ORIGINAL ARTICLE

Evaluation of the Emerging Multidrug-Resistant *Acinetobacter baumannii* in Clinical Samples from Tertiary Care Hospitals in Mysore, India - a Cohort Study

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Abstract

Objectives: *Acinetobacter baumannii* is an important emerging nosocomial pathogen of alarming significance. It has the propensity not only to cause much morbidity and mortality, but is also leading to the uselessness of the available limited antibiotic drugs due to the rampant resistance. **Materials and Methods:** The present study aims to document and evaluate the current situation on the available treatment options for *A. baumannii* nosocomial infection, mainly the carbapenem drug- imipenem, colistin, and tigecycline and to analyze the drug safety and any/all of the adverse drug reactions related to this drug therapy. **Results:** Results of this study probe that carbapenem resistance is seen in about 86% of all *Acinetobacter* isolates. Colistin is the best available treatment for multi-drug resistant species with 100% cure rate and fewer serious life threatening adverse effects with the long duration therapy that is required in this case. The only concern remained the patient compliance to the abdominal symptoms (56.7% of nausea, 14.43% vomiting and 4.12% diarrhea) which was statistically significant ($P = 0.049$). **Conclusion:** Overall, colistin therapy can be regarded as the best treatment for multi-drug resistant *A. baumannii*, which opens avenues for further studies on the pharmacokinetics and pharmacodynamics of this drug.

Key words: *Acinetobacter baumannii*, carbapenem resistance, hospital-associated infections, multi-drug resistant

INTRODUCTION

Acinetobacter baumannii is one pathogenic Gram-negative bacterium that has recently emerged as a serious nosocomial infection. It has catapulted itself to the center stage especially after its outbreak in the United States military hospitals in Iraq and Afghanistan.[1] The special ability of this bacterium to persist on inanimate surfaces has contributed significantly to the current status of infection rates.[2-4] Members of this genus were a rare cause of human infections till 1970s. Recent decades have seen a significant increase in the prevalence of *Acinetobacter* species infections in special settings.[5] *A. baumannii* species in particular are now an important and rapidly emerging cause of hospital-associated infections (HAI). Literature suggests that infections from *A. baumannii* tend to occur mainly in 4 types patient populations and settings: (i) Intensive care units (ICU); (ii) HAI outside ICU settings; (iii) infections in trauma patients, for example, in war and sites of natural calamities like earthquake sites; and (iv) community-acquired infections.[6] Among them, HAIs in ICU settings are a major challenge now in tertiary care hospitals. Literature also suggests an increase in community-acquired *A. baumannii* infections.[7]

The special ability to survive on artificial surfaces, resist desiccation, and ability to form bio-films allows it to persist for an extended period of time in hospital environments that has contributed to the rapid emergence of drug resistant strains.[8] Rapid emergence of multidrug-resistant

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A. baumannii (MDRAB) infections, Carbapenem resistant *A. baumannii* (CRAB) infections, and pandrug-resistant *A. baumannii* (PDRAB) infections is now a major public health concern, adding significantly to the cost of medical care, increase in morbidity and mortality of the already sick patients especially in tertiary care hospitals.[9] Poor compliance to hospital infection prevention protocols and poor adherence to proper antibiotic policies are believed to be the important cause for the emergence of such infections. For these reasons, such infections are common in certain European, Asian, South American countries, and significantly less common in the USA and Nordic countries.[10]

A wide spread resistance to antibiotics classified as MDRAB, CRAB, and PDRAB has literally reached an end of the "antibiotic road" with a harbinger of the so-called' post-antibiotic era.[9] This is the first ever comprehensive observational study performed in Mysore city on the incidence and trending drug therapies for the treatment of *A. baumannii* nosocomial infections in the tertiary care hospitals of the city, and compares the outcomes and drug safety parameters of the various classes of antibacterial mainly concentrating on carbapenems. The research here suggests that although *Acinetobacter* species were originally thought to be acquired from the traumatic injuries associated with the use of improvised explosive devices, subsequent studies have suggested that the nosocomial infection associated with their hospitalization is now widely attributed toward the multidrug-resistant species of *A. baumannii*.

