

## Acute kidney injury and COVID-19 in young adults in intensive care

Lesão renal aguda e COVID-19 em adultos jovens na terapia intensiva  
Lesión renal aguda y COVID-19 en adultos jóvenes en cuidados intensivosJosé Edilson de Oliveira<sup>1</sup>  <https://orcid.org/0000-0002-5737-1529>Talita Andrade dos Santos<sup>1</sup>  <https://orcid.org/0000-0002-0501-3279>Angélica Gonçalves Silva Belasco<sup>1</sup>  <https://orcid.org/0000-0002-5712-3680>Dulce Aparecida Barbosa<sup>1</sup>  <https://orcid.org/0000-0002-9912-4446>Eduesley Santana Santos<sup>2</sup>  <https://orcid.org/0000-0001-8545-5677>Miguel Angelo de Góes Junior<sup>3</sup>  <https://orcid.org/0000-0001-7687-3826>Carla Roberta Monteiro Miura<sup>1</sup>  <https://orcid.org/0000-0003-3528-3568>Cassiane Dezoti da Fonseca<sup>1,2</sup>  <https://orcid.org/0000-0002-2118-8562>

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## Descritores

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## Abstract

**Objective:** To describe acute kidney injury prevalence in young adults diagnosed with COVID-19 admitted to the Intensive Care Unit.**Methods:** This is a retrospective, quantitative and analytical study. The sample consisted of young adults (20 to 40 years old) admitted to Intensive Care Units, diagnosed with SARS-CoV-2 infection between March and December 2020. Data were obtained through electronic medical records, and kidney injury acute was defined by the creatinine value, according to the Kidney Disease Improving Global Outcomes guidelines criteria. Statistical significance was  $p \leq 0.05$ .**Results:** A total of 58 young adults were hospitalized, 63.8% of whom were male. Hypertension was present in 39.6%, obesity in 18.9%, and diabetes mellitus in 8.6%. Acute kidney injury was identified in 55.1%, with stage 3 predominating in 43.1% of them. In these patients, the use of mechanical ventilation and vasoactive drugs was significant in 92% as well as respiratory organ dysfunction (80%), followed by renal organ dysfunction (76%). Risk factors such as kidney transplantation or chronic kidney disease and obesity increased by 12.3 and 9.0 times, respectively, the chances of developing acute kidney injury.**Conclusion:** This study demonstrated a high kidney injury prevalence in young adults and its association with previous comorbidities. Obesity, kidney transplantation and chronic kidney disease increased the chance of young adults to develop acute kidney injury, resulting in outcomes in favor of morbidity and mortality.

## Resumo

**Objetivo:** Descrever a prevalência de lesão renal aguda em adultos jovens com diagnóstico da COVID-19 admitidos em unidade terapia intensiva.**Métodos:** Estudo retrospectivo, quantitativo e analítico. A amostra foi de adultos jovens (20 a 40 anos) admitidos em unidades de terapia intensiva, com diagnóstico de infecção por SARS-CoV-2 entre março e dezembro de 2020. Os dados foram obtidos por meio do prontuário eletrônico, e a lesão renal aguda foi definida pelo valor da creatinina, segundo critérios das diretrizes da *Kidney Disease Improving Global Outcomes*. A significância estatística foi de  $p \leq 0,05$ .**Resultados:** Foram internados 58 adultos jovens, sendo 63,8% do sexo masculino. A hipertensão arterial sistêmica esteve presente em 39,6%, a obesidade em 18,9% e o *diabetes mellitus* em 8,6%. A lesão renal aguda foi identificada em 55,1%, sendo o estágio 3 predominante em 43,1% deles. Nesses pacientes, o uso de ventilação mecânica e de drogas vasoativas foi significativo em 92%, assim como a disfunção orgânica respiratória (80%), seguida da renal (76%). Fatores de risco, como transplante renal ou doença renal crônica e obesidade, aumentaram em 12,3 e 9,0 vezes, respectivamente, a chance de desenvolver lesão renal aguda.<sup>1</sup>Escola Paulista de Enfermagem, Universidade Federal de São Paulo, São Paulo, SP, Brazil.<sup>2</sup>Universidade Federal de Sergipe, Aracaju, SE, Brazil.<sup>3</sup>Escola Paulista de Medicina, Universidade Federal de São Paulo, São Paulo, SP, Brazil.

