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Research Article

Multiple-Drug Resistant *A. Baumannii* Detected in Patients Admitted to Holy Family Hospital Rawalpindi

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Abstract

Antibiotic resistant *Acinetobacter baumannii* are considered as most threatening gram-negative nosocomial bacteria, significantly globally known for causing a health crisis. Infections caused by this pathogen are difficult and sometimes impossible to treat. Very limited antibiotics that may have the potential to be comparatively toxic are viable to treat these infections. It is also linked to high mortality in immune compromised patients. The present study includes 100 patients infected with multidrug resistant to *A. Baumannii* that were admitted in Holy Family Hospital, Rawalpindi, and Pakistan. Samples that showed most growth of microbes were collected from wounds (32%) followed by pus (28%) and the least infection was observed in tracheal tube secretion and urine was 28% and 4%, respectively. Our results indicate that highest prevalence of infection was found in burn unit (32%; n=32) followed by Medical (ICU) (33%; n=33) and surgical (ICU) (21%; n=21) and the least in surgical ward (14%; n=14). Results of biochemical tests includes oxidase negative, catalase positive, indole negative, citrate positive under aerobic condition. Antibiotics susceptibility testing revealed that pathogen was Multi Drug Resistant (MDR). Tigecycline, Colistin, moxifloxacin and polymyxin B, were sensitive drugs for the treatment of MDR *A. Baumannii*. Moxifloxacin, polymyxin B and Tigecycline were resistant too in some patients. Eighteen percent (18%) of the patients were sensitive to tigecycline and 3% were moxifloxacin sensitive were 3%. Ceftazidime, Cefepime, and ciprofloxacin Augmentin, Amikacin, Cefotaxime, Ceftriaxone, were highly resistant. 5% immunocompromised patients were expired. This indicates that antibiotic resistance is not only a major concern but also a main challenge in public health.

Keywords: Multi drug resistant; Pathogen; Antibiotics; Infections

Introduction

Most challenging *A. Baumanni* has inimitable antibiotic resistance attributes. Genus Acinetobacter comprises of catalase-positive, non-lactose-fermenting, oxidase- negative, non-fastidious, non-motile bacteria that are categorized as aerobic gram-negative coccobacilli that belong to the family *Moraxellaceae*. Over the last few years *A. Baumanni* has been a commonly known nosocomial pathogen and agent of wound infections, urinary tract, septicaemia, meningitis, skin and soft tissue, prosthetic devices, blood stream, respiratory tract infection, bacteremia, and pneumonia syndicated with mortality. These factors give the organism a headway for serious infections and helps it resist stressful environmental conditions [1,2]. Incomplete compliance with infection control procedures, selective pressure from antimicrobial use and presence of other infected patients in hospitals are the factors that facilitate persistence of infection by Acinetobacter species in patients [3]. *A. Baumannii* isolates show resistance to different effective classes of antibiotics such as Aminoglycosides, Carbapenems (Hassan and Kassem 2020), Cephalosporins, Fluoroquinolones, Quinolones, Polymyxin B, Tetracycline, Penicillin, Combination drugs and Sulphonamides [4]. Resistance to β-lactam antibiotics leads to notable mortality and morbidity. Carbapenem antibiotics are considered to be the last therapeutic option in order to treat VAP. Carbapenem-resistant strains are increasingly encountered [5]. Various possible mechanisms include efflux pumps, decrease in the permeability of the outer membrane, modification of penicillin-binding proteins and β-lactamases production. Carbapenem resistant mechanisms associated with carbapenem-hydrolysing enzymes belong to β-lactamases and Ambler class D (Shirmohammadlou et al. 2018).

This research article aimed to quantify the resistance profile of different antibiotics to *A. baumannii* strains as there is very little information about multidrug resistant *A. Baumannii* from Pakistan where this is a prevailing health concern. The strains were isolated from different wards of Holy Family Hospital, Rawalpindi.

Material and Methods

Sample collection

Clinical specimens of infected indoor and outdoor patients were collected from Holy Family Hospital, Rawalpindi. Pathogens were isolated from immune compromised patients and some were involved with other infections, of different age groups admitted at different wards including burn unit, surgical ward, medical ICU, and surgical ICU. Microbial samples from urine, pus, wound, tracheal tube and blood were cultured.

