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Invasive medical devices and icu mortality: a comparative study of patients with and without covid-19

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RESUMO

Objetivo: avaliar o tempo de permanência e o risco de óbito em pacientes com covid-19 em uso de dispositivos médicos invasivos internados em terapia intensiva. **Método:** estudo de abordagem quantitativa, longitudinal, do tipo coorte retrospectiva, com informações de 257 prontuários de pacientes adultos internados em terapia intensiva no período de 2020 a 2021 em um hospital universitário. A coleta de dados foi realizada em 2022, com duração de oito meses, por meio de um instrumento de coleta próprio e os resultados foram tabulados no Excel 2010 com análise estatística feita com o programa *Statistical Package for the Social Sciences* versão 20.0. Utilizou-se a análise de sobrevida com cálculo de *Hazard Ratio*. **Resultados:** houve elevada permanência de dispositivos médicos invasivos em pacientes com covid-19 durante a internação em terapia intensiva, com destaque para cateter venoso central e cateter nasoenteral, sendo que este mesmo grupo permaneceu maior tempo em utilização de tubo orotraqueal. O uso de dispositivos médicos invasivos no sétimo dia de internação aumentou e esteve fortemente associado ao risco de óbito nos pacientes com covid-19. **Conclusão:** os pacientes com covid-19 utilizaram mais dispositivos médicos hospitalares, sendo os principais deles tubo orotraqueal, cateter venoso central, cateter vesical de demora e cateter nasoenteral, tendo estes maiores tempos de permanência e risco de óbito em comparação aos pacientes sem diagnóstico de covid-19. As taxas de ventilação mecânica e uso de oxigenoterapia também foram mais elevadas no grupo de pacientes com covid-19.

Descritores: Unidades de Terapia Intensiva; Equipamentos e Provisões; COVID-19; Cuidados Críticos; Mortalidade.

ABSTRACT

Objective: o evaluate the length of stay and the risk of death among COVID-19 patients using invasive medical devices while admitted to intensive care units. **Method:** This was a quantitative, longitudinal study with a retrospective cohort design, based on data from 257 medical records of adult patients admitted to intensive care between 2020 and 2021 at a university hospital. Data collection was carried out in 2022 over a period of eight months using a structured collection instrument. The results were tabulated in Excel 2010. and statistical analyses were performed using the Statistical Package for the Social Sciences, version 20.0. Survival analysis was conducted, including calculation of the Hazard Ratio. **Results:** Prolonged use of invasive medical devices was observed in COVID-19 patients during their stay in the intensive care unit, with a particular prevalence of central venous catheters and nasoenteric tubes. This group also experienced longer use of orotracheal tubes. The use of invasive medical devices on the seventh day of hospitalization increased and was strongly associated with a higher risk of death among COVID-19 patients. **Conclusion:** COVID-19 patients used more hospital medical devices, with orotracheal tubes, central venous catheters, indwelling urinary catheters, and nasoenteric tubes being the most common. These devices were associated with longer durations of use and a higher risk of death compared to patients without a COVID-19 diagnosis. Rates of mechanical ventilation and oxygen therapy were also higher in the COVID-19 grou.

Descriptors: Intensive Care Units; Equipment and Supplies; COVID-19; Critical Care; Mortality.

