# RIFLE Classification: prospective analysis of the association with mortality in critical ill patiants

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## ABSTRACT

**Introduction:** The recent RIFLE classification defines three degrees for severity of acute kidney injury (AKI): RISK, INJURY and FAILURE and was associated with mortality according to the grading of the severity of AKI, but little valued at prospective studies. **Objective:** To evaluate the association of RIFLE score with mortality in critically ill patients and compare the clinical characteristics between them. **Method:** An observational prospective cohort study of 200 patients admitted to the ICU, from July/2010 to July/2011. Patients included were older than 18 years, had for more than 24 hours in the ICU and signed the Term of informed consent. **Results:** The frequence of AKI in the ICU was 47% (n = 95), the maximum RIFLE: Risk 4.5% (n = 09), Injury 11%(n = 23) and Failure 31.5% (n = 63). The ICU mortality was 25.5% (n = 51). The RIFLE categorized into class $RIFLE_{maximum}$ class Injury + Failure had a higher mortality compared to the subgroup categorized No LRA + AKI Risk class (53.3% *vs.* 4.4%) and the greater the relative risk of the patient so classified: RR = 3.3 (95%: 2.5 to 4.4) $p < 0.001$. RIFLE categorized as $RIFLE_{maximum}$ class Injury + Failure and $SOFA_{maximum}$ score, independently associated with ICU mortality after adjustment for multiple variables. **Conclusion:** The severity of AKI according to RIFLE criteria was a risk marker for mortality in this population. The LRA group class Injury + Failure was associated with increased mortality when compared to the subgroup Without AKI + AKI that remained in Risk class even after adjustments for multiple variables.

**Keywords:** acute kidney injury, apache, intensive care units, mortality, prognosis.

## INTRODUCTION

Acute renal failure (ARF) is defined as the abrupt deterioration in kidney function. It is common in hospitalized patients with poor prognosis. As a reflection of the interest and concern of the treating physicians, numerous scientific studies have been published on ARF. The lack of a consensus in a definition of ARF hampers the advances in the scientific research on the topic.[1]

In 2004, the Acute Dialysis Quality Initiative (a group of nephrologists) published the RIFLE classification in an attempt to standardize the definition of ARF. The acronym RIFLE refers to **R**isk (risk of renal dysfunction), **I**njury (injury/damage to the kidney), **F**ailure (failure of kidney function); **L**oss (loss of kidney function); and **E**nd-stage renal disease.[2] The first 3 classes of RIFLE have high sensitivity and are related to the degrees of severity of renal dysfunction; they are assessed by relative changes in the serum creatinine (SCr) levels or the glomerular filtration rate (GFR) from a baseline value and in the reduction of the urine flow rate (DU) calculated per kilogram of weight at a specific time. The last 2 classes have high specificity and an evolutionary character and are defined by the duration of the loss of renal function. The severity of the acute kidney injury (AKI) is determined on the basis of the most serious of the following 2 parameters: the relative change in the SCr level or GFR and the DU (Table 1).

In this paper, we use the term AKI to refer to a complex clinical syndrome

**Table 1** Proposed classification for acute kidney injury - RIFLE

| RIFLE Classification | GFR criterion | Urine flow criterion |
|---|---|---|
| Risk | Increase SCr ×1.5 or decrease in GFR > 25% | Diuresis < 0.5 ml/kg/h in 6h |
| Injury | Increase SCr x2 or decrease in GFR > 50% | Diuresis < 0.5 ml/kg/h in 12h |
| Failure | Increase SCr x3 or decrease in GFR > 75% or SCr > 4 mg/dl | Diuresis < 0.3 ml/kg/h in 24h or anuria for 24h |
| Loss | Complete loss of renal function for > 4 weeks | |
| End-stage kidney disease | Need for dialysis for > 3 months | |

RIFLE: Risk, Injury, Failure, Loss, End; GFR: Glomerular Filtration Rate; SCr: Serum creatinine. Adapted from CriticalCare.2004;8(4):R204-12.

that causes both structural and functional changes in the kidneys.

The RIFLE classification system was created with the goal of establishing the presence or absence of the disease in a particular patient or situation and to describe the severity of this syndrome. This classification was not created to predict mortality or an adverse clinical course, although it is logical to link that a more severe disease results in a worse clinical course. [2,3]

In 2008, Ricci et al. published a systematic review of 24 studies describing the epidemiology of AKI and assessing its association with the severity of the disease by applying the RIFLE classification. They reported a large heterogeneity in the study methods performed. Notably, different interpretations of the RIFLE criteria may produce different epidemiologic results. However, despite differences in the methodology of the various studies, the results showed an association of RIFLE classification with mortality, i.e., the risk of death increases with the increase in the severity of the disease. Although developed on the basis of prospective studies, the RIFLE classification system has been extensively validated was extensively studied in retrospective models.

