ECRONICON OPEN ACCESS

EC CLINICAL AND MEDICAL CASE REPORTS

Research Article

Comparative Analysis of Bacterial Co-Infections among COVID and Non-COVID ICU Patients in a Tertiary Care Hospital

Kumudini Panigrahi[1], Basanti Kumari Pathi[1], Samarth Krishna[1], Nishikanta Thatoi[1] and Jyoti Prakash Sahoo[2]*

[1]*Department of Microbiology, Kalinga Institute of Medical Sciences, KIIT University, India*

[2]*Department of Pharmacology, Kalinga Institute of Medical Sciences, KIIT University, India*

***Corresponding Author:** Jyoti Prakash Sahoo, Department of Pharmacology, Kalinga Institute of Medical Sciences, KIIT University, Bhubaneswar, Odisha, India.

Received: August 18, 2025; **Published:** September 17, 2025

Abstract

Background and Objectives: The COVID-19 pandemic had affected multiple aspects of health. Injudicious use of antibiotics had led to the development of drug resistance and hospital acquired infections (HAI). Hence, we mapped this study to evaluate the incidences of HAI among COVID and non-COVID ICU patients.

Methods: In this cross-sectional study, we included adult patients of either gender, who tested positive for SARS-CoV-2 by RT-PCR and were admitted to the ICU irrespective of their COVID-19 status. Relevant clinical and microbiological data were retrieved from the case sheets of the participants. All clinical specimens were processed according to standard microbiological procedures. Isolates were identified using VITEK-2 automated identification systems. Antimicrobial susceptibility testing (AST) was performed to determine the susceptibility profile of isolates against commonly used antibiotics. R software (version 4.4.1) was leveraged for the data analysis.

Results: 1355 (36.9%) of 3672 patients were eligible as per our study criteria. Of them, 719 (53.1%) were females. The median age of the study population was 53.5 (47.0-62.0) years [COVID: 55.8 (47.0-65.0) years; non-COVID: 51.5 (46.0-58.5) years; $p < 0.001$]. The median duration of ICU stay of the study population was 17.0 (14.0-21.0) days [COVID: 16.0 (13.0-20.0) days; non-COVID: 18.0 (15.0-22.0) days; $p < 0.001$]. The median value of serum procalcitonin level of the study population was 1.29 (0.71-2.07) ng/ml [COVID: 1.38 (0.71-3.01) ng/ml; non-COVID: 1.17 (0.71-1.32) ng/ml; $p = 0.02$]. 958 of 1355 (70.7%) patients [COVID: 572 of 839 (68.2%); non-COVID: 386 of 516 (74.8%); $p < 0.001$] had no pathogenic organisms in the AST. The most organisms found among COVID patients were *Acinetobacter baumannii* (74, 9%) and *Klebsiella pneumoniae* (68, 8%). The most organisms found among non-COVID patients were *Pseudomonas aeruginosa* (46, 9%) and *Acinetobacter baumannii* (28, 5%).

Conclusion: The COVID-19 ICU patients in our study were older, had higher PCT levels, and shorter ICU stays contrasted to non-COVID ICU patients. The AST findings revealed the predominance of multidrug-resistant Gram-negative pathogens. Tigecycline and meropenem remain the most effective antimicrobials for multiple pathogens. However, resistance against aminoglycosides, fluoroquinolones, and carbapenems mandate rational prescribing measures and strengthening of antimicrobial stewardship programs.

Keywords: *COVID-19 Infection; Hospital-Acquired Infection; Bacterial Co-Infection; ICU; Comparative Analysis*

Abbreviations

AST: Antimicrobial Susceptibility Testing; AMR: Antimicrobial Resistance; COVID: Corona Virus Disease; HAI: Hospital Acquired Infection; ICU: Intensive Care Unit; IQR: Interquartile Range; RT-PCR: Reverse Transcriptase Polymerase Chain Reaction

Introduction

The pandemic caused by severe acute respiratory syndrome corona virus 2 (SARS-CoV-2), has negatively impacted the multiple aspects of society. There was deterioration of global health landscape. Healthcare systems were under strain due to elevated morbidity and mortality rates [1]. As of 3rd May 2021, WHO reported 152,387,917 confirmed COVID-19 cases and 3,195,624 deaths globally. India accounted for 19,925,604 cases and 218,959 deaths. During the second wave (1st March to 3rd May), India reported 8,813,363 cases and 61,802 deaths, contributing to 44.23% of global cases and 28.23% of global deaths [2].