RESUMEN

Objetivo: evaluar el tiempo de permanencia y el riesgo de muerte en pacientes con COVID-19 que utilizan dispositivos médicos invasivos y que están hospitalizados en unidades de cuidados intensivos. **Método:** estudio de enfoque cuantitativo, longitudinal, del tipo cohorte retrospectiva, con información de 257 historias clínicas de pacientes adultos ingresados en cuidados intensivos entre 2020 y 2021 en un hospital universitario. La recolección de datos se realizó en 2022, con una duración de ocho meses, mediante un instrumento propio de recolección, y los resultados fueron tabulados en Excel 2010. El análisis estadístico se realizó con el programa Statistical Package for the Social Sciences versión 20.0. Se utilizó análisis de supervivencia con cálculo de la razón de riesgo (Hazard Ratio). **Resultados:** se observó una alta permanencia de dispositivos médicos invasivos en pacientes con COVID-19 durante la hospitalización en cuidados intensivos, con destaque para el catéter venoso central y el catéter nasoenteral. Este mismo grupo permaneció más tiempo utilizando el tubo orotraqueal. El uso de dispositivos médicos invasivos en el séptimo día de hospitalización aumentó y estuvo fuertemente asociado al riesgo de muerte en los pacientes con COVID-19. **Conclusión:** los pacientes con COVID-19 utilizaron más dispositivos médicos hospitalarios, siendo los principales el tubo orotraqueal, el catéter venoso central, el catéter vesical de demora y el catéter nasoenteral, con mayores tiempos de permanencia y riesgo de muerte en comparación con los pacientes sin diagnóstico de COVID-19. Las tasas de ventilación mecánica y el uso de oxigenoterapia también fueron más elevadas en el grupo de pacientes con COVID-19.

Descriptores: Unidades de Cuidados Intensivos; Equipos y Suministros; COVID-19; Cuidados Críticos; Mortalidad.

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Introdution

According to the Pan American Health Organization, SARS-CoV-2. also known as Severe Acute Respiratory Syndrome Coronavirus 2. was identified as the causative agent of COVID-19. It was first isolated in Wuhan, China, in December 2019. Due to its high transmission potential, elevated morbidity and mortality rates, and rapid global spread, the World Health Organization officially declared COVID-19 a pandemic on March 11. 2020 [(1)].

The infection caused by this virus presents a wide range of symptoms, varying from mild manifestations in most patients to severe clinical conditions in approximately 5% of cases. Patients with severe disease require advanced care in Intensive Care Units (ICUs). Moreover, individuals with pre-existing conditions such as hypertension, diabetes, obesity, kidney failure, and a history of smoking are more likely to experience worse outcomes compared to those without such comorbiditie [(2)].

Prolonged hospitalizations that result in death are common among patients admitted to ICUs, and this is no different for those with COVID-19. This combination of outcomes may be associated with the use of Invasive Medical Devices (IMDs), as these are employed with the aim of sustaining the lives of critically ill patients [(3)].

A medical device is defined as any instrument, apparatus, equipment, implant, in vitro diagnostic device, software, material, or other article intended for use in humans for specific medical purposes, whose primary intended action is not achieved by pharmacological, immunological, or metabolic means in the human body. This includes any device that penetrates the body either partially or completely [(4)].

Despite their clinical necessity, the use of IMDs can serve as a gateway for microorganisms and increase the risk of infections, contributing to the development of Healthcare-Associated Infections (HAIs). Therefore, the presence of IMDs may be a predictor of disease severity, length of ICU stay, and mortality [(3)].

In the ICU setting, long-term IMDs are particularly noteworthy, as they are closely associated with the severity of the patient's clinical condition and the duration of hospitalization. These include mechanical ventilation (MV), orotracheal tube (OTT), intravascular catheters such as central venous catheters (CVC), tracheostomy (TQT) [5.] indwelling urinary catheter (IUC life-support equipment, drains[6] and nasoenteric catheter (NEC)[(7)].

Therefore, this study poses the following research question: what is the frequency of IMD use and its association with mortality in ICU patients with or without a COVID-19 diagnosis?

In this context, the objective of the present article was to analyze the frequency of IMD use and the risk of death in ICU patients with and without a COVID-19 diagnosis.

Method

This is a quantitative, longitudinal, analytical study with a retrospective cohort design, based on data collected from 257 medical records. The study population consisted of adult patients admitted between 2020 and 2021 to two intensive care units of a university hospital that served as a referral center for COVID-19 care in northern Paraná, Brazil. The list of patients admitted to these intensive care units during the study period was obtained from a database provided by the hospital's statistics department. Data collection was carried out by three researchers over a period of eight months in 2022. The selected timeframe corresponds to the period when the hospital intensified care for COVID-19 patients during a phase of high transmission.