Therefore, considering that AKI is a very common, complex, clinical entity, particularly in critical patients, with a significant impact on fatal outcomes and that only a few prospective studies have been conducted in Brazil on the classification criteria of RIFLE, we undertook an observational prospective cohort study aimed to analyze the association of RIFLE classification with mortality in critically ill patients. A prospective design applied in a general ICU enables a closer assessment of the actual clinical situation in ICUs.

## Methods

### Studied population

The inclusion criteria were age above 18 years and ICU stay for longer than 24 hours at medical facilities in the city of Salvador, Bahia, Brazil, between July 2010 and July 2011. Patients who provided written informed consent were included in the study. The exclusion criteria were a history of chronic renal disease or renal transplantation and length of ICU stay for less than 24 hours. This research protocol was approved by the medical ethics in research committee of the Royal Spanish Beneficent Society.

### Study Protocol

The follow up of patients was observational and prospective during the patient's ICU stay until the outcome, discharge, or death. The researcher was not a member of the team assisting the patients in the study and did not take participate in the therapeutic decisions concerning these individuals. Information on patient identification, conditions associated with their hospitalization, clinical progress, and relevant laboratory data were collected from the medical records as per protocol.

The criterion of urine flow measurement was adapted. Although all patients were using a permanent urinary catheter, allowing continuous measurement and hourly recording of urine flow by the nursing staff, only the cumulative urine volume over 24 hours was assessed, and the weight of the patients was estimated at 60 kg, considering the average weight of an eutrophic adult. Patients were grouped into the following categories by urinary flow: urinary flow < 30 ml/h (Risk), < 18 ml/h (Injury), and < 4 ml/h (Failure). Subsequently, analysis of the criteria for diagnosis and classification of AKI were carried out. The clinical endpoint was ICU mortality.

The RIFLE classification was used, according to the prerequisites of the Acute Dialysis Quality Initiative Group (ADQI),[2] for the definition and classification of acute renal failure. The evolutionary RIFLE criteria were not considered: loss of kidney function and end-stage renal disease. The ADQI recommended the use of the MDRD equation as an alternative in the absence of the serum creatinine measurements. The value of baseline serum creatinine, in this study, was established as the lowest creatinine value measured before ICU admission. In cases where the baseline creatinine value was unknown, this value was calculated by the simplified MDRD formula, assuming approximately 75 ml min/1.73m$^2$ as the value of "normal" GFR.

GFR=186x-$\left|\right.$ Scr $\left|\right.^{-1.154}$x $\left|\right.$ Age $\left|\right.^{-0.203}$x $\left|\right.$ 0.742 if female $\left|\right.$ x $\left|\right.$ 1.210 if black $\left|\right.$.

The first classification of AKI patients considering any length of stay in the ICU was labeled as RIFLE-1, and $RIFLE_{maximum}$ ($RIFLE_{max}$) was considered as the highest criterion for classification. The studied population was categorized into 2 groups: one, with patients classified as No AKI + AKI $RIFLE_{max}$ Risk and another group, as AKI $RIFLE_{max}$ Injury + Failure class.

With regard to sepsis and septic shock, the definition criteria proposed by the 1991 Consensus Conference of the American College of Chest Physicians/Society of Critical Care Medicine Consensus Conference Committee (ACCP/CCM) were used. The ACCP/CCM Consensus Conference: (CHEST 1992, 101:1644-55) considers systemic inflammatory response syndrome (SIRS) as a response of the body to different situations, for example, trauma, major burn, and systemic infections. In the presence of at least 2 conditions among (a) body temperature > 38ºC or < 36ºC; (b) heart rate > 90 breaths per minute (bpm); (c) respiratory rate > 20 bpm or $pCO_2$ < 32 mmHg; (d) leucocytes > 12,000 cells/mm$^3$ or < 4000 cells/mm$^3$ or presence of 10% rods, sepsis was diagnosed when SIRS is the result of a confirmed infectious process and septic shock, when hypotension or hypoperfusion is present, induced by sepsis refractory to adequate volume resuscitation, thereby necessitating the use of vasoactive drugs. Although all physiological and laboratory data necessary to fulfill the definition criteria were collected by the researchers as part of the database for this study, the definitions of sepsis or septic shock were the responsibility of the medical staff who attended to patients in the ICU and were registered in the respective records as items of the problem list.

The prognostic scores Acute Physiology and Chronic Health Evaluation (APACHE II)[8] and Sequential Organ Failure Assessment (SOFA)[9] were calculated on admission, on the day of RIFLE-1 assessment, and on the day of $RIFLE_{max}$ assessment to avoid time-dependent bias. The Therapeutic Interventions Scoring System (TISS-28)[10] score was calculated only on admission. The scores were calculated with and without the relevant renal dysfunction score for the analysis of disease severity. To calculate the scores, the most altered values of the vital data and laboratory tests were used. In sedated patients, the Glasgow coma scale (GCS) was used to assess the state of consciousness immediately before sedation. All the data needed for the calculation of prognostic scores were collected.

