



ACUTE KIDNEY INJURY: COMMON PROBLEM IN THE POSTOPERATIVE PERIOD AFTER VALVE SURGERY

LESÃO RENAL AGUDA: PROBLEMA FREQUENTE NO PÓS-OPERATÓRIO DE CIRURGIA VALVAR

LESIÓN RENAL AGUDA: PROBLEMA FRECUENTE EN EL POST-OPERATORIO DE CIRUGÍA VALVULAR

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ABSTRACT

Objective: identifying the factors related to and the repercussions of valve surgery on renal function by means of the classification Kidney Disease: Improving Global Outcomes (KDIGO). **Method:** quantitative, observational, longitudinal, and prospective study conducted in the intensive care unit (ICU) at a private hospital specialized in cardiology, with a 47-patient sample. Data collection took place through a structured questionnaire and Fisher's exact test was used in statistical analysis, as well as the chi-square and Kruskal-Wallis tests (with a significance level of $p < 0.05$). **Results:** in this study, 83% of the patients progressed to renal dysfunction. Higher body mass index (BMI), positive end-expiratory pressure (PEEP), and noradrenaline use were significantly related to the occurrence of kidney injury or renal failure ($p = 0.002$, $p = 0.02$, and $p = 0.05$, respectively). **Conclusion:** BMI, PEEP, and noradrenaline use were significantly associated with acute kidney injury (AKI) in the postoperative period and, when combined with heart valve surgery, predisposed most of the patients to AKI. **Descriptors:** Acute Kidney Injury; Postoperative Period; Thoracic Surgery; Risk Factors; Health Evaluation.

RESUMO

Objetivo: identificar os fatores relacionados e as repercussões da cirurgia valvar sobre a função renal por meio da classificação Kidney Disease: Improving Global Outcomes (KDIGO). **Método:** estudo quantitativo, observacional, longitudinal e prospectivo realizado na unidade de terapia intensiva (UTI) de hospital privado especializado em cardiologia, com amostra de 47 pacientes. A coleta de dados ocorreu por meio de um questionário estruturado e a análise estatística empregou o teste exato de Fisher, além dos testes qui-quadrado e Kruskal-Wallis (com nível de significância de $p < 0,05$). **Resultados:** neste estudo, 83% dos pacientes evoluíram com disfunção renal. Índice de massa corporal (IMC) mais elevado, pressão positiva no final da expiração (PEEP) e uso de noradrenalina se relacionaram de forma significativa com a ocorrência de lesão ou falência renal ($p = 0,002$, $p = 0,02$ e $p = 0,05$, respectivamente). **Conclusão:** IMC, PEEP e uso de noradrenalina representaram fatores significativamente associados a lesão renal aguda (LRA) no pós-operatório e, quando combinados a cirurgia cardíaca valvar, predispueram a maioria dos pacientes a LRA. **Descritores:** Lesão Renal Aguda; Período Pós-Operatório; Cirurgia Torácica; Fatores de Risco; Avaliação em Saúde.

RESUMEN

Objetivo: identificar los factores relacionados y las repercusiones de la cirugía valvular sobre la función renal mediante la clasificación Kidney Disease: Improving Global Outcomes (KDIGO). **Método:** estudio cuantitativo, observacional, longitudinal y prospectivo realizado en la unidad de cuidados intensivos (UCI) de un hospital privado especializado en cardiología, con una muestra de 47 pacientes. La recogida de datos se realizó a través de un cuestionario estructurado y se utilizó la prueba exacta de Fisher en el análisis estadístico, así como las pruebas chi-cuadrado y Kruskal-Wallis (con un nivel de significancia de $p < 0,05$). **Resultados:** en este estudio, el 83% de los pacientes evolucionaron con disfunción renal. Un índice de masa corporal (IMC) más alto, presión positiva al final de la espiración (PEEP) y uso de noradrenalina se relacionaron significativamente con la ocurrencia de lesión renal o insuficiencia renal ($p = 0,002$, $p = 0,02$ y $p = 0,05$, respectivamente). **Conclusión:** IMC, PEEP y uso de noradrenalina se asociaron significativamente con la lesión renal aguda (LRA) en el postoperatorio y, cuando se combinaron con cirugía valvular cardíaca, predispusieron a la mayoría de los pacientes a la LRA. **Descriptor:** Lesión Renal Aguda; Período Postoperatorio; Cirugía Torácica; Factores de Riesgo; Evaluación en Salud.