A pre-designed data collection instrument, previously validated through a pilot study involving ten patients from the same ICUs, was used. This instrument included personal information (sex, age, marital status, and place of origin) as well as clinical data (reason for admission, date of admission, length of hospital stay, clinical history, primary diagnosis, confirmation or not of COVID-19 infection, mechanical ventilation parameters, duration of IMD use, and administration of antibiotics, corticosteroids, and/or vasoactive drugs, along with clinical outcome).

The information was obtained from electronic medical records stored in the MedView platform, which the hospital uses for patient care documentation. These records were provided by the hospital's medical records and statistics service. Inclusion criteria comprised all adult patients admitted to the two ICUs for more than 24 hours and who had used at least one invasive medical device. Exclusion criteria included medical records with incomplete data. As this is a retrospective study based on medical records, there was no loss to follow-up.

The data were tabulated and reviewed using Microsoft Office Excel® 2010. and statistical analysis was performed using the Statistical Package for the Social Sciences, version 20.0. Descriptive analyses of absolute and relative frequencies were conducted for nominal or categorical variables, and measures of central tendency were analyzed using mean, standard deviation, median, and interquartile range. For nominal variables, the chi-square test was applied, with a significance level set at $p < 0.05$. Survival curves were constructed to assess IMD use and the associated risk was evaluated through the calculation of the Hazard Ratio (HR).

This study was conducted in accordance with the principles outlined in Resolution No. 466/2012 of the Brazilian National Health Council and was approved by a Research Ethics Committee on March 23. 2022. under CAAE number 5211517.X.XXX.XXX. The study complied with national and international regulations governing research involving human subjects.

To ensure transparency and methodological rigor in the description of data, statistical analysis, and interpretation of findings, the design and reporting of this study followed the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) checklist guidelines).

Results

A total of 257 medical records of individuals hospitalized in the aforementioned ICUs were analyzed, covering patients aged between 28 and 93 years. Of these, 155 patients (60.31%) were male and 102 (39.69%) were female, with a mean age of 58.9 ± 14.6 years. For the purposes of this analysis, patients were categorized into groups with and without COVID-19. as well as by the presence or absence of comorbidities.

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The main comorbidities are presented in Table 1. A higher prevalence of comorbidities was observed among patients with COVID-19 (60.7%), with the most common conditions being Systemic Arterial Hypertension (SAH), Type 2 Diabetes Mellitus (T2DM), Dyslipidemia (DLP), and Obesity. An association was found between Chronic Obstructive Pulmonary Disease (COPD)/smoking and COVID-19 infection(p:0.00).

Table 1. Comorbidities Presented by COVID-19 Patients Admitted to the ICU.

Main Comorbidities	With covid-19 n(%)	Without covid-19 n(%)	*p*-valor
SAH	90 (69,2%)	40 (30,8%)	0,32
T2DM	53 (71,6%)	21 (28,4%)	0,93
CVA	4 (57,1%)	3 (42,9%)	0,37
DLP	20 (74,1%)	7 (25,9%)	0,79
Obesity	33 (76,7%)	10 (23,3%)	0,44
CKD/AKI	4 (50,0%)	4 (50,0%)	0,16
Smoker/COPD	29 (55,8%)	23 (44,2%)	0,00*
Other Cardiopathies	21 (60,0%)	14 (40,0%)	0,08
Other Comorbidities	156 (70,3%)	66 (25,6%)	0,12

Os dados são expressos em números absolutos e porcentagens. Teste qui-quadrado (*p < 0,05).
Source: authors

The median hospital stay for patients with COVID-19 was 32 days (IQR: 134), compared to a median of 30 days (IQR: 64) in the non-COVID-19 group. However, there was a significant difference between the minimum and maximum lengths of stay in days (p:0.008).

There was a high duration of IMD use in both groups, with particular emphasis on the Nasoenteric Catheter (NEC), Indwelling Urinary Catheter (IUC), and Mechanical Ventilation (MV), with median durations of 30. 29. and 28 days, respectively. Among these IMDs, the median duration of IUC use differed between groups, with a notably wider interquartile range observed in the COVID-19 group.

Regarding the two advanced airway devices (OTT and MV), both showed longer durations of use in the COVID-19 group (p = 0.029 and p = 0.000. respectively) when compared to the non-COVID-19 group. These data are presented in Table 2.