### Statistical analysis

Statistical analyses were performed using the SPSS software version 17.0 (SPSS INC. Chicago, IL USA). Descriptive statistics were used to characterize the population. The continuous variables were presented as mean ± standard deviation or minimum value-maximum value or as median (interquartile range, 25-75%) according to the distribution. The means were compared using the *t* test when normally distributed and by the Mann-Whitney *U* test when not. Categorical variables were analyzed by the $\chi^2$ test or Fisher's exact test when this was not possible.

Univariate analysis and logistic regression were performed to assess the impact of different baseline characteristics that were statistically significant for the occurrence of the most severe AKI and mortality. A priori, the variables analyzed were use of diuretics on ICU admission, TISS-28 and non-renal APACHE II scores calculated on ICU admission, and the non-renal SOFA score calculated on the $RIFLE_{max}$ day. The scores calculated with results not consistent with renal dysfunction were chosen to avoid multicollinearity.

Mortality and survival time among the 2 sample groups classified by $RIFLE_{max}$ were analyzed using duration of stay in the ICU from the day of diagnosis of RIFLE as a variable, by using the $\chi^2$ test and the Kaplan-Meier survival curve. For the comparative analysis between the 2 groups, the log-rank test was used. Patients who were discharged from the ICU were censored.

## Results

During the study period, 200 patients were assessed, of 53.3% (n = 107) were female, with an average age of 66 years (± 16.7). Clinical admissions were more common than surgical admissions (67.5% vs. 32.5%), with 27.3% of the patients being admitted for impairment of the respiratory tract, 26.3%, for neurological injuries; and 21.7%, for cardiac causes. The duration of stay in the ICU was 12 days (interquartile range [IQR]: 4-17 days; Table 2).

The most common causes associated with the development of AKI were as follows: septic shock in 74.2% (n = 42); sepsis in 22.5% (n = 20); low cardiac output, in 17%; and other causes, in 12 (13, 4%).The frequency of AKI on admission to the ICU was 36% (n = 72) and 47.5% (n = 95) on the day of discharge or death.

Nine patients (4.5%) were deemed to have $RIFLE_{max}$ Risk; 23 (11%), Injury; and 63 (31.5%), Failure (Figure 1).

The overall ICU mortality was 25.5% (n = 51), with 53.3% of the cases being from the group AKI $RIFLE_{max}$ Injury + Failure and 4.4%, from the group No AKI + $RIFLE_{max}$ Risk. The category $RIFLE_{max}$ Injury + Failure was found to be associated with mortality with a relative risk (RR) = 7.46 (95% confidence interval [CI]: 3.2 to 17.2; $p < 0.001$), Pearson's $\chi^2 = 62.2$ df.[1]

The $RIFLE_{max}$ Injury + Failure class, the TISS-28 scores, and non-renal $SOFA_{max}$ were found to be independently associated with mortality, even after adjustment for other variables (Table 3).

Mortality at 20 and 30 days of ICU admission was 55% and 80%, respectively, for the group $RIFLE_{max}$ Injury + Failure; for the group No AKI + $RIFLE_{max}$ Risk, it was 20% after 20 days of ICU admission and remained stable thereafter. On comparison of the survival curves of the 2 groups, the long-rank test showed $p < 0.001$ (Figure 2).

The groups No AKI + AKI $RIFLE_{max}$ Risk and AKI $RIFLE_{max}$ Injury + Failure differed in age ($p < 0.002$). The group AKI Injury + Failure class required diuretics ($p < 0.001$), vasoactive drugs ($p < 0.001$), mechanical ventilation ($p < 0.001$), and multiple medications ($p < 0.001$) on admission to the ICU (Table 4) more frequently than No AKI + AKI $RIFLE_{max}$ Risk and had higher APACHE II and SOFA scores at ICU admission, at the time of AKI diagnosis, and on the day they reached $RIFLE_{max}$, even after the withdrawal of the scores corresponding to alterations in renal function. Similarly, they presented higher TISS-28 scores on admission (Table 5).

