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Carbapenem-Resistant Acinetobacter baumannii in Critically Ill Patients: Risk Factors, Treatment Challenges, and Infection Control Strategies

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A B S T R A C T

Carbapenem-resistant *Acinetobacter baumannii* (CRAB) has become a major global health threat, particularly in intensive care units (ICUs), due to multidrug resistance, limited therapeutic options, and high mortality. Understanding its prevalence, risk factors, resistance patterns, and outcomes is essential to guide therapy and infection control. To determine the prevalence of CRAB among ICU patients, evaluate its antimicrobial susceptibility, identify associated risk factors, and compare clinical outcomes with carbapenem-sensitive *A. baumannii* (CSAB) infections. A prospective observational study from January 2024 to July 2024. A total of 870 respiratory samples (sputum and endotracheal aspirates) yielded 105 *A. baumannii* isolates, identified by conventional methods and MALDI-TOF. Antimicrobial susceptibility was performed using Kirby–Bauer disc diffusion. Clinical and demographic data were collected, and statistical analysis was carried out to determine risk factors and outcomes. Among 105 isolates, 30 (28.6%) were CRAB. Patients with CRAB were older (mean 65 years), more frequently hypertensive (66.7%), had longer ICU stays (22.6 ± 8.1 days), and required mechanical ventilation more often (93.3%). Independent risk factors included prior antibiotic use (OR 5.33), prolonged ventilation (OR 10.45), and ICU stay >7 days (OR 10.4). CRAB were 100% sensitive to colistin, and 70% sensitive to tigecycline. Mortality higher in CRAB patients compared with CSAB (50% vs. 20%, p =0.004). CRAB infections in ICU patients are associated with high mortality, extensive resistance. Reinforced infection control practices, rational antibiotic use, and antimicrobial stewardship are critical to reducing CRAB burden.

Introduction

Acinetobacter baumannii is a type of bacteria that can cause serious infections, especially in hospital settings such as intensive care units (ICUs). Over the past two decades, it has become a major concern due to its ability to develop resistance to many antibiotics, including carbapenems, which are often used as a last resort treatment for severe infections[1,5]. Carbapenem-resistant *Acinetobacter baumannii* (CRAB) infections are associated with high rates of illness and death, particularly among patients in critical care units[8,11].

Several studies have shown that CRAB can spread easily in hospitals, especially during outbreaks or times of increased healthcare strain, such as the COVID-19 pandemic[6,7]. Many factors increase the risk of CRAB infection, including prolonged ICU stay, use of mechanical ventilation, previous antibiotic use, and invasive procedures[2,4]. In neonatal and adult ICUs, CRAB bloodstream infections have been linked to poor outcomes and limited treatment options[4]. The present study was done to determine the prevalence of CRAB among ICU patients, evaluate its antimicrobial susceptibility, identify associated risk factors, and compare clinical outcomes with carbapenem-sensitive *A. baumannii* (CSAB) infections. Treating CRAB is difficult due to its resistance to multiple antibiotics. Although colistin remains one of the few effective drugs, its use is limited by toxicity and questions about the optimal duration of treatment[1,9].

Materials and Methods

Study design and settings: this is a prospective observational study conducted from January 2024 to July 2024 in a tertiary care hospital, western Rajasthan.

Sample size: 105 respiratory samples (Sputum and Endotracheal aspirates) from ICU patients.

Data collection: demographic data were collected in a proforma (Age, sex, name) with underline clinical conditions after taking informed patient consent.

Sample Processing

All respiratory samples received from various ICUs were processed by both conventional method and Automated method (MALDI TOF) as per standard laboratory protocol.Antibiotic susceptibility were done on Mueller hinton agar plate by kirby bauer disc diffusion method as per CLSI guidline 2024[13]. Isolates with meropenem zone size (10µg) ≤ 14mm and for Imipenem (10µg) ≤ 18mm were considered carbapenem resistant *Acinetobacter baumanii* (CRAB). Colistin Susceptibility was done by colistin broth Disc Elution method [13].

Results and Discussion

Total 870 respiratory samples were received in study time period (January 2024 to July 2024). Out of this in 105(12.06%) samples Acinetobacter baumanii were isolated. Out of 105 bacterial isolates 30 (28.57%) were carbapenem resistant Acinetobacter baumanii (CRAB) and 75 (71.42%) were Carbapenem sensitive Acinetobacter baumanii (CSAB).