With this background, the aim of the present study was to assess the prevalence of *A. baumannii*-HAI in tertiary care centers with an emphasis on the prevalence of antibiotic resistance among different isolates in Mysore city and to evaluate the role of compliance to hospital infection prevention protocols at tertiary care hospitals.

MATERIALS AND METHODS

Study design and criteria

This is an observational prospective cohort study conducted in Mysore city, the third largest city in the state of Karnataka, India, during the months of June 2014 to August 2014. This was an ideal setting for the research on this emerging pathogen as the Medical College Hospital facility and the other tertiary care hospitals in this city provide the best authentic data for the purpose of this research. The initial sample size was fixed at 50, to be included after they agreed to the below mentioned inclusion and exclusion criteria for the study [Table 1]. Five tertiary care hospitals within the city limits were included in this study. Prior approval was obtained from the Institutional Ethics Committee (JSS/MC/IEC/811/2013-14) dt: 05/05/2014, and each patient selected for observational evaluation signed a written informed consent, explained in his/her own language before participating in the study.

Data source and variables

Efficacy variables are clinical and microbiological variables with collection of data from the patient's clinical, administrative, and laboratory records.

In this scenario, there were three outcomes: (i) Cure, (ii) failure of treatment, and (iii) missing data. The patients were grouped based on the criteria for the duration of therapy and symptom resolution. Cure is when the symptoms subsided after a minimum of 5–14 days after administration of the study drugs with no demonstrable microbiological proof of *Acinetobacter*. Failure of treatment is when the signs and symptoms persisted for a duration of more than or equal to 2 days, with a minimum of 5 days of the drug administration and microbiologically demonstrable presence of *Acinetobacter*. Missing is if the duration of treatment was <2 days or 2 doses. While the duration of the therapy can be fixed based on the extent of infection, the course duration was anywhere between 5 and 14 days.

Identification and antibiotic sensitivity test

The isolation and characterization were using the standard methods such as colony observation and Gram staining. Isolates were evaluated for their antibiotic resistance patterns of *A. baumannii* isolates against various antibiotics using disc diffusion by Kirby–Bauer method.[11] Further, based on the test results bacteria were classified as sensitive, resistant, inducible resistance and missing data as per the recommendations from Clinical Laboratory Standard Institute. Multidrug-resistant species were evaluated in different specimens and wards.

Statistical analysis

The statistical analyses were carried out using SPSS version Software (version 21.0, Chicago, USA). All continuous data were expressed as Mean ± Standard Deviation and categorical data were expressed as proportions and percentages. Treatment outcomes across all the recordings were noted and analyzed using one-way analysis of variance (ANOVA) along with tests for significance and student t-test for clinical cure. Calculation of odds ratio was done with 95% confidence intervals. A two-tailed $P < 0.05$ was considered significant. Missing data were reported without imputing the data.

RESULTS

A total of 82 patients were initially screened over five tertiary care hospitals in Mysore from June 2013 to August 2014, 50 of who were specifically chosen based on their willingness to be a part of this study, having satisfied the inclusion and exclusion criteria. The percentage of isolates of *Acinetobacter*

Table 1: Generalandinfection-specificinclusionandexclusioncriteriaforpatients in a study of emerging *Acinetobacter baumannii* nosocomial infections and drug resistance