Although antibiotics are ineffective against COVID-19, they were often used in suspected cases due to the difficulty in excluding secondary bacterial infections-a serious and common complication in hospitalized patients, occurring in 10 - 15% of cases [3,4]. The mortality rate in COVID-19 patients with secondary bacterial infections is approximately 50% [4].

Irrational use of antibiotics led to emergence of multidrug-resistant organisms [1,5]. Hence, in COVID-19 patients, understanding the etiology of secondary bacterial infections is essential for timely and appropriate treatment, as well as for promoting rational antibiotic use to prevent adverse outcomes. However, limited microbiological studies are done on the profile of such infections in these patients and antibiotics are often used empirically. This practice has hindered efforts to control bacterial infections and reduce antimicrobial resistance, making the global problem increasingly complex.

To address this gap, the present cross-sectional study was conducted to provide evidence-based insights that can support effective antibiotic stewardship during COVID-19 management. The study aimed to compare the prevalence of infections in COVID ICU and Non-COVID ICU patients in a tertiary care hospital. We also assessed their serum procalcitonin level. We also determined the bacteriological profile of the patients and their antimicrobial susceptibility testing (AST) patterns.

Materials and Methods

This cross-sectional study was conducted from January 2021 to December 2021 at Kalinga Institute of Medical Sciences, India. Before commencing the study, we obtained the ethics approval from the concerned authority (KIIT/KIMS/IEC/708/2021 dated 27/07/2021). All participants or their close relatives provided consents before the enrolment.

Our study included adult patients of either gender, who tested positive for SARS-CoV-2 by RT-PCR and were admitted to the ICU irrespective of their COVID-19 status. We analyzed all of their samples used for culture and sensitivity testing. We excluded people with viral infections, contaminated samples, normal flora, or missing records.

Relevant clinical and microbiological data were retrieved from the case sheets of the participants. We recorded the demographic details like age, sex, type of clinical specimen (i.e. sputum, ET aspirate, blood, urine, wound swab), microbiological findings (i.e. isolated bacterial species, Gram staining, AST findings). All clinical specimens were processed according to standard microbiological procedures. Isolates were identified using VITEK-2 automated identification systems. AST was performed to determine the susceptibility profile of isolates against commonly used antibiotics.

For this cross-sectional study, we adopted convenience sampling as we did not know the prevalence of COVID and related HAI in our institution. We used the Shapiro-Wilk test to ensure that the collected data were normally distributed. For categorical variables, frequency and proportion were used as summary statistics. The continuous data was presented using the median and interquartile range (IQR). Descriptive statistics were used to summarize patient characteristics, types of bacterial isolates, and resistance patterns. We used Pearson's chi-square test to compare sociodemographic characteristics. The Wilcoxon test was calibrated to analyze the continuous data. For data analysis, we used R software (version 4.4.3) [6]. The statistical tests were two-tailed. The p-values less than 0.05 were interpreted as statistically significant.

Results

We screened a total of 3672 patients with the study criteria. 1031 patients had either only viral infection or did not have any infection during their hospital stay. 978 patients had contaminated flora in their culture reports. 309 patients had incomplete data. Hence, we excluded those 2317 people. The remaining 1355 (36.9%) subjects met the eligibility criteria. Of them, 719 (53.1%) were females. The sociodemographic traits have been elucidated in table 1. The median age of the study population was 53.5 (47.0-62.0) years [COVID: 55.8 (47.0-65.0) years; non-COVID: 51.5 (46.0-58.5) years; p < 0.001]. The age distribution of the study participants is shown in figure 1.

