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Acute Kidney Injury after Coronary Artery Bypass Grafting in Diabetic and Non-Diabetic Patients

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ABSTRACT

Introduction: In recent years, there has been a lack of reliable studies comparing the incidence of acute renal failure after coronary artery bypass grafting (CABG) in patients with and without diabetes. The present study aims to compare the frequency of acute kidney injury (AKI) in diabetic patients and non-diabetics who underwent CABG.

Methods and Materials: All patients aged 40-85 years undergoing on-pump beating CABG surgery and admitted to the cardiac surgery intensive care unit (ICU) between April 2017 and April 2025 were included in the study. Patients were divided into two groups: the control group (non-diabetic patients) and the case group (diabetic patients). Information was extracted from the patients' files, and the incidence of AKI was monitored daily based on changes in creatinine and glomerular filtration rate (GFR) according to the acute kidney injury network (AKIN) criteria.

Results: A total of 214 patients were included in the study, with 104 patients (48.60%) diagnosed with diabetes. There were without no significant differences between the two groups in terms of gender (p=0.386), age (p=0.774), weight (p=0.514), body mass index (BMI) (p=0.143) and ejection fraction (EF) (p=0.055). Regarding the incidence of AKI, there was no significant difference between the two groups based on AKI on the first day after surgery (p=0.347). However, there was significant difference between the two groups based on AKI on the second day after surgery (p=0.013).

Conclusion: The results of the present study showed that the incidence and severity of AKI on the second day after surgery were lower in patients with diabetes compare to non-diabetic patients.

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Introduction

Acute kidney injury (AKI), is a sudden decline in renal function that develops within 7 days, as indicated by an increase in serum creatinine or a decrease in urine output, or both. It is a common complication in cardiac surgery patients, with a reported incidence of 20 to 30% (1). Causes of AKI are classified as prerenal (due to decreased blood flow to the kidney), intrinsic renal (due to damage to the kidney itself), or postrenal (due to blockage of urine flow) (2).

Notable prerenal causes of AKI include

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sepsis, dehydration, excessive blood loss, low blood pressure or cardiogenic shock, heart failure, cirrhosis, and certain medications like angiotensin-converting enzyme (ACE) inhibitors (3). Intrinsic renal causes of AKI include acute tubular necrosis, glomerulonephritis, lupus nephritis, certain antibiotics, and chemotherapeutic agents. Postrenal causes of AKI include kidney stones, bladder cancer, neurogenic bladder, enlargement of the prostate, narrowing of the urethra, and certain medications like anticholinergics (4,5). Although the exact mechanism of AKI after coronary artery bypass grafting (CABG) is uncertain, many of the mentioned predisposing factors may be the cause.

AKI may lead to a number of complications, including metabolic acidosis, high potassium levels, uremia, changes in body fluid balance, increased treatment costs, major adverse cardiovascular events, the need for dialysis, longer hospital length of stay, and increased short and long-term mortality (6). People who have experienced AKI are at an increased risk of developing chronic renal failure in the future. Management of AKI includes treatment of the underlying cause and supportive care, such as renal replacement therapy (7,8).

In this study, we compare the incidence of AKI in diabetic and non-diabetic patients who have undergone on pump beating CABG to analyze the impact of diabetes on post operative renal function.

Materials and Methods

In our retrospective study, 214 consecutive patients with coronary artery disease who underwent isolated on-pump beating CABG from April 2017 to April 2025 were enrolled. The included patients were divided into two groups: diabetic (Group 1) and non-diabetic (Group 2) based on medical history and lab data. Serum creatinine levels were analyzed pre operatively, as well as 24 and 48 hours postoperatively.

The basic inclusion criteria for our study were preoperative serum creatinine levels less than 2 mg/dL, elective CABG surgery, and availability of complete hospital records. All patients were confirmed to have no liver or renal disorders, hematologic disorders, significant carotid stenosis, or peripheral vascular disease before enrollment. Preoperative coronary angiography and trans-thoracic echocardiography (TTE) were done in all patients. Excluded from the study were patients with a history of preoperative end-stage renal disease (ESRD) or hemodialysis, sepsis, use of nephrotoxic drugs within a week before CABG, and death on the first day of operation.