	Inclusion
1. General	• Patients with pneumonia, skin and soft tissue infections, bacteremia and urinary tract infections after 48 h hospitalization were chosen after taking informed consents • Age-group, ≥13 year, and weight ≥40 kg • Treatment of at least one dose of the study drug- Carbapenems namely, Imipenem, Colistin, Tigecycline
2. Samples	• Blood – 5 ml venous blood, only once • Pus • Urine • Cerebrospinal fluid • Sputum • Aspirates
3. Pneumonia	• Characteristic pneumonia symptoms such as baseline chest radiograph showing new or progressive infiltrates, consolidation with or without effusion • Symptoms such as cough, purulent sputum production, rales and/or signs of pulmonary consolidation, dyspnea, tachypnea, and/or hypoxemia, fever (temperature, 38°C [100.4°F] taken orally, 38.5°C [101.2°F] tympanically, or 39°C [102.2°F] rectally); respiratory rate of 130 breaths per minute; systolic hypotension; heart rate of 120 beats per minute; altered mental status; requirement for mechanical ventilation; elevated total peripheral WBC count of 110,000 cells/mm^3, with 115% immature neutrophils (band forms), or leukopenia (WBC count of <4500 cells/mm^3) • If patient is HIV-positive, CD4 cell count of 1200 cells/mm^3 • Culture of ≥1 blood sample that yielded *Acinetobacter* spp. and 1 of the following findings: Symptoms of sepsis (fever [temperature, >38°C], chills, or hypotension)
4. Bacteremia	• Sepsis, septic shock and disseminated intravascular coagulation • Bloodstream infection in a patient with a documented primary infection elsewhere (secondary bacteremia)
5. Meningitis	• Clinical signs of meningitis (fever, meningeal signs, and low consciousness level) • Pleocytosis, low glucose level, and elevated protein • Level in the cerebrospinal fluid • Isolation of A. *baumannii* from cerebrospinal fluid • Treatment with ampicillin/sulbactam/Imipenem/Meropenem
6. Urinary tract infection	• Urine culture growing a single organism in concentrations of ≥10^5cfu/mLor • Growing two organisms each in concentrations of ≥10^5 CFU/mL in symptomatic patients
7. Skin or wound infection	• Skin and soft tissue infections were identified on the basis of definitions of the Infectious Diseases Society of America
	Exclusion
Patients were excluded if	• They had co-infections caused by pathogens other than *Acinetobacter baumannii* species • Drop-outs during the study • Pregnant females and children • Lung carcinoma, cystic fibrosis or active tuberculosis (known or suspected).

spp. were 2.18%, 4.5%, 1.1%, 4.1%, and 3.93% in the five hospitals over a period of 15 months.

Identification of *A. baumannii* isolates

Based on the colony characteristics, the isolates were evaluated on blood and MacConkey agar. While on MacConkey agar the colonies appeared as non-lactose fermenters, on the blood agar they appeared 1–2 mm in diameter showing characteristics such as dome-shaped, muciodal, smooth to pitted surface, and non-pigmented appearance. They were confirmed as *A. baumannii* using API20 E kits.

Resistant *A. baumannii* in various organs

Among the 50 samples evaluated, highest prevalence was observed in the endotracheal aspirate/bronchoalveolar lavage/tracheostomy aspirate - 28 (56%) followed by blood - 9 (18%), sputum- 7 (14%), pus - 5 (10%), and cerebrospinal fluid (CSF) - 1 (2%).

Patients with carbapenem sensitive *Acinetobacter* spp. received carbapenem class of antibacterial drugs (hereafter referred to as "carbapenem sensitive group") and carbapenem resistant *Acinetobacter* spp. received colistin or tigecycline (hereafter referred to as carbapenem resistant group). In the carbapenem

sensitive group (n = 7), the patients mostly represented the extremes of age (2 patients <3 days old and 2 patients more than 60 years old), with a mean age of 43.28 years.± 34.82, while in the carbapenem resistant group (n = 43) which form 86% of the infections, showed a more widely distributed patient base ranging from 5 days to 82 years of age (mean age=52.74 years ± 22.61). Male: female ratio was 6:1 in carbapenem sensitive group and 29:14 in the carbapenem resistant group. Other than this, patients were evenly distributed between the groups, based on other demographic variables [Table 2].