Parameter	Total (n = 1355)	COVID (n = 839)	Non-COVID (n = 516)	p-value
Age (years)	53.5 (47.0-62.0)	55.8 (47.0-65.0)	51.5 (46.0-58.5)	< 0.001
Age > 60 years	401 (29.6%)	304 (36.2%)	97 (18.8%)	< 0. 001
Females	719 (53.1%)	406 (48.4%)	313 (60.7%)	< 0. 001
Socioeconomic status				
Lower	317 (23.4%)	165 (19.7%)	152 (29.5%)	< 0.001
Lower-middle	868 (64.1%)	580 (69.1%)	29 (55.8%)	
Upper-middle	170 (12.5%)	94 (11.2%)	76 (14.7%)	
Duration of ICU stay (days)	17.0 (14.0-21.0)	16.0 (13.0-20.0)	18.0 (15.0-22.0)	< 0.001
Ventilator usage (days)	14.0 (10.0-18.0)	13.0 (9.0-17.0)	16.0 (13.0-20.0)	< 0.001
Catheter *in-situ* (days)	15.0 (11.0-20.0)	14.0 (10.0-18.0)	18.0 (14.0-22.0)	< 0.001
Procalcitonin level (ng/ml)	1.29 (0.71-2.07)	1.38 (0.71-3.01)	1.17 (0.71-1.32)	0.02

Table 1: *The sociodemographic traits of the study population.*

The continuous and categorical variables are presented as median (IQR) and frequency (proportion), respectively.

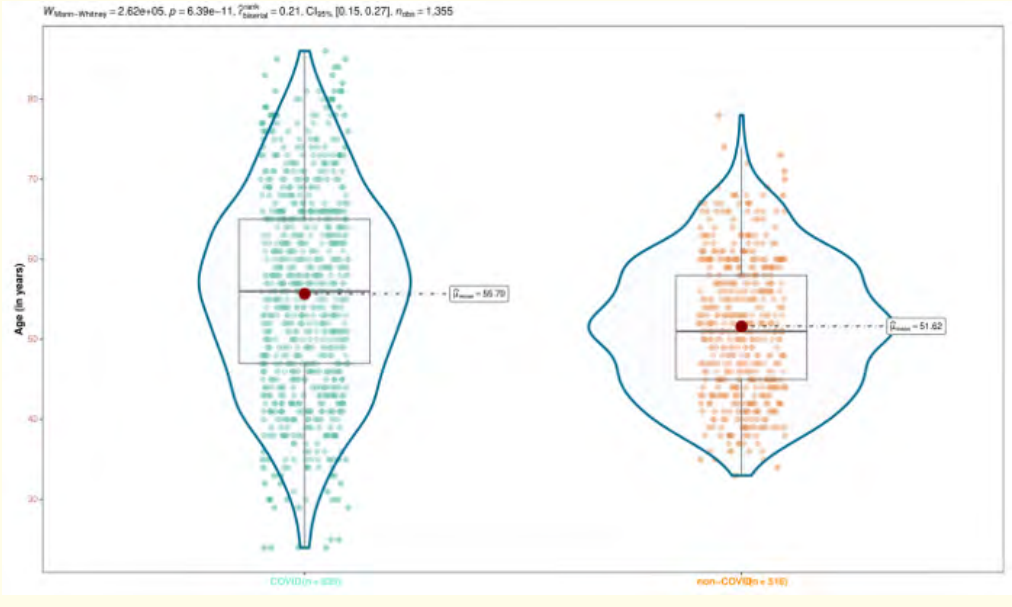

Figure 1: *Age distribution of the participants.*

The box-violin-jitter plots demonstrate the age of the COVID and non-COVID patients. The width of the violin plot corresponds to the number of participants with their age on the y-axis. The box-whisker and jitter plots illustrate the age values. The Mann-Whitney test was used to calculate the p-value.

The median duration of ICU stay of the study population was 17.0 (14.0-21.0) days [COVID: 16.0 (13.0-20.0) days; non-COVID: 18.0 (15.0-22.0) days; p < 0.001]. The median duration of ventilator requirement of the study population was 14.0 (10.0-18.0) days [COVID: 13.0 (9.0-17.0) days; non-COVID: 16.0 (13.0-20.0) days; p < 0.001]. The median duration of *in-situ* catheter of the study population was 15.0 (11.0-20.0) days [COVID: 14.0 (10.0-18.0) days; non-COVID: 18.0 (14.0-22.0) days; p < 0.001]. The median value of serum procalcitonin level of the study population was 1.29 (0.71-2.07) ng/ml [COVID: 1.38 (0.71-3.01) ng/ml; non-COVID: 1.17 (0.71-1.32) ng/ml; p = 0.02]. Figure 2-5 portray the durations of ICU stay, ventilator requirement, *in-situ* catheter, and serum procalcitonin level of the study participants, respectively.