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INTRODUCTION

Cardiovascular diseases, as a public health issue, represent one of the universal causes of hospitalization; in this scenario, cardiopathies are among the conditions with the highest mortality rates in the world.¹

In turn, these heart diseases, depending on their complexity, require cardiac surgery to correct a congenital or acquired defect. In the postoperative period, a patient may progress to vascular, pulmonary, and kidney complications, among others. Acute kidney injury (AKI) is highlighted in this scenario as a kidney complication after cardiac surgery and it is characterized as the second most common cause of hospitalization in intensive care units (ICUs).²

Thus, AKI as a problem has been configured as a global health epidemic with increasing incidence, something which increases the long-term risks of multiple comorbidities and mortality, along with rising health care costs.³ It is known that as a result of advances in preventive and therapeutic strategies, the mortality rate associated with AKI has shown a significantly decreasing trend over the decades among hospitalized patients.⁴ However, on the other hand, the mortality rates among critically ill patients with AKI remain high and they affect between 81.8% and 93.3% of the individuals.^{5,6}

In the general context, in the postoperative after cardiac surgery, AKI, depending on its definition and the study scenario, affects from 2.4% to 58.6% of the adult patients.^{7,8}

Scientific evidence obtained with 321 patients who underwent valve surgery confirms that 41% of the patients evolved postoperatively with AKI. Another study also indicates that up to 49% of the valve surgeries may predispose to the occurrence of this pathology. Also in this scenario, it is worth emphasizing that about 1.5% of the patients affected by AKI require renal replacement therapy, which increases the chance of mortality by up to 60%.¹⁰

The most powerful strategy to prevent progression from AKI to chronic kidney disease (CKD) is prevention. To do this, the definition of AKI should be clear and incorporated by health service practitioners, so that their identification can be early, in such a way as to minimize the risk that patients progress to it.¹¹

There is a global incentive to improve the lack of knowledge and understanding on the recognition, diagnosis, and management of AKI patients in the health systems.¹²

The adoption of newer technologies and better collaboration between health centers may enable resource sharing to help educators and health practitioners to pursue more effective and more flexible educational and clinical approaches and overcome some barriers in early identification and treatment.

It is known that AKI is common and often preventable. Nurses should be capable of recognizing it. By means of prevention or early detection, these practitioners may help reducing morbidity and mortality associated with AKI, improving the patients' quality of life and reducing the financial impact of AKI.¹⁴

According to the Kidney Disease Improving Global Outcomes (KDIGO), kidney injury is defined as an abnormality of kidney structure or function, with health implications. It may occur abruptly and be dealt with or become chronic.¹⁵

Currently, the classification KDIGO has gained prominence regarding the definition of AKI. Published in 2012, it is proposed to identify AKI in the presence of elevated serum creatinine levels, above 0.3 mg/dL over baseline within a 48-hour period, or when there is an increase greater than or equal to 1.5 times the baseline serum creatinine within 7 days, or when the urine output is reduced to less than 0.5 mL/kg/h within 6 hours.¹⁵

OBJECTIVE

- Identifying the factors related to and the repercussions of valve surgery on renal function by means of the classification Kidney Disease: Improving Global Outcomes (KDIGO).

METHOD

Quantitative, observational, longitudinal, prospective study conducted in the ICU at a private hospital specialized in cardiology in the Brazilian Federal District.

The convenience sample consisted of 47 patients admitted to the ICU. Data was collected during the period from February to August 2016. Adult patients in the postoperative period of heart valve surgery and those without history of kidney disease prior to ICU admission were included and those in palliative care, undergoing vascular and myocardial revascularization surgeries were excluded.

For data collection, patients were monitored clinically and laboratorially for seven days, through information in the medical records. Weekly visits were made and a structured questionnaire with items related to sociodemographic identification, clinical variables (comorbidities, medicines in use),

prognostic score (APACHE II), ventilatory variables, hemodynamic variables (blood pressure, heart rate, peripheral oxygen saturation), a laboratory variable, such as serum creatinine and the patients' urinary output was applied.

To evaluate renal function, the classification KDIGO was applied by the researcher - which allows staging renal function based on serum creatinine and urinary output (Table 1).¹⁵

Table 1. Classification KDIGO. Brasília (DF), Brazil, 2016.

