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# Hemoglobin decrease: risk for acute kidney injury after myocardial revascularization

*Redução de hemoglobina: risco para lesão renal aguda após revascularização do miocárdio*

*Reducción de la hemoglobina: riesgo de lesión renal aguda después de la revascularización miocárdica*

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**ABSTRACT**

**Objective:** to determine whether decreased hemoglobin rate after myocardial revascularization surgery interferes with patients' renal function. **Method:** this prospective, observational study was conducted between February and June 2016 with 51 patients who underwent myocardial revascularization surgery at a specialist cardiology hospital specializing in the Federal District. Data were collected using a structured instrument. The Fisher's exact, Chi-square and Kruskal-Wallis tests were used for statistical analysis. Results were considered significant at $p \leq 0.05$. The research project was approved by the research ethics committee (Protocol 44999215.9.0000.0026). **Results:** 45 patients (78.9%) developed acute kidney injury after myocardial revascularization. Oldest age (64 ± 9 years, p = 0.05), cardiopulmonary bypass time (p = 0.05), body mass index (p = 0.02), use of antibiotics (p = 0.03), and decreased hemoglobin rate (p = 0.04) contributed to acute kidney injury. **Conclusion:** decreased hemoglobin rate was statistically associated with acute kidney injury following myocardial revascularization.
**Descriptors:** Nursing; Myocardial Revascularization; Hemoglobins; Acute Kidney Injury.

**RESUMO**

**Objetivo:** verificar se a redução da taxa de hemoglobina no pós-operatório de revascularização do miocárdio interfere na função renal dos pacientes. **Método:** estudo observacional e prospectivo, desenvolvido entre fevereiro e junho de 2016, com 51 pacientes que realizaram cirurgia de revascularização do miocárdio em um hospital especializado em cardiologia do Distrito Federal. Os dados foram coletados por meio de um instrumento estruturado. O teste exato de Fisher, Qui-quadrado e Kruskal-Wallis foram empregados para análise estatística. Considerou-se significativo resultados com p≤0,05. Projeto de pesquisa aprovado pelo Comitê de Ética, protocolo 44999215.9.0000.0026. **Resultados:** entre os pacientes, 45 (78,9%) evoluíram com lesão renal aguda após revascularização do miocárdio. Idade mais elevada (64±9 anos, p=0,05), tempo de circulação extracorpórea (p=0,05), índice de massa corporal (p=0,02), uso de antibióticos (p=0,03) e redução da taxa de hemoglobina (p=0,04), contribuíram para lesão renal aguda. **Conclusão:** a redução da taxa de hemoglobina foi associada estatisticamente à lesão renal aguda após revascularização do miocárdio.
**Descritores:** Enfermagem; Revascularização Miocárdica; Hemoglobinas; Lesão Renal Aguda.

**RESUMEN**

**Objetivo**: verificar si la reduciendo la tasa de hemoglobina en el postoperatorio de revascularización miocárdica interfiere con la función renal de los pacientes. **Método:** estudio observacional prospectivo realizado entre febrero y junio de 2016 con 51 pacientes que se sometieron a una cirugía de revascularización miocárdica en un hospital especializado en cardiología en el Distrito Federal. Los datos fueron recolectados utilizando un instrumento estructurado. La prueba exacta de Fisher, Chi-cuadrado y Kruskal-Wallis se utilizaron para el análisis estadístico. Los resultados se consideraron significativos con p≤0.05. Proyecto de investigación aprobado por el Comité de Ética, protocolo 44999215.9.0000.0026. **Resultados:** se observó que 45 (78,9%) pacientes desarrollaron lesión renal aguda después de la revascularización miocárdica. Edad avanzada (64 ± 9 años, p = 0.05), tiempo de circulación corporal extra (p = 0.05), índice de masa corporal (p = 0.02), uso de antibióticos (p = 0.03) y tasa de hemoglobina reducida (p = 0.04), contribuyó a lesión renal aguda. **Conclusión:** reduciendo la tasa de hemoglobina contribuyó a lesión renal aguda después de la revascularización miocárdica.
**Descriptores:** Enfermería; Revascularización Miocárdica; Hemoglobinas; Lesión Renal Aguda.