Table 2. Duration of Invasive Medical Device Use in ICU Patients With and Without COVID-19.

IMD Duration	With covid-19 Median (IQR)	Sem covid-19 Median (IQR)	*p*-valor
Hospital	32 (134)	30 (64)	0,008*
OTT	17 (35)	15 (26)	0,000*
TQT	16 (114)	14 (54)	0,985
MV	28 (80)	28 (59)	0,029*
NEC	30 (123)	30 (45)	0,263
CVD	29 (120)	29 (63)	0,050*
CVC	21 (59)	16 (31)	0,579
Drains	14 (53)	7.5 (9)	0,188

Median duration in days. IQR: 75th – 25th percentile. Data are expressed as absolute numbers. OTT: Orotracheal Tube; TQT: Tracheostomy; MV: Mechanical Ventilation; NEC: Nasoenteric Catheter; IUC: Indwelling Urinary Catheter; CVC: Central Venous Catheter. *Mann-Whitney test for independent samples.
Source: authors

The data on patients using IMDs on the day of ICU admission and on the 7th day of hospitalization are presented in Table 3.

All patients were using at least one IMD on the first day of ICU admission; however, patients with COVID-19 had higher usage rates of OTT, NEC, IUC, and CVC. On the 7th day of ICU hospitalization, there was an increase in the frequency of IMD use among COVID-19 patients compared to those without COVID-19 (p = 0.00). The most common site for CVC insertion in both groups was the jugular vein. The COVID-19 group also showed a higher use of drains, particularly thoracic drains.

Table 4 below presents the types of mechanical ventilation and oxygen therapy used in patients with and without COVID-19.

There was a predominance of VCV-mode mechanical ventilation on the first day of admission, which remained consistent in the COVID-19 group on the 7th day of hospitalization. Upon ICU admission, the COVID-19 group showed high usage rates of high-flow masks (52.9%), whereas the non-COVID-19 group predominantly remained on room air (RA). On the 7th day of hospitalization, the non-COVID-19 group showed similar rates of oxygen catheter (O2 catheter) and RA use. At the time of hospital discharge, most patients were no longer receiving oxygen therapy, with no significant difference between the COVID-19 and non-COVID-19 groups.

Table 3. Patients Using Invasive Medical Devices on the Day of ICU Admission and on the 7th Day of Hospitalization.

IMD	With covid-19 n(%)	Without covid-19 n(%)	*p*-valor
OTT Admission	63 (24,5%)	36 (14,0%)	0,01*
OTT Day 7	165 (64,2%)	43 (16,7%	0,00*
TQT Admission	3 (1,1%)	1 (0,3%)	0,88
TQT Day 7	6 (2,3%)	2 (0,7%)	0,84
NEC Admission	68 (26,4%)	32 (12,4%)	0,25
NEC Day 7	165 (64,2%)	51 (19,8%)	0,00*
IUC Admission	87 (33,8%)	43 (16,7%)	0,06
IUC Day 7	167 (64,9%)	53 (20,6%)	0,00*
CVC Admission	72 (28,1%)	31 (12,1%)	0,56
CVC Day 7	170 (66,4%)	58 (22,6%)	0,00*
CVC Insertion Site			
Femoral	47 (18,2%)	12 (4,6%)	0,02*
Jugular	77 (29,9%)	32 (12,4%)	
Subclavian	38 (14,7%)	9 (3,5%)	
Drains Admission	5 (1,9%)	3 (1,1%)	0,55
Drains Day 7	16 (6,3%)	4 (1,5%)	0,38
Type of Drain			
Thoracic	10 (3,8%)	5 (1,9%)	0,87
Other	2 (0,7%)	1 (0,3%)	

Chi-square test. Data are expressed as absolute numbers and percentages. Significance at $p < 0.05$. OTT: Orotracheal Tube; TQT: Tracheostomy; MV: Mechanical Ventilation; NEC: Nasoenteric Catheter; IUC: Indwelling Urinary Catheter; CVC: Central Venous Catheter.
Source: authors

Figure 1 shows the survival curve in relation to the length of hospital stay among COVID-19 patients using OTT, IUC, CVC, and NEC on the 7th day of hospitalization .