Stages	Serum creatinine	Urinary output
Stage 1.	1.5 to 1.9-fold increase in baseline creatinine or a 0.3 mg/dL increase.	Less than 0.5 mL/kg/h for 6 to 12 hours.
Stage 2.	2.0 to 2.9-fold increase in baseline creatinine.	Less than 0.5 mL/kg/h for a time greater than or equal to 12 hours.
Stage 3.	A 3.0-fold increase in baseline creatinine or a 4.0 mg/dL increase or onset of dialysis in patients under 18 years of age with a creatinine clearance of less than 35 mL/min/1.73 m ² .	Less than 0.3 mL/kg/h for a time greater than or equal to 24 hours or anuria for a time equal to or greater than 12 hours.

Source: Adapted from the KDIGO clinical practice guideline for acute kidney injury, 2012.

We adopted as baseline creatinine the last value of serum creatinine prior to ICU admission; when it was not available, we adopted the lowest creatinine value within the first week of ICU admission.

In this study, a patient with a 1.5 to 1.9-fold increase in baseline creatinine and/or a > 0.3 mg/dL increase or a < 0.5 mL/kg/h decrease in urinary output for 6 to 12 hours.¹⁵

The Acute Physiology and Chronic Health Evaluation (APACHE II), a severity score adopted in this study, represents a scoring system to determine the organ dysfunction degree or failure rates. The score is based on six variables relevant to the respiratory, cardiovascular, hepatic, hematopoietic (coagulation), renal, and neurological systems.¹⁶

In compliance with Resolution CNS no. 466/2012, this study was approved by the Research Ethics Committee of the Cardiology Institute of the Brazilian Federal District, under the Brazilian Certificate of Submission for Ethical Assessment (CAAE) no. 44999215.9.0000.0026.

Descriptive data was expressed in absolute frequency (n) and relative frequency (%), average value and standard deviation, and median value and quartiles 1 and 3.

Categorical variables were analyzed using Fisher's exact test or chi-square test. The analysis of continuous variables was performed using Kruskal-Wallis non-parametric test. *P* values < 0.05 were considered significant.

RESULTS

The results showed a predominance of women (66%). The participants' age and

average body mass index (BMI) was 53 ±15 years and 26.0 ±5.7 kg/m², respectively.

The ICU length of stay was estimated at around 4 ±3.7 days. Regarding the outcome of the ICU and in-hospital care, there was no difference: in both segments, 95.7% of the patients evolved to hospital discharge and 4.83% to death. In addition, 83% progressed with renal dysfunction, according to the classification KDIGO.

The most frequent comorbidities were arterial hypertension (48.9%), followed by functional class II/III heart failure (38.3%). Among the patients monitored, 12.8% had a ventricular ejection fraction below 50%.

The average time of surgery and extracorporeal circulation was 253 ±67 and 109 ±35 minutes, respectively. The median time of anoxia was 85 minutes.

The invasive ventilatory strategy generally lasted for a median time of 870 minutes. Of the total number of patients, 18 (38.3%) had used invasive mechanical ventilation. The average positive end-expiratory pressure (PEEP) used during treatment was 8.9 ±1.0 cmH₂O. Also, the average APACHE II index was 10.7 ±4.1 and postoperative mortality affected an average of 13.7 ±7.4 patients.

It was estimated that 96% of the patients required a vasopressor drug due to hemodynamic instability. Noradrenaline was administered to 72.3% of them. The vast majority (97.9%) of the patients received antibacterial prophylaxis and almost 90% received a diuretic drug.

As observed, according to the creatinine criterion, 40.4% of the patients were stratified with risk of kidney injury and 19.1% with kidney injury itself. Likewise, 36.2% of patients in stage 1 (risk) and 29.8% in stage 2

(kidney injury - intermediate severity stage) were identified using the urinary output criterion. Only 2.1% of the participants were classified in stage 3 (renal failure) by the urinary output criterion, a stage of greater severity of renal dysfunction. Regarding the creatinine criterion, it was observed that the

urine output criterion tended to show better performance in the evaluation of renal dysfunction (Table 2).

Table 2. Renal function distribution of patients in dysfunction stages according to the classification KDIGO. Brasília (DF), Brazil, 2016.

Stage	Creatinine criterion*	Urinary output criterion
Stage 1/Risk	19 (40.4%)	17 (36.2%)
Stage 2/Injury	9 (19.1%)	14 (29.8%)
Stage 3/Failure	0 (0.0%)	1 (2.1%)

The highest BMI was significantly related to the occurrence of kidney injury or renal failure ($p = 0.002$).