Majority of the cases were respiratory tract-related infections, including ventilator-associated pneumonia 5 (10%) and 30 (60%) in the two groups, respectively. The striking observation was the lack of urinary tract infections caused by *Acinetobacter* spp. in the study period in Mysore city. The more serious infection leading to meningitis was seen in one patient. Bacteremia was the second most serious infection having an incidence of 2 (4%) in the carbapenem sensitive group and 7 (14%) in the carbapenem resistant group, but notably more fatal, leading to the death of one subject (2 days old male baby) in spite of early diagnosis. Skin and soft tissue infections were the last in the detected cases amounting to 5 cases (10%) in the carbapenems resistant group. In the study cohort, there were a total of 28 comorbid conditions reported in 22 (51.78%) individuals. Diabetes mellitus was the highest reported comorbidity (n = 11 [39.28%]) followed by hypertension (n = 9 [32.14%]), renal insufficiency (n = 8 [28.57%]). They seemed to show a varying prognosis in due course of the treatment.

Antibiotic sensitivity pattern

Out of all the isolates of *Acinetobacter*, the antibiotic sensitivity testing using Kirby–Bauer method showed that all the isolates were sensitive to tigecycline and colistin, the two higher antibiotics reserved for very serious non-responding cases only. There were 18 isolates that were either resistant (n = 7 [14%]) or had inducible resistance (n = 11 [22%]) to imipenem and meropenem, the two drugs that were previously the gold standards for the treatment of *A. baumannii* infections. There was a 100% resistance toward penicillin and the extended spectrum penicillin-oxacillin, and also the group of fluoroquinolones-ofloxacin. Furthermore, 98% resistance was observed with cephalosporins- cefotaxime and ceftriaxone, the previous treatment alternatives to carbapenems. About 10% isolates were sensitive to gentamycin.

Further, with respect to the cure rates carbapenem sensitive group had 85.71% cure rates after treatment with imipenem. There was also one death reported in this study that belonged to this group, whereas there was 90.69% cure rates in the carbapenem resistant group who were treated using tigecycline and colistin. It was also noted that tigecycline was the preferred choice of drug to treat carbapenem resistant isolates of *A. baumannii*. Table 3 provides details of all the antibiotics tested and their corresponding antibiotic susceptibility test results. Overall, there were no dropouts of participants from the study.

Safety parameters

There were a total of 160 reported adverse events during the study. There were the expected trends as far as each of the three drugs under consideration. Among the serious adverse drug effects, imipenem gave rise to seizure in 1 patient (10%) who also had renal failure (10%) and imipenem resistant bacterial infection (10%) and died during the

Table 2: Summary of baseline demographics and clinical characteristics of study population

	No.(%) of total patients		
Characteristic	**Carbapenem sensitive (n=7)**	**Carbapenem resistant (n=43)**	***P*-value**
Sex			
Male	6 (12%)	29 (58%)	0.1505
Female	1 (2%)	14 (28%)	
Type of infection			
Pneumonia/RTI	5 (10%)	30 (60%)	0.2335
Bacteremia	2 (4%)	7 (14%)	
Meningitis	0	1 (2%)	
Skin and soft tissue infection	0	5 (10%)	
Urinary tract infection	0	0	
Age in years (mean ± SD)	52.74 years±22.61	52.74 years±22.61	
Co-morbidities			
Diabetes mellitus	(n=28)		0.2801
Hypertension	11 (39.28%)		
Renal insufficiency	9 (32.14%)		
(creatinine >1.5 mg/dL)	8 (28.57%)		