Data were collected from patients' medical records, including demographics, drug history, and medical risk factors such as dyslipidemia, hypertension, and smoking. Intra operative data included the number of operative and intensive care unit (ICU) transfusion units, cardiopulmonary bypass (CPB) time (in minutes) and number of grafts per patient. Postoperatively, outcome variables included AKI, low cardiac output condition, reoperation, serious arrhythmia, postoperative myocardial infarction (MI), respiratory failure, stroke, intra-aortic balloon pump (IABP) insertion, ICU and hospital length of stay, in-hospital and early mortality (within thirty days).

Postoperative AKI in the study was defined and classified according to the AKIN classification, which defines an increase in serum creatinine by 0.3 mg/dL or more or a 50% or greater increase from baseline level (Table 1). Serum creatinine levels were recorded on the morning of the operation day, and after 24 and 48 hours postoperatively.

Statistical analysis was performed using the SPSS software package (ver. 21.0, IBM). Data were expressed as mean ± standard deviation.

Table 1. Demographic features of diabetic and non-diabetic groups.

Variable	Diabetic	Non diabetic	P-value
Age	63.12±10.1	62.64±10.1	0.774
Weight	72.5±12.68	70.31±13.37	0.514
BMI	26.25 (25.47 – 27.04) (95% CI)	25.57 (24.75 – 26.39) (95% CI)	0.143
EF	40.19 (37.84 – 42.54) (95% CI)	43.55 (41.46 – 45.63) (95% CI)	0.055

To analyze the relationship between variables, clinical data were compared using the chi-square test, Mann-Whitney U test, and independent t-test where re appropriate. A p-value < 0.05 was considered statistically significant. This study was approved by the Ethics Committee of Mashhad University of Medical Sciences (code IR.IAU.MSHD.REC.1400.315).

Results

Between April 2017 and April 2025, a total of 214 consecutive patients (aged 40-85 years) with coronary artery disease were enrolled for on-pump-beating coronary revascularization. Among them, 104 patients were diabetic (48.60%). There was no difference between the two groups in terms of gender (p=0.386), age (p=0.774), weight (p=0.514), body mass index (BMI) (p=0.143) and ejection fraction (EF) (p=0.055) (Table 1).

The incidence of AKI showed no significant difference between diabetic and non-diabetic patients on the first day after surgery (P=0.347). However, on the second day after surgery, AKI was significantly lower in the diabetic group (P=0.013) (Table 2 and 3).

There were no significant differences between diabetic and non-diabetic patients in terms of operation time, number of grafts per patient, time to extubation, and mean body fluid balance on the first day.

The mean levels of blood urea and creatinine in both groups were significantly lower on the operation day compared to the first and second operation days (p<0.001).

The results obtained from the study showed that AKI did not occur in 77% of non-diabetic patients and 83% of diabetic patients on the first day after surgery. Among the patients who had AKI, 17% of non-diabetic patients were in stage 1 and 4.5% were in stage 3; among the patients with diabetes, 10% were in stage 1 and 7% were in stage 3. Despite the fact that patients with diabetes had more stage 3 acute kidney injury than patients without diabetes, this difference between the two groups was not statistically significant (Table 2).

On the second postoperative day, nearly 12.5% of patients with diabetes had AKI, while this rate was nearly 28% in patients without diabetes. The difference between the two groups on the second day after surgery was statistically significant, and statistical tests indicated that AKI was more common in the group of patients without diabetes. Also, out of 28% of non-diabetic patients who had AKI, 14.5% were in stage 1, 4.5% in stage 2 and 9% in stage 3. But out of 12.5% of diabetic patients with AKI, 5.8% were in stage 1, 2.9% in stage 2 and 3.9% were in stage 3. This means that in addition to the fact that the overall incidence of AKI was higher in patients without diabetes, these patients also experienced more advanced stages of AKI than diabetic patients (Table 3).

Table 2. Frequency of AKI in diabetic and non-diabetic groups in first day.

	AKIN 0	AKIN 1	AKIN 2	AKIN 3	P-value
Diabetic	86 (82.7%)	11 (10.6%)	0	7 (6.7%)	0.347
Non-diabetic	85 (77.3%)	19 (17.3%)	1 (0.9%)	5 (4.5%)	

Table 3. Frequency of AKI in diabetic and non-diabetic groups in second day.

