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Cardiorenal syndrome type 1: prevalence and associated factors

Síndrome cardiorrenal tipo 1: prevalência e fatores associados

Síndrome cardiorenal tipo 1: prevalencia y factores asociados

ABSTRACT

Objective: To assess cardiorenal syndrome type 1: prevalence and associated factors. **Methods:** Cross-sectional study involving patients with acute heart failure, ≥ 18 years and length of stay ≥ 48 hours. The association between dependent and independent variables was performed by crude and adjusted analyses, using a binary logistic regression model. **Results:** A total of 226 patients were assessed, 53.6% males and 75.0% ≥ 60 years old. There was a prevalence of 12.4% of acute kidney injury (AKI), with mortality in patients with AKI being 35.7% and without AKI 9.1%. There was a statistical association between AHF and contrast (PR = 398.32; CI = 7.56-20995.44), intravenous vasodilators (PR = 21.79; CI = 2.73-173.63), admission risk score (PR = 23.03; CI = 1.61-329.06) and lack of interconsultation with a nephrologist (PR = 16.97; CI = 3.86-74.58). Conclusion: AKI was prevalent in patients with acute heart failure (AHF), with longer hospital stay and mortality. Some predictive factors for the development of AKI, not yet addressed in the literature, were lack of interconsultation with a nephrologist, admission risk score and intravenous vasodilators.
Descriptors: Cardiorenal syndrome; Hospitalization; Heart failure.

RESUMO

Objetivo: Avaliar a síndrome cardiorrenal tipo 1: prevalência e fatores associados. **Métodos:** Estudo transversal em pacientes com insuficiência cardíaca aguda, ≥ 18 anos e tempo de internamento ≥ 48 horas. A associação entre variáveis dependentes e independentes foi realizada por análise bruta e ajustada, utilizando modelo de regressão logística binária. **Resultados:** Foram avaliados 226 pacientes, 53,6% sexo masculino e 75,0% ≥ 60 anos. Verificou-se prevalência de 12,4% de injúria renal aguda (IRA), sendo a mortalidade em pacientes com IRA de 35,7% e sem IRA de 9,1%. Houve associação estatística entre IRA e contraste (RP =398,32; IC = 7,56-20995,44), vasodilatadores endovenosos (RP = 21,79; IC = 2,73-173,63), escore de risco admissional (RP = 23,03; IC = 1,61-329,06) e não interconsulta com nefrologista (RP = 16,97; IC = 3,86-74,58). **Considerações finais:** A IRA foi prevalente em pacientes com insuficiência cardíaca aguda (ICA), com maior tempo de internamento e mortalidade. Alguns fatores preditivos ao desenvolvimento de IRA, ainda não abordados pela literatura, foram não interconsulta com nefrologista, escore de risco admissional e vasodilatadores endovenosos.
Descritores: Síndrome cardiorrenal; Hospitalização; Insuficiência cardíaca.

RESUMEN

Objetivo: Evaluar el síndrome cardiorrenal tipo 1: prevalencia y factores asociados. **Métodos:** Estudio transversal en pacientes con insuficiencia cardiaca aguda, ≥ 18 años y estancia ≥ 48 horas. La asociación entre variables dependientes e independientes se realizó mediante análisis crudo y ajustado, utilizando un modelo de regresión logística binaria. **Resultados:** Se evaluaron 226 pacientes, 53,6% del sexo masculino y 75,0% ≥ 60 años. Hubo una prevalencia del 12,4% de insuficiencia renal aguda (FRA), con mortalidad en pacientes con FRA del 35,7% y sin FRA del 9,1%. Hubo asociación estadística entre IRA y contraste (PR = 398,32; IC = 7,56-20995,44), vasodilatadores intravenosos (RP = 21,79; IC = 2,73-173,63), puntuación de riesgo al ingreso (PR = 23,03; IC = 1,61-329,06) y no consulta con nefrólogo (RP = 16,97; IC = 3,86-74,58). **Consideraciones finales:** Las IRA fueron prevalentes en pacientes con ICA, con estancia hospitalaria más prolongada y mortalidad. Algunos factores predictivos para el desarrollo de LRA, aún no abordados en la literatura, fueron la ausencia de consulta con un nefrólogo, la puntuación de riesgo de ingreso y los vasodilatadores intravenosos.
Descriptores: Síndrome cardiorrenal; Hospitalización; Insuficiencia cardíaca.

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INTRODUCTION

Heart failure (HF) is characterized by a complex clinical syndrome related to an overload of the heart, causing this organ to be unable to work properly, leading to a series of structural and/or functional dysfunctions[1,2]. HF is a chronic disease that affects many individuals in all countries, developed and developing, with a high prevalence and incidence rate, as well as being one of the main causes of hospitalization and death around the world, and is a serious public health problem[1,2].