Sample processing

Different media were used for inoculation of specimens like Blood agar, MacConkey agar Mueller-Hinton agar and Tryptic Soy Agar (TSA) according to the characteristics under study. Lactose fermenters and non-fermenters were differentiated by MacConkey agar while blood agar medium was used to distinguish between haemolytic and non-haemolytic colonies. Acinetobacter baumannii

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was cultivated on Tryptic Soy agar in growth chamber at 65°C for 48 hours under aerobic conditions in lab.

After culturing, various conventional biochemical tests were applied to confirm that the strains isolated were *A. Baumannii* such as citrate, malonate consumption, motility and indole production, fermentation of sugars, urease, and catalase and oxidase tests (Table 1) as well as Gram staining and colony morphology are standard microbiological methods for characterization and identification of isolates. Our desired pathogens were identified using different morphological test such as Citrate test; colour of medium turned green to red, catalase positive test; it makes air bubbles, and oxidase positive; colour less redox changes into blue or maroon in colour for diagnostic purposes, Antibiotic resistance patterns against different groups of antibiotics was determined against *A. Baumannii*. Antibiotics susceptibility testing was carried out by disk diffusion method on Mueller-Hinton agar as per laboratory protocol. Isolates were tested for susceptibility to various concentration of antibiotics as amikacin (30 µg), Gentamicin (10 µg), Tobramycin (10 µg), Imipenem (10 µg), Meropenem (10 µg), Ceftazidime (30 µg), Ceftriaxone (30 µg), Piperacillin (100 µg), Tazobactam (110 µg), Minocycline (30 µg), Sulbactam/Cefoperazone (105 µg), Tigecycline (15 µg), Colistin (10 µg), Ciprofloxacin (5 µg), Polymyxin (300 µg), Levofloxacin (5 µg), Cefepime (30 µg), Tetracycline (30 µg), Doxycycline (30 µg), Trimethoprim sulfamethoxazole (23.7/1.25 µg), Augmentin (30 µg) and Cefotaxime (30 µg). *A. Baumannii* was resistant to different antibiotics as multi drug resistant.

Results

Samples were collected from patients admitted in different wards of the Holy family hospital in Rawalpindi, Pakistan to determine the sensitivity and drug resistance. Biochemical tests such as Oxidase, catalase, citrate, indole and motility were applied to confirm that the strains isolated were *A. Baumannii*. Results of phenotypic tests includes oxidase negative, catalase positive, indole negative, citrate positive under aerobic condition at optimum temperature of 33°C to 35°C. Morphological tests include (i) Citrate test; colour of medium turned green to red, (ii) catalase positive test; it makes air bubbles, and (iii) oxidase positive; colourless redox changes into blue or maroon in colour.

Our strain of interest *A. Baumanni* successfully, moreover, for clinical purpose resistant antibiotics against pathogen was determined, for that antibiotics susceptibility testing was carried out. Different groups of antibiotics with various concentrations was used and revealed that isolates were Multi Drug Resistant (MDR). None of the isolate was pan-drug resistant. Tigecycline, Colistin, moxifloxacin and polymyxin B, were sensitive drugs for the treatment of MDR *A. Baumannii* as Colistin is 100% sensitive drug. Other moxifloxacin, polymyxin B and Tigecycline were resistant too in some patients. 18% of the patients were sensitive to tigecycline and 3% were moxifloxacin sensitive. Augmentin, Amikacin, Cefotaxime, Ceftriaxone, Ceftazidime, Cefepime, and ciprofloxacin were highly resistant in our assess. 5% mortality rates recorded by hospital acquired nosocomial infection, patients were Immuno compromised. It's difficult for weaker immune system to compete with other coinfections. Patients resistant to tigecycline and meropenem were calculated to be 82% and 2% respectively, among which meropenem showed a much lower resistance pattern. Highest prevalence of *A. Baumannii* was found in patients of burn unit (32%) followed by medical (ICU) (33%), surgical (ICU) (21%), and the least in surgical ward (14%). Samples that showed most growth of microbes were collected from wounds (32%) followed by pus (28%) and the least infection was observed in tracheal tube secretion and urine (28% and 4%).

