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Acute kidney injury in an intensive care unit. A single-center, cross-sectional study in Ecuador.

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Abstract

Introduction: Acute kidney injury (AKI) affects up to 75% of critically ill patients and is one of the causes of admission to intensive care. The objective of this cross-sectional study was to understand the local reality of diagnosing acute kidney injury.

Methodology: This cross-sectional study was conducted at the Provincial General Teaching Hospital of Riobamba, Ecuador, from January to June 2024. Patients aged 15 years or older admitted to the intensive care unit were included. The following demographic data were collected: age, sex, presence of sepsis, comorbidities, and the following laboratory variables: creatinine, urea, potassium, calcium, chloride, hemoglobin, leukocytes, procalcitonin, CRP, blood gases, and antibiotics. The KDIGO criteria were used to define the presence of acute kidney injury. The sample was probabilistic. Odds ratios are presented to determine the associations between acute kidney failure and various variables.

Results: We analyzed 145 patients admitted to the ICU; 90 had AKI (62% [95% CI: 54%-70%]). The factors associated with the development of AKI were the use of diuretics (OR 11.68 (1.5--90.7), $P = 0.004$; HBP, 9.95 (1.27--77.93), $P = 0.008$; the use of diuretics (OR 4.25 (2.07--8.72), $P < 0.001$; shock, 2.67 (1.15--6.18), $P = 0.02$; the use of vasopressors, 2.67 (1.15--6.18), $P = 0.02$; and the use of blood derivatives, 2.68 (1.29--5.58), $P = 0.008$. A total of 12.22% required dialysis. The mortality of patients with IRA was 22.2% (13.5–30.98%).

Conclusions: In this report, AKI was highly prevalent, and AKI-associated mortality is consistent with international reports.

Palabras claves:

Acute Kidney Injury, Intensive Care Unit, Epidemiology.

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Acute renal injury (ARF) affects up to 75% of critically ill patients, 20% of whom receive renal replacement therapy (RRT) [1, 2]. ARI has become a global health problem, with increases in morbidity, mortality and costs for the health systems of various countries [3]. Most of the epidemiological data of patients with ARF in the ICU are from developed countries [4]. In Latin America, the information available on IRA is scarce and variable; of 307 ARI studies worldwide, only 4% come from Latin America [5].

Until 2017, only 10 countries in Latin America had publications on the ARI [6]. In Ecuador, there are few studies of this pathology in critically ill patients; a possible reason is that few nephrologists are interested in critical nephrology because most concentrate their work in dialysis centers [7].

Acute kidney injury is a clinical syndrome characterized by an abrupt decrease in kidney function [8]. The KDIGO 2012 (Kidney Disease Improving Global Outcomes) guidelines describe the diagnostic criteria for ARF and classify it into 3 stages, taking into account the serum creatinine level and the volume of urine excreted per unit of time [9]. Some biomarkers, such as cystatin C, proenkephalin A, interleukin (IL)-18, tissue metalloproteinase-2 (TIMP-2) and insulin-like growth factor binding protein 7, are relatively accurate at predicting ARF; however, their cost and unavailability in many countries present problems [10].

Current reports on ARF in the intensive care unit (ICU) show wide variation in the prevalence rate. In this context, conducting this study will allow us to understand our local reality about this clinical condition and help doctors initiate better preventive measures to avoid its appearance in critical patients, diagnose and treat it in a timely manner and avoid its risks in the short and long term. The objective of this study was to determine the prevalence of acute kidney injury in critically ill patients at a reference center in Riobamba, Ecuador.

Materials and methods

Study design

This was an observational, cross-sectional study. The source is retrospective.

Stage

The study was carried out in the intensive care unit of the Provincial General Teaching Hospital of Riobamba, Ecuador. The study period was from January 1 to June 30, 2024.

Participants

Patients older than 15 years and admitted to the intensive care unit were included in the study. Patients were not excluded.