Cardiovascular problems, such as acute heart failure (AHF), can cause dysfunctions in other organs, such as the kidneys, leading to the development of a new condition called cardiorenal syndrome type 1 (CRS1), when one organ causes acute dysfunction in another organ. This occurs due to neurohumoral and inflammatory activation, entailing renal hypoperfusion due to a decrease in cardiac output[1,4].

AHF can be related to many factors, such as pre-established diseases – including diabetes and arterial hypertension –, lack of medication adherence or other cardiovascular diseases, such as acute coronary syndrome[1,5].

Studies have shown that, during hospitalization, the rate of patients who develop acute kidney injury (AKI) is quite significant and may be associated with longer hospitalizations for HF, stays in Intensive Care Units (ICUs), greater use of vasoactive drugs, higher average age, male gender, in addition to having a worse prognosis, since they have a higher mortality rate, re-hospitalizations and higher public health costs[3,6].

A Brazilian retrospective cohort study showed an association between patients with HF who developed CRS1, where patients who developed AHF had higher mortality (32% × 9.8% in the group without AHF, p = 0.04, with an odds ratio (OR) of 8.187 and a confidence interval of 1.402-17.190, p = 0.020). Another study found that 54.1% of the patients had CRS1, of whom 28% died, with this outcome being associated with diseases related to renal dysfunction (73% × 26.9%, OR = 3.13, p < 0.001). There is a relationship between patients with CRS1 and length of stay, with these patients remaining in hospital for three days or more compared to patients without renal dysfunction[3,7].

An international study conducted with 20 patients analyzed the level of lipopolysaccharides (LPS) and pro-inflammatory cytokines, where an increase in these markers was observed in patients who had CRS1 when compared to patients who only had AHF (IQR 77.8-217.6 × IQR 12.0-17.0, p = 0.008), showing a relationship with kidney damage, increased oxidative stress and inflammatory processes[8].

This research, which aims to assess cardiorenal syndrome type 1: prevalence and associated factors, was proposed in view of the importance of identifying the disease, its appropriate treatment, and the relevance of a rapid diagnosis of this dysfunction, as well as the gap in the literature that could answer the following question: is the occurrence of CRS1 associated with increased mortality in patients with AHF?