A. Baumannii classified as multiple drugs resistant on the basis of results of most clinical isolates that showed resistance to most of antibiotics (Table 2).

Discussion

In the health care setting, multi-drug resistant *A. Baumannii* is a quickly evolving pathogen, where it causes infections like bacteremia, meningitis, pneumonia, wound infection, and urinary-tract infection (Eliopoulos et al. 2008). Several studies have been reported efficacy of resistant antibiotics in different cities of Pakistan as shown in Table 3.

In the present study, the maximum prevalence of *A. Baumannii* infections was observed in the ETT (wound) specimens followed by pus, tracheal secretion and urine which is consistent with prior reports showing that the common source nosocomial A baumannii infections are respiratory infections, pus, and wound (Babaei et al. 2015).

Maximum prevalence of *A. Baumannii* was found in burn unit (32%) followed-by Medical (ICU) (33%), surgical (ICU) (21%) and minimum in surgical ward (14%) as previously reported [6]. The resistance of *A. Baumannii* to different antibiotic was determined by disc diffusion method.

Current study suggests that a higher percentage of MDR *A. Baumannii* is observed in male individuals as compared to females as shown in previous study [7]. This is similar to our analysis. Performed a study in which MDR *A. baumannii* caused 42.85% of infections in which 25.8% were female patients and 74.2% were male [6]. Excessive percentage of nosocomial infections were observed in males (76.0%) than females (23.9%) by [8]. Our results similar with these reported studies. Our study showed that Tigecycline, Colistin, moxifloxacin and polymyxin B, were sensitive drugs. Moxifloxacin, polymyxin B and Tigecycline were resistant too in some cases. 18% of the patients were sensitive to tigecycline and 3% were moxifloxacin sensitive were 3%. Ceftazidime, Cefepime, and ciprofloxacin Augmentin, Amikacin, Cefotaxime, Ceftriaxone, were highly resistant.

Conclusion

Demand of research about *A. baumannii* is increasing progressively because of its emergence as a nosocomial pathogen. A limited number of antibiotics are accessible for treatment, being a challenge for public health. Pragmatically originated strategies and screen-based programmes are required to develop novel antibiotics. Further research is required to new strategies and antibiotics in order to be able to fight bacterial infections caused by resistant bacteria like *A. Baumannii*.

Ethical Approval

The current study was approved from ethical committee of Quaid I Azam University Islamabad.

Table 1: Biochemical characteristics of *A. Baumannii*.

Motility	Oxidase	Catalase	Indole	Aerobic	Citrate	G+C	Temp (C°) Optimum
Non- motile	Negative	Positive	Negative	Strict aerobic	Positive	33%-49%	33-35

Table 2: Epidemiological data and antimicrobial resistance patterns of the isolates.