**Table 2** Clinical and demographic characteristics of critically ill patients defined by the RIFLE classification

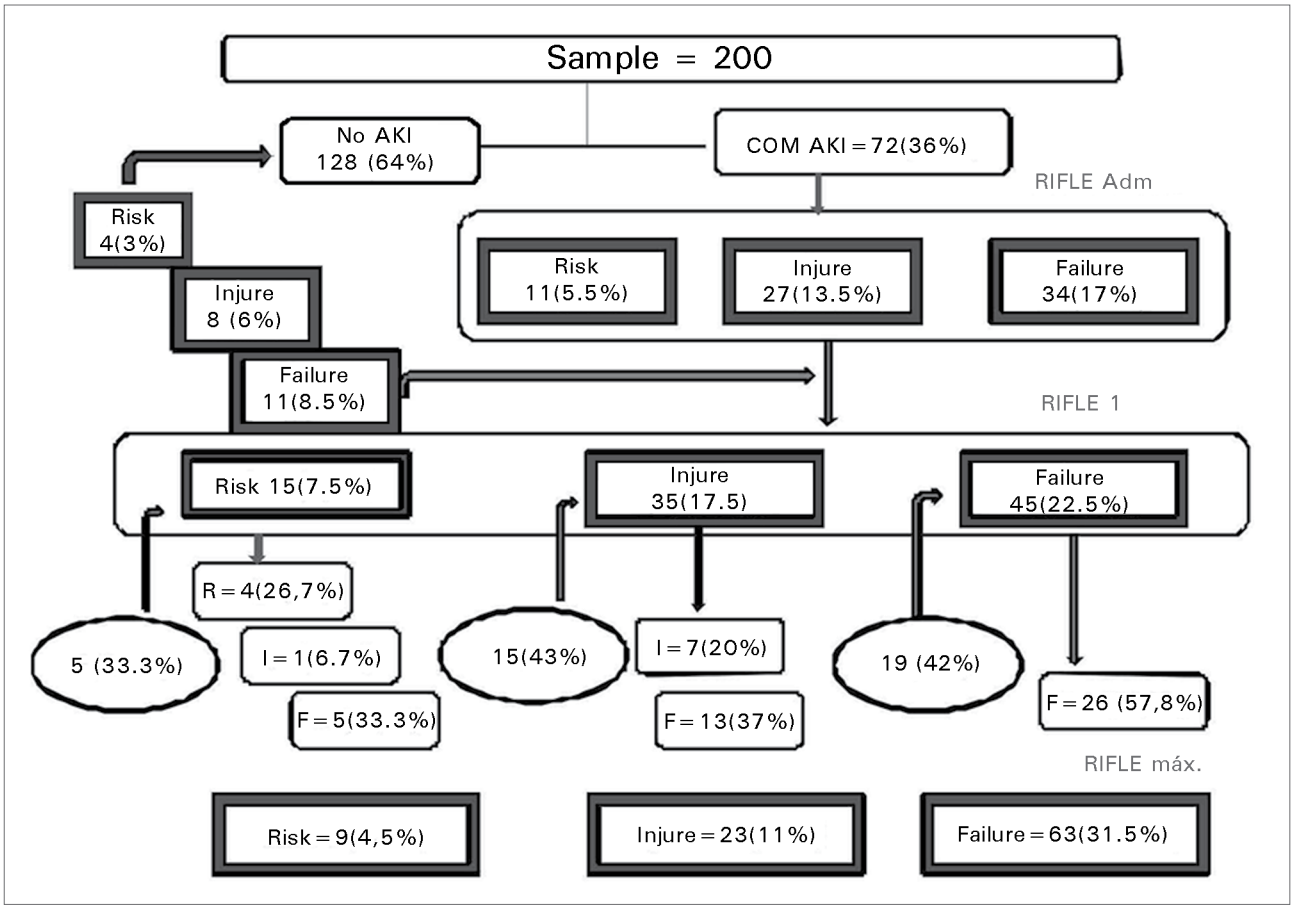
| Characteristic | N = 200 |
|---|---|
| Age (years) (± SD) | 66(± 16.7) |
| Gender N (%) Female | 107 (53.5) |
| Days of stay in the ICU (IQR) | 12 (4-17) |
| Comorbidities associated with admission N(%) | |
| DM + HTN or DLP | 99 (49.5) |
| Cancer/Oncological therapy | 34 (17) |
| CHF class IV | 06 (3) |
| Immunosuppression | 3 (1.5) |
| Surgical admission N (%) | 65 (32.5) |
| Impaired system on ICU admission N (%) | |
| Respiratory | 54 (27.3) |
| Neurological | 52 (26.3) |
| Cardiac | 43 (21.7) |
| Poly trauma | 02 (1) |
| Others | 47 (23) |
| Use of mechanical ventilation N (%) | 79 (39.5) |
| Use of vasoactive drugs N (%) | 55(27.5) |
| Use of diuretic N (%) | 54 (27) |
| Mean blood pressure (SD) | 94 (± 26.7) |
| Serum creatinine mg/dl (minimum value-maximum value) | 1 (0.2-9.8) |
| APACHE II (± SD) | 13 (± 6.6) |
| Non-renal APCHE II (± SD) | 12.3 (± 5.9) |
| SOFA (IQR) | 3 (0-5) |
| Non-renal SOFA (IQR) | 2 (0-4) |
| TISS-28 (± SD) | 21 (± 7.3) |
| Glasgow (± SD) | 13.3 (± 3) |

SD: Standard Deviation; IQR: Interquartile Range; RIFLE: Risk, Injury, Failure, Loss, End-stage; DM: Diabetes Mellitus; HTN: Hypertension; DLP: Dyslipidemia; APACHE II: Acute Physiology and Chronic Health Evaluation version II; non-renal APACHE II: Acute Physiology and Chronic Health Evaluation version II without the score for renal failure; SOFA: Sequential Organ Failure Assessment score; non-renal SOFA: Sequential Organ Failure Assessment score without the score for renal failure; TISS-28: The Therapeutic Intervention Score System; Glasgow: Glasgow Coma Scale.