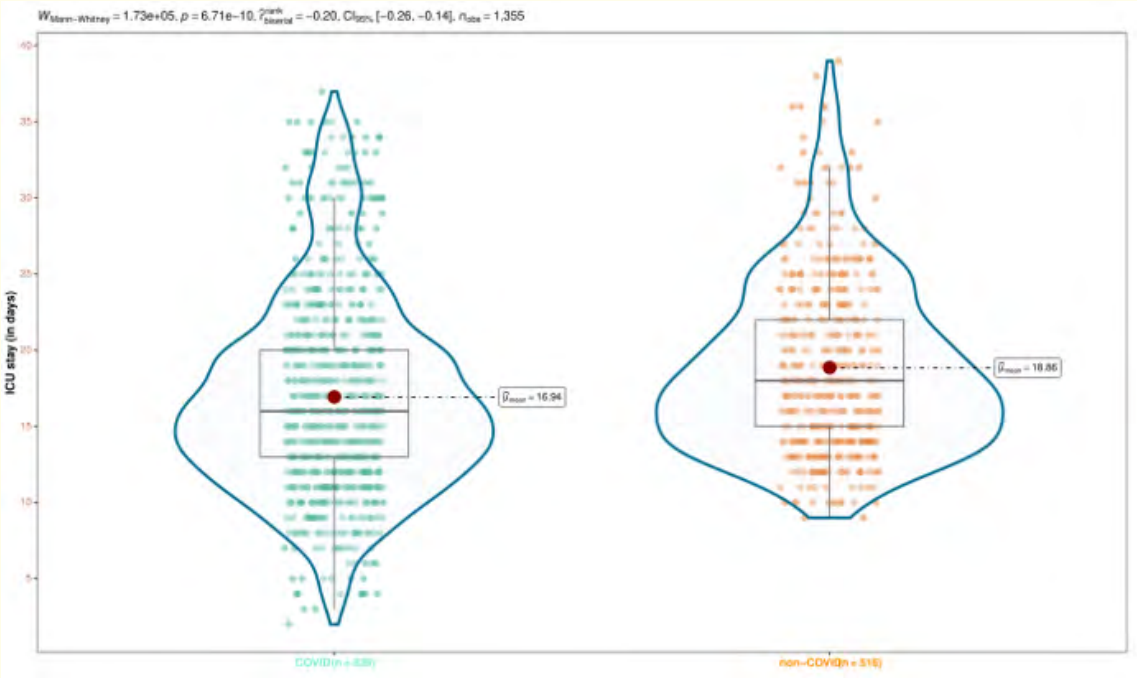

Figure 2: *Duration of ICU stay of the participants.*

The box-violin-jitter plots demonstrate the duration of ICU stay of the COVID and non-COVID patients. The width of the violin plot corresponds to the number of participants with their ICU stay on the y-axis. The box-whisker and jitter plots illustrate the hospitalization durations. The Mann-Whitney test was used to calculate the p-value.