Sample ID	Gender	Specimen	Hospital/ward	Antimicrobial susceptibility pattern	Antimicrobial resistance pattern
1	M	Pus	HFH Rawalpindi/Surgical	CST, PB	AMC,CTX,CRO,CAZ, FEP,CIP,TZP,IPM,TGC,AMK
2	M	Pus	HFH/MICU	CST, PB	AMC,CTX,CRO,CAZ, ,FEP,CIP,TZP,AMK,IPM, TGC,
3	F	Pus	HFH/SICU	CST, PB	AMC ,CTX,CRO, CAZ,FEP,CIP,TZP,AMK,IPM,TGC
4	M	Pus	HFH/ MICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM
5	F	ETT tip	HFH/ MICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
6	F	Wound	HFH/Burn Unit	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
7	M	Urine	HFH/MICU	TGC, CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP
8	M	Wound	HFH/ Burn Unit	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
9	F	Wound	HFH/ Burn Unit	CST, PB	AMC,CTX,CRO,CAZ,CIP, TZP,AMK,IPM
10	M	ETT tip	HFH/ Burn Unit	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,TGC
11	F	Pus	HFH/Surgical	TGC,CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP TZP,AMK,IPM
12	M	Wound	HFH/ Burn Unit	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
13	M	Pus	HFH/MICU	CST, PB	AMC,CTX,CRO,CAZ,CIPTZP,AMK,IPM
14	F	Tracheal tube	HFH/MICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
15	M	Wound	HFH/ Burn Unit	TGC, CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP TZP,AMK,IPM
16	F	Wound	HFH/Surgical	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
17	M	Pus	HFH/MICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
18	F	Tracheal tube	HFH/MICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
19	F	Pus	HFH/Burn	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
20	M	Tracheal tube	HFH/SICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM
21	M	Pus	HFH/MICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
22	M	Tracheal tube	HFH/MICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM
23	M	Tracheal	HFH/Burn	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM
24	M	Pus	HFH/SICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
25	M	Tracheal tube	HFH/MICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
26	F	Wound	HFH/SICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK
27	F	Wound	HFH/Surgical	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
28	F	Wound	HFH/ Burn Unit	CST, PB	AMC,CTX,CRO,CAZ,CIP,TZP,AMK,IPM,TGC
29	F	Tracheal tube	HFH/MICU	TGC, CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP
30	F	Pus	HFH/SICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
31	M	Tracheal tube	HFH/SICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK
32	M	Wound	HFH/Burn unit	TGC, CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK
33	F	Tracheal tube	HFH/ Burn unit	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
34	M	ETT tip	HFH/ Burn unit	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM
35	F	Tracheal	HFH/ Burn unit	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
36	F	Pus	HFH/Surgical	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,MEM
37	F	Tracheal tube	HFH/MICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
38	M	Wound	HFH/MICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
39	M	Pus	HFH/SICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
40	F	Pus	HFH/SICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK
41	F	Wound	HFH/ Burn unit	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
42	M	Wound	HFH/ Burn unit	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
43	M	ETT tip	HFH/ Burn unit	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
44	M	Wound	HFH/SICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
45	F	Wound	HFH/ Burn unit	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
46	M	Wound	HFH/SICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
47	M	ETT tip	HFH/MICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
48	F	Pus	HFH/ Burn unit	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
49	F	Pus	HFH/SICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
50	M	Pus	HFH/Surgical	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK
51	M	Wound	HFH/ Burn unit	TGC, CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM
52	F	Tracheal tube	HFH/Surgical	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK
53	M	Tracheal tube	HFH/Surgical	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
54	F	Tracheal tube	HFH/Surgical	TGC, CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM
55	M	Pus	HFH/MICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM
56	M	Wound	HFH/Burn Unit	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM
57	F	Tracheal tube	HFH/MICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,
58	F	Pus	HFH/MICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
59	F	Wound	HFH/MICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM
60	F	Pus	HFH/MICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM
61	M	Wound	HFH/Burn	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
62	F	Wound	HFH/SICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
63	F	Wound	HFH/MICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM
64	M	ETT tip	HFH/Surgical	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
65	F	Wound	HFH/Burn	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
66	F	Pus	HFH/SICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC

67	F	Wound	HFH/Burn unit	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
68	M	Pus	HFH/MICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
69	F	Pus	HFH/MICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
70	M	Pus	HFH/SICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
71	M	Tracheal tube	HFH/Surgical	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
72	M	Tracheal tube	HFH/MICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
73	M	Tracheal tube	HFH/Burn	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
74	F	Wound	HFH/SICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
75	F	Wound	HFH/SICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
76	F	ETT tip	HFH/Burn	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
77	M	Pus	HFH/MICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
78	M	Pus	HFH/MICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
79	M	Wound	HFH/Burn	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
80	M	Tracheal tube	HFH/SICU	TGC, PB	CAZ, CRO, TZP,MXF,AMK
81	F	Tracheal tube	HFH/MICU	PB, CST	AMC,CTX,CRO,CAZ,FEP,TZP,MXF,IPM
82	M	Tracheal tube	HFH/SICU	TGC,PB	CAZ,CRO,TZP,MXF,AMK
83	M	Tracheal tube	HFH/MICU	MXF, TGC,CST	AMC, CTX, CRO, CAZ,FEP, CIP, TZP, AMK, IPM
84	F	Pus	HFH/SICU	TGC, CST, MXF	CAZ, IPM,AMK,TZP
85	F	Wound	HFH/MICU	CST,PB,TGC	AMC,CIP,CTX,CRO,FEP,TZP,AMK,IPM
86	F	Foley tip	HFH/BURN	TGC,CST,PB	MXF,CAZ,IMP,TZP
87	M	Wound	HFH/MICU	TGC,CST,PB	MXF, AMK,CAZ,TZP,IMI
88	M	Tracheal tube	HFH/BURN	CS,PB	CR,IMI
89	F	ETT tip	HFH/SICU	CST,TGC	AMK,TZP,IMI,CRO,MXF
90	M	Foley tip	HFH/SICU	CST,TGC,MXF	CRO,IMI,TZP
91	M	Wound	HFH/BURN	CS,TGC	TZP,IPM,CRO,AMK,MXF
92	F	Wound	HFH/MICU	TGC,CST,PB	CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM
93	M	Tracheal tube	HFH/MICU	CST,PB	TGC,CTX,CRO,CAZ,TZP,AKM
94	M	Pus	HFH/SICU	CST,PB	CTX,CIP,FEP,CRO,CAZ,TZP,AKM,IMP
95	F	Tracheal tube	HFH/MICU	TGC,CST,PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IMP
96	F	Wound	HFH/SICU	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
97	F	Tracheal tube	HFH/burn unit	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
98	M	Tracheal tube	HFH/burn Unit	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
99	M	Tracheal tube	HFH/burn unit	CST, PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IPM,TGC
100	M	Tracheal tube	HFH/burn unit	CST,PB	AMC,CTX,CRO,CAZ,FEP,CIP,TZP,AMK,IMP