	AKIN 0	AKIN 1	AKIN 2	AKIN 3	P-value
Diabetic	97 (93.3%)	6 (5.8%)	3 (2.9%)	4 (3.8%)	0.013
Non diabetic	73 (66.4%)	16 (14.5%)	5 (4.5%)	10 (9.1%)	

Table 4. Comparison of GFR on operation day, first and second day after operation in diabetic and non-diabetic groups.

Day	Diabetic	Non diabetic	P-Value
Operation day	67.3 ± 22.7	66.7 ± 23.2	0.721
First day	64.4 ± 22.4	63.8 ± 21.9	0.713
Second day	63.8 ± 21.6	64.3 ± 22.1	0.751

Discussion

One of the significant side effects of coronary artery bypass surgery is acute kidney damage. In the present study, we compared the incidence of acute kidney injury after beating coronary artery bypass surgery with a pump between diabetic and non-diabetic patients. A total of 214 patients were examined in two groups with and without diabetes, and the age, sex, weight, BMI and EF of the two groups were similar.

The results obtained from the study showed that AKI did not occur in 77% of non-diabetic patients and 83% of diabetic patients on the first day after surgery. Among the patients who had AKI, non-diabetic patients, 17% were in stage 1 and 4.5% were in stage 3; Among the patients with diabetes, 10% were in stage 1 and 7% were in stage 3. Despite the fact that patients with diabetes had more stage 3 acute kidney injury than patients without diabetes, this difference between the two groups was not statistically significant.

On the second postoperative day, nearly 12.5% of patients with diabetes had AKI, while this rate was nearly 28% in patients without diabetes. The difference between the two groups on the second day after surgery was statistically significant, and statistical tests indicated that AKI was more common in the group of patients without diabetes. Also, out of 28% of non-diabetic patients who had AKI, 14.5% were in stage 1, 4.5% in stage 2 and 9% in stage 3, but out of 12.5% of diabetic patients with AKI, 5.8% were in stage 1, 2.9% in stage 2 and 3.9% were in stage 3. This means that in addition to the fact that the overall incidence of AKI was higher in patients without diabetes, these patients also experienced more advanced stages of AKI than diabetic patients.

Several mechanisms seem to be involved in the development of AKI in patients with diabetes compared to other patients.

1) Hyperglycemia can increase oxidative stress and aggravate ischemia-reperfusion injury (9).

2) An increase in cell glucose load leads to mitochondrial dysfunction and as a result kidney damage (10).

3) Inflammation is one of the main factors in causing kidney damage and it has been shown that hyperglycemia can increase inflammatory cytokines such as interleukin-6, tumor necrosis factor alpha and interleukin 18 (11). Therefore, it seems that hyperglycemia can lead to increased inflammation and, as a result, increased damage to the kidney. Endothelial dysfunction caused by hyperglycemia can also lead to kidney damage (12). However, the mechanism of AKI following CABG is multifactorial, including endothelial dysfunction, microcirculatory dysfunction, formation of microvascular thrombi, tubular injury, and intra renal inflammation, which can alter renal perfusion and lead to AKI. During surgery, low flow, low pressure, rapid temperature reduction, use of CPB, and vasopressors can lead to renal hypoperfusion. After CABG, systemic inflammatory processes are activated for several days, which inevitably lead to changes in microvascular function, which may lead to renal hypoperfusion and ischemia even in the absence of arterial hypotension (13).

Our study showed that the duration of surgery was not significantly different in patients who suffered from different stages of AKI. This finding means that probably in the patients examined in the present study, the duration of surgery did not have a significant effect on the development of AKI (either on the first day or on the second day) after the operation.

Also, the studies conducted on the number of grafts in patients showed that the average number of grafts in patients who were in each stage of AKI was about 3 and there was no difference between the groups in terms of the number of grafts. This was true both in patients with diabetes and in patients without diabetes.

The next issue that was investigated was the duration of intubation of the patients. The comparison between patients with different stages of AKI showed that the duration of intubation in patients with different stages of AKI (either on the first day after surgery or on the second day after surgery) was not significantly different from each other. There was no difference between different stages of AKI both in patients with diabetes and in patients without diabetes.