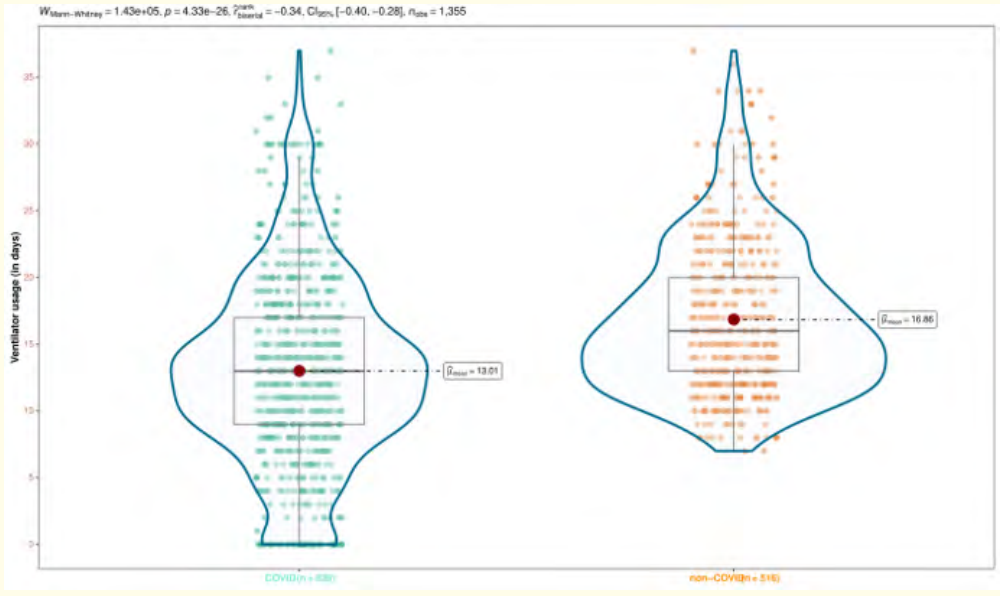

Figure 3: *Duration of ventilator requirement of the participants.*

The box-violin-jitter plots demonstrate the duration of ventilator requirement of the COVID and non-COVID patients. The width of the violin plot corresponds to the number of participants with their duration of ventilator usage on the y-axis. The box-whisker and jitter plots illustrate the duration of ventilator requirement. The Mann-Whitney test was used to calculate the p-value.

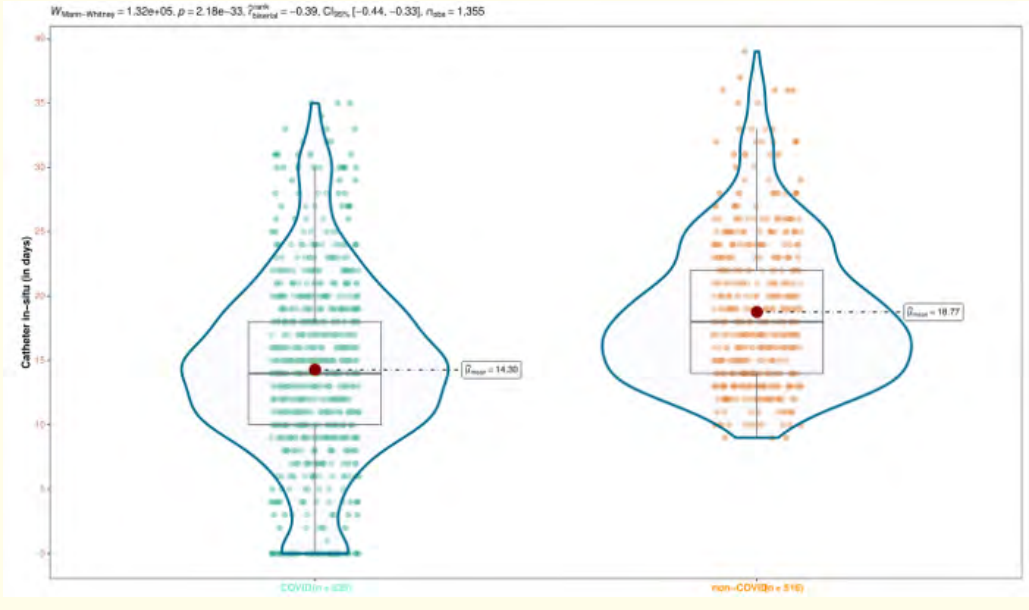

Figure 4: *Duration of in-situ catheter of the participants.*

The box-violin-jitter plots demonstrate the duration of in-situ catheter of the COVID and non-COVID patients. The width of the violin plot corresponds to the number of participants with their duration of in-situ catheter on the y-axis. The box-whisker and jitter plots illustrate the duration of in-situ catheter. The Mann-Whitney test was used to calculate the p-value.