Table 3: Reported efficacy of resistant antibiotics in different cities of Pakistan.

S. No	City	Antibiotics	Resistant	Years	Ref
1	Islamabad	Cephalosporins, carbapenems, flouroquinolones and β-lactam drugs	100%	2013	Begum et al. [6]
		Tigecycline and minocycline	0%		
		Tetracycline	65.93%		
2	Islamabad, Lahore	Ceftriaxone	98.80%	2014	Hasan et al. [9]
		Meropenem	65.50%		
		Piperacillin-tazobactam	84.40%		
		Levofloxacin	74.40%		
		Piperacillin	94.40%		
		Trimethoprim-sulfamethoxazole	95.50%		
		Amikacin	76.60%		
		Tigecycline	20%		
		Colistin	50%		
		Minocycline	83.30%		
		Cefepime	93%		
3	Karachi	Amikacin	91%		Irfan et al. [10]
		Polymyxin	0%		
		Aztreonam	92%		
		Tetracycline	70%		
		Piperacillin/tazobactam	97%		
		Gentamicin	97%		
		Cotrimoxazole	87%		
		Chloramphenicol	89%		
		Ceftazidime, Cefipime,Ceftriaxone, Cefixime, Meropenem, Ciprofloxacin	100%		
		Ampicillin/sulbactam	84%		
4	Lahore	Cefuroxime, Cefixime, Meropenem, Imipenem	100%	2016	Anwar et al. [7]
		Colistin sulphate	15.20%		
		Sulbactam/cefoperazone	18.20%		
		Gentamicin	71.20%		
		Ceftriaxone	98.50%		
		Cefotaxime	98.50%		
		Amikacin	83.30%		
		Piperacillin/tazobactam	83.30%		