## INTRODUCTION

Several factors associated with cardiac surgery, including aortic clamping, Cardiopulmonary Bypass (CPB), blood transfusion rate, and high dose of vasopressors, can induce ischemia and reperfusion cycles, increase oxidative damage and renal and systemic inflammation, and contribute to the onset of Acute Kidney Injury (AKI)[1].

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The incidence of AKI after Coronary Artery Bypass Graft (CABG) has remained high and can affect nearly 54% of the patients, substantially contributing to the increase in morbidity and mortality in the short and long term, which inevitably generates high health costs[1,2].

Cardiopulmonary Bypass (CPB), frequent in cardiac surgeries, contributes to blood clotting due to platelet dysfunction, decreased clotting factors, and increased fibrinolytic activity[3]. Although the duration of CPB is recognized as a risk factor for AKI, the association between changes in hemoglobin rates, need for blood transfusion, and renal dysfunction are still unclear[4,5]. It is believed that the reduction of circulating hemoglobin resulting from hemolysis and the increase in free plasma hemoglobin by aggressive fluid resuscitation are multi-factorial conditions that can contribute to the development of AKI by triggering renal hypoxia and by increasing oxygen consumption and renal tubular oxidative stress[6].

Most of the risk factors for AKI after cardiac surgery are classified as non-modifiable; however, anemia, the hemoglobin rate, and blood transfusion have been recognized as potentially modifiable, even though the triggering mechanisms of renal impairment are not completely understood in this scenario. The inter-relationship between these variables and AKI has not yet been widely reported[7], which motivated the development of this study.

Thus, understanding the risk factors can contribute to the planning of actions to prevent AKI, which is fundamental in the hospital setting, where the susceptibility of a patient and the administration of potentially nephrotoxic agents can be assessed before surgery. Identifying patients susceptible to AKI offers an opportunity for the health team to optimize care management in high-risk situations, such as changes in the hemoglobin rate, and thus improve monitoring and control[6].

In this context, nursing has a fundamental and irreplaceable role in identifying patients at potential risk of developing AKI, contributing to minimizing or preventing the evolution of an acute pathology to a permanent condition and with serious complications, through the identification of risk indicators (chronic non-communicable diseases, diabetes mellitus, arterial hypertension, chronic kidney disease, pre-existing conditions, and old age), improving both the management and the quality of care based on strategies for laboratory and hemodynamic monitoring.

Therefore, this study aims to verify whether the reduction in the hemoglobin rate in the postoperative period of myocardial revascularization interferes with the renal function of the patients.

## METHOD

This is an observational, longitudinal, and prospective study of a quantitative nature, developed between February and June 2016 in a general Intensive Care Unit (ICU) of a private hospital specialized in cardiology in the Federal District, Brazil.

Of the 122 adult patients admitted to the ICU during follow-up, 57 were included consecutively for convenience. The reasons for the losses were length of stay, death or transfer, in a period of up to 48 hours of stay in intensive care. Patients aged 18 years old or older who underwent myocardial revascularization surgery without a history of previous kidney injury were included. Patients who underwent contrast tests in the 48 hours prior to the surgical procedure and with hemoglobin below 8 g/dL were excluded.

To evaluate kidney function, the creatinine criterion of the KDIGO (Kidney Disease Improving Global Outcome) classification was adopted[8]. This classification defines AKI as an increase of 0.3 mg/dL of baseline creatinine in less than or equal to 48 hours, or as a reduction in urinary output < 0.5 ml/kg/hour for 6 hours. It progressively stratifies the severity of AKI in stages, 1 (risk), 2 (kidney injury), and 3 (kidney failure), adopting as reference the worst value of serum creatinine[9]. For the purposes of the study, the last result of serum creatinine measured prior to hospitalization in the ICU was adopted as baseline but, when unavailable, the lowest value identified in the first seven days after admission to the ICU was considered[9].