Conflicts of interest: nothing to declare.

**Conclusão:** Este estudo demonstrou alta prevalência de lesão renal em adultos jovens e sua associação com comorbidades prévias. Obesidade, transplante renal e doença renal crônica elevaram a chance de o adulto jovem desenvolver lesão renal aguda, resultando em desfechos a favor da morbimortalidade.

## Resumen

**Objetivo:** Describir la prevalencia de lesión renal aguda en adultos jóvenes con diagnóstico de COVID-19 admitidos en unidad de cuidados intensivos.

**Métodos:** Estudio retrospectivo, cuantitativo y analítico. La muestra fue de adultos jóvenes (20 a 40 años) admitidos en unidades de cuidados intensivos, con diagnóstico de infección por SARS-CoV-2 entre marzo y diciembre de 2020. Los datos se obtuvieron por medio de historias clínicas electrónicas, y la lesión renal aguda fue definida por el valor de la creatinina, de acuerdo con criterios de las directrices de la *Kidney Disease Improving Global Outcomes*. La significación estadística fue de  $p \leq 0,05$ .

**Resultados:** Hubo 58 adultos jóvenes internados, el 63,8 % de sexo masculino. La hipertensión arterial sistémica estuvo presente en el 39,6 %, la obesidad en el 18,9 % y la diabetes *mellitus* en el 8,6 %. Se identificó lesión renal aguda en el 55,1 %, de nivel 3 como predominante en el 43,1 % de los casos. En esos pacientes, el uso de ventilación mecánica y de drogas vasoactivas fue significativo en el 92 %, así como también la disfunción orgánica respiratoria (80 %), seguida de la renal (76 %). Los factores de riesgo, como trasplante renal o enfermedad renal crónica y obesidad, aumentaron 12,3 y 9,0 veces respectivamente la probabilidad de presentar lesión renal aguda.

**Conclusión:** Este estudio demostró alta prevalencia de lesión renal en adultos jóvenes y su asociación con comorbidades previas. La obesidad, el trasplante renal y la enfermedad renal crónica aumentaron la probabilidad de que los adultos jóvenes presenten lesión renal aguda, lo que da como resultado desenlaces a favor de la morbimortalidad.

## Introduction

The coronavirus disease 2019 (COVID-19) pandemic caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was declared in March 2020 by the World Health Organization (WHO) after reports of cases spread across the world. Initially, the outbreak emerged in Wuhan, China, leading patients to develop respiratory diseases and with the involvement of other systems, such as the kidney.<sup>(1,2)</sup> This virus is transmitted by aerosols, droplets, fomites and contact, with a high rate of transmissibility.<sup>(3,4)</sup>

The disease can cause mild to more severe symptoms, such as pneumonia, respiratory distress syndrome, circulatory shock and acute kidney injury (AKI). These symptoms are linked to the fact that SARS-CoV-2 has a high affinity for angiotensin-converting enzyme 2 (ACE-2), which is expressed in some organs, on transport into cells, causing dysregulated immune system response, cytokine storm, and systemic inflammation.<sup>(4-6)</sup> This inflammation caused by COVID-19 leads to endothelial dysfunction and hypercoagulability, causing damage to organs such as the kidneys, and, consequently, to the emergence of AKI.<sup>(6-8)</sup>

AKI has been observed in approximately 20 to 40% of individuals admitted to Intensive Care Units (ICUs) in Europe and the United States infected with the COVID-19 viruses.<sup>(9)</sup> Some post-mortem studies performed on the renal endothelium have demonstrated the presence of SARS-CoV-2 in the

renal tubular epithelium and podocytes, through the entry of an ACE-2-dependent pathway, causing mitochondrial dysfunction, acute tubular necrosis, and protein leakage into Bowman's capsule.<sup>(10)</sup> However, the association between COVID-19 and the development of AKI may involve several mechanisms and have a multifactorial origin, such as the association of previous comorbidities.<sup>(11,12)</sup>