Table1. Presents the demographic and clinical characteristics of patients with *Acinetobacter baumannii* infections, comparing those with CRAB to CSAB isolates. The mean age of CRAB patients was significantly higher than that of CSAB patients (65 vs. 60 years; $p = 0.045$). The gender distribution was comparable between the two groups, with males comprising 60% of the CRAB group and 56% of the CSAB group ($p = 0.712$).

Among comorbidities, hypertension was significantly more prevalent in CRAB patients (66.7%) compared to CSAB patients (40%; $p = 0.025$). While diabetes and chronic respiratory disease were more frequent in CRAB patients (50% vs. 33.3% and 40% vs. 24%, respectively), these differences were not statistically significant ($p = 0.110$ and $p = 0.145$, respectively).

Sputum was the predominant source of *A. baumannii* isolates in both CRAB and CSAB groups (60% & 69.3% respectively. (Table 2)

The antibiotic susceptibility profile of the CRAB & CSAB isolates are summarized in Table 3. All isolates were susceptible to colistin (100%) followed by tigecycline (70%). Amongst CRAB isolates, moderate sensitivity shown by Gentamicin (33.33%) followed by levofloxacin (26.66%), ampicillin–sulbactam (16.66%). None of the isolates were susceptible to meropenem or imipenem, confirming the carbapenem-resistant nature of the strains**.** Whereas CSAB isolates were 100% sensitive to colistin, Tigecycline, meropenem & imipenem drugs.

Analysis of potential risk factors for CRAB infection among ICU patients revealed that prior antibiotic use was significantly more common in the CRAB group compared to the CSAB group (80% vs. 40%; OR = 5.33, 95% CI: 2.0–14.2; $p = 0.001$). Prolonged mechanical ventilation was strongly associated with CRAB infection (93.3% vs. 56%; OR = 10.45, 95% CI: 2.0–54.5; $p = 0.001$). An ICU stay of more than 7 days was also a significant risk factor (86.7% vs. 40%; OR = 10.4, 95% CI: 3.4–31.6; $p < 0.001$). (as per table 4). Table 5 below showed comparison of clinical outcome between CRAB and CSAB. CRAB infections were associated with

significantly higher mortality compared to CSAB infections (50% vs. 20%; $p = 0.004$). The mean length of hospital stay was markedly longer in CRAB patients (26.4 ± 10.3 days) than in CSAB patients (14.2 ± 5.6 days; $p < 0.001$).

In the present study patients with carbapenem-resistant *Acinetobacter baumannii* (CRAB) were older on average (p-value 0.04) than those with carbapenem-susceptible strains. This finding is consistent with Iovleva *et al.,*[1]. and Zhang *et al.,*[12], who reported that older age is a common risk factor for CRAB infections, likely due to age-related decline in immunity and a higher prevalence of comorbidities. Similarly, Uwingabiye *et al.,*[2] observed a higher proportion of elderly patients in CRAB cases in an ICU setting. However, Kumar *et al.,*[4], studying neonatal ICU patients, did not find age as a determining factor, highlighting that age-related risk may be more relevant in adult ICU populations.

Hypertension was significantly (p-value 0.025) more common among CRAB patients in our study, aligning with Jiang *et al.,*[5]. and Montrucchio *et al.,*[6].who linked cardiovascular comorbidities with increased vulnerability to CRAB infections. Other comorbidities like diabetes and chronic respiratory disease were more frequent in the CRAB group but did not reach statistical significance (p-value=0.110 & 0.145 respectively), a pattern also noted by Azimzadeh *et al.,*[7]. and Pogue *et al.,*[8]., suggesting that while comorbidities contribute to risk, their individual effect may vary between settings.

