

# Acute kidney injury after coronary artery bypass grafting: assessment using RIFLE and AKIN criteria

*Lesão renal aguda no pós-operatório de revascularização do miocárdio: avaliação pelos critérios RIFLE e AKIN*

Vinicius José da Silva Nina<sup>1</sup>, Maryanne Miranda Matias<sup>2</sup>, Dyego José de Araújo Brito<sup>3</sup>, José Albuquerque de Figueiredo Neto<sup>4</sup>, Léa Barroso Coutinho<sup>5</sup>, Rayssa Fiterman Rodrigues<sup>6</sup>, Vinicius Giuliano Gonçalves Mendes<sup>7</sup>, Shirlyne Fabianni Dias Gaspar<sup>8</sup>

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## Abstract

**Objective:** To compare the RIFLE (Risk, Injury, Failure, Loss and End-stage Renal Failure) and AKIN (Acute Kidney Injury Network) criteria for diagnosis of acute kidney injury after coronary artery bypass grafting.

**Methods:** Retrospective cohort. 169 patients who underwent coronary artery bypass grafting from January 2007 through December 2008 were analyzed. Information was entered into a database and analyzed using STATA 9.0.

**Results:** Patients' mean age was  $63.43 \pm 9.01$  years old. Predominantly male patients (66.86%) were studied. Acute Kidney Injury was present in 33.14% by AKIN and in 29.59% by RIFLE. Hemodialysis was required by 3.57% and 4.0% of the patients when AKIN and RIFLE were applied respectively. There was 4.0% and 3.57% mortality of patients with Acute Kidney Injury according to the RIFLE and AKIN criteria, respectively. In 88.76% of the cases, there was good agreement

between the two methods in the detection ( $\kappa=0.7380$ ) and stratification ( $\kappa=0.7515$ ) of Acute Kidney Injury.

**Conclusion:** This study showed that the RIFLE and AKIN criteria have a good agreement in the detection and stratification of acute kidney injury after coronary artery bypass grafting.

**Descriptors:** Myocardial revascularization. Acute kidney injury. Risk factors.

## Resumo

**Objetivo:** Comparar os critérios RIFLE (Risk, Injury, Failure, Loss and EndStage Renal Failure) e AKIN (Acute Kidney Injury Network) para diagnóstico de lesão renal aguda em pacientes no pós-operatório de revascularização do miocárdio.

**Métodos:** Coorte retrospectiva, a partir dos prontuários

1. PhD. Adjunct Professor. Head of the Cardiac Surgery Unit at University Hospital of Maranhão, São Luís, MA, Brazil. Discussion of outcomes and final review of the study.
2. Physician at University Hospital of Maranhão, São Luís, MA, Brazil. Literature review and data collection.
3. Physician at University Hospital of Maranhão, São Luís, MA, Brazil. Outcomes assessment.
4. PhD. Adjunct Professor at University Hospital of Maranhão, São Luís, MA, Brazil. Outcomes discussion.
5. Master's Degree from University Hospital of Maranhão, São Luís, MA, Brazil. Data collection.
6. Medical student at University Hospital of Maranhão, São Luís, MA, Brazil. Preparation and review of the study.
7. Physician at University Hospital of Maranhão, São Luís, MA, Brazil. Statistical analysis.

8. Resident Physician at University Hospital of Maranhão, São Luís, MA, Brazil. Translation and literature review.

This study was carried out at University Hospital of Federal University of Maranhão, São Luís, MA, Brazil.

Correspondence address:

Vinicius José da Silva Nina  
Hospital Universitário da Universidade Federal do Maranhão  
Rua Barão de Itapary, 227 – Centro – São Luís, MA, Brazil – Zip code:  
65020-070.  
E-mail: rvnina@terra.com.br

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Abbreviations, acronyms & symbols	
ADQI	Acute Dialysis Quality Initiative Group
AKI	Acute kidney injury
AKIN	Acute Kidney Injury Network
AMI	Acute myocardial infarction
ARF	Acute renal failure
CABG	Coronary artery bypass grafting
CPB	Cardiopulmonary bypass
HD	Hemodialysis
ICU	Intensive care unit
RIFLE	Risk, Injury, Failure, Loss and End-stage Renal Failure
RRT	Renal replacement therapy

de 169 pacientes submetidos à cirurgia de revascularização do miocárdio, de janeiro de 2007 a dezembro de 2008. As informações foram inseridas em um banco de dados e analisadas pelo software STATA 9.0.