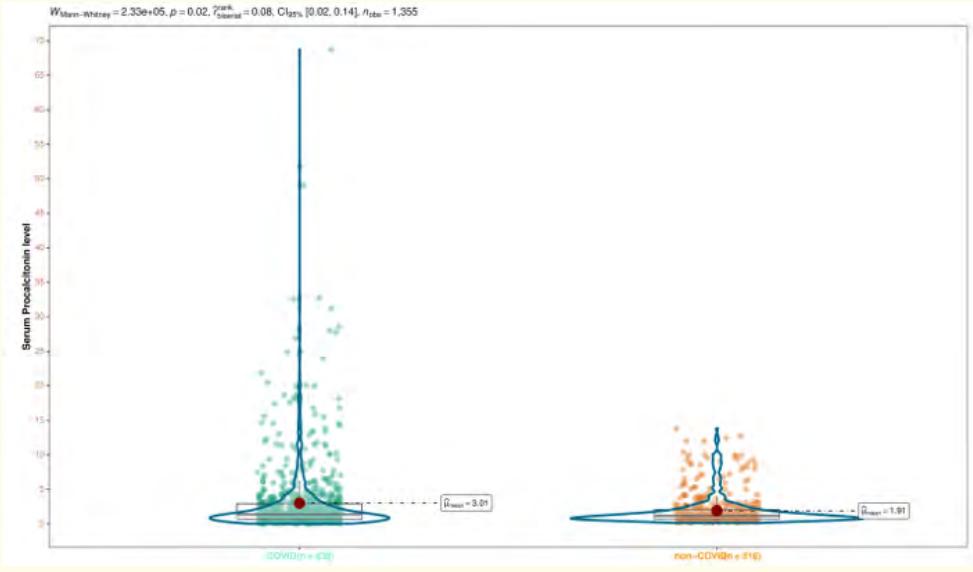

Figure 5: *Serum procalcitonin level of the participants.*

The box-violin-jitter plots demonstrate the serum procalcitonin level of the COVID and non-COVID patients. The width of the violin plot corresponds to the number of participants with their serum procalcitonin level on the y-axis. The box-whisker and jitter plots illustrate the serum procalcitonin levels. The Mann-Whitney test was used to calculate the p-value.

The pie diagrams in figure 6 portray the AST findings of the study participants (both COVID and non-COVID). 958 of 1355 (70.7%) patients [COVID: 572 of 839 (68.2%); non-COVID: 386 of 516 (74.8%); p < 0.001] had no pathogenic organisms in the AST. The most organisms found among COVID patients were *Acinetobacter baumannii* (74, 9%) and *Klebsiella pneumoniae* (68, 8%). The most organisms found among non-COVID patients were *Pseudomonas aeruginosa* (46, 9%) and *Acinetobacter baumannii* (28, 5%). Table 2 demonstrates the drugs with the highest sensitivity and resistance towards the noted pathogens in both the subgroups.

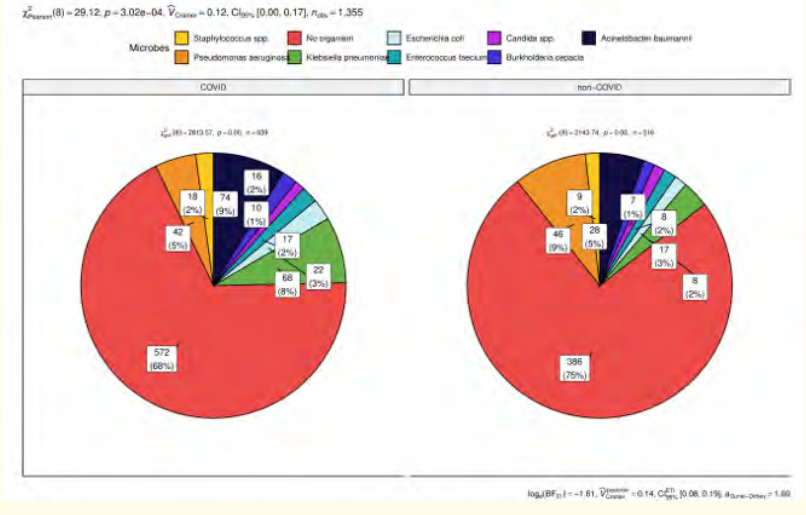

Figure 6: *AST findings of the participants.*

The pie diagrams present the AST findings of the study participants. The Pearson's chi-square test was used to calculate the p-value.

Pathogens	COVID group Maximum sensitivity	COVID group Maximum resistance	Non-COVID group Maximum sensitivity	Non-COVID group Maximum resistance
Acinetobacter baumannii	Tigecycline	Gentamicin	Tigecycline	Imipenem
Burkholderia cepacia	Meropenem	Amikacin	Meropenem	Levofloxacin
Candida spp.	Caspofungin	Fluconazole	Caspofungin	Flucytosine
Enterococcus faecium	Daptomycin	Erythromycin	Tigecycline	clindamycin
Escherichia coli	Tigecycline	Cefuroxime	Meropenem	Ciprofloxacin
Klebsiella pneumoniae	Tigecycline	Amikacin	Tigecycline	Ciprofloxacin
Pseudomonas aeruginosa	Meropenem	Gentamicin	Meropenem	Gentamicin
Staphylococcus spp.	Vancomycin	Clindamycin	Linezolid	Erythromycin