In our study, CRAB infection in ICU patients was strongly associated with prior antibiotic use, prolonged mechanical ventilation, longer ICU stays, and comorbidities. Prior antibiotic exposure (80%, OR = 5.33, p-value=0.001) was a major risk, consistent with reports from Iovleva *et al.,*[1]. Uwingabiye *et al.,*[2].and Jiang *et al.,*[5]. Prolonged mechanical ventilation (93.3%, OR = 10.45, pvalue=0.001) emerged as the strongest factor, in line with studies by Kumar *et al.,*[4], Vivo *et al.,*[3]. and Montrucchio *et al.,*[6].Extended ICU stays (>7 days, 86.7%, OR = 10.4) also significantly increased risk and findings are concordant with Azimzadeh *et al.,*[7], Pogue *et al.,*[8], and Zhang *et al.,*[12] who emphasized that prolonged ICU stays often coincide with multiple invasive procedures and repeated antibiotic courses, further amplifying the risk.

The presence of comorbidities was significantly associated with CRAB in our cohort (OR = 2.6,p value=0.040), consistent with reports from Bartal *et al.,*[10] and Karakonstantis *et al.,*[11], who observed that patients with underlying conditions such as diabetes, hypertension, chronic lung disease, or renal impairment are more vulnerable due to weakened immunity and frequent healthcare exposure. However, Uwingabiye *et al.,*[2] did not find comorbidities to be a statistically significant factor, suggesting that their impact may vary depending on population demographics and infection control practices.

Overall, our results reinforce existing literature that CRAB infection in ICU patients is largely driven by prolonged healthcare exposure, invasive devices, and prior antibiotic use. The similarities with global studies indicate that these risk factors are consistent across diverse settings, while minor differences, such as the variable impact of comorbidities, highlight the role of local epidemiology and patient profiles.

In our study, most *Acinetobacter baumannii* isolates were obtained from respiratory samples, with sputum being the most common source (66.7%), followed by endotracheal aspirates (33.3%). Among carbapenem-resistant strains (CRAB), 60% were from sputum and 40% from endotracheal aspirates, while in the carbapenem-sensitive group (CSAB), sputum accounted for nearly 70% of isolates.

Our findings are consistent with those of Uwingabiye *et al.,*[2]., who also reported that most *A. baumannii* isolates in ICU patients came from respiratory samples, reflecting the high vulnerability of intubated patients.

Similarly, Vivo *et al.,*[3]. and Jiang *et al.,*[5]. Observed that ventilator-associated pneumonia was a frequent manifestation of CRAB infection, highlighting the role of invasive respiratory devices in pathogen entry and colonization.

Overall, our results support the evidence that the respiratory tract is the major site for CRAB isolation in adult ICU settings. This emphasizes the need for targeted preventive measures, including strict adherence to ventilator care bundles, regular airway suctioning protocols, and early microbiological surveillance to detect colonization before it progresses to severe infection.

Table.1 Demographic & Clinical presentation of *Acinetobacter baumanii* isolates

Characteristic	CRAB Patients (n=30)	CSAB Patients (n=75)	p-value
Age (years) (mean age)	65	60	0.045
Male, n (%)	18 (60%)	42 (56%)	0.712
Female, n (%)	12 (40%)	33 (44%)	0.712
Comorbidities, n (%)			
Diabetes	15 (50%)	25 (33.3%)	0.110
Hypertension	20 (66.7%)	30 (40%)	0.025
Chronic Respiratory Disease	12 (40%)	18 (24%)	0.145
Mechanical Ventilation, n (%)	28 (93.3%)	48 (64%)	0.001

Table.2 Sample wise distribution of *Acinetobacter baumannii* Isolates (N=105)

Sample Type	CRAB (n=30)	CSAB (n=75)	Total (n=105)
Sputum, n (%)	18 (60%)	52 (69.3%)	70 (66.7%)
Endotracheal aspirate, n (%)	12 (40%)	23 (30.7%)	35 (33.3%)
Total	30 (28.6%)	75 (71.4%)	105

Table.3 Antibiotic sensitivity pattern of carbapenem resistant *Acinetobacter baumanii* CRAB (N=30) & carbapenem sensitive Acinetobacter baumanii CSAB(75)

Drugs	CRAB (N) (%)	CSAB (N)(%)
Ampicillin-Sulbactam (10/10µg)	05 (16.66%)	45 (60%)
Cefepime (30 µg)	01(.33%)	40 (53.33%)
Levofloxacin (5 µg)	08 (26.66 %)	63 (84%)
Piperacillin (100µg)	01 (3.33%)	45 (60%)
Piperacillin-Tazobactam(100/10 µg)	02 (6.66%)	68 (90.66%)
Ceftazidime (30 µg)	01 (3.33%)	35 (46.66%)
Ceftriaxone (30 µg)	01 (3.33%)	37 (49.33%)
Meropenem (10 µg)	00 (00%)	75 (100%)
Imipenem (10 µg)	00 (00%)	75 (100%)
Gentamicin (10 µg)	10 (33.33%)	73 (97.33%)
Tigecycline (15 µg)	21 (70%)	75 (100%)
Colistin broth disc elution	30 (100%)	75 (100%)