COVID-19 patients using an orotracheal tube on the 7th day had a 23% higher chance of progressing to death (HR: 0.270; CI: 0.168-0.433; p < 0.000). A similar result was observed among patients using an indwelling urinary catheter, who had a 37% higher chance of death (HR: 0.372; CI: 0.220-0.630; p < 0.000). The risk of death associated with the use of a central venous catheter in COVID-19 patients was 44% (HR: 0.443; CI: 0.247-0.795; p < 0.000). Additionally, 39% of COVID-19 patients who progressed to death were

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Table 4. Types of Mechanical Ventilation and Oxygen Therapy in ICU Patients With and Without COVID-19.

Types of MV and Oxygen Therapy	With covid-19 n(%)	without covid-19 n(%)	*p*-value
MV Adimission			
VCV	61 (23,9%)	31 (12,1%)	0,00*
PCV	3 (1,1%)	6 (2,3%)	
MV Day 7			
VCV	129 (51,3%)	28 (11,1%)	0,00*
PSV	15 (5,9%)	8 (3,1%)	
PCV	19 (7,5%)	8 (3,1%)	
Oxygen Therapy Admission			
AA	6 (3,8%)	12 (7,7%)	0,00*
MAF	82 (52,9%)	14 (9,0%)	
O2 Catheter	26 (16,7%)	8 (5,1%)	
NBZ	0 (0%)	2 (1,2%)	
MV	4 (2,5%)	2 (1,2%)	
Oxigenoterapia 7° dia			
AA	2 (4,5%)	13 (29,5%)	0,00*
MAF	9 (20,4%)	1 (2,2%)	
O2 Catheter	5 (11,3%)	12 (27,2%)	
NBZ	0 (0%)	1 (2,2%)	
MV	1 (2,2%)	0 (0%)	
High-Flow Oxygen Therapy			
AA	33 (43,4%)	22 (28,9%)	0,12
MAF	1 (1,3%)	0 (0%)	
O2 Catheter	6 (7,8%)	2 (2,6%)	
NBZ	3 (3,9%)	8 (10,5%)	
MV	0 (0%)	1 (1,3%)	

Chi-square test. Data are expressed as absolute numbers and percentages. Significance at p < 0.05. VCV: Volume-Controlled Ventilation; PCV: Pressure-Controlled Ventilation; PSV: Pressure Support Ventilation; RA: Room Air; HFM: High-Flow Mask; NBZ: Continuous Nebulization; MV: Venturi Mask.]
Source: authors

using a nasoenteric catheter on the 7th day of hospitalization (HR: 0.391; IC: 0.235 - 0.650; p<0.000).