Table 3: Antibiotic susceptibility test results of *Acinetobacter* isolates

Antimicrobial agent	Sensitive	Resistant	Inducible resistance	Data missing
Cefotaxime	1 (2%)	49 (98%)	0	0
Ceftriaxone	1 (2%)	49 (98%)	0	0
Ciprofloxacin	1 (2%)	47 (94%)	2 (4%)	0
Co-Trimoxazole	3 (6%)	47 (94%)	0	0
Gentamicin	5 (10%)	45 (90%)	0	0
Levofloxacin	3 (6%)	44 (88%)	3 (6%)	0
Linezolid	1(2%)	32 (64%)	0	17(34%)
Oxacillin	0	50 (100%)	0	0
Penicillin	0	50 (100%)	0	0
Ofloxacin	0	50 (100%)	0	0
Imipenem	7 (7%)	32 (64%)	11 (22%)	0
Meropenem	7 (14%)	32 (64%)	11 (22%)	0
Piperacillin+Tazobactam	2 (4%)	46 (92%)	2 (4%)	0
Tigecycline	50 (100%)	0	0	0
Colistin	50 (100%)	0	0	0

period of the study. More commonly, the triad of nausea (30%), vomiting (20%), and diarrhea (10%) was seen in this group. The carbapenem resistant group saw 30 patients treated with colistin and 13 patients treated with tigecycline. There were more reports of nausea with colistin therapy (56.70%) compared to tigecycline (28.30%), which showed most reports of pain at injection site (8%) and bradycardia (5.66%) which were expected. colistin therapy also brought out more reports of itching(11.34%). All the observations are statistically significant ($P < 0.05$) [Table 4].

DISCUSSION

The present study evaluates the prevalence of nosocomial infections caused by *A. baumannii* in patients with wide age groups. Literature suggests that *A. baumannii* has various virulence factors and its ability to persist on inanimate objects and environment for a prolonged period of time.[12] The fact that this pathogen infects hospital inmates, who are generally immuno-suppressed/immuno-compromised individuals and young children and war veterans with wound and burn injuries enable it to surmount the resistance to infection. A study of European intensive care units in 2009 reveals that *A. baumannii* was responsible for 19.1% of ventilator-associated pneumonia cases.[13] The failure to initiate immediate appropriate antibiotic treatment has a profound impact on the prognosis of this condition. The organism is exposed to various lower antibiotics in a sub minimum inhibitory concentrations dosage so that the resistance mechanisms are at work making it the resistant variety.[14] Therefore, early detection and careful review of the pathogenic variant will provide detailed information on the type of treatment that is required.[15,16]

In our study, majority of the infections were observed in the endotracheal aspirate/bronchoalveolar lavage/tracheostomy aspirate - 28 (56%) followed by blood - 9 (18%), sputum - 7 (14%), pus - 5 (10%), and CSF - 1 (2%). In accordance with our present findings, studies by Shanthi and Sekar[17] also revealed that most isolates were from the respiratory tract (41.8%), followed by urinary tract (25.5%), wound (20%), and blood (12.7%). Similarly, studies carried out by Begum *et al*.,[18] also demonstrated that the highest isolates were obtained from endotracheal tube specimens followed by tracheal secretions and pus. Furthermore, the resistance patterns were evaluated and the isolates were classified as sensitive, resistance, and inducible resistant types. Two treatment groups based on their resistance to carbapenems were considered. The objective of performing this study was to narrow down to safer alternative antibiotics for which *A. baumannii* has not developed resistance. In this regard, some progress was achieved when the adverse drug reactions (ADRs) noted were not a mere chance occurrence after applying the student's *t*-test and obtaining $P < 0.05$, thus statistically significant. Therefore, colistin could be considered as a safer drug for the treatment of MDRAB and CRAB. Tigecycline was a competent alternative to Colistin. However, its efficiency was hampered by the increased incidences of bradycardia (5.66%) and secondary infection by bacteria resistant to tigecycline. The present study suggests that tigecycline exhibits significantly higher mortality and more nephrotoxicity in comparison with that of colistin therapy.[19]

Overall, we can conclude that tigecycline +carbapenem combination therapy outcome was comparable with that of the tigecycline monotherapy as reported in a previous study.[20] On the contrary, Falagas *et al*.[21] reported that colistin

Table 4: Adverse drug reactions encountered in the study of antibiotic treatment *Acinetobacter baumannii* nosocomial infection