## INTRODUCTION

Acute kidney injury (AKI) is an important and prevalent complication in the prognosis of cardiac surgery [1]. The term AKI is used to reflect the entire spectrum of what is defined as the abrupt reduction in renal function, in hours or days, in which acute renal failure (ARF) is characterized by a decrease in the glomerular filtration rate and/or urinary volume, in addition to the loss of basic functions, such as the inability to maintain the hydro-electrolyte and basic acid balance [2]. Most estimates demonstrates that over 30% of patients undergoing cardiac surgery develop clinically severe renal damage [3], with the need for dialysis ranging from 1.4% to 7% [4,5] and mortality rate of 5% to 44% [6,7].

As a result of the lack of a standardized definition, AKI has received numerous definitions. In 2002, the Acute Dialysis Quality Initiative Group (ADQI) proposed the classification Risk, Injury, Failure, Loss and End-stage Renal Failure (RIFLE) classification. This classification system uses measurements of serum creatinine levels and urine output [8], having been validated in over 550,000 patients worldwide [9].

In 2005, the Acute Kidney Injury Network (AKIN), proposed improvements to the RIFLE criteria in order to make the detection of acute kidney injury clear and faster, by adopting a lower cutoff point for variation in serum creatinine [10].

Both RIFLE and AKIN criteria, used to rate the degree of AKI associated with mortality seems to correlate in a progressive manner and may predict its severity [11]. Thus, both classification systems help to standardize the definition and management of this disease. There have been few studies

**Resultados:** A média de idades dos pacientes foi de 63,43 ± 9,01 anos, havendo predominância do gênero masculino (66,86%). A lesão renal aguda foi detectada em 33,14% pelo AKIN e 29,59% pelo RIFLE. A hemodiálise foi necessária em 3,57% e em 4% dos pacientes, quando o AKIN e RIFLE foram aplicados, respectivamente. Foram a óbito 4% e 3,57% dos pacientes com Lesão Renal Aguda pelos critérios RIFLE e AKIN, respectivamente. Em 88,76% dos casos, ambos os métodos demonstraram boa concordância para detecção ( $\kappa=0,7380$ ) e estratificação ( $\kappa=0,7515$ ) de lesão renal aguda.

**Conclusão:** O presente estudo permitiu concluir que os critérios RIFLE e AKIN possuem boa concordância na detecção e estratificação da lesão renal aguda no pós-operatório de revascularização do miocárdio.

**Descritores:** Revascularização miocárdica. Lesão renal aguda. Fatores de risco.

comparing the two classification systems and they shown little difference between the two systems [12]. Therefore, there is no insight into the advantages of choosing one approach to define and classify the AKI as opposed to the another [12].

AKI is a serious complication in the postoperative period of cardiac surgery with major impact on mortality and length of intensive care unit (ICU) stay [13]. Early detection of AKI is of utmost importance in making decisions regarding appropriate therapy. The aim of this study was to compare the “RIFLE and AKIN” criteria in patients undergoing cardiac surgery at a university hospital, in order to identify the one that provides the best classification of renal injury and thereby contribute to better monitoring and outcome of these cases.

## METHODS

### Type of Study

We performed an analytical, retrospective cohort study, based on data obtained from medical records of patients undergoing cardiac surgery for coronary artery bypass grafting (CABG) at a University Hospital, from January 2007 to December 2008. Of the 305 patients who underwent this type of surgery, 169 were included in the study after the application of inclusion and non-inclusion criteria, considering a prevalence of AKI of 30% [4] a sample power of 80% and an alpha error of 5%.

### Inclusion Criteria

We included all patients older than 18 who underwent CABG alone.

**Non-inclusion criteria**

Patients undergoing CABG surgery associated with other procedures, patients with stage 5 chronic kidney disease and patients who died within 24 hours after surgery were not included in this study.

**Data Collection**

Laboratory tests, clinical presentation, hemodynamic and therapeutic monitoring, and postoperative evolution data for filling the protocol form were obtained from the medical records.

Creatinine clearance was estimated using the Cockcroft-Gault formula [14].

To assess the impairment of renal function in the postoperative period, RIFLE [15] and AKIN [16] ratings were used.