		Ceftazidime	97.00%		
		Ciprofloxacin	92.40%		
		Moxifloxacin	86.40%		
		Levofloxacin	86.40%		
5	Faislabad	Ceftazidime, cefotaxime, ceftriaxone and cefepime	98.50%	2017	Khurshid et al. [11]
		Imipenem and meropenem	97.80%		
		Tazobactam/piperacillin, fluoroquinolones	96.40%		
		Ciprofloxacin and levofloxacin	95%		
		Ampicillin/sulbactam	94.90%		
		Gentamicin	96%		
		Amikacin	94%		
		Trimethoprim-sulfamethoxazole	80.30%		
		Tobramycin	82%		
		Doxycycline	75%		
6	Karachi	Imipenem	96.60%	2008	Irfan et al. [10]
7	Peshawar	Aztreonam	83.80%	2019	Hameed et al. [12]
		Amikacin	90.30%		
		Ciprofloxacin	74.10%		
		Levofloxacin	54.80%		
		Cefepime	25.80%		
		Cefotaxime	77.40%		
		Imipenem	27.40%		
		Piperacillin/tozabactam	77.40%		
8	Islamabad	Colistin	3%	2016	Qadeer et al. [13]
		Tigecycline	33%		
		Minocycline	36%		
9	Karachi	Ampicillin	100%	2002	Shah et al. [14]
		Methicillin	-		
		Erythromycin	-		
		Co-trimoxazole	91.31%		
		Gentamicin	60.87%		
		Amikacin	26.09%		
		Cefazolin	73.92%		
		Cefotaxime	69.57%		
		Ceftazidime	65.22%		
		Ciprofloxacin	13.05%		
		Meropenem	0%		
		Vancomycin	-		
10	Karachi	Amikacine	95.78%	2017	Indhar et al. [15]
		Gentamicin	100%		
		Tetracycline	83.15%		
		Trimethoprim- sulfamethoxazole	9%5.78		
		Meropenem	94.70%		
		Imipenem	94.70%		
		Ceftazidime, Piperacillin- tazobactam , Ampicillin-sulbactam, Cefepime	100%		
		Colistin	0%		
11	Lahore	Piperacillin, ceftazidime, , cefepime and levofloxacin, ,ampicillinsulbactam, piperacillin-tazobactam, ticarcillin-clavulanic acid, ceftriaxone	90-100%	2020	Khalid et al. [16]
12	Lahore, peshawar	Ampicillin/sulbactam, piperacillin/tazobactam, meropenem, gentamicin, levofoxacin, and trimethoprim/sulfamethox azole, ceftazidime, ceftriaxone, cefepime, cefotaxime, tobramycin, ciprofoxacin	100%	2020	Karah et al. [17]
		Amikacin and imipenem	98.10%		
		Minocycline	32.70%		
		Doxycycline	30.80%		
		Colistin and polymyxin B	0%		
13	Karachi	Amikacin, Piperacillin / Tazobactam, Chloramphenicol, Polymixin B -Co-trimoxazole	92%	2016	Ali et al. [18]
		Amoxicillin+Calvulanic acid	97%		
		Ceftriaxone	96%		
		Ceftazidime	88%		
		Gentamicin	83%		
		Ciprofloxacin, Salbactam+Cefoperazone	90%		
		Tobramycin	30%		
		Imipenem	91%		
14	Lahore	Cefotaxime, Ceftazidime Ceftriaxone	99.20%	2016	Sohail et al. [19]
		Ampicillin/sulbactam	99.60%		
		Piperacillin/tazobactam	85.20%		
		Polymyxin	0%		

		Colistin	0.10%		
		Sulfamethoxazole/trimeth, Oprim	91.20%		
		Levofloxacin	97.20%		
		Tigecycline	0.70%		
		Cefepime	98.30%		
		Ciprofloxacin	97.30%		
		Doxycycline	73.70%		
		Imipenem	90.90%		
		Meropenem	90.80%		
		Tobramycin	74.60%		
		Gentamicin	93.60%		
		Amikacin	87.60%		
15	Islamabad	Cephalosporins	96.20%	2015	(Tahseen & Talib 2015)
		Cefoperazone+Sulbactam	73.10%		
		Tigecycline	11.50%		
		Piperacillin+Tazobactam	96.20%		
		Ampicilin	100%		
		Amikacin	50%		
		Carbapenem	96.20%		
		Quinolones	96.20%		
16	Islamabad	Cephalosporins, carbapenems, flouroquinolones	100%	2013	Begum et al. [6]
		Tigecycline and minocycline	0%		
		Tetracycline	65.93%		
17	Lahore	Ceftazidime, cefotaxime, ceftriaxone, cefepime	98.50%	2017	Khurshid et al. [11]
		Carbapenems (imipenem and meropenem)	97.80%		
		Tazobactam/piperacillin	96.40%		
		Fluoroquinolones (ciprofloxacin and levofloxacin)	94.90%		
		Gentamicin	96%		
		Amikacin	94%		
		Trimethoprim-sulfamethoxazole	80.30%		
		Tobramycin	82%		
		Doxycycline	75%		
18	Peshawar	Cephalosporins, penicillin	90-100%	2019	Khan et al. [20]

Informed consent

The study was approved by our institutional review board and informed consent taken from all participants.

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