Table.4 Risk Factors for CRAB Infection in ICU Patients

Risk Factor	CRAB Patients (n=30)	CSAB Patients (n=75)	Odds Ratio (95% CI)	p-value
Prior antibiotic use	24 (80%)	30 (40%)	5.33 (2.0-14.2)	0.001
Prolonged mechanical ventilation	28 (93.3%)	42 (56%)	10.45 (2.0-54.5)	0.001
ICU stay >7 days	26 (86.7%)	30 (40%)	10.4 (3.4-31.6)	<0.001
Presence of comorbidities	22 (73.3%)	38 (50.7%)	2.6 (1.1-6.4)	0.040

Table.5 Clinical Outcomes of CRAB vs Carbapenem sensitive Acinetobacter baumanii (CSAB) Patients

Outcome	CRAB Patients (n=30)	Non-CRAB Patients (n=75)	p-value
Mortality Rate, n (%)	15 (50%)	15 (20%)	0.004
Length of Hospital Stay (days)	26.4 ± 10.3	14.2 ± 5.6	<0.001
Discharge with Improvement, n (%)	10 (33.3%)	50 (66.7%)	0.002
Need for ICU readmission, n (%)	5 (16.7%)	6 (8%)	0.217

The present study antibiotic susceptibility results show that carbapenem-resistant *Acinetobacter baumannii* (CRAB) isolates in our study were resistant to most commonly used antibiotics, with 0% sensitivity to meropenem and imipenem. The highest sensitivity was observed to colistin (100%), followed by tigecycline (70%) and gentamicin (33.3%).

These findings are consistent with those reported by Iovleva *et al.,*[1]. who noted that colistin remains the most reliable drug against CRAB worldwide, with tigecycline often used as a second-line option. Similarly, Uwingabiye *et al.,*[2]. in their study found near-universal resistance to carbapenems and cephalosporins, with colistin sensitivity exceeding 95%.

Our tigecycline susceptibility rate (70%) is higher than that reported by Jiang *et al.,*[5] who observed increasing tigecycline resistance in Asian ICU settings, possibly due to widespread empirical use. In contrast, Vivo *et al.,*[3] and Pogue *et al.,*[8] described similar tigecycline sensitivity patterns to ours but highlighted concerns over its limited bactericidal activity and the need for combination therapy.

Colistin's universal sensitivity in our isolates is concordant with the findings of Katip *et al.,*[9]. Who demonstrated good survival rates with both short and long courses of colistin therapy, though nephrotoxicity remains a concern. Bartal *et al.,*[10]. and Zhang *et al.,*[12]. Stressed the importance of antimicrobial stewardship to preserve colistin efficacy as there is warning of emerging resistance against this also.

Overall, our results align with the global trend of extreme multidrug resistance in CRAB, leaving colistin and tigecycline as the main therapeutic options. The poor activity of β-lactams and carbapenems reinforces the need for strict infection control, prudent antibiotic prescribing, and research into novel therapeutic strategies to combat this pathogen.

In conclusion, Carbapenem-resistant *Acinetobacter baumannii* (CRAB) poses a serious threat in ICU settings, with limited therapeutic options restricted mainly to colistin and tigecycline. Prior antibiotic use, prolonged ventilation, extended ICU stay, and comorbidities were key risk factors. The findings reinforce the urgent need for robust hospital infection control measures, including strict adherence to hand hygiene, environmental decontamination and routine microbiological surveillance to detect and contain outbreaks promptly. Strengthened infection control practices and antimicrobial stewardship are urgently required to curb its impact in critical care.

Author Contributions

Kapil Choyal: Investigation, formal analysis, writing—original draft. Smita Kulshrestha: Validation, methodology, writing—reviewing. Richa Agrawal:—Formal analysis, writing—review and editing. Pankaj Khandelwal: Investigation, writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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