Of the patients initially classified into the class Risk, 40% progressed to a more severe stage of the disease, i.e., Injury (6.7%) or Failure (33.3%), while 26.3% had complete recovery of renal function and 14.7% had partial recovery. Among the patients who recovered renal function fully or partially, 18% died.

No patient initially classified into the Risk class and who remained at that stage of classification died.

**Figure 1.** Flowchart of the progression of acute kidney injury, as defined by the RIFLE classification, during the patients' stay in the ICU.



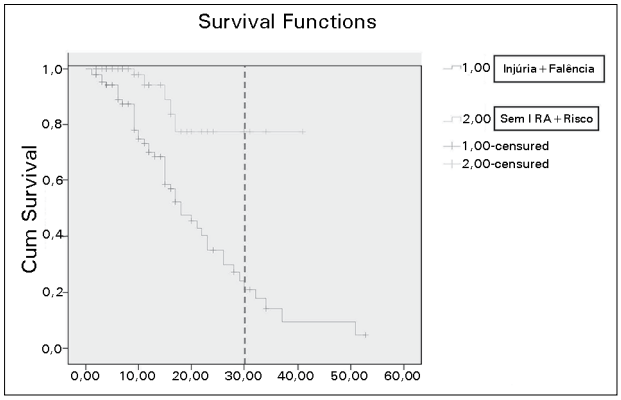

RIFLE Adm.: RIFLE classification on admission to the ICU; RIFLE 1: The first RIFLE classification at any given moment during admission; RIFLE max.: The highest RIFLE classification shown during stay in the ICU until outcome: discharge or death.

**Table 3** Impact of covariables on mortality, adjusted for RIFLE categories of No AKI + $RIFLE_{MAX}$ Risk class *vs.* $RIFLE_{MAX}$ Injury + Failure

| Variable | OR | CI 95% | *p* value |
|---|---|---|---|
| Use of diuretics on admission to the ICU | 1.03 | 0.40-2.67 | 0.949 |
| Non-renal APACHEII on admission | 1.03 | 0.95-1.10 | 0.403 |
| Categorized $RIFLE_{max}$ | 11.73 | 3.68-37.3 | 0.001 |
| Non-renal $SOFA_{max}$ | 1.28 | 1.09-1.52 | 0.003 |
| TISS-28 | 1.08 | 1.01-1.15 | 0.013 |

non-renal APACHEII: Acute physiology and chronic health evaluation version II without the score for renal failure; RIFLEmax: Highest AKI classification criterion achieved during stay in the ICU; non-renal SOFAmax: Sequential organ failure assessment score without the score for renal failure determined on the day of RIFLEmax achieved in the ICU; TISS-28: The therapeutic intervention score system.

**Figure 2.** Kaplan-Meier survival curve (in the ICU) among patients classified as $RIFLE_{max}$ Failure + Injury *vs.* No AKI + $RIFLE_{max}$ Risk.




Time: duration of stay in the ICU after RIFLE determination (Discharged patients were removed).

## Discussion

We noted a high frequency (47%) of AKI in critical care units. However, this value was lower than those reported by Hoste *et al.*[1] (67%) and Piccinni *et al.* (2010) (65.3%), but well above the 35.8% incidence of AKI published by Ostemann[7] and the 36% described by Bagshaw (2007).[11] The differences between these values may be explained by the methodological

**Table 4** Comparison of clinical and demographic data of the groups classified as No AKI + $RIFLE_{MAX}$ Risk *vs.* AKI $RIFLE_{MAX}$ Injury + Failure