Adverse event	No. of reports				*P*-value
	Carbapenem sensitive group	Carbapenem resistant group			
	Rx-Imipenem (*n*=7)	Rx-Colistin (*n*=30)	Rx-Tigecycline (*n*=13)	Total	
Nausea	3 (30)	55 (56.70)	15 (28.30)	70 (46.67)	0.049
Vomiting	2 (20)	14 (14.43)	12 (22.64)	26 (17.33)	
Diarrhea	1 (10)	4 (4.12)	5 (9.44)	9 (6.00)	
Itching	0	11 (11.34)	0	11 (7.33)	
Fever	1 (10)	6 (6.18)	2 (3.77)	8 (5.34)	
Seizure (Neurotoxicity)	1 (10)	0	0	0	
Nephrotoxicity	1 (10)	0	0	0	
Bronchospasm	0	0	0	0	
Pain at injection site	0	1 (1.04)	11 (20.75)	12 (8.00)	
Bradycardia	0	0	3 (5.66)	3 (2.00)	
Infections	1 (10)	6 (6.18)	5 (9.44)	11 (7.33)	
Total	10 (100)	97 (100)	53 (100)	150 (100)	160

with carbapenem as opposed to Colistin monotherapy fared poorly and therefore colistin monotherapy is a better choice if choosing this antibiotic. However, appropriate duration and dosing are yet to be standardized in order to achieve optimal treatment from the infection. Furthermore, the available data on the pharmacokinetics, pharmacodynamics of Colistin are very limited and this is an area that needs to be worked on.[22]

In terms of its mechanism, carbapenems are the choice of antibiotic for serious infections caused by *A. baumannii.* Yet, there is an increasing jeopardy with respect to the emergence of mechanisms of resistance such as enzymatic and membrane channel-based.[23]

CONCLUSION

Our results were consistent with our hypothesis that *A. baumannii* nosocomial infections are rapidly emerging as there were more than 3.16% of all isolates in the five tertiary care hospitals included in the study. There is also conclusive evidence from this report that carbapenem resistance is indeed very common amounting to almost 86% of the isolates. The best antibiotic for treatment as per the current study is found to be colistin, as there were fewer ADRs and patient compliance was generally better along with no evidence of any long-term effects associated with its prolonged treatment, even in case of imipenem sensitive cases of *A. baumannii*.

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CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest.

REFERENCES

1. Linz B, Mukhtar N, Shabbir MZ, Rivera I, Ivanov YV, Tahir Z, *et al*. Virulent epidemic pneumonia in sheep caused by the human pathogen *Acinetobacter baumannii*. Front Microbiol 2018;9:2616.
2. O'Shea MK. *Acinetobacter* in modern warfare. Int J Antimicrob Agents 2012;39:363-75.
3. Meghoo CA, Dennis JW, Tuman C, Fang R. Diagnosis and management of evacuated casualties with cervical vascular injuries resulting from combat-related explosive blasts. J Vasc Surg 2012;55:1329-37.
4. Murray CK. Epidemiology of infections associated with combat-related injuries in Iraq and Afghanistan. J Trauma Acute Care Surg 2008;64:S232-8.
5. Falagas ME, Karveli EA. The changing global epidemiology of *Acinetobacter baumannii* infections: A development with major public health implications. Clin Microbiol Infect 2007;13:117-9.
6. Shashank MP, Prithvi SS, Sujay S, Tejaswini M, Lakshmi VR, Jayanthi M, *et al*. The current status and perspectives for the emerging pandemic: Covid-19. Pathogen 2020;9:29.
7. Kim YA, Kim JJ, Won DJ, Lee K. Seasonal and