Extracorporeal circulation (ECC) time was, on average, 11 minutes longer in those patients who progressed with kidney injury or renal failure, although there was no significant relationship (Table 3).

Mechanical ventilation time was also slightly longer in patients with kidney injury or renal failure, averaging 870 minutes, while in patients with normal or at-risk renal function it was 855 minutes. There was a significant association ($p = 0.02$) of PEEP with the occurrence of kidney injury or renal failure.

Table 3. Relation between surgical variables and renal function of patients in the postoperative period of valve surgery admitted to the intensive care unit. Brasília (DF), Brazil, 2016.

Characteristics (n = 47)	Normal or at-risk (n = 29)	Injury or failure (n = 18)	P valor
Time of surgery (minutes) ⁱ	242 (216-263)	235 (205-349)	0.8
Time of ECC (minutes)	95 (90-124)	106 (91-128)	0.5
Time of anoxia (minutes)	84 (72-103)	88 (70-105)	0.7
Intraoperative complications	10 (34.5)	4 (22.2)	0.4
Time of MV (minutes)	855 (680-1068)	870 (682-1397)	0.4
PEEP	8 (8-8)	10 (9-10)	0.02
NIV	10 (45.5)	8 (47.1)	0.9
APACHE II	11.0 (8-13)	10.5 (8.5-13)	0.8
Mortality	12.9 (8.7-16.5)	12.1 (9.3-16.5)	0.8

PEEP = positive end-expiratory pressure; NIV = non-invasive ventilation; MV = mechanical ventilation; ECC = extracorporeal circulation.

ⁱ Fisher's exact test; Mann-Whitney test; chi-square test.

All patients who required a vasopressor drug (noradrenaline) progressed to kidney injury or renal failure ($p = 0.05$).

The most frequent postoperative complication both in patients with normal renal function or at risk (20.7%) and in those with kidney injury or renal failure (22.2%) was atrial fibrillation (AF).

DISCUSSION

AKI is one of the main postoperative complications of cardiac surgery^{10,17,18}, a fact also reflected in this study, considering that 83% of the patients progressed to some renal dysfunction.

Scientific evidence, as well as that provided by this study, showed that women are at higher risk of developing AKI.^{19,20} However, although this finding is not consensual, this variable is expressed as an independent factor for developing AKI.²¹

Several factors, such as intraoperative hypotension, chronic pulmonary disease, prolonged mechanical ventilation, infections, extracorporeal circulation, intra-aortic balloon use, alone or combined, may determine renal dysfunction in the postoperative of valve surgery. Individuals with advanced age have lower tolerance to hemodynamic changes, a finding that also predisposes to the occurrence of AKI.^{9,10,18} In

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this context, mechanical ventilation as an artificial ventilation strategy causes changes in cardiovascular hemodynamics and this leads to decreased renal blood flow, culminating in the glomerular filtration rate, and consequently in kidney injury.²²

Regarding weight, the average BMI of patients with kidney injury or renal failure was 26.0 kg/m². According to the Brazilian Ministry of Health, the optimal BMI should be between 18.5 and 24.9 kg/m². Therefore, the BMI of 25 kg/m² is considered as overweight and 30 kg/m² as obesity. The two conditions, overweight and obesity, represent risk factors for kidney injury, as they establish a series of structural, histologic, and kidney hemodynamic changes, among them increased glomerular filtration rate, increased effective plasma flow, and increased incidence of albuminuria and proteinuria.²³

It is noteworthy that 22% of the patients who evolved to kidney injury or renal failure in the postoperative had diabetes mellitus. It is known that diabetes mellitus is an independent risk factor for kidney injury.^{18,24} Increased risk of kidney damage in diabetic patients is generally associated with hemodynamic events, since diabetes mellitus increases glomerular filtration, a factor that implies exacerbation, as well as extravasation of macromolecules, such as albumin. This fact implies glomerular hypertrophy and thickening of the glomerular basement membrane, leading to decreased glomerular filtration rate.²³