The RIFLE classification provides a uniform definition for the AKI that includes criteria for three categories of injury: risk renal failure (R - Risk), renal injury (I) and renal failure (F). In addition it includes two classes of renal disease: renal function (L) and end-stage kidney disease (E) [17], defined according to function impairment, in a period of 4 weeks and 3 months, respectively [9] (Table 1).

The AKIN criteria adopted higher baseline serum creatinine levels: between 150 – 200%, 200 – 300% and > 300% for classifying the AKI in stages 1, 2 and 3, respectively. Since AKI stage 1 is analogous to RIFLE Risk, kidney injury corresponds to stage 2, and renal failure/renal replacement therapy (RRT) to stage 3 of AKIN [12] (Table 2).

**Statistical Analysis**

Quantitative variables were expressed as means and standard deviation, whereas qualitative variables were expressed as proportions and were compared using the chi-square test.

The t test was used to compare means.

The level of agreement of the RIFLE and AKIN classification criteria was assessed through kappa's test. Agreement was considered weak when kappa values were below 0.4, moderate for kappa values between 0.41 and

0.60, good for kappa values between 0.61 and 0.80, and excellent for kappa values above 0.80 [18]. Data processing was performed in STATA statistical software, version 9.0. The results were considered significant when  $P < 0.05$ .

**Ethical Aspects**

This study was approved by the Research Ethics Committee of the institution under record number 001811/2010-00 complying with the requirements of the Resolution of the National Health Council 196/96 for research involving humans.

**RESULTS**

Among the 169 patients studied, there was a predominance of males (66.86%). The mean age was  $63.43 \pm 9.01$  years-old, and 63.91% (108) were over 60 years-old. Of all patients studied, 33.14% (56) met the diagnostic criteria for AKI, based on the AKIN classification. According to the RIFLE criterion, 29.59% (50) of the patients developed AKI (Table 3).

Although forty-four (26.03%) patients were classified as having AKI by both criteria, 12 (7.10%) patients were considered ARF carriers only by AKIN, and 6 (3.55%) patients only by RIFLE.

There was no statistically significant association between the variables for gender, age, prior hypertension, extent and severity of coronary artery disease, the times cardiopulmonary bypass (CPB) and anoxia, number of grafts, need for blood transfusion, postoperative bleeding, use of vasopressors and the development of AKI by both criteria.

In patients with renal injury by RIFLE classification, obesity (36%,  $P=0.011$ ) and intraoperative ventricular tachycardia (4%,  $P=0.026$ ) were significantly associated with the development of AKI. In the group of patients with AKI by AKIN classification, prior angina (67.86%,  $P=0.024$ ), obesity (37.50%,  $P=0.002$ ), intraoperative ventricular tachycardia (3.57%,  $P=0.043$ ), postoperative acute myocardial infarction (AMI) (3.57%,  $P=0.043$ ) and vasodilators (73.36%  $P=0.006$ ) were significantly associated with the occurrence of renal impairment (Table 4).

Table 1. RIFLE classification.

Classification	Glomerular filtration rate	Urine output
Without ARF	Increased SCr < 1.5 x baseline or decrease in GFR $\geq$ 25%	$\leq$ 0.5 ml/kg/h
Risk (RIFLE-R)	Increased SCr from 1.5 to < 2.0 x baseline or decrease in GFR between 25-50%	<0.5 ml/kg/h for 6h
Injury (RIFLE-I)	Increased SCr from 2.0 to <3.0 x baseline or decrease in GFR > 50-75%	<0.5 ml/kg/h in 12 hours
Failure (RIFLE-F)	Increased SCr from 3.0 x baseline or decrease in GFR > 75% or Crs > 4mg/dL	<0.3 ml/kg/h in 24 hours or anuria for 12h
Loss	Complete loss of renal function; loss for more than 4 weeks	
CKD stage 5	Final stage of the disease for more than 3 months	

Source: Adapted from Bellomo, 2004. SCr = serum creatinine, GFR = glomerular filtration rate; CKD stage 5 = chronic kidney disease with = GFR <15 ml/min/1.73m<sup>2</sup>

Table 2. AKIN classification.