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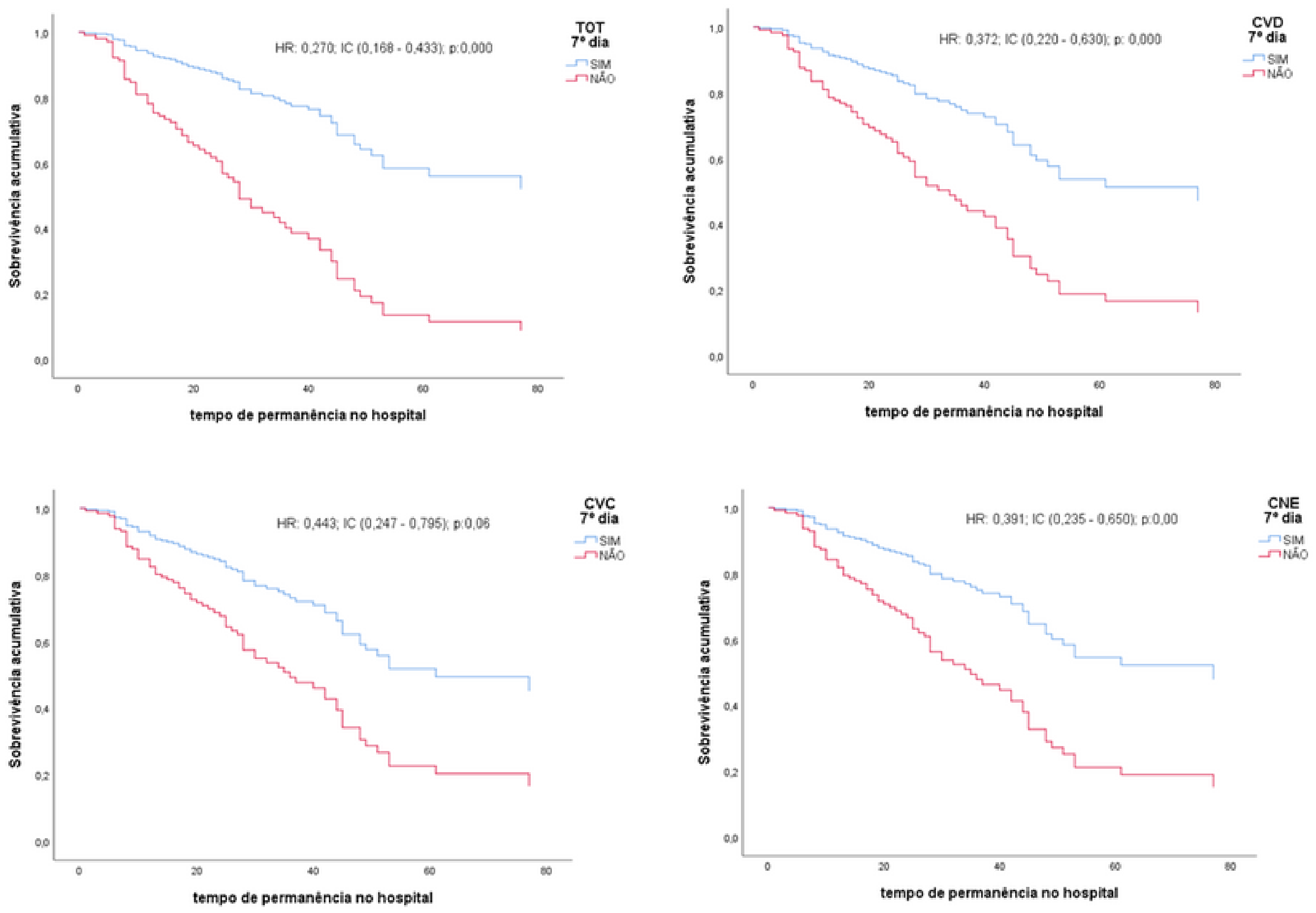

Figura 1. Curva de sobrevida e Hazard Ratio para uso de tubo orotraqueal, cateter vesical de demora, cateter venoso central e cateter nasoenteral em pacientes com covid-19 no 7º dia de internação.
Source: authors

Discussion

In the ICU, intensive care relies on IMDs, which are considered aggravating factors due to the high risk of contamination, especially in patients with COVID-19, primarily because of the severity and involvement of the respiratory system [8].

The use of IMDs in patients with prolonged hospital stays poses a risk for the development of HAIs, which are infections acquired during hospitalization and may have been in the incubation period at the time of patient admission [3]. HAIs represent one of the most significant complications related to patient safety worldwide, and the majority are associated with IMD use in ICU patients [8].

When analyzing extrinsic factors, the environment in which the patient is placed, combined with the quality of care provided, plays a crucial role in the development of HAIs. Patients admitted to ICUs with a COVID-19 diagnosis are more exposed to developing HAIs due to the complexity of their clinical condition [4].

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The main HAIs in the ICU are: Ventilator-Associated Pneumonia (VAP) related to the use of an orotracheal tube (OTT); Central Line-Associated Bloodstream Infection (CLABSI) related to the use of a CVC; and Catheter-Associated Urinary Tract Infection (CAUTI), associated with the use of an indwelling urinary catheter. These infections are estimated to result in mortality rates ranging from 15% to 35% among hospitalized patients using these IMDs [8.9].

This study shows that 73.1% of infections were associated with the use of IMDs, of which 53.7% were related to mechanical ventilation. Similar results were reported in 76.7% of COVID-19 patients who were undergoing mechanical ventilation [10].