Throughout the pandemic, the prevalence of studies with the population at an older age was observed, and Brazil stood out on the world stage with the increase in confirmed cases and deaths. The Brazilian population suffered a great impact, with its young people being hospitalized for the disease and often having unfavorable outcomes due to COVID-19 complications.<sup>(13-15)</sup>

In Brazil, young adults are characterized as a population that studies and works. Many of these young adults are responsible for supporting their families and, in the pandemic, faced the economic difficulties resulting from the confinement required by the measures imposed. These measures forced them to return to their work activities, contributing to greater virus transmission in the country due to the lack of adherence to non-pharmacological protocols, such as mask use and distancing.<sup>(16)</sup>

AKI incidence associated with COVID-19 in young adults is still little explored, so studies are needed in this population, which has shown significant rates of hospitalization in Brazilian ICUs. Thus, descriptive investigations that seek to characterize the profile of young adults hospitalized with

COVID-19 and the outline of their hospital stay in ICUs may support a safe multidisciplinary clinical practice for the early identification of AKI incidence in this population, with the aim of reducing morbidity and mortality in young adults.

This work aimed to describe AKI prevalence and the profile of young adult patients diagnosed with SARS-CoV-2 infection admitted to a single center of ICUs in the state of São Paulo.

## Methods

This is a retrospective and quantitative study. The sample consisted of all young adult patients admitted to the ICU, whose diagnosis was SARS-CoV-2 infection, from March to December 2020, in a reference university hospital for medium and high complexity care in the state of São Paulo, which provided services to the Brazilian Health System (SUS – *Sistema Único de Saúde*) and previously registered health plans.

For data collection, a survey was carried out using patients' electronic medical record, between March and December 2020, in search of young adult patients admitted to the COVID-19 ICUs. From this search, data were recorded in an instrument that was built based on a literature review on the subject, for collecting sociodemographic data and clinical data, in addition to the outcome of these individuals.<sup>(17-19)</sup>

Persons aged between 20 and 40 years and presenting SARS-CoV-2 infection as a diagnosis of ICU admission were included. For AKI classification, the Kidney Disease Improving Global Outcomes (KDIGO) guidelines criteria were used, which is an increase in serum creatinine of 0.3mg/dL in 48 hours or 1.5 times in 7 days. The KDIGO criteria were performed at two different times for stratification: creatinine on admission to the ICU and creatinine 48 hours after admission. Subsequently, patients were classified into two groups, according to the state of renal function: with and without AKI, and a subgroup to assess the AKI stage (KDIGO 1; KDIGO 2 and KDIGO 3).

The data obtained were entered into the Research Electronic Data Capture (REDCap) data

platform and analyzed using the R program, version 4.1.1 (R Studio, version 1.4.1106, LibreOffice, version 7.1.7.2). In the descriptive evaluation, numerical variables were explored by means of minimum and maximum values, and measures of centrality (mean) and dispersion (standard deviation), and categorical variables were explored by absolute frequencies and percentages. To assess categorical variables, the chi-square test or Fisher's test were used. To test the difference between means, Student's t test or non-parametric Mann-Whitney test were used. The Hosmer-Lemeshow test model ( $p$ -value=1) was used to analyze the logistic model estimate and Odds Ratio estimates. Statistical significance was considered for values of  $p \leq 0.05$ .

As this is a retrospective study, obtaining secondary data, participants or their families were located for signing the Informed Consent Form, ensuring the commitment to privacy and data confidentiality, used only to meet the objectives proposed in this study. The complete project was submitted and approved by *Plataforma Brasil*, under Opinion 4,585,548 and CAAE (*Certificado de Apresentação para Apreciação Ética* - Certificate of Presentation for Ethical Consideration) 42871121.1.0000.5505, by the Research Ethics Committee of the proposing institution, in compliance with the norms of Resolution 466/12 of the Brazilian National Health Council for research with humans.