Stage	Serum creatinine criteria	Urine output criteria
1	Increased SCr > or = 0.3 mg/dl (> or = 26.4 micromol/L) or increased > or = 150 - 200% (1.5 to 2-fold) from baseline	< 0.5 ml/kg/h for more than 6 hours
2	Increase SCr > at 200 - 300% (> 23 times) the basal value	< 0.5 ml/kg/h for more than 12 hours
3	Increased SCr > 300% (3 times) the basal value (or SCr > or = 4mg/dl) with surge increase greater than 0.5 mg/dL	< 0.3 ml/kg/h for 24 hours or anuria for 12 hours

Source: Adapted from Mehta, 2007. SCr = serum creatinine

Table 3. Incidence of AKI stratified by RIFLE and AKIN criteria.

RIFLE	Rate (n = 169)	AKIN	Rate (n = 169)
Without AKI	70.41% (119)	Without AKI	66.86% (113)
Risk	25.44% (43)	Risk	29.59% (50)
Injury	3.55% (6)	Injury	2.96% (5)
Failure	0.59% (1)	Failure	0.59% (1)

AKI = acute kidney injury

Table 4. Relationship of clinical variables and anthropometric ratings from AKI.

Variables	RIFLE		P	AKIN		P
	With AKI	Without AKI		With AKI	Without AKI	
Angina						
not	16 (32%)	59 (49.58%)	0.05	18 (32.14%)	57 (50.44%)	0.024
yes	34 (68%)	60 (50.42%)		38 (67.86%)	56 (49.56%)	
BMI						
weight normal	15 (30%)	15 (38.65%)	0.011	15 (26.78%)	46 (40.71%)	0.002
overweight	16 (32%)	20 (46.22%)		20 (35.72%)	51 (45.13%)	
obesity	19 (38%)	21 (15.13%)		21 (37.50%)	16 (14.16%)	
IVA						
no	48 (96%)	119 (100%)	0.026	54 (96.43%)	113 (100%)	0.043
yes	2 (4%)	0		2 (3.57%)	0	
PO-AMI						
no	49 (98%)	118 (99.16%)	0.51	54 (96.43%)	113 (100%)	0.043
yes	1 (2%)	1 (0.84%)		2 (3.57%)	0	
Vasodilator						
no	14 (28.57%)	50 (42.37%)	0.122	13 (23.64%)	51 (45.54%)	0.006
yes	35 (71.43%)	68 (57.63%)		42 (76.36%)	61 (54.46%)	

AKI = acute kidney injury, BMI = body mass index; IVA = intraoperative ventricular arrhythmia

Only two (1.18%) patients required hemodialysis (HD) by both criteria, corresponding to 3.57% of patients with AKI by AKIN criteria ( $P=0.043$ ) and 4% by the RIFLE criteria ( $P=0.026$ ). Of these, only the AKIN or RIFLE-F stage 3 patient died ( $P=0.001$ ). Overall mortality rate was 2.96%, where two of the five patients who died, were AKI carriers

by both criteria (Table 5).

When comparing the RIFLE and AKIN methods, there was good agreement in the detection of AKI in 88.76% of the cases ( $\kappa = 0.738$ ). Additionally, AKI stratification, also showed good agreement in 88.76% of the cases ( $\kappa = 0.7515$ ).

Table 5. Clinical outcomes stratified by the RIFLE and AKIN classifications.

Outcomes	Classification systems			
	RIFLE (n = 50)		AKIN (n = 56)	
Total Hemodialysis	2 (4%)*		2 (3.57%) **	
AKI Hemodialysis	Risk	0	Stage I	0
	Injury	1 (2%)	Stage II	1 (1.78%)
	Failure	1 (2%)	Stage III	1 (1.78%)
Total deaths	2 (3.57%)		2 (4%)	
AKI deaths	Risk	1 (2%)	Stage I	1 (1.78%)
	Injury	0	Stage II	0
	Failure	1 (2%)***	Stage III	1 (1.78%)***
Discharge	48		54	

AKI = acute kidney injury; \*P = 0.026, \*\*P = 0.043, \*\*\*P = 0.001 (Pearson chi-square test)

## DISCUSSION

Acute kidney injury associated with cardiac surgery is a clinical problem, with significant higher rates of mortality [13,19]. Volkmann et al. [20] demonstrated that AKI may be hidden in over 25% of patients who underwent CABG. Thus, the existence of a classification criterion to detect early kidney as well as a proposal to unify the classification/definition of AKI are essential [4,6,7].