Variables

Demographic data were collected, including age; sex; the presence of sepsis; comorbidities; and the following laboratory variables: creatinine, urea, potassium, calcium, chlorine, hemoglobin, leukocytes, procalcitonin, C-reactive protein (CRP), blood gas, and antibiotics.

Data sources/measurements

The source was direct. The information was collected through a form. Data from the institutional medical history were collected in the intensive care unit. In the present study, the KDIGO criteria were used to define the presence of acute kidney injury.

Biases

Observation and selection bias were avoided by applying the participant selection criteria. The principal investigator always maintained the data via a guide and records approved in the research protocol to avoid possible interviewer, information and recall biases. When the standard deviation of the data was uncertain, corrections were made through onsite reviews of anomalous data. Two researchers independently analyzed each record in duplicate, and the variables were entered into the database after verifying their agreement.

Study size

The sample was probabilistic. Riobamba reports 177,213 inhabitants, of which 67.22% are older than 15 years, which represents 119,122 inhabitants. The requirement to enter intensive care is 39 cases per 10,000 inhabitants/year in Ecuador, which represents a possible need of 691 cases for the city of Riobamba as a whole in 1 year of study. The study was planned for a six-month cycle, so 346 cases were included. Using the EPI Info 7.2 program (CDC Atlanta, March 2025), in hemodialysis programs, with a 95% confidence level, a prevalence of hemodialysis requirements of 17% in intensive care units, and a confidence limit of 5%, the estimated sample included 133 cases.

Quantitative variables

The results are presented as frequencies and percentages. Categorical variables were not converted to scale variables.

Statistical analysis

The quantitative variables are reported as the means and standard deviations. The categorical variables are described in terms of frequencies and percentages. The odds ratio was used to determine the presence of acute renal failure. For all statistical analyses described, a level of statistical significance was considered to be a *P* value of less than 0.05. For the statistical analysis, IBM Corp. (2020) was used. IBM SPSS Statistics for Windows (Version 27.0) [Software]. Armonk, NY: IBM Corp.

Results

Participants

A total of 145 patients were included, fulfilling the expected sample size.

Group description

The data of the total population (P = 145) were analyzed, which represents the total number of admissions to the ICU from January to June 2024, of which 48.96% (n = 71) are women and 51.03% are men (n = 74), with an average age of 43 years.

The number of patients who had ARF in the ICU was 90. Therefore, we establish that the prevalence of ARF in the ICU from January to June 2024 ((90/145) * 100) is 62% (95% CI: 54% -70%).

Table 1. Characteristics of the population studied.

	Admissions to ICU (n: 90)	IC 95%
Age	50.0	45-55
Baseline creatinine (mg/dl)	0.95	0.81-1.09
Creatinine in ICU (mg/dl)	2.97	2.22-3.72
Urea (mg/dl)	98.08	83.18-112.9)
Potassium (meq/L)	4.24	4.05-4.42
Calcium (mg/dl)	8.19	8-8.38
Chlorine (meq/l)	105.85	104.2-107.5
Hemoglobin (g/dl)	13.29	12.69-13.99
Platelets (u/ul)	223.5	199.6-247.3
Leukocytes (u/ul)	13.27	11.96-14.57
Procalcitonin (ng/ml)	15.09	8.93-21.26
C-reactive protein (mg/l)	120.6	96.3-144.9
Ph (units)	7.31	7.28-7.34
PO_2 (mmHg)	95.75	86.59-104.91
$PaCO_2$ (mmHg)	30.93	28.68-33.17
HCO_3 (mmHg)	16.10	14.91-17.30
Lactate (mmol/L)	3.2	2.62-3.78
Sodium (meq/L)	138.17	136.81-139.52

Prc: C-Reactive Protein; PO2: partial pressure of oxygen; PCO2 Partial Pressure of Carbon Dioxide; HC03: Sodium bicarbonate.

A total of 78 patients (86%) experienced ARF upon admission to the ICU, and 13.3% (n = 12) developed ARF during their hospitalization in the ICU. According to the KDIGO classification, 46.7% (n = 42) of patients with ARF had KDIGO stage I, 23.3% (n = 21) had KDIGO stage II, and 30% (n = 27) had KDIGO stage III.