METHODOLOGY

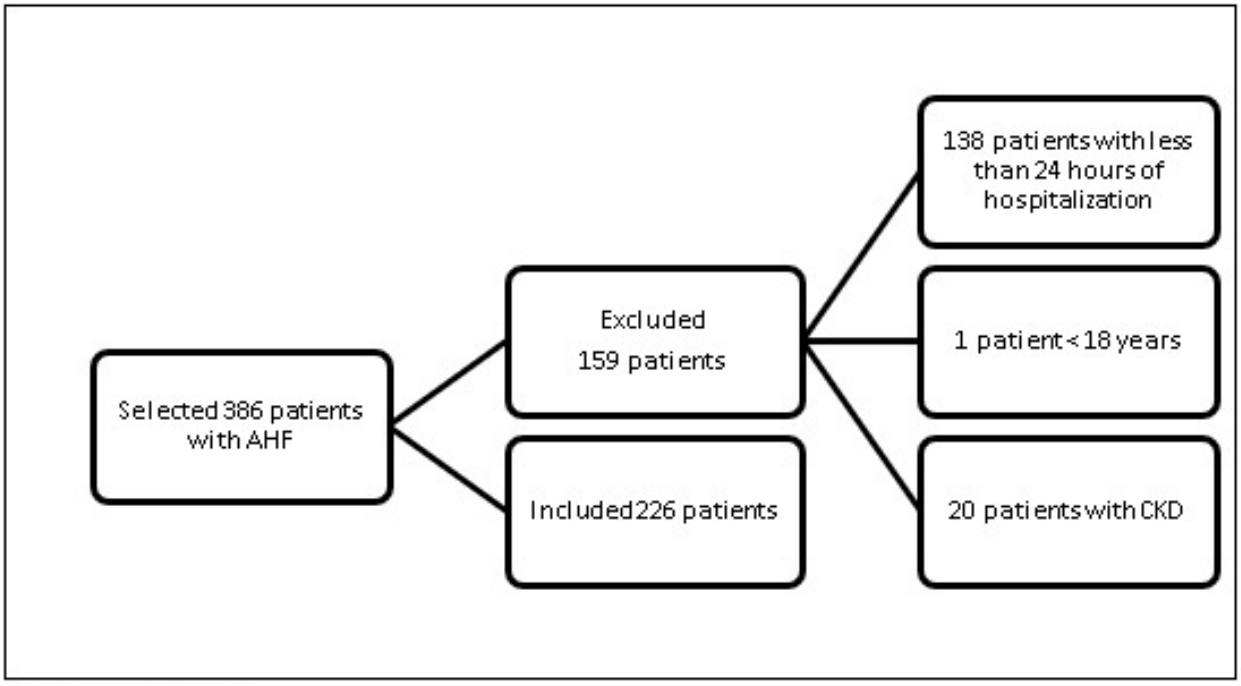
Study design and setting

This is a cross-sectional and retrospective study, with a descriptive and analytical approach, which is part of a larger project called "Pharmaceutical Care: assessing the use of medications in a regional hospital", conducted in a large state reference hospital located in the southwest region of Bahia. The institution is under the direct management of the Health Department of the State of Bahia (Sesab, as per its Portuguese acronym), has 276 beds and serves a population of more than 600,000 inhabitants from 27 cities in the south-central health region. This unit offers specialties in medical clinic, surgical and orthopedic clinic, pediatrics, emergency/urgency, psychiatry, neurosurgery and intensive care. It is important to underline that it also offers extracurricular internship programs for technical and higher education courses in the health area, internships and multiprofessional residencies, in addition to being a field for extension and research.

Sample, inclusion and exclusion criteria

The sample selected included patients admitted to hospital, aged ≥ 18 years, males and females, with a discharge diagnosis of AHF (new or acute chronic), according to the International Classification of Diseases, and health-related problems (ICD) with a discharge filter based on the ICD-10 of AHF and its etiologies, encompassing: ICDs (I11, I50, I500, I501, I509, I083, I110, I119, I25, I255, I358, I420, I426 and I429). Patients who stayed in hospital for less than 48 hours and patients with chronic kidney disease (hemodialysis, stage V) reported in their medical records were excluded, according to the inclusion chart, Figure 1.

Figure 1 – Inclusion and exclusion chart of patients hospitalized with AHF (Bahia, Brazil, 2019-2020)



Source: Designed by the authors.

Data collection

During data collection, a structured and standardized form developed by the team on Google Forms was used, available and stored on the researchers' drive. In addition, a pilot test was carried out with the data collection instrument, where the medical records of ten patients who were not part of the sample were analyzed, as they were admitted in a period not included in the research, which took into consideration the period from January 2019 to December 2020, with data collection being carried out by previously trained and qualified staff.

Description of variables:

Dependent variable

The variable AKI – classified according to the criteria of Kidney Disease: Improving Global Outcomes (Kdigo) as an increase in serum creatinine values greater than or equal to 0.3 mg/dL (> 26.5 µmol/L) in 48 hours and/or an increase in serum creatinine ≥ 1.5 times the known baseline value within seven days and/or urine output < 0.5 mL/kg/h for 6 to 12 hours(9), assessed during a hospitalization for decompensated HF – was categorized into yes and no. For the yes, the presence of one of the criteria described (creatinine alteration and/or urine output) was considered, and the prevalence was calculated by the number of patients who had AKI over the total number of patients assessed.

Independent variables

The following sociodemographic variables were assessed and categorized: gender (female and male), age (non-elderly, < 60 years and elderly, ≥ 60 years), race/color (white and non-white), marital status (with and without partner).

For the clinical variables, health conditions and lifestyle: length of hospital stay (in days), clinical outcome (death and no death), hemodialysis, drinker, smoker, diabetes mellitus (DM), systemic arterial hypertension (SAH) and report of renal dysfunctions in the medical record (nephropathy) were categorized as yes or no.

Regarding the definition of CRS1, the following were assessed: description of the CRS in the medical record, diagnosis of AKI, assessment by the nephrologist, categorized as yes or no. A previous history of acute myocardial infarction (AMI), whether the patient was in the postoperative period of heart surgery and whether he or she used contrast during hospitalization, yes or no, was also assessed. In this study, CRS1 is defined by the presence of AKI in patients with AHF.

The values of the laboratory tests were collected from the medical records, and the changes in the values of creatinine, urea, blood count and lactate were recorded, using the reference value established by the laboratory of the hospital in question as a parameter.

Heart failure was classified according to etiologies (hypertensive, ischemic, valvular, chagasic, congestive and alcoholic cardiomyopathies) and the type of ventricular dysfunction by left ventricular ejection fraction (LVEF), < 40% or reduced LVEF, 40-49% or intermediate LVEF and ≥ 50% or preserved LVEF(1).