Nonetheless, arterial hypertension was also observed in this study, as well as in other scientific analyses, such as a risk factor for renal dysfunction, considering that 61.1% of the hypertensive patients in this study evolved to kidney injury or renal failure.²⁴ This fact may also be confirmed through the study by Dordetto²⁴, which found that 66.6% of the patients who underwent cardiac surgery were hypertensive, showing a close relationship with the results of this study. Changes in blood pressure cause a series of structural changes in the arteries and arterioles, including lumen narrowing in the renal arterioles, culminating in glomerular damage.²⁵

Out of the total number of patients, 94.4% of those with kidney injury or renal failure evolved to acidosis. One explanation for this acid-base imbalance is anchored in extracorporeal circulation, considering it as a depressant of oxygen supply to the cardiovascular tissue, a factor that may also contribute to the occurrence of cardiac arrhythmias.²⁴

Extracorporeal circulation, besides maintaining the heart's vital functions during cardiac surgery⁷, also promotes the release of inflammatory mediators, considering that the blood comes into contact with a surface other than the endothelial surface.²⁶ In general, the longer the use of ECC in cardiac surgery, the greater kidney, coagulation, and autoimmune disorders.²⁴ On the other hand, studies show that the shorter the time of ECC, the lesser renal dysfunction, however, the findings of our study revealed a prolonged time, something that culminated in severe renal dysfunction, in this case in renal failure itself.

The most frequent complication among patients in the postoperative period was AF. This arrhythmia, besides being frequent in the postoperative period of cardiac surgery, is related to some comorbidities. However, other complications, such as infections, prolonged use of mechanical ventilation, hemodynamic instability, and use of vasoactive drugs should also be considered.

Scientific evidence, such as that of this study, demonstrated that using noradrenaline as a vasopressor drug was significantly associated with the occurrence of AKI.^{27,28} Renal dysfunction is known to be one of the most important reasons for mortality and morbidity after surgery or due to prolonged surgical time²⁹, thus early identification of factors that affect renal function may be beneficial in the evaluation of patient outcomes. Above all, it is key to manage fluid infusion and hemodynamic monitoring in the postoperative period, considering they represent significant factors for renal function stability.³⁰

CONCLUSION

Out of the patients undergoing valve surgery, most of them progressed with renal dysfunction, evidencing that this surgery, depending on the patient's clinical status, predisposes to AKI.

The factors significantly related to the occurrence of AKI in the postoperative of patients who underwent valve surgery were BMI, PEEP, and vasopressor drug use.

Early identification of risk factors for AKI in the postoperative period of valve surgery favors the early intervention of health professionals, minimizes health problems and mortality, in addition to reducing costs for the health system.