Table 2: *AST findings of the study population.*

Discussion

The present cross-sectional study was conducted in a tertiary care hospital of Eastern part of Odisha, with an aim to compare the prevalence of co-infections in COVID ICU and Non-COVID ICU patients. Bacteriological profiles and antimicrobial susceptibility patterns of the culture isolated pathogens were evaluated. Serum procalcitonin levels of the patients were also analyzed. In our study, a total of 3672 patients were with the study criteria, but we excluded 2317 people due to lack of evidences of secondary bacterial infections. The remaining 1355 (36.9%) subjects met the eligibility criteria. The median age of the study population among COVID-19 patients 55.8 (47.0-65.0) years; which was higher than non-COVID ICU patients, 51.5 (46.0-58.5) years; p<0.001]. Also, the proportion of patients in > 60 yrs of age were higher in COVID group. The results are consistent with large COVID cohorts showing greater severity and ICU admission rates among older adults [2]. Zhou., *et al*. in their study with Multivariable regression showed increasing odds of in-hospital death associated with older age (odds ratio 1.10, 95% CI 1.03-1.17, per year increase; p = 0.0043) [4].

Among COVID ICU, female patients were lower in proportion (48.4%) in comparison to non-COVID ICU (60.7%) [5]. In a meta-analysis by Krishnan A., *et al.* including 39 studies, 53.3% of the cases were males. Men were at a markedly increased risk of developing severe cases compared with women [6]. Different studies have reported about lower proportion of females in the COVID cohort reflects reported sex differences in COVID-19 severity and ICU admission (male predominance in severe cases) seen in multiple cohorts. This could be attributed to biologic (i.e. hormonal, immunologic) or behavioral differences [5,7].

Our study found that non-COVID patients had significantly longer ICU stays, [COVID: 16.0 (13.0-20.0) days; non-COVID: 18.0 (15.0-22.0) days; p<0.001]. The median duration of ventilator requirement was also longer for non-COVID ICU patients, [COVID: 13.0 (9.0-17.0) days; non-COVID: 16.0 (13.0-20.0) days; p < 0.001]. This may be due to the early hospital discharge or may be due to increased mortality rate among COVID-19 patients. Other studies also reported similar type of distribution [2,4,7-9]. Increased hospitalization and Prolonged exposure to invasive devices are important risk factor for healthcare-associated infections (HAIs), and may partly explain differences in infection patterns between groups. Procalcitonin levels were significantly higher in COVID-19 patients compared to non-COVID patients (1.38 versus 1.17 ng/mL). While elevated PCT can suggest bacterial coinfection, several studies have reported variable PCT kinetics in COVID-19, with elevated levels potentially reflecting systemic inflammation rather than confirmed bacterial infection [8]. Therefore, PCT should be interpreted in conjunction with microbiological results and clinical assessment to avoid unnecessary antibiotic use.

In the present study, 70.7% of patients had no pathogenic organisms isolated. This proportion was significantly higher among non-COVID patients (74.8%) than COVID patients (68.2%, p<0.001). The absence of pathogenic growth of cultures may be due to factors like empirical antibiotic use before sampling, low bacterial burden, non-bacterial etiologies, or the limitations of culture-based diagnostics,

particularly in critically ill patients [9,10]. Similar culture-negativity rates have been reported in ICU cohorts, with studies citing figures ranging from 50-75%, especially during the COVID-19 pandemic [10]. Among culture-positive cases, *Acinetobacter baumannii* and *Klebsiella pneumoniae* predominated in the COVID group, while *Pseudomonas aeruginosa* and *Acinetobacter baumannii* were most common in the non-COVID group.

This distribution aligns with a study from Turkey, secondary infection rate was reported as 29.7% among COVID-19 cases and the mortality as 52.5% in ICU. Gram negative pathogens were the most common cause (72.5%) of secondary infections and carbapenem resistance rate was 62.1%22 [11]. Also, global surveillance data indicates that Gram-negative pathogens are major contributors to ICU-acquired infections, particularly ventilator-associated pneumonia and bloodstream infections [2,4]. The predominance of *A. baumannii* in COVID-19 patients may be linked to prolonged ICU stay, extensive device use, and high selective pressure from empiric carbapenem use during the pandemic [3,12]. In contrast, the higher proportion of *P. aeruginosa* in the non-COVID group could be related to patient case-mix, including surgical or trauma cases with different environmental exposures.

