Published online 2022 September **Original Article**

Evaluation of the Incidence of Acute Kidney Injury Following Coronary Artery Bypass Graft Surgery

Behrooz Mottahedi[1], Mahdi Kahrom[1], Kambiz Alizadeh[1*], Mina Amirbeik[2], Azra Izanloo[3], Mehran Mottahedi[4]

[1] Department of Cardiovascular Surgery, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran
[2] Student Research Committee, Faculty of Medicine, Islamic Azad University, Mashhad Branch, Mashhad, Iran
[3] Razavi Cancer Research Center, Razavi Hospital, Imam Reza International University, Mashhad, Iran
[4] Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran

*** *Corresponding author*:** Kambiz Alizadeh, Department of Cardiovascular Surgery, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran. Email: kambizalizadeh@gmail.com Fax: +985136002894

Received 2021-December-26**; Accepted** 2022-August-23

Abstract

Background: Coronary artery bypass grafting (CABG) is one of the most common surgical methods in patients with coronary artery disease, a well-known complication of which is renal injury after surgery. Here we try to understand the factors involved in the incidence of acute renal injury in our patients.

Objective: The present study aimed to evaluate the incidence and etiology of acute kidney injury (AKI) following CABG**.**

Methods: This study was performed on 181 patients undergoing CABG surgery. The AKI was also recorded after registering demographic information and clinical indications. Chi-square, Mann-Whitney, and independent t-tests were used for data comparison.

Results: The findings of our study pointed out that AKI following CABG in our patients was 3.9% and showed no significant relationship with age, gender, hypertension, diabetes, type of surgery, hypercholesterolemia, number of clogged arteries, smoking, and length of surgery; however, blood urea was found to be significantly higher preoperatively in patients with AKI.

Conclusion: As evidenced by the obtained results, AKI following CABG in the studied patients was 3.9% and was not significantly associated with age, gender, hypertension, diabetes, type of surgery, hypercholesterolemia, number of clogged vessels, smoking, and the length of surgery. Nonetheless, urea was observed to be significantly higher in patients with AKI before surgery. Studies with larger sample sizes are recommended.

Keywords: Acute kidney injury (AKI), CABG, Incidence

Background

Coronary heart disease is the leading cause of death in most societies today; moreover, it is associated with high morbidity, disability, people's diminished work capacity and productivity, as well as increased financial costs (1). Today, therapeutic methods, such as coronary angioplasty, are used to open up blocked coronary arteries (2); nonetheless, coronary artery bypass graft (CABG) surgery is still one of the most common treatments. One of the major complications of CABG is acute kidney injury (AKI), with an incidence rate of 6.7%-39% (3-4), leading to increased mortality and morbidity. (5-6) The AKI increases the length of stay in hospitals and intensive care units (ICUs) (1 and 7) and incurs higher costs. (1) Kidney replacement therapy (RRT) is required in 1.6%-7.7% of cases following cardiac surgery, which may aggravate mortality in patients. (8) Several preoperative risk factors are predictors of AKI after heart surgery, including age (9-10), the interval between angiography and surgery (11), blood transfusion (9.4), serum creatinine (12,13), diabetes (14), high-risk according to Euro SCORE (18), and the use of nephrotoxic drugs.

The use of cardiopulmonary bypass (CPB) has also been suggested as a predictor of kidney injury (KI) aggravation following CABG (15). In addition to prophylactic drugs, the incidence of AKI could be reduced by controlling predisposing factors. In light of the aforementioned issues, the present study aimed to investigate the incidence of AKI after CABG and its related factors in a general university hospital in Mashhad over a one-year period

Methods

In this cross-sectional study, all the patients who were referred to a general university hospital for CABG surgery over one year and met the inclusion criteria were evaluated for AKI. The patients who were willing to participate in the study were selected after signing an informed consent form. Individuals with previous kidney renal injury were excluded from the study. A total of 180 patients were evaluated during this period, and their demographic information, history of the disease,

as well as laboratory factors of urea and creatinine, were recorded. Intraoperative information, such as the length of surgery and surgical technique (on or off-pump), were also recorded.