temperature-associated increase in community-onset *Acinetobacter baumannii* complex colonization or infection. Ann Lab Med 2018;38:266.
8. Lin MF, Lan CY. Antimicrobial resistance in *Acinetobacter baumannii*: From bench to bedside. World J Clin Cases 2014;2:787.
9. Sartelli M, Hardcastle TC, Catena F, Chichom-Mefire A, Coccolini F, Dhingra S, *et al*. Antibiotic use in low and middle-income countries and the challenges of antimicrobial resistance in surgery. Antibiotics 2020;9:497.
10. Wang CH, Hsieh YH, Powers ZM, Kao CY. Defeating antibiotic-resistant *Bacteria*: Exploring alternative therapies for a post-antibiotic era. Int J Mol Sci 2020;21:1061.
11. Yao H, Liu J, Jiang X, Chen F, Lu X, Zhang J. Analysis of the clinical effect of combined drug susceptibility to guide medication for carbapenem-resistant *Klebsiella pneumoniae* patients based on the Kirby-Bauer disk diffusion method. Infect Drug Resist 2021;14:79.
12. Tavakol M, Momtaz H, Mohajeri P, Shokoohizadeh L, Tajbakhsh E. Genotyping and distribution of putative virulence factors and antibiotic resistance genes of *Acinetobacter baumannii* strains isolated from raw meat. Antimicrob Resist Infect Control 2018;7:1.
13. Koulenti D, Lisboa T, Brun-Buisson C, Krueger W, Macor A, Sole-Violan J, *et al*. Spectrum of practice in the diagnosis of nosocomial pneumonia in patients requiring mechanical ventilation in European intensive care units. Crit Care Med 2009;37:2360-9.
14. Ramu R, Shirahatti PS, Dhanabal SP, Zameer F, Dhananjaya BL, Prasad MN. Investigation of antihyperglycaemic activity of banana (Musa sp. Var. Nanjangud rasa bale) flower in normal and diabetic rats. Pharmacogn Mag 2017;13:S417.
15. Nguyen M, Joshi SG. Carbapenem resistance in *Acinetobacter baumannii*, and their importance in hospital-acquired infections: A scientific review. J Appl Microbiol 2021.
16. Vinusha HM, Kollur SP, Revanasiddappa HD, Ramu R, Shirahatti PS, Prasad MN, *et al*. Preparation, spectral characterization and biological applications of Schiff base ligand and its transition metal complexes. Results Chem 2019;1:100012.
17. Shanthi M, Sekar U. Multi-drug resistant *Pseudomonas aeruginosa* and *Acinetobacter baumannii* infections among hospitalized patients: Risk factors and outcomes. J Assoc Physicians India 2009;57:636-8.
18. Begum S, Hasan F, Hussain S, Shah AA. Prevalence of multi drug resistant *Acinetobacter baumannii* in the clinical samples from tertiary care hospital in Islamabad, Pakistan. Pak J Med Sci 2013;29:1253.
19. Shivasharanappa N, Ramith R, Anil KS, Vivek KG, RajukumarK, Vijay K, *et al*. Toxicopathological studies on the effects of T-2 mycotoxin and their interaction in juvenile goats. PLoS One 2020;15:e0229463.
20. Schafer JJ, Goff DA, Stevenson KB, Mangino JE. Early experience with tigecycline for ventilator-associated pneumonia and bacteremia caused by multidrug-resistant *Acinetobacter baumannii*. Pharmacotherapy J Hum Pharmacol Drug Ther 2007;27:980-7.
21. Falagas ME, Rafailidis PI, Kasiakou SK, Hatzopoulou P, Michalopoulos A. Effectiveness and nephrotoxicity of colistin monotherapy vs. colistin-meropenem combination therapy for multidrug-resistant Gram-negative bacterial infections. Clin Microbiol Infect 2006;12:1227-30.
22. Kempf M, Djouhri-Bouktab L, Brunel JM, Raoult D, Rolain JM. Synergistic activity of sulbactam combined with colistin against colistin-resistant *Acinetobacter baumannii*. Int J Antimicrob Agents 2012;39:180.
23. Walther-RasmussenJ,HøibyN.OXA-typecarbapenemases. J Antimicrob Chemother 2006;57:373-83.

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