Original Article

Prevalence and Antimicrobial Resistance Pattern of *Acinetobacter baumannii* in the Orthopedic Surgery Department of Imam Hussein Hospital from 2021 to 2024

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Abstract

Background: Nosocomial infections caused by *Acinetobacter baumannii* in orthopedic patients represent a growing challenge due to their prevalence, environmental persistence, and high levels of antimicrobial resistance. The increasing prevalence of resistant strains emphasizes the urgent need to improve infection control measures, antimicrobial surveillance, and develop new therapeutic options. This study aimed to determine the prevalence of nosocomial infection caused by *Acinetobacter baumannii* and its antibiotic resistance status in patients in the orthopedic ward of Imam Hussein Hospital from 2021 to 2024.

Materials and Methods: Bacterial samples from orthopedic surgery patients at Imam Hussein Hospital were collected, stored at -20°C, and re-cultured on blood agar and selective media to ensure purity and accurate identification. *Acinetobacter baumannii* was confirmed using colony morphology, staining, Triple sugar Iron agar (TSI), and oxidase tests. Antibiotic resistance to imipenem, meropenem, and other antibiotics was assessed via disk diffusion, with colistin MIC determined per CLSI guidelines. Data were analyzed using SPSS version 22.

Results: Of the 680 samples, 45 cultures were positive for Acinetobacter. All 45 Acinetobacter strains tested showed complete susceptibility to colistin. Among other antibiotics, ampicillin-sulbactam was relatively more effective with 17.8% susceptibility. Acinetobacter strains were susceptible to amikacin and imipenem in only one case, and were resistant in 95.6% and 97.8% of cases, respectively. For gentamicin, only one out of 17 tests showed Intermediate susceptibility, and the rest were resistant. For meropenem, one out of 42 tests showed Intermediate susceptibility, and the rest showed complete resistance. All Acinetobacter strains were completely resistant to the antibiotics cefepime, cefotaxime, ceftazidime, ceftriaxone, ciprofloxacin, levofloxacin, piperacillin-tazobactam, and cotrimoxazole. For minocycline, complete susceptibility was observed in both cases. Tetracycline susceptibility was also evaluated in 38 strains, of which only three were sensitive and 35 were resistant.

Conclusion: This study confirms the rising resistance of *Acinetobacter baumannii* to multiple antibiotics, including cephalosporins, carbapenems, tetracyclines, and ciprofloxacin, limiting treatment to colistin and ampicillin-sulbactam. Hospital-acquired infections pose significant health and economic burdens, necessitating vigilant monitoring of resistance patterns, optimized antibiotic use, and stringent preventive measures, such as hand hygiene and equipment sterilization, to mitigate their impact.

Keywords: *Acinetobacter baumannii*, Resistance, Antibiotics

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Introduction

Acinetobacter baumannii is a gram-negative, opportunistic pathogen recognized as a leading cause of nosocomial infections worldwide[1,2]. Its ability to persist in hospital environments, facilitated by its resistance to desiccation and disinfectants, contributes to its prevalence in healthcare settings[3]. The bacterium's capacity to develop resistance to multiple antibiotics, including carbapenems, poses significant challenges for infection control and treatment[4]. In orthopedic surgery, *A. baumannii* is a notable pathogen in surgical site infections (SSIs), often presenting with multidrug-resistant (MDR) profiles that complicate clinical management[5].

The prevalence of *A. baumannii* in orthopedic SSIs has been documented in various studies, highlighting its impact on patient outcomes and hospital resource utilization[5]. For instance, a study at El-Hehal Hospital identified *A. baumannii* as the third most common causative agent of orthopedic SSIs, with 93.3% of isolates exhibiting MDR, resisting antibiotics such as cephalosporins, aminoglycosides, and carbapenems. This high resistance rate underscores the need for continuous surveillance and robust infection control measures in orthopedic departments. Additionally, *A. baumannii* has been isolated from various hospital departments, including Orthopedics and Traumatology, indicating its widespread presence[6].

Globally, the rise of carbapenem-resistant *A. baumannii* (CRAB) has been identified as a critical public health threat, with prevalence rates varying significantly across regions, from low in some areas to nearly 100% in others[7]. This resistance is driven by mechanisms such as beta-lactamase production, efflux pumps, and reduced membrane permeability, further complicating treatment[8]. The increasing incidence of MDR-*A. baumannii* is associated with higher mortality rates and elevated healthcare costs, particularly in settings with prolonged hospital stays and invasive procedures[7].