Table 1 and Table 2 present the univariate analysis of the quantitative and qualitative variables for patients with ARF (n = 90).

Multivariate analysis

The risk factors for the presence of acute kidney injury were the use of blood products, contrast agents, diuretics, vasopressors, a shock episode, and a history of arterial hypertension.

Table 2. Characteristics of the population studied.

	Admissions to ICU (n: 90)	IC 95%
Qualitative variables		
65 years or more	27.78%	18.3-37.2%
50 years or more	54.44%	44.0-64.9%
Men	62.22%	52.0-72.4%
Women	37.78%	
Sepsis	48.89%	38.4-59.4%
HT	15.56%	7.9%-23.2%
Preeclampsia/Eclampsia	5.56%	0.73%-10.4%
DM	18.89%	10.6-27.1%
Heart disease	13.33%	6.2-20.5%
Respiratory disease	7.78%	2.1-13.4%
Obesity	7.78%	2.1-13.4%
Neoplasia	2.22%	- 0.88%-5.3%
Hypothyroidism	11.11%	4.49%-17.73%
ERC	12.22%	5.3%-19.1%
Hematuria	35.56%	25.5-45.6%
Proteinuria	23.33%	14.4-32.2%
Ventilation	70.00%	60.4-79.7%
Shock	86.67%	79.5-93.8%
Vasopressors	86.67%	79.5-93.8%
Diuretics	65.56%	55.6-75.6%
Nitroimidazoles	11.11%	4.5-17.7%
Macrolides	14.44%	7.0-21.9%
Vancomycin/Glycopeptides	20.00%	11.6-28.4%
Aminoglycosides	20.00%	11.6-28.4%
Colistin	1.11%	1.10%-3.3%
Carbapenemic	28.89%	19.3-38.4%
Penicillins	70.00%	60.4-79.7%
Lincosamide	8.89%	2.90-14.9%
Cephalosporins	4.44%	0.10%-9.78%
Contrast	17.78%	9.7%-25.8%
Blood products	47.78%	37.3-58.3%
TSR	12.22%	5.32%-19.12%
UTI mortality	22.22%	13.5-30.98%

HT: Arterial Hypertension; DM: Diabetes Mellitus; CKD: Chronic Kidney Disease; RRT: renal replacement therapy.

Table 3 . Chi ²/Fisher and OR in relation to the presence of acute kidney injury.

Variable	OR	OR IC 95% Lower limit	OR IC 95% Upper limit	*P*
Sepsis	-	-	-	0.224
HT	9.95	1.27	77.93	0.008
DM	-	-	-	0.111
Heart disease	0.59	0.51	0.68	0.004
Respiratory disease	0.6	0.52	0.69	0.045
Obesity	-	-	-	0.483
Hypothyroidism	0.59	0.51	0.68	0.14
ERC	0.59	0.51	0.67	0.007
Shock	2.67	1.15	6.18	0.02
Vasopressors	2.67	1.15	6.18	0.02
Diuretics	4.25	2.07	8.72	<0.001
Nitroimidazoles	-	-	-	0.448
Macrolides	-	-	-	0.54
Vancomycin	-	-	-	1.53
Aminoglycosides	-	-	-	0.41
Colistin	-	-	-	0.12
Carbapenems	-	-	-	0.87
Penicillins	-	-	-	0.6
Lincosamides	-	-	-	0.18
Cephalosporins	0.2	0.06	0.71	0.007
Use of contrast	11.68	1.5	90.74	0.004
Use of blood products	2.68	1.29	5.58	0.008

HT: arterial hypertension. DM: Diabetes mellitus. CKD: chronic kidney disease.

There were protective factors, such as the group of patients under exclusive treatment with cephalosporins, the group of patients with a preestablished diagnosis of chronic kidney disease, hypothyroidism, respiratory disease, and heart disease (Table 3 and Figure 1).