With regard to the use of medications, it was assessed whether patients hospitalized with AHF used diuretics, oral antihypertensive drugs, intravenous

vasodilators, cardiotonic glycosides, inotropic drugs, vasoconstrictors, sedation and analgesia, and antibiotic therapy.

The admission risk approach (clinical risk profile) was classified as low risk, for patients with a good response to drug treatment and without decompensated comorbidity, with the possibility of discharge within 72 hours; intermediate risk, for patients with an inappropriate response to initial treatment, requiring referral to the ICU; high risk, for patients diagnosed with a decompensating factor with imminent risk to life, referred within 24 hours to the ICU, according to the Brazilian heart failure guidelines(1).

The ADHERE scale, admission risk score, was used as the dependent variable, being categorized as low risk (BUN ≤ 43 mg/dL and SBP ≥ 115 mmHg), low intermediate (BUN ≤ 43 mg/dL and SBP ≤ 115 mmHg), medium intermediate (BUN ≥ 43 mg/dL and SBP ≥ 115 mmHg), high intermediate (BUN ≥ 43 mg/dL, Cr < 2.7mg/dL, SBP ≤ 115mmHg) and high (BUN ≥ 43 mg/dL, Cr ≥ 2.7 mg/dL, SBP ≤ 115mmHg), using the variables SBP, BUN/urea, and serum creatinine(1).

As for urine filtration and elimination rates, anuria (which comprises the absence of urine production and elimination) and oliguria (comprised of a reduction in urine volume) were assessed – anuria < 0.3mL/kg/h of diuresis in more than 12 hours and oliguria < 0.5mL/kg/h of diuresis in 6-12 hours, categorized as yes or no(9).

Data analysis

In order to carry out the descriptive analysis of the categorical variables, frequencies (absolute and relative), averages and standard deviation were calculated for the continuous variables. Pearson's chi-square test and Fisher's exact test were used to compare the proportions of the categorical variables, with a significance level of 0.05.

The association between the dependent and independent variables was analyzed using a crude and adjusted binary logistic regression model. The magnitude of the association was calculated using the prevalence ratio (PR) with confidence intervals (CI) of 95% and a significance level of 0.05. The model-building strategy was held by deleting variables until the final model was obtained, where those with $p < 0.05$ remained. The Hosmer-Lemeshow test was used to check the adequacy of the models.

Data processing and analysis were carried out using the Statistical Package for the Social Sciences (SPSS) for Windows (IBM SPSS. 21.0, 2012, Armonk, NY: IBM Corp.).

Ethical aspects

The research was approved by the Research Ethics Committee of the institutions involved, with Opinion n° 4.229.023, issued by the National Council, and was approved with CAAE n°: 34826020.1.0000.0055.

RESULTS

This study assessed 226 patients admitted with a diagnosis of AHF, with an average length of stay of 13.1 ± 15.7 days (30 ± 27 days with AKI and 12.9 ± 15.6 days without AKI), 12.8% of whom were admitted to the ICU and 38.1% to the nursing ward.

In the patients assessed (n = 83), the most common types of AHF etiology were cardiomyopathies (39.9%), hypertensive (20.6%), ischemic (13.2%), valvular (10.8%),

alcoholic (7.2%), chagasic (4.8%), congenital (2.4%) and peripartum (1.1%). With regard to the type of ventricular dysfunction (n = 83), reduced LVEF was the most frequent (71.1%), followed by preserved (15.6%) and intermediate (13.3%).

The prevalence of patients with AHF was 12.4%, where mortality among these patients with AHF was 35.7%, while, among those without AHF, it was 9.1%. In the relationship between sociodemographic and clinical characteristics and AHF, there was a predominance of males (53.6%), those without a partner (72.7%), those aged ≥ 60 years (75%), those with hypertension (89, 3%) and with an intermediate/high risk admission approach (53.6%), with a statistical association between the outcome ($p < 0.001$), alcohol consumption (drinker) ($p = 0.006$), nephropathy ($p < 0.001$), admission risk profile ($p = 0.006$) and ICU admission ($p < 0.001$), as displayed in Table 1.