## Results

This study was composed of 58 young adult patients admitted to the ICU with a diagnosis of COVID-19, observing a prevalence of males, with 63.8%. The sample's mean age was  $33.0 \pm 5.62$  years. Of the group without AKI, males accounted for 61.5%, and within the group with male AKI, 64% developed AKI KDIGO 3. AKI was identified in 55.1% of the total sample, with KDIGO stage 3 predominant in 43.1% of the group with AKI. The definition and stage of AKI were defined by means of serum creatinine values at admission and another 48 hours after admission to the ICU, and urinary volume re-

duction was defined according to KDIGO guidelines. Of the 32 young adults who developed AKI, 93.75% (n=30) had previous comorbidities, such as hypertension, obesity and diabetes mellitus. Comorbidities were statistically significant (p=0.01), with emphasis on obesity (p=0.002). Young adults with obesity represented 18.9% of the sample that developed AKI KDIGO 3, and they were 28% of patients with previous comorbidities. Hypertension was present in 39.6% of the sample that developed AKI at some stage. Within the group without AKI with comorbidities, 11.5% were hypertensive. Patients with diabetes mellitus accounted for 8.6% of the sample that developed AKI. Young adults who needed an ICU vacancy were initially admitted to the hospital's emergency room or inpatient units. Among young adults who did not develop AKI, 88.46% (n=23) were discharged from the ICU and 11.54% (n=3) died (p=0.05), as shown in Table 1.

**Table 1.** Acute kidney injury prevalence in young adult patients with COVID-19

Variables	Without AKI (n=26)	KDIGO 1 (n=2)	With AKI (n=32)		p-value
			KDIGO 2 (n=5)	KDIGO 3 (n=25)	
Age	32.65±5.35	30.00±8.48	37.20±0.83	33.96±5.65	0.257*
Sex					
Male	61.5	50	80	64	0.920 <sup>†</sup>
Female	38.4	50	20	36	0.920 <sup>†</sup>
Ethnicity/color					
White	53.8		80	52	
Brown	30.7	50	20	40	0.920 <sup>†</sup>
Black	15.3	50		8	
Comorbidities					
Yes	69.2	50	100	90	0.010 <sup>†</sup>
No	26.9			4	0.050 <sup>†</sup>
Hypertension	11.5	50	60	60	0.080 <sup>†</sup>
DM	7.6		20	8	0.670 <sup>†</sup>
Obesity	11.5	0	20	28	0.002 <sup>†</sup>
Origin					
Emergency room	61.5	50	80	64	0.920 <sup>†</sup>
Inpatient unit	38.4	50	20	36	0.920 <sup>†</sup>
Outcome					
Discharge	88.4	50	60	60	0.050 <sup>†</sup>
Death	11.5	50	40	40	0.050 <sup>†</sup>

Results expressed as mean ± standard deviation or %. \*Kruskal-Wallis test; <sup>†</sup>Fisher's exact test. AKI - acute kidney injury; KDIGO - Kidney Disease Improving Global Outcomes; DM - diabetes mellitus

During the ICU stay of these young adults with COVID-19, the need for mechanical ventilation, use of vasoactive drugs, corticosteroids associated

with presence or absence of AKI and data from laboratory tests were analyzed (Table 2).