Data were collected daily, from the patient's admission to the ICU until the time of discharge to the inpatient unit, using a structured collection instrument, consisting of the following variables: identification, demographic, clinical data (previous diseases, medications in use, and pre-surgery laboratory tests), surgical data (time of surgery, time of cardiopulmonary bypass, use of vasoactive drugs, time of intubation, post-surgery laboratory tests and type of surgery), length of stay in the ICU, and the Acute Physiology and Chronic Health Evaluation II (APACHE II) prognostic index[10].

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The laboratory and hemodynamic parameters were extracted from the records of the patients' medical charts, namely: altered systolic pressure when < 90 or > 140 mmHg, altered diastolic pressure when < 60 or > 100 mmHg, altered hematocrit when < 35% or > 47%, altered hemoglobin when < 11.7g/dL, altered lactate when <20 mg/dl, acidosis when arterial pH < 7.35, and alkalosis when arterial pH > 7.45, leukocytosis (increase in the number of leukocytes) when > 11,000 $mm^3$.

For statistical analysis, the patients were divided into two groups: those who did not present AKI (12 patients) and those who presented AKI (45 patients), of any severity according to the KDIGO classification (stages 1, 2, and 3).

The results were expressed in descriptive statistics, by means of absolute frequency (n), relative frequency (%), mean and standard deviation. The categorical data were analyzed using Chi-square tests with Yates' correction, Mann Whitney's test, and Fisher's exact test. Results were considered significant with a p-value ≤ 0.05

In compliance with Resolution 466/2012, this project was submitted and approved by the Research Ethics Committee of the Institute of Cardiology of the Federal District under protocol No. 44999215.9.0000.0026.

## RESULTS

A total of 57 patients were followed-up, with predominance of the female gender (54.4%) and a mean age of 63±9 years old. The Body Ma'ss Index (BMI) was 29.7±5.23 kg/$m^2$. As for the cardiac function, 43.9% had an ejection fraction below 50%; and 10.5%, below 40%. The most frequent comorbidities were systemic arterial hypertension (SAH) (75,4%) and dyslipidemias (61.4%). According to the biological variables, changes in hematocrit were observed in all the patients, and alterations in hemoglobin in 96.5% of the cases. The acid-base imbalance was identified in 89.4% of the patients, and altered lactate in 71.9%. Most of the patients (98.2%) evolved to ICU discharge in 4.9±8.8 days.

According to the urine output criterion of the KDIGO classification, 38.6% presented AKI of lesser severity (risk); 17.6%, AKI of intermediate severity (kidney injury); and 1.8%, AKI of greater severity (kidney failure). When the renal function was assessed using the serum creatinine criterion, the less severe stage (risk) predominated among the patients (49.1%), but still 5.3% of the patients were classified as intermediate (injury), and 1.8% as stage 3 renal failure.

Older patients evolved significantly with AKI (p=0.05), as well as those with a history of alcoholism (p=0.04). Among the 45 (78.9%) patients who developed acute kidney injury, 36 (80%) had a medical diagnosis of arterial hypertension and 21 (46.7%) of diabetes mellitus, although there was no statistically significant correlation between these chronic diseases and the development of AKI (Table 1).

Regarding the surgical aspects, the time of cardiopulmonary bypass (CPB) was associated with the development of AKI (p=0.05), in contrast to the time of anoxia (p=0.4) and of the APACHE II (p=0.5). Almost all the patients received as myocardial graft the left internal mammary artery (93%) and more than half needed three myocardial grafts (61.4%). The surgeries with CPB predominated (96.5%) and their mean time was 93 minutes with anoxia of 79 minutes.

The main postoperative complication was an increase in the leukocyte count (leukocytosis, above 11,000 mm 3) in 14% of the patients, followed by pulmonary congestion (7%). The use of a diuretic was observed in more than 50% of the patients (73.7%). All showed alterations in hematocrit (100%) and hemoglobin was reduced (< 11.7 g/dL) in 96.5% of the cases, which justified the need for blood transfusion in 54.4% of the cases. Most of the patients evolved with AKI (78.9%). It was observed that all the patients with kidney injury showed alterations in serum hemoglobin and that 57% required blood transfusion, with the relationship between the alteration in the hemoglobin rate and AKI being significant by the Fisher's test (p=0.04).