Research has indicated that the IMDs most commonly associated with infections are the indwelling urinary catheter (IUC) at 83.4%, the orotracheal tube (OTT) at 68.3%, and the central venous catheter (CVC) at 39%. Among these patients, 64.9% required antimicrobial treatment. These infections are considered significant complicating factors in the care of hospitalized patients, as they contribute to increased morbidity and mortality rates, prolonged hospital stays, and elevated post-infection treatment costs [3.8].

It is well established that COVID-19 patients admitted to ICUs exhibit an intense inflammatory response, which facilitates the onset and progression of infectious complications[6]. As a result, the use of antimicrobials has become increasingly common, driving the rise in the incidence of multidrug-resistant microorganisms and promoting the occurrence of HAIs, particularly ventilator-associated pneumonia (VAP) [10].

The occurrence of HAIs is statistically higher among individuals who progressed to death compared to those who were discharged, indicating that these infections may contribute to increased mortality rates among patients with COVID-19 [6]. In a study conducted in the ICU of a hospital in Spain, among 57 hospitalized COVID-19 patients who developed infections, 31 progressed to death [6].

Therefore, monitoring the use of IMDs and promoting professional training on the prevention of infections related to these devices are essential for reducing the incidence of HAIs. Such measures contribute to shortening hospital stays and lowering the risk of death in patients with secondary diagnoses such as COVID-19 [8].

Thus, it is evident that the occurrence of adverse events related to IMD use in critically ill patients is a significant concern in the ICU, as it can lead to potentially severe clinical consequences. This study highlighted that, among the various factors that may increase the risk of mortality in patients with COVID-19, the use of IMDs stands out due to their potential to increase the risk of infection in these individuals.

As limitations, this study relied on medical records, which are subject to the individual practices and documentation styles of each healthcare professional. It is important to note the use of secondary data, which may contain inconsistencies, as well as the scarcity of studies that simultaneously examine COVID-19, ICU settings, and HAIs. However, the data presented here may contribute to future research on the topic, supporting the arguments made and helping to prevent deaths in COVID-19 patients while increasing their chances of survival.

Conclusion

COVID-19 patients were the ones who most frequently required the use of IMDs, with the main devices being orotracheal tubes (OTT), central venous catheters (CVC), indwelling urinary catheters (IUC), and nasoenteric catheters (NEC). These patients had longer hospital stays and a higher risk of death compared to those without COVID-19.

Mechanical ventilation and oxygen therapy rates were also higher in the COVID-19 group. Thus, the use of some type of IMD is prevalent among ICU patients, raising concerns due to its direct association with the development of HAIs. Given the complexity of the clinical condition and the intense inflammatory response caused by SARS-CoV-2 infection in COVID-19 patients, it is essential to implement effective techniques and strategies in supportive care and treatment. These measures aim to reduce the incidence of HAIs and, consequently, prolonged hospitalizations and mortality risk among COVID-19 patients.

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None

Author Contributions

Gamba, FF: Research conception and design, data acquisition, data analysis and interpretation, writing of the manuscript, critical revision of the manuscript for important intellectual content. Ribeiro, RP: Research conception and design, data acquisition, data analysis and interpretation, writing of the manuscript, critical revision of the manuscript for important intellectual content. Peixoto, JC: Data acquisition, data analysis and interpretation, writing of the manuscript, critical revision of the manuscript for important intellectual content. Leachi, HFL: Research conception and design, data analysis and interpretation, writing of the manuscript, critical revision of the manuscript for important intellectual content. Faustino, F: Research conception and design, data analysis and interpretation, writing of the manuscript, critical revision of the manuscript for important intellectual content. Silva, AP: Data analysis and interpretation, writing of the manuscript, critical revision of the manuscript for important intellectual content. Silva, LGPS: Data analysis and interpretation, writing of the manuscript, critical revision of the manuscript for important intellectual content. Rocha, AFR: conception and design of the research, acquisition of data, statistical analysis, analysis and interpretation of data, writing of the manuscript, critical revision of the manuscript for important intellectual content.

Conflict of Interest

The authors have no conflict of interest.

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