Table 1 – Association between sociodemographic and clinical characteristics with AKI in patients hospitalized with AHF (Bahia, Brazil, 2019-2020)

Variables	AKI*		p-value**
	Yes (%)	No (%)	
Gender (n = 226)			0,477
Male	15 (53,6)	120 (60,6)	
Male	13 (46,4)	78 (39,4)	
Marital status (n = 199)			0,715
With partner	6 (27,3)	55 (31,1)	
Without partner	16 (72,7)	122 (68,9)	
Age group (n = 226)			0,201
< 60 years	7 (25,0)	74 (37,4)	
≥ 60 years	21 (75,0)	124 (62,6)	
Race (n = 204)			0,407
White	1 (4,2)	3 (1,7)	
Non-white	23 (95,8)	177 (98,3)	
Outcome (n = 225)			0,000
Death	10 (35,7)	18 (9,1)	
No death	18 (64,3)	179 (90,9)	
Drinker (n = 222)			0,006
Yes	6 (21,4)	12 (6,2)	
No	22 (78,6)	182 (93,8)	
Nephropathy (n = 220)			0,000
Yes	3 (10,7)	1 (0,5)	
No	25 (89,3)	191 (99,5)	

Diabetes mellitus (n = 220)			0,734
Yes	9 (32,1)	68 (35,4)	
No	19 (67,9)	124 (64,6)	
SAH*** (n = 219)			0,382
Yes	25 (89,3)	158 (82,7)	
No	3 (10,7)	33 (17,3)	
Smoker (n = 222)			0,596
Yes	3 (10,7)	28 (14,4)	
No	25 (89,3)	166 (85,6)	
Admission risk approach (n = 224)			0,006
Low	13 (46,4)	147 (80,3)	
Intermediate/high	15 (53,6)	36 (19,7)	
Admission risk score (n = 226)			0,004
Low	2 (7,1)	66 (34,4)	
Intermediate/high	26 (92,9)	126 (65,6)	
Admitted to the ICU**** (n = 226)			0,000
Yes	11 (39,3)	18 (9,1)	
No	17 (60,7)	180 (90,9)	

Source: Designed by the authors.
*AKI: Acute kidney injury.
**Pearson's chi-square, significance level p < 0.05.
***SAH: Systemic Arterial Hypertension.
****ICU: Intensive care unit.

In the laboratory analysis, it was observed that 96.3% of the patients with AHF did not have an increase in lactate and 89.3% had an altered blood count. With regard to renal markers (urea and creatinine), the average creatinine was 1.8mg/dL (SD = ±0.9) and 1.2mg/dL (SD = ±0.5), while urea was 80.1mg/dL (SD = ±33.7) and 54.76mg/dL (SD = ±29.5), taking into consideration patients with and without AHF, respectively.

In the AKI assessment variables, patients with nephropathies were associated with the development of AKI (p = < 0.001), as was the use of contrast (p = < 0.001) and patients who had undergone hemodialysis (p = 0.000). All the patients with AKI had altered levels of creatinine, 92% had altered levels of urea, 60.7% had not had an inter-consultation with a nephrologist, 38.9% had oliguria and 23.5% had anuria (Table 2).

Table 2 – Association between clinical and laboratory variables with AKI in patients hospitalized with AHF (Bahia, Brazil, 2019-2020)

Variables	AKI*		p-value**
	Yes (%)	No (%)	
Altered lactate (n = 214)			0,008
Yes	1 (3,7)	0 (0)	
No	26 (96,3)	187 (100,0)	
Altered creatinine (n = 226)			0,001
Yes	28 (100,0)	48 (24,2)	
No	0 (0)	150 (75,8)	
Altered urea (n = 205)			0,001
Yes	23 (92,0)	103 (57,2)	
No	2 (8,0)	77 (42,8)	
Consultation with nephrologist (n = 226)			0,000
Yes	11 (39,3)	7 (3,5)	
No	17 (60,7)	191 (96,5)	
Postoperative in heart surgery (n = 226)			0,877
Yes	1 (3,6)	6 (3,0)	
No	27 (96,4)	192 (97,0)	
Acute myocardial infarction (n = 226)			0,989
Yes	2 (7,1)	14 (7,1)	
No	26 (92,9)	184 (92,9)	
Use of contrast (n = 226)			0,000
Yes	4 (14,3)	1 (0,5)	
No	24 (85,7)	197 (99,5)	
Anuria (n = 82)			0,004
Yes	4 (23,5)	2 (3,1)	
No	13 (76,5)	59 (96,9)	
Oliguria (n = 79)			0,000
Yes	7 (38,9)	2 (3,3)	
No	11 (61,1)	63 (96,7)	
Hemodialysis (n = 226)			0,000
Yes	3 (10,7)	0 (0)	
No	25 (89,3)	198 (100)	

Source: Designed by the authors.
*AKI: Acute kidney injury.
**Pearson's chi-square, significance level $p < 0.05$.

When comparing the pharmacological groups, there was a predominance of the use of diuretics (96.4%), oral antihypertensives (92.9%) and antibiotics (78.6%); followed by sedation and analgesia (42.9%), cardiotonic glycosides (32.1%), intravenous vasoconstrictors (28.6%), inotropes and intravenous vasodilators, both with 21.4%, Table 3.