Logistic regression

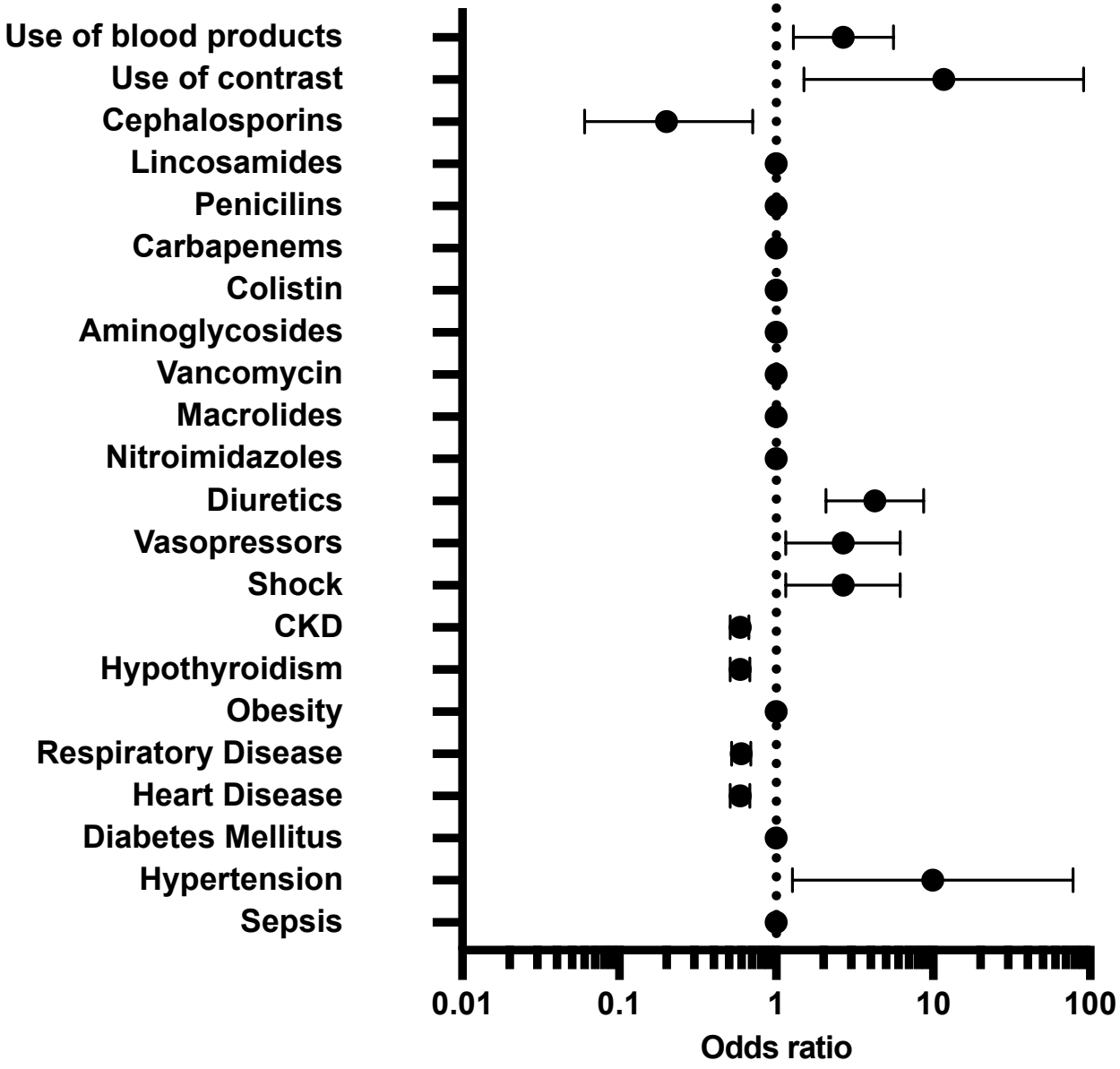
The multiple regression model revealed that the factors that could predict the presence of acute kidney injury were age, sex, history of vancomycin, colistin, and contrast media use (Table 4).