Given the escalating challenge of MDR-*A. baumannii* and its association with poor clinical outcomes, understanding its prevalence and resistance patterns in specific hospital settings is crucial. This study aims to investigate the prevalence and antibiotic resistance profiles of *A. baumannii* isolated from patients in the orthopedic surgery department of Imam Hossein Hospital between 2022 and 2025. By providing insights into the local epidemiology of this pathogen, this research will contribute to the development of targeted antimicrobial stewardship and infection prevention strategies.

Methods

Study Design and Setting: This retrospective cross-sectional study was conducted at the orthopedic department of Imam Hussein Hospital, Tehran, Iran, from March 2021 to March 2024, following approval from the Ethics Committee of Shahid Beheshti University of Medical Sciences. The study aimed to investigate the prevalence and antimicrobial resistance patterns of hospital-acquired *Acinetobacter baumannii* infections among patients who underwent orthopedic surgery.

Ethical Considerations: The study adhered to the ethical principles outlined in the Declaration of Helsinki. All data were extracted from patients' medical records and laboratory results, ensuring confidentiality and integrity throughout the research process. The Ethics Committee of Shahid Beheshti University of Medical Sciences approved the study protocol (IR.SBMU.MSP.REC.1403.543).

Study Population: The study included all patients who underwent orthopedic surgery at Imam Hussein Hospital between March 2021 and March 2024 and developed hospital-acquired infections caused by *Acinetobacter baumannii*. A census sampling method was employed, including all eligible patients. The inclusion criteria were as follows:

- Patients who underwent orthopedic surgery during the study period.
- Patients diagnosed with hospital-acquired *Acinetobacter baumannii* infections.

- Patients with complete medical records.

The exclusion criteria included:

- Patients with incomplete culture or antibiogram results.
- Patients with community-acquired infections.
- Patients with immunodeficiency.
- Patients receiving immunosuppressive medications.
- Patients who underwent non-orthopedic surgeries.

Sample Collection and Processing: Clinical samples were collected from the orthopedic department and the intensive care unit (ICU) of Imam Hussein Hospital. Samples were transported to the Infectious Diseases Research Center laboratory and stored at -20°C. To ensure purity and accurate identification of *Acinetobacter baumannii*, samples were re-cultured on blood agar and MacConkey agar. Bacterial identification was performed using standard microbiological techniques, including colony morphology, Gram staining, triple sugar iron (TSI) test, and oxidase test.

Antimicrobial Susceptibility Testing: Antimicrobial susceptibility was assessed using the disk diffusion method in accordance with the Clinical and Laboratory Standards Institute (CLSI) guidelines. The antibiotics tested included ampicillin-sulbactam, piperacillin-tazobactam, ceftazidime, cefepime, imipenem, meropenem, gentamicin, amikacin, tobramycin, minocycline, sulfamethoxazole, and ciprofloxacin. For colistin, the minimum inhibitory concentration (MIC) was determined (Table 1).

Table 1. *Antimicrobial Susceptibility Testing method*.

Antibiotic	Testing Method
Ampicillin-sulbactam	Disk Diffusion
Piperacillin-tazobactam	Disk Diffusion
Ceftazidime	Disk Diffusion
Cefepime	Disk Diffusion
Imipenem	Disk Diffusion
Meropenem	Disk Diffusion
Gentamicin	Disk Diffusion
Amikacin	Disk Diffusion
Tobramycin	Disk Diffusion
Minocycline	Disk Diffusion
Sulfamethoxazole	Disk Diffusion
Ciprofloxacin	Disk Diffusion
Colistin	MIC

Results were interpreted based on CLSI criteria. The materials used included Mueller-Hinton agar (BD, USA), 0.9% saline for preparing bacterial suspensions to 0.5 McFarland standard, oxidase disks, and antibiotic disks (MAST, UK).

Statistical Analysis: Data were analyzed using SPSS software (version 22.0). Descriptive statistics, including means and medians, were calculated for two groups. The normality of variable distributions was assessed using the Kolmogorov-Smirnov test. For normally distributed quantitative variables, comparisons between groups were performed using the t-test; for non-normally distributed variables, the Mann-Whitney U test was applied. Qualitative variables were analyzed using the Chi-square test. Associations were reported as odds ratios (OR) with 95% confidence intervals (CI). A p-value of <0.05 was considered statistically significant. In cases requiring comparison of a variable across two different conditions with non-normal data, the Wilcoxon signed-rank test was used. The Shapiro-Wilk test was also employed to verify normality, with a p-value <0.05 indicating a deviation from normal distribution.