REFERENCES

- Pereira KSM, Oliveira JCP, Carvalho FC, Bellen BV. Complicações cardíacas em cirurgia vascular. *J Vasc Bras* [serial on the internet]. 2016 [cited 2017 May 10];15(1):16-20. Available from: <http://www.scielo.br/pdf/jvb/2016nahead/1677-5449-jvb-1677-5449003515.pdf>
- Mao H, Katz N, Ariyanon W, Blanca-Martos L, Adýbelli Z, Giuliani A, et al. Cardiac surgery-associated acute kidney injury. *Cardiorenal Medicine* [serial on the internet]. 2013 [cited 2017 May 10];3(3):178-99. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3884176/>
- Shiao CC, Wu PC, Huang TM, Lai TS, Yang WS, Wu CH, et al. Long-term remote organ consequences following acute kidney injury. *Crit Care* [serial on the internet]. 2015 [cited 2017 May 10];19:438. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4699348/>
- Kataria Y. Epidemiology of acute kidney injury in critically ill children and young adults. *Ann Clin Biochem* [serial on the internet]. 2017 [cited 2017 May 10];54(3):416. Available from: <http://journals.sagepub.com/doi/pdf/10.1177/0004563217693559>
- Cunha NA, Duarte TTP, Magro MCS. Oligúria e disfunção renal em pacientes críticos. *Rev Enferm UFPE On Line* [serial on the internet]. 2017 [cited 2017 Jul 1];11(6):2316-22. Available from: <https://periodicos.ufpe.br/revistas/revistaenfermagem/article/viewFile/23393/19048>
- Gomes TM, Valadares AFM, Duarte TTP, Magro MCS. Septic patients with acute kidney injury: the reality of intensive care units. *Rev Enferm UFPE On Line* [serial on the internet]. 2016 [cited 2017 Jul 1];10(9):3190-6. Available from: <http://www.revista.ufpe.br/revistaenfermagem/index.php/revista/article/view/9571/pdf/10929>
- Xie X, Wan X, Ji X, Chen X, Liu J, Chen W, et al. Reassessment of acute kidney injury after cardiac surgery: a retrospective study. *Intern Med* [serial on the internet]. 2017 [cited 2017 Jul 10];56(3):275-82. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5348450/>
- Wu B, Sun J, Liu S, Yu X, Zhu Y, Mao H, et al. Relationship among mortality of patients with acute kidney injury after cardiac surgery, fluid balance and ultrafiltration of renal replacement therapy: an observational study. *Blood Purif* [serial on the internet]. 2017 [cited 2017 Jul 10];44(1):32-9. Available from: <https://www.karger.com/Article/Abstract/455063>
- Sampaio MC, Máximo CA, Montenegro CM, Mota DM, Fernandes TR, Bianco AC, et al. Comparison of diagnostic criteria for acute kidney injury in cardiac surgery. *Arq Bras Cardiol* [serial on the internet]. 2013 [cited 2017 Jul 15];101(1):18-25. Available from: http://www.scielo.br/pdf/abc/v101n1/en_aop5280.pdf
- Santana-Santos E, Oliveira LB, Rodrigues ARB, Soares MM, Amaral JH, Matos IV, et al. Lesão renal aguda em pacientes submetidos à cirurgia cardíaca: incidência, fatores preditivos e desfechos segundo o critério RIFLE. *Rev Soc Cardiol Estado de São Paulo*. 2016;26(2):60-4.
- Bellomo R, Ronco C, Mehta RL, Asfar P, Boissramé-Helms J, Darmon M, et al. Acute kidney injury in the ICU: from injury to recovery - reports from the 5th Paris International Conference. *Annals of Intensive Care* [serial on the internet]. 2017 [cited 2017 Jul 15];7(1):49. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5418176/>
- Kirwan CJ, Wright K, Banda P, Chick A, Mtekateka M, Banda E, et al. A nurse-led intervention improves detection and management of AKI in Malawi. *J Ren Care* [serial on the internet]. 2016 [cited 2017 Jul 15];42(4):196-204. Available from: <http://onlinelibrary.wiley.com/doi/10.1111/jorc.12172/abstract>
- Xu G, Baines R, Westacott R, Selby N, Carr S. An educational approach to improve outcomes in acute kidney injury (AKI): report of a quality improvement project. *BMJ* [serial on the internet]. 2014 [cited 2017 Jul 15];4(3):e004388. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3963099/>
- Hulse C, Davies A. Acute kidney injury: prevention and recognition. *Nurs Times*. 2015;111(30-31):12-5.
- Kidney Disease: Improving Global Outcomes (KDIGO). Clinical practice guideline for acute kidney injury. *Kidney Int* [serial on the internet]. 2012 [cited 2017 Jul 20];2(Suppl 1):1-138. Available from: http://www.kdigo.org/clinical_practice_guidelines/pdf/KDIGO%20AKI%20Guideline.pdf

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Acute kidney injury: common problem in...