Table 4 . Prevalence ratio adjusted to qualitative variables.

	Wald Chi-Square	df	Sig.	RP	95% CI Lower limit	95% CI Upper limit
(Intercept)	37.141	1	<0.001	0.252	0.162	0.393
Age 50 or older	8.737	1	0.003	1.559	1.161	2.092
Sex	6.994	1	0.008	1.431	1.097	1.867
Vancomycin/Glycopeptides	5.096	1	0.024	1.458	1.051	2.024
Colistin	4.872	1	0.027	0.189	0.043	0.830
Use of contrast	9.866	1	0.002	1.517	1.170	1.967

Dependent variable: ARI. RP: Prevalence ratio.

Figure 1. Risk factors for the presence of acute kidney injury.



Discussion

The present study revealed a high prevalence of ARF in ICU patients (62%), which is similar to that reported in multicenter studies [2]. Although the prevalence data are variable, the incidence can vary from 255.5% to 41.6% in different reports [11 -14]. These differences in study variations could be due to sample size and the other diagnostic criteria used to define ARFs, such as RIFLE (Risk, Injury, Failure, Loss, End Stage), AKIN (Acute Kidney Injury Network), and KDIGO. In the present study, the KDIGO criteria were used because they better identify patients with this pathology than the RIFLE and AKIN criteria do [15].

Of the 62% of the patients who developed ARF, 86% had ARF upon admission to the ICU, and 13.3% developed ARF during their hospitalization in the ICU. It is estimated that two-thirds of the patients with ARIs begin before admission to hospitalization as community-acquired acute kidney injury (ARI-AC). In addition, differentiating ARIs from disease-related chronic kidney disease can be difficult,

which is a point to be considered for subsequent studies with more rigorous registration and follow-up.

According to the KDIGO classification, the prevalence of ARF in our study was 46.7%, 23.3%, and 30% for KDIGO 1, KDIGO 2, and KDIGO 3, respectively. This differs from the findings of a study at a Regional Hospital in Southeast Pará, Brazil, where stages 2 and 3 of KDIGO occurred in 70% of the sample [16]. The stage of ARF predicts mortality and decreased kidney function and is linked to adverse short-term and long-term outcomes [17]. Importantly, we should not underestimate minor changes in creatinine, as indicated in previous studies; slight increases (25–50%) in serum creatinine from baseline were associated with higher mortality, longer hospital stays, and increased medical costs [18].

In the present study, individuals aged 50 years or older were 6.1 times more likely to present with ARF, which could be due to greater susceptibility to kidney changes associated with age, comorbidities, or risk factors [14]. Males are 3.39 times more likely to have ARIs. According to a global perspective on ARF, the incidence of ARF in the ICU is 40%, with a higher incidence in men (57%) compared to women (42%), and the distribution by age of presentation is 50% for older adults [7, 19].

Patients with hypertension were 9.98 times more likely to have ARF in this study than were those without hypertension. High blood pressure is an independent risk factor for the development of ARF [12]. This pathology stands out in 52.2% of patients with ARF [19]. Similar results have been reported in critical patients with ARF, such as those with arterial hypertension (30.1/100 patients) and diabetes mellitus (22/100 patients) [20].

This study revealed that the presence of shock, and therefore the use of vasopressors, was associated with a 2.67-fold greater probability of developing ARF. These data are consistent with the evidence, since among the most common causes of acute renal failure (ARF) in intensive care units (ICUs) are sepsis and septic shock [21]. The use of diuretics results in a 4.25-fold greater likelihood of developing ARF; the KDIGO 2012 guidelines recommend avoiding the use of diuretics to prevent ARF or in the treatment of established ARF. It can only be considered a treatment for ARF in the case of fluid overload [9].

People who underwent imaging tests with contrast agent were 11.68 times more likely to have ARF; however, this is not considered contrast-induced nephropathy since it is defined as an increase in creatinine> 0.5 mg/dl in the next 48 hours after receiving radiological contrast agent and excluding other causes of acute damage, and the patients already had established ARF.