Vasoactive drugs were used by 38 patients. When analyzing the use of these drugs related to AKI prevalence, young adults classified as KDIGO 3 accounted for 92% of the sample. Organ dysfunctions were present in 38 young adults. Respiratory and kidney (p<0.001) dysfunctions had the most statistically significant value, affecting 80 and 76% of patients with AKI KDIGO stage 3, respectively. Sepsis was another clinical data analyzed in young adult patients with COVID-19 admitted to the ICU. Sepsis occurrence in patients with AKI KDIGO stage 3 was 41.3% (p≤0.001). Pulmonary sepsis was present in 62.1% (n=36) of young adults. Patients who did not develop AKI and had pulmonary sepsis accounted for 46.15% (n=12). Bloodstream sepsis corresponded to 15.5% (n=9) of young adults. Serum creatinine and serum urea of the groups with AKI showed a significant increase in relation to the group without AKI. D-dimer biomarker showed a difference between patients without AKI and the KDIGO stage 1 group (p<0.05). Arterial blood gas parameters (pH, partial pressure of oxygen, partial pressure of carbon dioxide and bicarbonate) showed a significant difference between the groups without and with AKI, characteristic of renal metabolic compensation (p<0.05). The urinary volume variable showed a significant reduction in the KDIGO stage 3 group compared to other groups. This data revealed the possibility to measure urinary volume (p<0.05) in controlled environments, such as ICU. Bivariate and Odds Ratio analyzes revealed that patients who underwent kidney transplantation or had chronic kidney disease were more likely to develop KDIGO stage 3 (p=0.001). Hypertensive and obese young adults with COVID-19 also showed significant values in the analysis (p=0.069; p=0.008). Thus, undergoing a kidney transplant or having chronic kidney disease increases the chance of developing AKI KDIGO stage 3 by 12.3 times, and being obese increases the chance of developing the same type of injury by 9.0 times (Table 3).

**Table 2.** Clinical parameters of acute kidney injury in young adult patients with COVID-19 during Intensive Care Unit hospitalization

Variables	Without AKI (n=26)	With AKI (n=32)			p-value
		KDIGO 1 (n=2)	KDIGO 2 (n=5)	KDIGO 3 (n=25)	
Used mechanical ventilation	42.3	50	60	92	<0.001
Norepinephrine	46.1	50	60	92	0.008
Vasopressin	7.6	50	20	40	0.021
Corticosteroid	50	50	60	88	0.011
Sepsis	42.3	100	40	80	<0.001
Respiratory organ dysfunction	30.7	50	40	80	<0.001
Hematologic organ dysfunction	15.3	50	20	24	0.515
Kidney organ dysfunction	15.3	50	20	76	<0.001
RRT	7.6	50	20	80	<0.001
Conventional hemodialysis	7.6	50	20	88	<0.001
Serum creatinine, mg/dL	0.87± 0.61	1.24 ±0.30	2.32 ±0.36	5.24± 1.97	<0.001*
Serum urea, mg/dL	41.62±32.37	75±82.02	70.60±34.70	93.76±52.70	0.001*
CRP, mg/dL	127.42±118.69	208.69±149.86	188.26±80.58	167.74±130.45	0.500*
Lymphocytes, U/mm <sup>3</sup>	1.292.80±656.19	2.064±62.22	481.40±274.73	1.202.16±589.97	0.012†
D-dimer, mg/dL	2.56±3.33	9.36±6.71	0.84±0.31	3.96±4.60	0.036*
LDH, U/L	525.9±367.67	777.5±74.24	432.33±323.70	577.73±423.55	0.415*
Lactate, mg/dL	23.31±44.24	28.5±23.33	14.40±3.78	13.78±7.86	0.527*
pH	7.38±0.14	7.32±0.01	7.39±0.08	7.35±0.09	0.042*
PaO <sub>2</sub> , mmHg	73.18±33.14	74.10±13.01	83.06±39.52	95.46±31.40	0.044*
PaCO <sub>2</sub> , mmHg	43.67±29.30	34.15±0.91	36.26±6.12	35.40±13.96	0.698*
HCO <sub>3</sub> , mmol/L	21.71±5.41	17.45±0.07	22.44±4.10	18.88±5.96	0.026*
Urinary volume, mL/24hours	1.575±537.05	1.297±710.64	2.050±859.26	723.18±938.36	0.008*

Results expressed as % or mean ± standard deviation. \*Kruskal-Wallis test; †analysis of variance. AKI – acute kidney injury; KDIGO – Kidney Disease Improving Global Outcomes; RRT – renal replacement therapy; CRP – C-reactive protein; LDH – lactic dehydrogenase; PaO<sub>2</sub> – partial pressure of oxygen; PaCO<sub>2</sub> – partial pressure of carbon dioxide; HCO<sub>3</sub> – bicarbonate.