Regarding the medications used, the use of antibiotics to treat infections related to health care showed a significant association for the development of renal failure (p=0.03). The mean time of mechanical ventilation (MV) was 840±320 minutes. Patients who developed AKI required longer MV, although this relationship was not significant (p=0.1). All the patients used vasoactive drugs (VADs), such as noradrenaline (84.2%) but, as a positive inotrope, dobutamine stood out (96.5%).

The patients who evolved in the stages of kidney injury and failure (stages 2 and 3 from KDIGO) of renal function impairment (n=45) also showed alterations in hemoglobin in 100% of the cases (p=0.04), of which the majority required blood transfusion (66.7%) (p=0.3).

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**TABLE 1:** Correlation of acute kidney injury with the clinical characteristics of patients in the postoperative period of myocardial revascularization (n=57). Federal District, Brazil, 2016.

| Characteristics | Without AKI (n = 12) | With AKI (n = 45) | p value |
|---|---|---|---|
| Female gender | 6 (50.0) | 25 (55.6) | 0.7 |
| Age (years old) [a] | 59±8 | 64±9 | 0.05 |
| BMI* (kg/m2)[a.ii] | 26.8±4.3 | 27.2±4.3 | 0.7 |
| **Comorbidities** | | | |
| Diabetes | 3 (25.0) | 21 (46.7) | 0.2 |
| Hypertension | 7 (58.3) | 36 (80.0) | 0.1 |
| Alcoholism | 2 (16.7) | 0 (0.0) | 0.04 |
| Smoking | 4 (33.3) | 15 (33.3) | 0.6 |
| DLP | 5 (41.7) | 30 (66.7) | 0.1 |
| **Hospital Outcome**[i] | | | |
| Discharge | 12 (100.0) | 42 (93.3) | 0.8 |
| Death | 0 (0.0) | 1 (2.2) | |
| **ICU Outcome** | | | |
| Discharge | 12 (100.0) | 44 (97.8) | 0.8 |
| Death | 0 (0.0) | 1 (2.2) | |
| Altered Systolic Pressure | 7 (58.3) | 38 (84.4) | 0.06 |
| Altered Diastolic Pressure | 9 (75.0) | 42 (93.3) | 0.1 |
| Hemoglobin <11.7 g/dL | 10 (83.3) | 45 (100.0) | 0.04 |
| Altered lactate | 10 (83.3) | 31 (68.9) | 0.3 |
| Alkalosis | 3 (25.0) | 5 (11.1) | 0.2 |
| Acidosis | 7 (58.3) | 36 (80.0) | 0.1 |

[a]Mean ± SD; [i]2 patients without information, [ii]1 patient without information, [iii]4 patients without information; Chi-square test with Yates correction, Fisher's exact test, Mann-Whitney's test; Altered systolic pressure when < 90 or > 140 mmHg; Altered diastolic pressure when < 60 or > 100 mmHg; Altered lactate when < 20 mg/dL; Acidosis when arterial PH < 7.35; Alkalosis when arterial PH > 7.45.

## DISCUSSION

Regarding the reduction in the hemoglobin rate, although not recognized as an exclusive factor for AKI[11], our results showed that it has an inducing effect of AKI triggering the need of blood transfusion in the postoperative period of myocardial revascularization. Diverse scientific evidence has signaled a direct association between the drop in postoperative hemoglobin and the consequent need for blood transfusion and the increase in the rate of AKI[4,11].

The mechanisms related to the development of AKI in the postoperative period of cardiac surgery originate from the reduction of renal perfusion triggered by cardiopulmonary bypass[7]. Hemoglobin reduction, as identified in the present study, manifests itself as a villain, interfering with the proper functioning of the renal system by increasing the risk of the patient developing AKI[12].

The drop in the hemoglobin rate, as it triggers the need for transfusion, generates a pro-inflammatory response and thus impairs oxygen distribution to the renal parenchyma, exacerbating the oxidative stress of the tissues. In turn, in patients with an association of comorbidities, this can increase the predisposition to AKI[13].

