed consent was obtained in accordance with institutional guidelines. The study was conducted in compliance with the ethical principles of the Declaration of Helsinki.

Table 1: Distribution of Klebsiella Isolates

Category	Number (n = 150)	Percentage
Carbapenem-Resistant	58	38.7%
Carbapenem-Susceptible	92	61.3%

Table 2: Distribution of Isolates by Clinical Specimen

Specimen	CRK (n = 58)	CSK (n = 92)	p-value
Urine	20 (34.5%)	38 (41.3%)	0.38
Blood	10 (17.2%)	12 (13.0%)	0.47
Sputum	12 (20.7%)	16 (17.4%)	0.62
Pus	9 (15.5%)	14 (15.2%)	0.96
ET Aspirate	7 (12.1%)	12 (13.0%)	0.87

Table 3: Antimicrobial Resistance Pattern

Antibiotic	CRK (%)	CSK (%)	p-value
Ceftriaxone	96.5	65.2	<0.001
Ciprofloxacin	89.6	54.3	<0.001
Amikacin	72.4	28.3	<0.001
Piperacillin-Tazobactam	81.0	40.2	<0.001
Colistin	5.1	2.2	0.31

Table 4: Multidrug Resistance (MDR) Comparison

Category	MDR Present	MDR Absent	p-value
CRK (n = 58)	52 (89.7%)	6 (10.3%)	<0.001
CSK (n = 92)	34 (37.0%)	58 (63.0%)	

Table 5: Comparison of Mean Resistance (Number of Antibiotic Classes)

Group	Mean ± SD	p-value
CRK	4.8 ± 1.2	<0.001
CSK	2.3 ± 0.9	

RESULTS

A total of 150 Klebsiella isolates were analyzed. Out of these, 58 (38.7%) were identified as carbapenem-resistant, while 92 (61.3%) were carbapenem-susceptible. Out of 150 Klebsiella isolates analyzed, 58 (38.7%) were identified as carbapenem-resistant while 92 (61.3%) were carbapenem-susceptible. The distribution of isolates across different clinical specimens was comparable between the two groups, with no statistically significant difference.

Carbapenem-resistant isolates demonstrated significantly higher resistance to commonly used antibiotics, including ceftriaxone, ciprofloxacin, amikacin, and piperacillin–tazobactam ($p < 0.001$). However, resistance to colistin remained low in both groups and was not statistically significant. A markedly higher proportion of multidrug resistance was observed among carbapenem-resistant isolates compared to susceptible isolates (89.7% vs 37.0%, $p < 0.001$). Additionally, carbapenem-resistant isolates exhibited resistance to a greater number of antibiotic classes overall.

These findings indicate a strong association between carbapenem resistance and multidrug resistance, highlighting the limited therapeutic options and the growing challenge of managing such infections in clinical settings.

DISCUSSION

The findings of this study demonstrate that a considerable proportion of Klebsiella isolates exhibited resistance to carbapenems, reflecting a significant therapeutic challenge within the study setting. The observed rate indicates that resistance is no longer sporadic but represents an established and clinically relevant problem[10].

Several factors may have contributed to the level of resistance identified. Frequent use of broad-spectrum antibiotics, especially in critically ill patients, can create selective pressure that promotes the survival of resistant organisms. In addition, prolonged hospitalization and the use of invasive medical devices may facilitate both the development and transmission of such strains within healthcare facilities[11].

A notable observation in this study is the extensive resistance displayed by carbapenem-resistant isolates across multiple antibiotic groups. This suggests that resistance is not limited to a single mechanism but likely involves a combination of factors acting simultaneously[12]. As a result, treatment options become increasingly restricted, often requiring the use of less conventional or more toxic drugs.

The high proportion of multidrug resistance among carbapenem-resistant isolates further emphasizes the seriousness of the issue. When organisms exhibit resistance to multiple classes of antibiotics, routine treatment regimens may no longer be effective, leading to delays in appropriate therapy and potentially poorer clinical outcomes[13].

Although resistance to colistin remained relatively low in this study, reliance on such last-resort antibiotics is not without concern[14]. Increased use may eventually contribute to the emergence of resistance even to these agents, which would further complicate treatment strategies.

The distribution of resistant and susceptible isolates across different specimen types did not show meaningful variation, indicating that resistance is not confined to a specific type of infection. Instead, it appears to be widely present across various clinical conditions, highlighting the need for hospital-wide preventive measures rather than isolated interventions.

From a practical standpoint, these findings underline the importance of tailoring antibiotic therapy based on local susceptibility patterns. Routine surveillance and timely reporting of resistance data can support clinicians in selecting appropriate treatments and avoiding unnecessary use of broad-spectrum agents[15].

This study also adds region-specific information that can contribute to a better understanding of resistance trends in the area. Such localized data are important for designing targeted strategies aimed at controlling the spread of resistant organisms[16].

Certain limitations should be acknowledged. The study was conducted in a single institution, which may limit the broader applicability of the findings. Additionally, detailed molecular analysis was not performed, and therefore the exact mechanisms responsible for resistance could not be determined[17,18].

CONCLUSION

This study highlights a significant burden of carbapenem resistance among Klebsiella isolates in a tertiary care setting. Resistant strains demonstrate a high level of multidrug resistance, making treatment increasingly difficult.

Ongoing surveillance, appropriate antibiotic stewardship, and early detection of resistant strains are essential to limit the spread of resistance and improve patient outcomes.

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