**Table 3.** Risk factors for developing acute kidney injury stage 3 in young adult patients with COVID-19 admitted to an Intensive Care Unit

Variables	OR*	95%CI	p-value†
Kidney transplantation or chronic kidney disease	12.3	(2.8 - 63.8)	0.001
Hypertension	3.4	(0.9 - 13.9)	0.069
Obesity	9.1	(1.9 - 52.1)	0.008

\*Odds Ratio with values only of variables with statistical significance, p-value <0.05; †Hosmer-Lemeshow test (p value=1). OR – Odds Ratio; 95%CI – 95% confidence interval.

## Discussion

This study demonstrated a high prevalence of AKI associated with males, white ethnicity and comorbidities such as obesity, kidney transplantation and chronic kidney disease, diabetes mellitus and hypertension.

The kidney has shown to be a vulnerable organ to SARS-CoV-2's action. The inflammatory storm induces a process of systemic vasodilation, which perpetuates renal tissue hypoperfusion, resulting in hypoxia with apoptosis and tubular necrosis. Additionally, the presence of ACE2 in tubular cells and podocytes favors the virus' direct action on the renal epithelium. In this regard, some studies have glimpsed the relationship between COVID-19 and AKI in critically ill patients.<sup>(5,10,11,19)</sup>

AKI associated with COVID-19 was initially identified in older adults who required intensive care. Due to the fragility of this population, initial studies focused on them and demonstrated that most older adults who developed AKI were male and white.<sup>(5,20)</sup>

Young adults were a poorly studied population at the beginning of the pandemic, due to the lower number of cases in ICUs, but this study brought results similar to those performed with populations in general and with older adults. The profile of young adults with COVID-19 in the ICU who developed AKI at some stage was white men, corroborating other studies.<sup>(5,10,13,21)</sup>

In relation to AKI incidence, as described in some studies of COVID-19 patients, males had a higher prevalence compared to females. Male individuals are at greater risk of being infected by the virus and having clinical complications.<sup>(19)</sup>

Comorbidities were risk factors present in COVID-19 patients who developed AKI, including hypertension, obesity and diabetes mellitus. Hypertension is considered the main risk factor for patients who developed AKI and experienced a wors-

ening of their outcome during their ICU stay. This investigation corroborates data from other studies that demonstrated a higher AKI KDIGO stage 3 prevalence when hypertension was present.<sup>(22,23)</sup>

Regarding diabetes mellitus, this study revealed a low prevalence, both in the group without and with AKI. Young age can be a justification for this data in comparison to studies with older adults.<sup>(13,21,22)</sup>

On the other hand, obesity was characterized in this study as a predictor of worsening kidney function and a risk factor for developing AKI, similar to other investigations on the relationship between obesity and COVID-19. The high concentration and amount of adipose tissue infer that SARS-CoV-2 has an affinity for these cells, which have a large amount of ACE-2.<sup>(22,24)</sup> Thus, obese patients become a reservoir of the virus, facilitating its dissemination in other organs. Obese young adult patients with COVID-19 had a high AKI incidence, as did the obese older population.<sup>(25)</sup> This investigation demonstrated that obesity can increase the chance of KDIGO stage 3 by 9.1 times, and this is the most prevalent comorbidity in young adults who developed AKI.