Table 3 – Association between use of medication and AKI in patients hospitalized with AHF (Bahia, Brazil, 2019-2020)

Medications	AKI*		*p*-value**
	Yes (%)	**No (%)**	
Use of diuretics (n = 226)			0,359
Yes	27 (96,4)	181 (91,4)	
No	1 (3,6)	17 (8,6)	
Use of antihypertensives (n = 226)			0,864
Yes	26 (92,9)	182 (91,9)	
No	2 (7,1)	16 (8,1)	
Use of inotropes (n = 226)			0,003
Yes	6 (21,4)	11 (5,6)	
No	22 (78,6)	187 (94,4)	
Use of sedation and analgesia (n = 226)			0,000
Yes	12 (42,9)	30 (15,2)	
No	16 (57,1)	168 (84,8)	
Use of intravenous vasodilators (n = 226)			0,000
Yes	6 (21,4)	5 (2,5)	
No	22 (78,6)	193 (97,5)	
Use of vasoconstrictors (n = 226)			0,000
Yes	8 (28,6)	13 (6,6)	
No	20 (71,4)	185 (93,4)	
Use of cardiotonic glycosides (n = 226)			0,800
Yes	9 (32,1)	59 (29,8)	
No	19 (67,9)	139 (70,2)	
Use of antibiotics (n = 226)			0,000
Yes	22 (78,6)	73 (36,9)	
No	6 (21,4)	125 (63,1)	

Source: Designed by the authors.
*AKI: Acute kidney injury.
**Pearson's chi-square, significance level p < 0.05.

In the crude regression analysis, with regard to mortality, patients who developed AKI (35.7%) were five times more likely to die during hospitalization (PR = 5.52; CI = 2.2-13.76, p = < 0.000). With regard to the medications used, in the adjusted analysis, patients who used intravenous vasodilators were 15 times more likely to have AKI than those who did not use it (PR = 15.03; CI = 2.5-90.3; p = < 0.003) and those who were using antibiotics were three times more likely to develop AKI (PR = 3.4; CI = 1.0-71.2; p < 0.05).

The use of contrast during hospitalization revealed that individuals who used it were around 400 times more likely to develop AKI than those who did not use it (PR = 398.32; CI = 7.56-20995.44). Those who did not have an interconsultation with a nephrologist were 16 times more likely to have AKI (PR = 16.97; CI = 3.86-74.58) compared to those who did. Similarly, patients who already have a report of kidney dysfunction in their medical records (nephropathy) are about 30 times more likely to have AKI (PR = 32.05; CI = 2.11-486.22), Table 4.

Table 4 – Crude and adjusted analysis results for comparison of selected variables and AKI (Bahia, Brazil, 2019-2020)

Variables	Crude analysis		Adjusted analysis	
	PR* (95% CI)	p-value**	PR (95% CI)	p-value
Age group (n = 226)				
< 60 years	1,79 (0,7-4,4)	< 0,201		
≥ 60 years	1			
Outcome (n = 225)				
Death	1			
No death	5,52 (2,2-13,76)	< 0,000		
Nephropathy (n = 220)				
Yes	1		1	
No	22,92 (2,29-228,9)	< 0,000	32,05 (2,11-486,22)	0,012
Admission approach (n = 224)				
Low	1			
Intermediário/alto	3,46 (1,54-7,78)	< 0,006		
Admission risk score (n = 226)				
Low			1	
Intermediate/high			23,03 (1,61-329,06)	0,021

Admitted to the ICU*** (n = 226)				
Yes	1			
No	6,47 (2,63-15,9)	< 0,000		
Interconsultation with nephrologist (n = 226)				
Yes	1		1	
No	17,6 (6,1-51,1)	< 0,000	16,97 (3,86-74,58)	< 0,000
Use of contrast (n = 226)				
Yes	1		1	
No	32,83 (3,5-305,9)	< 0,000	398,32 (7,56-20995,44)	0,003
Use of inotropes				
Yes	1			
No	4,63 (1,56-13,77)	< 0,003		
Use of sedation and analgesia				
Yes	1			
No	4,2 (1,81-9,76)	< 0,000		
Use of intravenous vasodilators				
Yes	1		1	
No	10,56 (2,97-37,34)	< 0,000	21,79 (2,73-173,63)	0,004
Use of vasoconstrictors				
Yes	1			
No	5,69 (2,11-15,38)	< 0,000		
Use of antibiotics				
Yes	1			
No	6,28 (2,43-37,34)	< 0,000		
Hosmer-Lemeshow test			0,894	

Source: Designed by the authors.
*PR: Prevalence ratio.
**Pearson's chi-square, significance level p < 0.05.
ICU: Intensive Care Unit.