In the general context, the incidence of AKI was high (78.9%) and, when compared to previous studies[4,14], showed superiority in relation to the values found (8.29% and 37.5%) in other studies, using the same classification criterion, KDIGO, during the postoperative period of cardiac surgery. The KDIGO classification has been implemented in clinical and surgical practices to support early detection and the design of additional measures to control the progression of kidney damage. It allows for a standardized assessment of the severity of AKI and estimates for the epidemiological measures[15].

In the postoperative period of cardiac surgery, the high percentages of AKI in critical care are generally due to several factors such as age, prolonged CPB use, use of nephrotoxic drugs, elevated BMI, altered hemoglobin rates, and blood transfusion[16,17], conditions also identified in the present study.

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Advanced age is also recognized as a risk factor for AKI[4,18], given the physiological reduction in renal blood flow and the lower capacity for hemodynamic adaptation of these patients, when exposed to CPB and to nephrotoxic drugs[19]. Prolonged CPB time has shown to be a major cause of AKI in the postoperative period of cardiac surgery[20], in addition to predisposing to a reduction in hemoglobin and triggering of the need for transfusion of blood components, exacerbating the risk of renal impairment[21].

Among the nephrotoxic drugs, vasoactive drugs and antibiotics stand out[22]. These represent one of the main drug classes that cause damage to the renal tubules and, therefore, induce AKI. They also cause hemodynamic alterations, and acute interstitial nephritis, in addition to nephrotic proteinuria, increasing the susceptibility toglomerular injury[23].

Overall, alcohol use was associated with the development of AKI. The scientific evidence, as well as this study, showed that prolonged use of alcohol can trigger cell injuries in various body tissues, including kidney cells, and also determine tissue necrosis and development of AKI[24]. Although it was not significantly associated with AKI, metabolic acidosis was present in 80% of those with kidney injury. Metabolic acidosis is considered a nephrotoxic factor associated with the progression of kidney disease. The mechanism is believed to involve increased interstitial generation of ammonia (with activation of the complement pathway), increased local production of endothelin, and activation of the renin-angiotensin-aldosterone system (RAAS). These factors predispose to interstitial renal fibrosis and to the acceleration of muscle mass loss, in addition to determining increases in morbidity and mortality in patients with renal injury[25].

In this context, the importance of nursing care in the intensive care environment is highlighted, where immediate surgical care centered on patients is necessary to maintain safety. The nurse's work in the multidisciplinary team constitutes a pillar, facing the technological challenges that affect the complexity of health care, and must be based on scientific evidence[26].

In this perspective, it is verified that, when assuming the importance of patient-centered care, it is up to the nurse, amid the responsibilities in the care management process, to perform a detailed physical examination, and to execute procedures and interventions related to treatment, in addition to evaluating laboratory tests, such as serum hemoglobin. It is recognized that the nurse, as the professional responsible for the management of patient care, must act in a manner aimed at achieving the quality of health services with an emphasis on comprehensive care focused on human needs[26].

## CONCLUSION

Patients undergoing myocardial revascularization with a reduced hemoglobin rate progressed significantly with AKI. Factors such as age, duration of CPB, use of antibiotics, and alcoholism contributed even more to the development of AKI.

This study reinforces the repercussion of the drop in the hemoglobin rate on the renal function in the postoperative scenario. Limitations in the control of serum hemoglobin and in the careful assessment of the need for blood transfusion stand out among the clinical conditions that can predispose to renal impairment.

Knowing the factors related to the occurrence of AKI contributes to the guidance of health professionals, including nurses, enabling the design of a systematic assessment in health, as well as individualized intervention plans favoring the prevention of renal damage and preventing the progression of the acute to chronic event. The limitations of this study are concentrated in its small sample size and in it having been conducted a single center.

It is hoped that this study can support the health practice, based on an interdisciplinary approach, characterized by the interaction of the nursing team with other health teams to recognize risk factors related to acute kidney injury, as well as to contribute to the promotion of individualized interventions in care management.

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