| Variable (N) | No AKI + $RIFLE_{max}$ Risk N = 114 (57%) | $RIFLE_{max}$ Injury + Failure N = 86 (43%) | RR (CI: 95%) | *p* value |
|---|---|---|---|---|
| Age (years) | 63.8 (± 15.5) | 69.8 (± 16.5) | - | 0.002¹ |
| Gender | | | | |
| Female | 59 (51.9%) | 48 (55.8%) | 0.91 (0.66-1.25) | 0.001° |
| Comorbidities | | | | |
| DM/HTN/DLP | 39 (34.2%) | 19 (22%) | 0.92 (0.66-1.27) | 0.360° |
| Cancer/Oncological therapy | 59 (51.8%) | 40 (46.5%) | 1.50 (1.0-2.0) | 0.025° |
| CHF class IV | 14 (12.3%) | 20 (23.3%) | 1.50 (0.87-2.8) | 0.220° |
| Type of admission | | | | |
| Clinical | 62 (54.4%) | 73 (84.9%) | 2.7 (1.62-4.5) | 0.001° |
| Surgical | 52 (45.6%) | 13 (15.1%) | - | - |
| Origin | | | | |
| Ward | 30 (26.3%) | 56 (66%) | 2.50 (1.70-3.60) | 0.001° |
| Emergency | 37 (32.5%) | 13 (15.3%) | 0.53 (0.32-0.88) | 0.006° |
| Surgical center | 38 (33.3%) | 12 (14%) | 0.49 (0.29-0.83) | 0.002° |
| Others | 99 (7.9%) | 4 (4.8%) | 0.70 (0.30-1.62) | 0.360° |
| Reason for admission | | | | |
| Respiratory | 18 (15.8%) | 36 (43) | 2.0 (1.40-2.60) | 0.001° |
| Neurological | 42 (36.8%) | 10 (12%) | 0.37 (0.21-0.67) | 0.001° |
| Cardiac | 27 (23.7%) | 16 (19%) | 0.84 (0.5-1.3) | 0.437° |
| Others | 27 (23.7%) | 22 (26%) | - | - |
| On admission to the ICU | | | | |
| Use of multiple medications | 79 (69%) | 78 (90.7%) | 2.6 (1.4-5) | 0.001° |
| Use of mechanical ventilation | 34 (29.8%) | 45 (52.3%) | 1.68 (1.0-2.3) | 0.001° |
| Use of vasoactive medication | 16 (13.0%) | 39 (45.4%) | 2.2 (1.7-2.9) | 0.001° |
| Use of diuretic | 5 (4.4%) | 49 (57%) | 3.5 (2.6-4.7) | 0.001° |
| Average blood pressure (± SD) | 100 (± 25.6) | 87.4 (± 26) | - | 0.001¹ |
| Serum creatinine (± SD) | 0.72 (± 0.27) | 1.5 (± 1.4) | - | 0.001¹ |

AKI: Acute Kidney Injury; DM: Diabetes Mellitus; HTN: Hypertension; DLP: Dyslipidemia; SD: Standard Deviation; ¹ *Student's t-test*; ° $\chi^2$ (Chi-Square) test, $p < 0.05$.

differences between the studies. The frequencies of AKI observed by Santos[12] and De Abreu *et al.*[13] in Brazil are closer to that determined in the present study. Both showed that 40.3% of their patients developed AKI.

Our findings indicated that the AKI category AKI Injury + Failure was independently associated with higher mortality and showed a higher RR of death (RR = 7.46; 95% CI: 3.2-17.2 $p < 0.001$). In 2008, Ricci *et al.*[4] observed that the RIFLE classification was associated with the RR of death, progressively with the increase of the score rating. The Risk class was associated with a RR of 2.40 (95% CI: 1.94-2.97) for death compared to patients without AKI, while the classes Injury and Failure were associated with a mortality of 4.15 (95% CI: 3.14-5.48) and 6.37 (95% CI: 5.14-7.9), respectively. Previous studies have also shown similar results.[1,7,11,14,15] Only 2 studies, by Bell *et al.*[16] and Macarriello *et al.*[17], had different results. This may be attributed to the fact that both sought to assess this association in a population of patients receiving renal replacement therapy (RRT), at the start of RRT.

Patients who developed AKI in our study were more severely ill, as represented by the higher prognostic scores of SOFA and APACHE II; these patients also required more aggressive treatment at the ICU, as indicated by the higher TISS-28 score than those without kidney injury (data not shown). This factor was also associated with severity of renal injury, i.e.,

**Table 5** Comparison of prognostic scores between groups without AKI + AKI RIFLE maximum class Risk and with AKI RIFLE maximum class Injury + Failure