Patients with ARF are 1.14 times more likely to undergo RRT. Approximately 5% to 10% of ARF patients require RRT during their stay in the ICU [22]. Similar to a study published in 2020, in Ecuador, 10.6% of patients who developed kidney injury in the ICU required dialysis therapy [23]. In another study, 23.5% of patients who required hemodialysis were hospitalized in critical care [24].

Current data indicate that up to 14% of critically ill patients receive RRT during their stay in the ICU and are treated with intermittent hemodialysis or one of the continuous renal replacement therapy techniques [25].

We found that patients with ARF are 15.43 times more likely to die in the ICU. In a previous report, the mortality rate was 22%, with sepsis being the main cause of death in 50% of patients [15,16].

There are limitations in the diagnosis of AKI when baseline serum creatinine is unknown, causing a delay in the diagnosis of AKI in nonoliguric patients whose baseline renal function is unknown.

Most causes of ARIs in developing countries are preventable [26]. For this reason, strategies to improve outcomes and reduce the burden of ARF require effective interventions, such as greater access to medical care and timely diagnosis [27].

Prevalence studies provide essential data for understanding the epidemiology of a specific disease [28]. This study offered relevant data, and statistics were used to determine probabilities and risks, with the odds ratio and prevalence ratio being the most notable. These statistics are used in cross-sectional studies, and to establish risk, we prefer the prevalence ratio since our percentage of patients with ARF exceeded 20% [29, 30].

Strengths and limitations:

The significance of this study provides an epidemiological foundation for intervention efforts. The limitations of this research stem from its retrospective design, as it is impossible to have complete control over the data in the registered databases. Additionally, as it is conducted at a secondary-level hospital with an intensive care unit holding 8 beds, some data may be biased, as patients with ARF are often referred to other healthcare centers due to limited physical space. Furthermore, the inability to accurately identify patients with a prior diagnosis of established CKD may have led to an overestimation of ARF when relying on baseline creatinine values. In this context, we recommend this work as a basis for future prospective studies. Future research on ARF should consider specific factors such as blood pressure control, use of antihypertensive medications, presence of diabetic peripheral neuropathy, pressure regulation in the arterial line system, blood flow estimation, and circadian rhythm of blood pressure. Even within more specific populations, the risk of ARF remains. Risk factors linked to the development of postpartum hemorrhage include patients with postoperative open fractures, sepsis, or oncological diseases [31 -40].

Conclusion

In this study, we show that the prevalence of acute kidney injury is high (62%) in patients admitted to the ICU and that it occurs early. Male patients and those older than 50 years are more likely to develop ARF. Twelve percent of patients with AKI required RRT. Patients with HT and the presence of shock have a greater probability of developing ARF. The mortality of patients with AKI is 22%.

Abbreviations

HT: arterial hypertension.
ARF: Acute kidney injury.
RRT: renal replacement therapy.

ICU: intensive care unit.

Supplementary information
The supplementary materials have not been declared.

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Authors' contributions
Erika Belén Carpio Alvarado: Conceptualization, methodology, research, Writing - Original draft, Project management, Supervision, validation, visualization, Writing - review and edition.

Katerin Fernanda Trujillo Rodríguez: Conceptualization, Project management, Supervision, validation, visualization, Writing - review and edition.

Carlos Andrés Yépez Salgado: Conceptualization, methodology, research, Writing - Original draft.

Estefania Dayana Caisatoa Cabrera: Conceptualization, methodology, research, Writing - Original draft.
All the authors read and approved the final version of the manuscript.

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Availability of data or materials
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Declarations

Ethics committee approval and consent to participate
The study was approved by the Ethics Committee for Research in Human Beings at the National University of Chimborazo (UNACH).

Consent for publication
It does not apply when specific images, radiographs or photographs of patients are not published.

Conflicts of interest
The authors declare that they have no conflicts of interest.

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