The AST profiles in our study indicate worrying trends of multidrug resistance. Among both groups of patients, *A. baumannii* and *K. pneumoniae* isolates were highly susceptible to tigecycline. However, the high resistance to aminoglycosides (gentamicin, amikacin) and fluoroquinolones underscores the declining utility of these agents for empirical therapy in our setting. For *P. aeruginosa*, meropenem remained the most active agent in both groups of patients, though the persistence of gentamicin resistance is concerning. In *Enterococcus faecium*, daptomycin and tigecycline retained high activity, while macrolide and lincosamide resistance was common, consistent with global *E. faecium* antimicrobial resistance (AMR) trends [7]. The isolation of *Candida spp*. in ICU patients reflects the burden of invasive fungal infections in this population, with caspofungin showing highest activity, as expected for azole-resistant *Candida*.

Conclusion

The COVID-19 ICU patients in our study were older, had higher PCT levels, and shorter ICU/device exposure durations compared to non-COVID ICU patients. The culture and AST data reveal a predominance of multidrug-resistant Gram-negative pathogens, with distinct organism profile between COVID and non-COVID ICU patients. Tigecycline and meropenem remain the most active agents for several key pathogens, but high resistance rates to aminoglycosides, fluoroquinolones, and carbapenems call for urgent strengthening of antimicrobial stewardship programs and rational prescribing measures.

Acknowledgements

We would like to acknowledge our participants and their family members for their invaluable cooperation and support.

Conflict of Interest

The authors declare that there is no conflict of interest.

Funding Source

The authors declare that there was no external source of funding.

Bibliography

1. Ribeiro Edlainny Araujo., *et al*. "Clinical, epidemiological, and laboratory profiles of bacterial infection or colonization among patients hospitalized in COVID-19 and non-COVID-19 intensive care units (ICUs) in Southeast Pará". *Medicina (Ribeirão Preto)* 56.3 (2023).

2. Sathyakamala Ravichandran., *et al*. "A comparative study on bacterial co-infections and prevalence of multidrug resistant organisms among patients in COVID and non-COVID intensive care units". *Journal of Preventive Medicine and Hygiene* 63.1 (2022): E19-E26.

3. Huang C., *et al*. "Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China". *Lancet* 395 (2020): 497-506.

4. Zhou Fei., *et al*. "Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study". *The Lancet* 395.10229 (2020): 1054-1062.

5. Li Jie., *et al*. "Etiology and antimicrobial resistance of secondary bacterial infections in patients hospitalized with COVID-19 in Wuhan, China: a retrospective analysis". *Antimicrobial Resistance and Infection Control* 9.1 (2020): 153.

6. R Core Team. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, 2020 (2025).

7. Krishnan Anand., *et al*. "Predictors of mortality among patients hospitalized with COVID-19 during the first wave in India: a multisite case-control study". *The American Journal of Tropical Medicine and Hygiene* 108.4 (2023): 727.

8. Massey Benjamin., *et al*. "Procalcitonin levels and antibiotic use associations with COVID-19 disease severity in hospitalized adults and the potential for an increase in antibiotic resistance: a cross-sectional clinical and public health analysis". *Journal of Public Health and Emergency* 7 (2023).

9. Jha Onkar K., *et al*. "Helmet NIV in acute hypoxemic respiratory failure due to COVID-19: change in PaO_2/FiO_2 ratio a predictor of success". *Indian Journal of Critical Care Medicine* 25.10 (2021): 1137-1146.

10. Langford Bradley J., *et al*. "Bacterial co-infection and secondary infection in patients with COVID-19: a living rapid review and meta-analysis". *Clinical Microbiology and Infection* 26.12 (2020): 1622-1629.

11. Kaçmaz Bahar., *et al*. "COVID-19 associated bacterial infections in intensive care unit: a case control study". *Scientific Reports* 13.1 (2023): 13345.

12. Syed RF., *et al*. "A comparative study of *Acinetobacter* infections in COVID and non-COVID patients". *Journal of Infectious Diseases and Epidemiology* 8 (2022): 250.

Volume 8 Issue 10 October 2025
©All rights reserved by Jyoti Prakash Sahoo., *et al.*