| | All N = 200 | Without AKI + AKI RIFLE Risk N = 114 (57%) | RIFLE Injury + Failure N = 86 (43%) | *p*-value |
|---|---|---|---|---|
| On ICU admission | | | | |
| Glasgow coma scale | 13.3 (3-5) | 13.5 (3-15) | 12.6 (3-15) | 0.021ǂ |
| Apache II | 13.3 (1-38) | 10.4 (1-24) | 18.1 (3-38) | 0.001ǂ |
| Non-renal Apache II | 12.3 (1-36) | 10.3 (1-24) | 15.9 (3-36) | 0.001ǂ |
| SOFA | 3.45 (0-5) | 1 (0-3) | 5.5 (3-8) | 0.001€ |
| Non-renal SOFA | 2.62 (0-4) | 1 (0-2.5) | 4 (1-7) | 0.001€ |
| TISS-28 | 20.9 (8-44) | 19 (8-34) | 23 (11-37) | 0.001ǂ |
| On the day of RIFLE-1 | | | | |
| Non-renal Apache II | 12.4 (1-36) | 10.3 (1-24) | 16 (3-36) | 0.001ǂ |
| Non-renal SOFA | 2 (0-4) | 1 (0-2.5) | 4 (1-7) | 0.001€ |
| On the day of $RIFLE_{maximum}$ | | | | |
| Non-renal Apache II | 12.4 (1-33) | 13.8 (8-24) | 15.7 (8-33) | 0.001ǂ |
| Non-renal SOFA | 2 (0-4) | 0.5 (0-3) | 4 (1-7) | 0.001€ |
| Death N (%) | 51 (25.5%) | 5 (4.4%) | 46 (53.3%) | 0.001° |

SOFA - Sequential Organ Failure Assessment Score. Non-renal SOFA: Sequential Organ Failure Assessment Score without kidney failure score. APACHE II: Acute Physiology and Chronic Health Evaluation version II. Non-renal APACHE II: APACHE II without kidney failure score. TISS-28: The Therapeutic Intervention Score System. RIFLE 1: Corresponds to the first criterion for classification as soon as AKI is diagnosed. $RIFLE_{Maximum}$: Corresponds to the highest classification criterion of AKI presented at any time during the intensive care unit (ICU) stay. ǂ *Student t-test*; € Mann-Whitney; ° $\chi^2$ (Chi-Squared); $p < 0.05$. The values are shown as average or median (minimum-maximum).

the higher the achieved RIFLE class, the higher were the prognostic scores calculated, both on admission and on the day of development of renal injury and on the day the $RIFLE_{max}$ was achieved, even after excluding, from the scores, the values related to renal dysfunction. These results are consistent with those of previous studies.[1,18] This demonstrates that the development of AKI in an intensive care setting is probably part of more severe systemic impairment (such as sepsis and septic shock) and that the severity of kidney injury is directly associated with mortality.

The pathophysiological changes inherent to acute renal dysfunction or due to the adverse effects of RRT may be considered as contributing factors, despite the better efficiency of technology in this area, as well as to reduced morbidity.[11,19,20] In this sense, the medical procedures used have extended the hospitalization time without reducing mortality. However, it is unclear whether AKI is an independent predictor of risk of death or a mere adjuvant to a more severe disease stage.[20-23]

Clermont *et al.* (2002),[22] in a prospective and multicenter study comparing the impact of acute and chronic renal failure in the evolution of critically ill patients, found that patients with AKI not requiring dialysis had higher mortality than patients without AKI. In turn, the mortality in patients with AKI requiring dialysis was twice as high as that reported in patients with chronic renal failure, thereby suggesting that the increased mortality associated with AKI is not simply due to the loss of function of the organ alone, but due to all the clinical circumstances surrounding this syndrome.

The RIFLE classification criterion allows the evaluation of the progression of renal injury.[11] AKI showed dynamic clinical applicability where milder categories progress to more serious conditions.[1] It has been shown, in this study, that 40% of the patients classified as RIFLE class Risk progressed to the more severe classes of Injury or Failure and that such progression carried important prognostic implications. However, none of the patients initially classified with AKI class Risk and who remained in this classification stage died.

Hoste *et al.*[1] were the first to assess progression of AKI in a large sample of critically ill patients. In their study, Hoste classified patients with AKI according to the RIFLE classification with the maximum score ($RIFLE_{max}$). The concept of $RIFLE_{max}$ for Hoste, as in this study, was the highest classification score shown during stay in the ICU. Hoste showed that 50% of patients who developed AKI and were classified as class Risk by RIFLE had progressed in class Injury

or Failure. Another study by Piccinni *et al*. (2011)[18], aimed to determine the epidemiology of AKI 10 ICUs in Italy, demonstrated that from the patients initially classified as Risk, 38% progressed to class Injury or Failure and had a poor outcome. Meanwhile, among those who recovered their renal function fully or partially, 18% of patients in the present study and 14.7% in study by Piccinni *et al*. died.

In this study, old age showed no association with the severity of AKI. In a study by Hoste, the association of old age and a high score of disease severity with the occurrence of AKI did not apply to groups of patients with AKI, classified by RIFLE, who progressed to the more severe degrees of severity; in other words, patients who progressed to the RIFLE classes of Injury and Failure were not older, nor were their disease severity scores higher than those who remained in the Risk class, even after excluding the values corresponding to renal dysfunction. This confirmed that the severity of AKI is associated with mortality. It was not possible to confirm these findings in the present study because of the small size of the sample of patients classified into RIFLE class Risk.