Results

Patient Demographics and Clinical Characteristics: A total of 45 patients admitted to the orthopedic department of Imam Hossein Hospital, who underwent orthopedic procedures and subsequently developed nosocomial infections caused by *Acinetobacter baumannii*, were enrolled in this study. Admissions spanned four years: 15 patients in 2021, 12 in 2022, 10 in 2023, and 8 in 2024. Of these, 29 (64%) were male and 16 (36%) were female. Patient ages ranged from 13 to 85 years, with a mean age of 56.2 years (standard deviation [SD]=19.4). The duration of hospital stays ranged from 4 to 43 days, with a mean of 16.4 days (SD=9.5).

The predominant surgical intervention was internal fixation for femoral shaft fractures, performed in 22 patients, followed by tibial shaft fractures in 12 patients, double forearm fractures in 4 patients, and pertrochanteric femoral fractures in 2 patients. One patient underwent surgery for a distal femoral fracture, a double leg fracture, and a humeral fracture. Additionally, two patients had concurrent acetabular

and pertrochanteric femoral fractures requiring surgical intervention. A summary of patient demographics and surgical procedures is presented in Table 2.

Table 2. Demographic and Clinical Characteristics of Study Patients.

Characteristic	Value
Total patients	45
Gender	
- Male	29 (64%)
- Female	16 (36%)
Age (years)	
- Range	13–85
- Mean (SD)	56.2 (19.4)
Length of hospital stay (days)	
- Range	4–43
- Mean (SD)	16.4 (9.5)
Surgical procedures	
- Femoral shaft fracture	22
- Tibial shaft fracture	12
- Double forearm fracture	4
- Pertrochanteric femoral fracture	2
- Distal femoral fracture	1
- Double leg fracture	1
- Humeral fracture	1
- Concurrent acetabular and pertrochanteric femoral fractures	2

Antibiotic Susceptibility Testing: Antibiotic susceptibility testing was conducted on 45 *A. baumannii* isolates. The number of isolates tested varied by antibiotic: 40 for ampicillin-sulbactam, 44 for amikacin, 40 for cefepime, 32 for cefotaxime, 44 for ceftazidime, 10 for ceftriaxone, 22 for ciprofloxacin, 1 for co-amoxiclav, 45 for colistin and imipenem, 17 for gentamicin, 25 for levofloxacin, 42 for meropenem, 2 for minocycline, 38 for tetracycline, 34 for piperacillin-tazobactam, and 5 for cotrimoxazole.

All 45 isolates demonstrated susceptibility to colistin. Ampicillin-sulbactam exhibited the next highest susceptibility rate at 17.8%. Susceptibility to amikacin and imipenem was observed in only one isolate each, reflecting resistance rates of 95.6% and 97.8%, respectively. Among the 17 isolates tested for gentamicin, one showed intermediate susceptibility, with the remainder resistant. Similarly, of the 42 isolates tested for meropenem, one exhibited intermediate susceptibility, while the rest were resistant.

Complete resistance (100%) was observed for cefepime, cefotaxime, ceftazidime, ceftriaxone, ciprofloxacin, levofloxacin, piperacillin-tazobactam, and cotrimoxazole across all tested isolates. Minocycline, tested in two isolates, showed full susceptibility. Of the 38 isolates tested for tetracycline, three were susceptible, and 35 were resistant. Detailed antibiotic resistance patterns are provided in Table 3.

Discussion

The increasing prevalence of antibiotic-resistant *Acinetobacter baumannii* in hospital settings poses a significant challenge to infection control, particularly in high-risk areas such as orthopedic surgery departments. Environmental contamination and other factors highlight the role of hospital surfaces and water sources as potential reservoirs for *A. baumannii*, contributing to its transmission and persistence in clinical environments.

This study investigated the prevalence and antibiotic resistance patterns of *A. baumannii* in orthopedic patients at Imam Hussein Hospital over four years. The predominance of male patients aligns with findings from similar studies, potentially reflecting higher rates of trauma-related orthopedic interventions among males[5]. The surgical procedures, primarily internal fixation for fractures such as femoral shaft (22 cases), tibial shaft (12 cases), and double forearm fractures (4 cases), underscore the association between complex orthopedic surgeries and increased infection risk, a trend also noted by Xie et al. (2020) who linked prolonged operations and implant use to elevated surgical site infection (SSI) rates[10].

A key finding is the universal sensitivity of all 45 *A. baumannii* isolates to colistin, positioning it as a critical therapeutic option in this setting. This is consistent with global reports where colistin remains effective against multidrug-resistant (MDR) *A. baumannii*[11]. However, the isolates exhibited significant resistance to other antibiotics, with only 17.8% sensitivity to ampicillin-sulbactam, and near-complete resistance (95.6–97.8%) to amikacin, imipenem, gentamicin, and meropenem. Total resistance was observed against cefepime,

Table 3. Antibiotic Susceptibility Patterns of *Acinetobacter baumannii* Isolates.