DISCUSSION

This study, carried out with patients diagnosed with AKI, revealed a high prevalence (12.4%) of AHF, as well as a high mortality rate for patients with this comorbidity, corroborating other studies which also found a high prevalence (27.87%[10], 28.4%[3] and 61.73%[7]) and mortality (28.8%[11] and 25.7%[12]). These results show that these patients require special care from health professionals and managers in order to avoid deaths and additional costs associated with care.

Reduced LVEF was the most frequent in this experiment. The literature indicates that AHF is more prevalent when there is reduced left ventricular ejection fraction compared to normal LVEF; however, it can be present in both, and it is necessary to monitor the cardiological profile of patients predisposed to renal dysfunctions, using tests like echocardiograms and renal function markers[1,13]. A study conducted with 172 patients with AKI showed statistical significance ($p = 0.027$) in patients with LVEF < 30% who developed cardiorenal syndrome when compared to those who did not develop it[6].

The estimation of the patient's admission risk profile and in-hospital mortality should be based on the admission approach (clinical risk profile), which analyzes the clinical manifestation of AKI and also the risk score, with the ADHERE registry being the most validated. With regard to the admission risk approach, Rodhe et al.[1] found that 80.0% of the patients were at low or intermediate risk, which is similar to what was found in the current study. For the risk score, it was found that the higher the risk score (intermediate and high), the greater the development of AHF, precisely because this score uses the values of urea (BUN - Blood Urea Nitrogen) and serum creatinine.

In this study, it was found that AHF is associated with elderly and male patients, who, according to the pertinent literature, are highly likely to develop CRS1, because the clinical profile of individuals with HF mainly involves the elderly people who have multiple diseases, including ischemic disease, DM, SAH and cardiovascular diseases, revealing high morbidity and mortality[14,15]. A study carried out in a hospital center also indicated that males represented the gender most involved in CRS1, which can be explained by the fact that these individuals seek out primary care services less often and there is less adherence to medication, which can lead to decompensation of chronic diseases[16].

In this study, it was observed that patients without a diagnosis of AHF had more DM than those with it, in contrast to the data described in the pertinent literature; while SAH has a high incidence in patients with AKI, whether or not they have developed AHF. The study by Zhao et al.[3] revealed that patients with DM had a higher prevalence of renal dysfunction (62.6%, $p < 0.01$)[3].

The analysis of laboratory tests for renal markers showed that the average levels of creatinine and urea in patients without AHF were lower than in patients with AHF. The study by Chertow et al.[17] noted that small increases in serum levels of creatinine were considerably associated with increased mortality in patients with AHF.[17] AlHwiesh et al.[18] (2018) observed that some of the determining factors for CRS1 and clinical outcome are linked to serum levels of creatinine and urea[18].

The average length of stay for patients without AKI was 13 days and for those with

AKI 30, confirming that the presence of this illness prolongs the length of stay. In the study by Fernandes, it was observed that hospitalization days without AHF were 20.88 days, while with AHF, 28.53 (p = 0.006)[6] – perhaps this is related to the need for these patients to be admitted to ICUs.

When patients do not respond adequately to drug treatment and require removal of fluids and reduction of nitrogenous waste, it is necessary to use alternative methods, such as ultrafiltration or hemodialysis[1]. With regard to hemodialysis, this study found similar results to those by Nascimento et al. .[16] (2021) and Vandenberghe et al.[19] (2016), with dialytic AHF being associated with worse clinical outcomes, for example, an increase in the mortality rate, which was significantly higher for individuals with AHF compared to those without AHF. Accordingly, one can certify the existence of a positive and significant similarity between AHF and patients who died in the sample of this study – a fact observed in other studies introduced in the pertinent literature[11,13].

With regard to the medications used by the patients analyzed, there was a higher frequency of diuretics and other oral antihypertensives. As the treatment of decompensated HF aims to reduce congestion or ensure perfusion pressures, it is necessary to use diuretics to control congestion, which is present in approximately 85.0% of the patients[1,20]. Furosemide (loop diuretic) and thiazide diuretics, a class of drugs that aim to increase the elimination of electrolytes and water, while also acting as vasodilators[20], are the most commonly prescribed during treatment. The early introduction of diuretics in AKI is associated with lower mortality, when controlled for kidney function, age, blood pressure, among other independent risk factors[21].