Similar to others, this study demonstrates that, by adopting lower values of variation in serum creatinine as a marker of renal injury the AKIN criteria identified more acute kidney injury than RIFLE [12,21].

Patients rated with AKI by both criteria were predominantly elderly (> 60 years), male, with hypertension, angina, obesity and overweight. The same profile was found by Brito et al. [4], using other classification criteria.

AKI after CPB has occurred between 1% and 15% [22]. Several authors have associated CPB time with the development of AKI in the cardiac surgery postoperative [23-25]. Changes such as contact with nonendothelial surfaces, exclusion of pulmonary flow, presence of minimally pulsatile or nonpulsatile continuous flow may contribute to the pathogenesis of AKI associated with this procedure [12,19].

The positive impact of the absence of CPB on renal function during the postoperative period of cardiac surgery has been described in a coronary randomized clinical trial where 4752 patients undergoing CABG were randomly allocated into two groups according to whether cardiopulmonary bypass was used. The authors observed a lower incidence of AKI in the off-pump group (28%) when compared to the on-pump group (32.1%), with P=0.01 [26]. In the same context, Chawla et al. [27], studying patients with chronic kidney disease in nondialytic stages, observed a reduction in mortality and a need for renal replacement therapy among those patients who had undergone surgery without CPB, especially when the levels of glomerular filtration rate were lower. In the present study,

all patients underwent CABG with CPB, and, for both criteria, those who developed AKI, had longer cardiopulmonary bypass; however, the sample size did not allow for statistical significance between the CPB time and acute renal injury outcome to be determined.

In this study obesity was associated with the development of AKI by RIFLE and AKIN criteria. Similar findings using other classification methods of AKI have been found by Conlon et al. [24] and Pontes et al. [28]. This finding can be attributed to greater endothelial dysfunction in obese patients [24].

Although not statistically significant, the transfused patients in this study had more AKI, as in the TRACS study in which transfusion was associated with postoperative AKI [29].

Ventricular tachycardia during surgery was also associated with AKI by both criteria. The postoperative AMI was statistically associated only by AKIN criteria. The low cardiac output due to these events may be directly responsible for renal hypoperfusion which culminates with AKI [13].

Furthermore, it was observed that angina pectoris was also associated with AKI according to the AKIN classification. The ischemic acute syndrome may be secondary to the formation of atherosclerotic plaques or thrombus development [23] and thus suggest greater likelihood of ischemic attacks in other organs and systems leading to hypoperfusion. This association was reported in other studies in patients who developed AKI [4,7].

Association of use of vasopressors with AKI, although well established [7], was not observed in this study. However, vasodilator drugs are statistically associated with AKI, which is not very clear in the literature. It is possible that this association is a result of AMI cases in this study, since the use of vasodilator drugs is useful in cases where the appropriate volume replacement and optimization of cardiac output with inotropic agents do not reverse the condition of low output, as in cases of cardiogenic shock after AMI [30].

Two (1.9%) patients required hemodialysis (HD), one being classified as AKIN stage 2 or RIFLEI; the other, AKIN stage 3 or RIFLE-F.



Other studies show a rate among dialysis patients who develop AKI, according to various classifications ranging from 1.4% to 7% [4,5,31].

Although AKIN has been proposed in order to improve RIFLE sensitivity, in this study, there was not a significant difference in the incidence and mortality of AKI in the CABG postoperative detected by both criteria, similar to the study by Cruz et al. [32], which found that mortality rates in RIFLE and AKIN groups did not differ significantly. Bagshaw et al. [12] also found no statistical significance in terms of incidence and hospital mortality of AKI, according to RIFLE or AKIN criteria in the first 24 hours after admission.

In this study, the RIFLE and AKIN methods showed good concordance in relation to the incidence and strata of severity of acute kidney injury in agreement with studies by Dan et al. [31] and Zappitelli et al. [33] who found excellent concordance between RIFLE and AKIN in AKI classification in adult and pediatric patients, respectively.

The retrospective design and sample size are limitations of this study. However, it has clinical relevance and it was not limited to assessment of only the first 24 hours of ICU admission, allowing for the assessment of other outcomes, such as the need for dialysis and the occurrence of death secondary to AKI.

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