Young adults with COVID-19 who developed AKI, especially AKI KDIGO stage 3, had a high number of deaths, with a 40% increase in mortality. Mortality increase may be a result of factors other than the onset of AKI, such as length of hospital stay, presence of sepsis, organ dysfunction, use of vasoactive drugs, need for mechanical ventilation and its duration.<sup>(13,26,27)</sup>

Due to compromised gas exchange and severe hypoxemia in patients with COVID-19, they often need mechanical ventilation, and prolonged use of this respiratory support is associated with the onset of AKI and increased morbidity and mortality.<sup>(13,26)</sup>

Young adults hospitalized with COVID-19 used vasoactive drugs, and 26 of them developed AKI. Vasoactive drugs are widely used in ICUs due to patients' hemodynamic instability. These drugs may contribute to the onset of AKI, as they cause severe vasoconstriction, reducing renal flow. The most used vasoactive drug in ICU settings is norepinephrine.<sup>(28)</sup>

The present investigation showed that 26 young adults with COVID-19 used corticosteroids to improve disease symptoms. As a reaction to the presence of the COVID-19 virus, the immune system has an exacerbated response, causing a worsening of patients' symptoms. Corticoids are used to help reduce and treat disease symptoms.<sup>(29)</sup>

AKI is the second most common organic dysfunction in patients with COVID-19. Although the pathophysiology of AKI associated with COVID-19 is multifactorial, the virus has its mechanism of entry into cells through ACE-2, expressed by kidney cells.<sup>(5)</sup>

One of the treatments of choice for patients hospitalized in ICUs is renal replacement therapy in the presence of KDIGO 3 AKI. The present investigation revealed that 24 young adults hospitalized required renal replacement therapy, and the modality of choice was conventional hemodialysis in all prescriptions. The mortality rate was 41.6%.<sup>(30)</sup>

Chronic kidney disease was considered an important risk factor for AKI in young adults. It is known that the progression of kidney disease can have a multifactorial etiology, such as the presence of hypertension, associated or not with diabetes mellitus. The sample of this study revealed a significant number of young adults with hypertension and chronic kidney disease, and both were associated with the development of KDIGO 3 AKI. Chronic kidney disease is pathophysiologically a complex condition that involves imbalance of electrolytes, hormones and vitamins, resulting in complications such as infections, edema, osteopenia, among others. Thus, patients with chronic kidney disease are susceptible to the virus and, during an ICU stay, it is necessary to use renal replacement therapy.<sup>(31,32)</sup>

This investigation revealed that 65.5% of patients developed sepsis of different foci, and pulmonary was the most prevalent. The emergence of secondary infections in patients with COVID-19 can have many associated factors, such as a deregulated immune response.<sup>(5,33)</sup> After the virus is recognized by cells, the innate and adaptive immune system begins to produce cytokines to maintain the body's homeostasis. One of the cytokines responsi-

ble for the deregulated immune response is interferon-gamma, responsible for inducing macrophage activity and stimulating the release of pro-inflammatory, pro-fibrotic and immune response regulatory cytokines. Elevated levels of cytokines can result in sepsis, septic shock, and multiple organ failure. Therefore, infections in patients with COVID-19 are quite prevalent, which increases AKI incidence and condition severity.<sup>(34,35)</sup>

This study has limitations, as it was carried out at a single center, with a population characteristic of this service and the number of participants does not characterize the general population, requiring larger studies with new participants.

The data found in the investigation may contribute to a multidisciplinary clinical practice oriented towards the prevention and tracking of risk factors for AKI and also subsidize the construction of care protocols.

## Conclusion

In young adult patients with COVID-19 admitted to ICUs, obesity, hypertension, kidney transplantation and chronic kidney disease were the morbidities considered as predictors of AKI. Respiratory system dysfunction requiring mechanical ventilation, use of corticosteroids and sepsis were also associated with the development of AKI in young adults. Recognizing the risk factors for developing AKI in this population will support preventive actions for modifiable factors, with a view to reduce AKI incidence in young adults with COVID-19 in a critical situation as well as unfavorable outcomes and morbidity and mortality.

## Collaborations

Oliveira JE, Fonseca CD, Miura CRM, Belasco AGS e Barbosa DA contributed to study conception and design, data analysis and final writing of the manuscript to be published. Santos TA, Queiroz SS, Goes Junior MA e Silva PG contributed to study conception and design and data collection.

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