Antibiotic	Susceptibility	Percentage	Frequency
Ampicillin-sulbacta	Sensitive	17.8	8
	Intermediate	8.9	4
	Resistant	62.2	28
Amikaci	Sensitive	2.2	1
	Intermediate	0	0
	Resistant	95.6	43
Cefepime	Sensitive	0	0
	Intermediate	0	0
	Resistant	88.9	40
Cefotaxime	Sensitive	0	0
	Intermediate	0	0
	Resistant	71.1	32
Ceftazidime	Sensitive	0	0
	Intermediate	0	0
	Resistant	97.8	44
Ceftriaxon	Sensitive	0	0
	Intermediate	0	0
	Resistant	22.2	10
Ciprofloxaci	Sensitive	0	0
	Intermediate	0	0
	Resistant	48.9	22
Co-amoxiclav	Sensitive	0	0
	Intermediate	0	0
	Resistant	2.2	1
Colisti	Sensitive	100	45
	Intermediate	0	0
	Resistant	0	0
Imipene	Sensitive	2.2	1
	Intermediate	0	0
	Resistant	97.8	44
Gentamicin	Sensitive	0	0
	Intermediate	2.2	1
	Resistant	35.6	16
Levofloxaci	Sensitive	0	0
	Intermediate	0	0
	Resistant	55.6	25
Meropene	Sensitive	0	0
	Intermediate	2.2	1
	Resistant	91.1	41
Minocycline	Sensitive	4.4	2
	Intermediate	0	0
	Resistant	0	0
Tetracycline	Sensitive	6.7	3
	Intermediate	0	0
	Resistant	77.8	35
Piperacillin-tazobactam	Sensitive	0	0
	Intermediate	0	0
	Resistant	75.6	34
Cotrimoxazole	Sensitive	0	0
	Intermediate	0	0
	Resistant	11.1	5

cefotaxime, ceftazidime, ceftriaxone, ciprofloxacin, levofloxacin, piperacillin-tazobactam, and cotrimoxazole. These patterns mirror those reported by Helal et al. (2015), who found 93.3% of *A. baumannii* isolates in orthopedic SSIs to be MDR, with high resistance to carbapenems[5]. Similarly, Gogou et al. (2013) documented an MDR *A. baumannii* outbreak in an orthopedic unit with widespread carbapenem resistance[12].

The high resistance rates observed may be attributed to selective pressure from frequent antibiotic use in orthopedic wards, as suggested by Motbainor et al. (2020), who linked nosocomial MDR infections to hospital environmental factors and invasive procedures[11]. In our study, sensitivity to minocycline in two cases and mixed tetracycline results (3 sensitive, 35 resistant) offer limited alternative options, highlighting the therapeutic challenge posed by MDR strains. This resistance profile is particularly concerning in orthopedic settings, where infections can delay healing and necessitate prolonged hospitalization, as noted by Ellis et al. (2015)[13].

Comparatively, our findings differ from Helal et al. (2015), where *Staphylococcus aureus* dominated orthopedic SSIs (44.4%), with *A. baumannii* accounting for only 16.67% of cases[5]. This discrepancy may reflect regional variations in microbial epidemiology or differences in infection control practices. The complete colistin sensitivity in our study contrasts with emerging resistance concerns elsewhere, emphasizing the need for stewardship to preserve its efficacy[11].

Limitations include the retrospective design and a relatively small sample size (45 isolates), which may not fully capture the trends in resistance. Future studies should incorporate molecular analyses to identify resistance genes, such as OXA-type carbapenemases, which are prevalent in *A. baumannii* isolates in Iran[14].

In conclusion, the high MDR burden of *A. baumannii* in this orthopedic cohort necessitates robust infection control and targeted antibiotic strategies to mitigate its impact on patient outcomes.

Conclusion

The current study, consistent with previous research, highlights the alarming trend of *Acinetobacter baumannii* resistance to most antibiotic classes, including cephalosporins, carbapenems, tetracyclines, and ciprofloxacin. This severely limits treatment options to colistin and, to a lesser extent, ampicillin-

sulbactam. Overall, hospital-acquired infections represent a significant challenge to healthcare systems, threatening patient safety with high prevalence and severe complications while imposing substantial costs on healthcare systems. These findings underscore the importance of monitoring antibiotic resistance patterns, optimizing antibiotic use, and enhancing preventive measures such as hand hygiene and equipment sterilization. Controlling hospital-acquired infections and microbial resistance requires the implementation of precise and coordinated strategies by healthcare professionals and policymakers to minimize the health and economic impacts of this challenge.

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Conflict of interest

The authors further declare that they have no conflict of interest.

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