16. Knaus WA, Draper EA, Wagner DP, Zimmerman JE. APACHE II: a severity of disease classification system. *Crit Care Med*. 1985;13(10):818-29.
17. Miranda M, Hossne Júnior NA, Branco JNR, Vargas GF, Fonseca JHAP, Pestana JOMA. Estudo da fase intra-hospitalar da revascularização cirúrgica do miocárdio em pacientes dialíticos. *Arq Bras Cardiol* [serial on the internet]. 2014 [cited 2017 Jul 20];102(2):128-33. Available from: <http://www.scielo.br/pdf/abc/v102n2/0066-782X-abc-abc20130231.pdf>
18. Santos JCO, Mendonça MAO. Fatores predisponentes para lesão renal aguda em pacientes em estado crítico: revisão integrativa. *Rev Soc Bras Clin Méd* [serial on the internet]. 2015 [cited 2017 Jul 20];13(1):69-74. Available from: <http://files.bvs.br/upload/S/1679-1010/2015/v13n1/a4780.pdf>
19. Souza AL, Salgado CG, Mourilhe-Rocha R, Mesquita ET, Lima LC, Mattos ND, et al. Implante de válvula aórtica por cateter e seus fatores de morbimortalidade em experiência de 5 anos no Brasil. *Arq Bras Cardiol* [serial on the internet]. 2016 [cited 2017 Jul 20];106(6):519-27. Available from: http://www.scielo.br/pdf/abc/v106n6/pt_0066-782X-abc-20160072.pdf
20. Levi TM, Souza SP, Magalhães JG, Carvalho MS, Cunha AL, Dantas JG, et al. Comparação dos critérios RIFLE, AKIN e KDIGO quanto à capacidade de predição de mortalidade em pacientes graves. *Rev Bras Ter Intensiva* [serial on the internet]. 2013 [cited 2017 Jul 25];25(4):290-6. Available from: <http://www.scielo.br/pdf/rbti/v25n4/0103-507x-rbti-25-04-0290.pdf>
21. Nascimento MS, Aguiar TC, Silva AVE, Duarte TTP, Magro MCS. Lesão renal aguda no pós-operatório de cirurgia cardíaca. *Acta Paul Enferm* [serial on the internet]. 2015 [cited 2017 Jul 25];28(4):367-73. Available from: <http://www.scielo.br/pdf/apv/v28n4/1982-0194-ape-28-04-0367.pdf>
22. Santos LL, Magro MCS. Ventilação mecânica e a lesão renal aguda em pacientes na unidade de terapia intensiva. *Acta Paul Enferm* [serial on the internet]. 2015 [cited 2017 Jul 25];28(2):146-51. Available from: <http://www.scielo.br/pdf/apv/v28n2/1982-0194-ape-28-02-0146.pdf>
23. Vieira Júnior JM, Suassuna JHR. O acometimento renal na hipertensão arterial e *diabetes mellitus* tipo 2: como identificar e prevenir A visão do nefrologista. *Revista Hospital Universitário Pedro Ernesto* [serial on the internet]. 2013 [cited 2017 Jul

- 25];12(Suppl 1):53-60. Available from: <file:///D:/7083-25160-1-PB.pdf>
24. Dordetto PR, Pinto GC, Rosa TCSC. Pacientes submetidos à cirurgia cardíaca: caracterização sociodemográfica, perfil clínico-epidemiológico e complicações. *Rev Fac Ciênc Méd Sorocaba* [serial on the internet]. 2016 [cited 2017 Jul 25];18(3):144-9. Available from: <file:///D:/25868-80866-1-PB.pdf>
25. Alves AB, Bastos DP, Silva DA. Avaliação da comorbidade entre hipertensão arterial sistêmica e insuficiência renal. *Acta Biomed Bras* [serial on the internet]. 2014 [cited 2017 Jul 30];5(2):49-59. Available from: <file:///D:/86-155-1-SM.pdf>
26. Santana-Santos E, Marcusso ME, Rodrigues AO, Queiroz FG, Oliveira LB, Rodrigues AR, et al. Estratégias de prevenção da lesão renal aguda em cirurgia cardíaca: revisão integrativa. *Rev Bras Ter Intensiva* [serial on the internet]. 2014 [cited 2017 Jul 30];26(2):183-92. Available from: <http://www.scielo.br/pdf/rbti/v26n2/0103-507X-rbti-26-02-0183.pdf>
27. Gupta S, Sengar GS, Meti PK, Lahoti A, Beniwal M, Kumawat M. Acute kidney injury in pediatric intensive care unit: incidence, risk factors, and outcome. *Indian J Crit Care Med* [serial on the internet]. 2016 [cited 2017 Jul 30];20(9):526-9. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5027745/>
28. Korula S, Balakrishnan S, Sundar S, Paul V, Balagopal A. Acute kidney injury-incidence, prognostic factors, and outcome of patients in an Intensive Care Unit in a tertiary center: a prospective observational study. *Indian J Crit Care Med* [serial on the internet]. 2016 [cited 2017 Jul 30];20(6):332-6. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4922285/>
29. Rodríguez MO, Hernández JAB, Bárcenas MTA, Cerezo AR, Artiñano MAVO, Alameda CV. Effect of priming solution and ultrafiltration on post-operative bleeding and blood transfusion in cardiac surgery. *Randomized controlled trial. Rev Esp Anesthesiol Reanim*. 2015;62(2):81-9.
30. Saberi K, Salehi M, Rahmanian M, Bakhshandeh AR, Massoumi GR. Appropriate blood component therapy can reduce postcardiac surgery acute kidney injury through packed cell transfusion reduction. *Journal of Research in Medical Sciences* [serial on the internet]. 2017 [cited 2017 Jul 30];22:80. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5508503/>

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