The average duration of hospitalization of patients in ICU after surgery was also investigated. The obtained results showed that there was no significant difference in terms of duration of hospitalization in ICU between different stages of AKI when grouping patients based on the occurrence of AKI on the first day after surgery. However, when patients were divided based on AKI on the second day after surgery, a significant difference was observed in diabetic patients between the duration of hospitalization in ICU in different stages of AKI. This difference was that the shortest duration of hospitalization in ICU was observed in patients without AKI (stage 0), followed by stage 1 patients, and the longest duration of hospitalization in ICU was reported in patients with stage 3 AKI.

Fluid balance study of the patients indicated that both in diabetic and non-diabetic patients, there was no significant difference in the fluid balance of the patients on the first day after surgery in different stages of AKI. This means that there is no relationship between the fluid balance of patients on the first day after surgery and the development of AKI in them. Investigations on fluid balance of patients on the second day after surgery showed that in patients with diabetes who had AKI on the second day after surgery, there was a significant difference in fluid balance between different stages of AKI.

Thus, the highest positive fluid balance was observed in stage 3 AKI, which was 2.2 liters on average. After that, there were stage 1 patients, whose fluid balance was 1.8 liters on average, and finally, the lowest fluid balance was observed in patients without AKI (stage 0), which was 1.3 liters on average.

Data from this study show that on the first day after surgery, AKI had not occurred in 77% of non-diabetic patients and 83% of diabetic patients.

In a study published in 2020 by Wang et al. (14), the authors investigated the effect of diabetes mellitus on the development of AKI after coronary artery bypass surgery in China. A total of 4325 patients were included in the study, and they were divided into three categories including patients without diabetes, with diabetes and oral medication, and with diabetes and insulin, and the incidence of AKI was measured by AKIN criteria. The results showed that 11% of patients without diabetes, 15% of patients with diabetes and oral medication, and 26% of patients with diabetes and insulin had AKI.

The analyzes showed that the risk of developing AKI in patients with diabetes and oral medication was 1.26 times and in patients with diabetes and insulin was 3.92 times that of patients without diabetes. Also, patients in the diabetes and insulin group had more severe stages of AKI compared to the diabetes and oral medication group, and this relationship was also present when comparing patients with diabetes and oral medication with patients without diabetes.

In our study, AKI occurred on the second postoperative day in non diabetic patients more often than in diabetic patients, and its severity was also higher. In general, the findings of our study are not similar to Wang's findings.

In another study published in 2015 by Hertzberg et al. (15), researchers reviewed data on more than 36,000 CABG surgeries in Sweden. The results showed that the incidence of AKI in patients with type 1 diabetes, type 2 diabetes and people without diabetes was 32%, 20% and 13% respectively. Compared to patients without diabetes, the odds ratio of AKI for patients with type 1 diabetes was calculated as 4.89 and for patients with type 2 diabetes as 1.27.

In another study conducted by Kunt et al. (16) in Turkey, the authors investigated the impact of metabolic syndrome on the development of AKI after CABG surgery. 500 patients who underwent CABG and whose renal function was normal before surgery were included in the study and divided into two groups with and without metabolic syndrome. The development of AKI was defined according to the RIFLE criteria. The results showed that the incidence of AKI in patients with and without metabolic syndrome was 31% and 12%, respectively.

Our study has two fundamental differences with the study of Kunt et al. First, the criteria for defining AKI in our study were different from this study. And secondly, in our study, patients with diabetes were included in the study. However, in many cases, diabetes mellitus and metabolic syndrome are associated with each other, and probably many patients with metabolic syndrome in Kunt et al.'s study also had diabetes. In general, the findings of this study are consistent with the results obtained in our study.

Conclusion

Acute kidney injury is one of the common complications after cardiac surgery and it has been shown to affect patient outcomes such as progression to chronic kidney disease (CKD), cardiovascular effects, and even death. Small changes in postoperative creatinine can be associated with harmful side effects. In recent years, several dozen cohort studies with a sample size of over 2 million people have investigated the relationship between AKI and the risk of CKD, diabetic nephropathy, and death (17). In this study, we showed that the risk of AKI after surgery is lower in patients with diabetes mellitus than in other people, probably due to more precise glucose management or induced glucose diuresis in this group of patients. In order to prevent the development of the aforementioned adverse effects, it is better to take measures to prevent the development of AKI in these patients, or if it occurs its proper management.

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Declarations of conflict of interest

The authors have no conflicts of interest to disclose.

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