The purposes of antihypertensive drugs are to reduce blood pressure, which increases due to a reduction in glomerular filtration rate, a factor associated with AHF, and to reduce morbidity and mortality from cardiovascular diseases[1,6,20]. Thus, it was found that the frequency of use of these drugs in this study is intended to control both pathologies, and they are also used in the outpatient management of heart failure.

The use of drugs like inotropes, vasoconstrictors, intravenous vasodilators and sedation and analgesia is related to the severity of each patient requiring more "powerful" drug interventions and intensive care. The use of positive inotropic agents is extremely important in the pharmacotherapy of individuals with hypotensive AKI, as it improves myocardial contractility by increasing intracellular calcium, allowing cardiac output to increase[20]. A literature review cites an independent association between the development of AHF and the need for ventilation; vasopressor support; hyperphosphatemia; hyponatremia; high levels of lactate and hypophosphatemia (negatively correlated)[22].

In the final logistic regression model, intravenous vasodilators were associated with AHF, which is related to the ideal treatment for patients with a warm-congestive hemodynamic profile in the absence of arterial hypotension, cardiogenic shock, hypovolemia and sepsis. According to the Brazilian AKI guideline, these drugs act to reduce left ventricular filling pressures in order to improve cardiac output and renal perfusion[1]. Excessive reduction in blood pressure can reduce renal function, which is why it is important to periodically

assess serum levels of creatinine during the administration of vasodilators. It should be noted that patients with pre-existing renal dysfunction, advanced age or aortic valve stenosis are at greater risk of AHF[21].

In a cohort study with a population of 8,131 patients, there was a higher incidence of vasoactive drugs (17.0% × 4.3%; p < 0.001)[12], as well as nephrotoxic antibiotics in patients with AHF – it is known that some classes of these drugs have potential nephrotoxic power, especially if administered for a prolonged period of time[11]. Despite technological advances, the risk of hospitalized patients developing a hospital-acquired infection is very high, and this can be a factor in decompensating HF. Another cohort study, carried out in four hospitals in Sergipe, showed that patients with AKI developed more infections (65.5%, n = 19 vs. 39.4%, n = 28; p = 0.018)[23]. The study by Lima et al.[11], which assessed the relative risk (RR) of developing AKI using antibiotics, showed a significant result similar to this study (RR = 3.0321; CI = 1.63-5.61).

In the current research, patients who used contrast were associated with the development of AHF. The administration of contrast media is cited as the third most common cause of AHF in hospitalized patients, 11.0% of the total assessed, and is also associated with an increased risk of major adverse events, including the initiation of dialysis[21,24]. The pertinent literature reports that the simultaneous use of iodized contrast and other nephrotoxic drugs represented independent risk factors for the development of nephrotoxicity[21,24].

With regard to consultations with a nephrologist, a physician who specializes in treating kidney-related diseases, it was found that patients who did not have an interconsultation with this professional had a 16-fold increase in the chance of manifesting AHF (PR = 16.97; CI = 3.86-74.58), suggesting that the specialist, when asked for an interconsultation, can change the clinical outcome of these patients. Nonetheless, the period of the consultation was not assessed, since, in most cases, the professional is called late, and not to act early.

According to some studies, the development of CRS is associated with prolonged hospitalizations for HF, patients who require ICU admission and those who use more vasoactive drugs and have a worse prognosis[3,6,21]. In the current study, there was a high frequency of patients with AHF who required ICU admission, as well as the use of vasoactive drugs and a higher mortality rate, which requires a differentiated approach for these patients, as well as multidisciplinary care, which is correlated with a reduction in readmission and mortality rates[21].

The limitations of this study refer to the lack of information contained in the medical records, the impossibility of determining the temporality of the associations, as well as the non-generalizability of the data, due to the fact that the study was conducted in a single hospital. Despite this, it revealed aspects that denote a certain robustness, such as the characterization of the sample, the study method and the tests applied, retrospectively analyzing and showing the prevalence of the sociodemographic and clinical delineation of patients, making it possible to portray the profile of patients hospitalized with AKI who may develop AHF, thus configuring an innovative study in terms of assessing the admission approach (clinical risk profile) and the admission risk

score (ADHERE scale) with AHF. .

CONCLUSION

It was noted that there was a significant prevalence of AHF in patients hospitalized with AKI, leading to longer hospital stays and higher mortality. The predictive factors for the development of cardiorenal syndrome, which have not yet been addressed in the literature, were nephropathy, lack of interconsultation with a nephrologist, admission risk score and intravenous vasodilators. The data obtained can assist emergency health professionals, especially nurses, in identifying and providing care that predisposes to the development of CRS, as well as reducing public spending by decreasing the length of hospital stay.

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