This study has its limitations. The patients evaluated had received treatment at the same research center. Therefore, caution is necessary when extrapolating the data collected to other services. Another limitation was that the population mainly comprised patients with severe clinical conditions and consequently the recruitment of more number of such patients, was not possible. The ADQI group recommended the use of the MDRD equation in to overcome the limitation for the lack of serum creatinine. Since this equation is an estimation of creatinine levels, published results on its accuracy are conflicting. Although the estimated value of serum creatinine was used in only 20% of the sample in this study, the use of this determination may have contributed to misclassification. It is known that calculated serum creatinine levels cannot be substituted for actual creatinine values; however, the validation of the MDRD was not the aim of this study.

On the other hand, few Brazilian studies involve a prospective analysis of the RIFLE score and adhere to the rules of the ADQI. A real-time analysis approach will enable the assessment of the actual clinical situation in ICUs and ensure reliability of the data collected and the statistical analysis performed.

Our results indicate that the frequency of AKI among ICU patients remains high. Critically ill patients developing AKI are severely ill and require aggressive treatment. The RIFLE classification is an easily applicable instrument and useful for the definition and classification of AKI in critical patients. It is important to understand that the severity of kidney injury is associated with the severity of disease and mortality in this population and that acting in cases of AKI in which the $RIFLE_{max}$, has been reached can mean lost time and effort. Further studies should be directed towards the analysis of the population in the risk class that has a high probability of progressing to the more severe classes and, often, to irreversible and fatal outcomes.

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### CLASSIFICAÇÃO DE RIFLE: ANÁLISE PROSPECTIVA DA ASSOCIAÇÃO COM MORTALIDADE EM PACIENTES CRÍTICOS

RIFLE CLASSIFICATION: PROSPECTIVE ANALYSIS OF THE ASSOCIATION WITH MORTALITY IN CRITICAL ILL PATIENTS

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Devido a um equívoco, a Tabela 5 não foi publicada, na página 376 da versão em português da revista, segue abaixo:

**TABELA 5** COMPARAÇÃO DOS ESCORES PROGNÓSTICOS ENTRE OS GRUPOS SEM LRA + LRA $RIFLE_{MÁXIMO}$ CLASSE RISCO E COM LRA $RIFLE_{MÁXIMO}$ CLASSE INJÚRIA+FALÊNCIA

| | Todos N = 200 | Sem LRA + LRA RIFLE Risco N = 114(57%) | RIFLE Injuria + Falência N = 86 (43%) | Valor de *p* |
|---|---|---|---|---|
| Na admissão na UTI | | | | |
| Escala de coma de Glasgow | 13,3 (3-5) | 13,5 (3-15) | 12,6 (3-15) | 0,021[ǂ] |
| Apache II | 13,3 (1-38) | 10,4 (1-24) | 18,1(3-38) | 0,001[ǂ] |
| Apache II não renal | 12,3(1-36) | 10,3(1-24) | 15,9(3-36) | 0,001[ǂ] |
| SOFA | 3,45(0-5) | 1(0-3) | 5,5(3-8) | 0,001[€] |
| SOFA não renal | 2,62(0-4) | 1(0-2,5) | 4(1-7) | 0,001[€] |
| Tiss-28 | 20,9(8-44) | 19(8-34) | 23(11-37) | 0,001[ǂ] |
| No dia do RIFLE-1 | | | | |
| Apache II não renal | 12,4(1-36) | 10,3(1-24) | 16(3-36) | 0,001[ǂ] |
| SOFA não renal | 2(0-4) | 1(0-2,5) | 4( 1-7) | 0,001[€] |
| No dia do $RIFLE_{máximo}$ | | | | |
| Apache II Não renal | 12,4(1-33) | 13,8( 8-24) | 15,7(8-33) | 0,001[ǂ] |
| SOFA não renal | 2(0-4) | 0,5(0-3) | 4(1-7) | 0,001[€] |
| Morte n (%) | 51(25,5%) | 5(4,4%) | 46(53,3%) | 0,001° |

SOFA – Sequencial Organ Failure Assement Score. SOFA não renal: Sequencial Organ Failure Assement Score sem a pontuação que corresponde à insuficiência renal. APACHE II: Acute Physiology and Chronic Health Evaluation versão II. APACHE II não renal: APACHE II sem a pontuação que corresponde à insuficiência renal. TISS-28: The Terapeutic Intervention Score System. RIFLE 1: Corresponde ao primeiro critério de classificação tão logo feito diagnóstico de LRA. $RIFLE_{Máximo}$: Corresponde ao maior critério de classificação da LRA apresentado em qualquer tempo durante a permanência na UTI.[ǂ]Test *t* de Student; [€] Mann-Whitney; ° $\chi^2$ (Qui -Quadrado) $p < 0,05$. Os valores estão apresentados em média ou mediana (valor mínimo-valor máximo).