The AKI was diagnosed by comparing serum creatinine levels before and 72 h after the CABG surgery. Accordingly, serum creatinine above 2 mg/dL or greater than 50% surge from baseline (72 h postoperatively) was set as the reference criterion.

study was approved by the Ethics Committee of Mashhad University of Medical Sciences (code IR.IAU.MSHD.REC.1398.146). In order to investigate the relationship between the variables, Chi-square and Mann-Whitney tests were used in this study. All analyses were performed by SPSS software (version 21).

Results

In this study, 180 patients undergoing CABG with a mean age of 63.8 ± 9.84 years were examined. In terms of gender, 57.2% of subjects were male. The demographic information of participants is presented in Table 1.

Table 1. Patients' basic information

Variables	Percentage (N)
Sex / male	**57.2% (103)**
History of hypertension	**52.2% (94)**
History of diabetes	**37.8% (68)**
History of hypercholesterolemia	**33.9% (61)**
Smoking history	**21.7% (39)**

Moreover, 73.9% of patients underwent on-pump surgery. The mean length of surgery was 214.08±31.185 min. Most subjects (86.1%) had three and four clogged vessels, and the rest (13.9%) had a blockage in two or one vessel. Out of 180 patients, 3.9% (n=7) suffered from AKI after surgery. There was no significant difference by age (P=0.264); nonetheless, the age group of 60-70 years was the most vulnerable (71%) for AKI. The incidence of AKI was not significantly different between the two genders (P=0.463) and among patients with hypertension (P=0.711). The diabetic patients were not significantly different in the incidence of AKI (P=0.999).

The results of the present study did not reveal a significant difference between the on-pump and off-pump groups in terms of the method of surgery (P=0.686), although it was higher in the on-pump group(85%). There was no significant difference in the incidence of AKI in terms of hypercholesterolemia(P=0.690). Most subjects with AKI belonged to the group of patients with the three-vessel disease (3VD) (86%); however, the difference between subjects with two or three clogged vessels was not significant(P=0.999). There was no significant difference in the incidence of AKI between smokers and non-smokers (P=0.999). Based on intraoperative factors, no significant difference was observed in the length of surgery (P=0.409). Mann-Whitney test demonstrated that there was no significant relationship between people with abnormal and normal preoperative creatinine (P=0.101); nonetheless, this relationship was significant for preoperative urea levels (P=0.01).

Discussion

The current study aimed to evaluate the incidence of AKI after CABG surgery at a general hospital in Mashhad, Iran. As evidenced by the obtained results, the rate of AKI following CABG in our sample was 3.9%, which is not significantly related to age, gender,

hypertension, diabetes, type of surgery, hypercholesterolemia, number of clogged vessels,

smoking, and length of surgery. However, urea was significantly higher in patients with AKI before surgery. Despite a significant difference in urea and creatinine between people with and without AKI, the preoperative urea value was highly significant.

In a cohort study in the United States, Thakar et al. (2003) investigated 244,660 people undergoing open heart surgery. In this study, 2.36% of women and 1.6% of men developed AKI, which indicated a statistically significant difference (16). The prevalence of AKI estimated in this study was lower than that of the present research. On the other hand, in our study, no association was detected between the incidence of AKI and gender. This difference can be attributed to disparity in sample size, patients' demographic indicators, the control of confounders, and the sampling method. In a study by Schopka et al. (2014) in Germany, 1,428 patients undergoing CABG were examined in a cohort study, in which 25% and 26.6% of patients in the off-pump and on-pump groups developed AKI, of whom 1.8% and 2.9% required kidney transplantation, respectively. (17) The prevalence of renal failure in the referred study was significantly higher than in the present research (about six times higher). This

difference can be ascribed to differences in the underlying disease of patients, inclusion and exclusion criteria, surgical procedures, length of surgery, and variables affecting the incidence of AKI.

In a study conducted by Kumada et al. in 2013 (18), the reported incidence of AKI after CABG surgery was higher than that of the current research; moreover, diabetes and hypertension showed a significant association with the incidence of acute coronary syndrome. In a study by Ghani et al. (2012) in Iran, 535 patients undergoing CABG surgery were investigated in a cohort study. In this clinical trial, 9.4% and 4.1% in the off-pump and pump groups developed AKI, respectively. There was no statistically significant difference between the two groups, and the severity of kidney injury was identical in both groups (19). The reported prevalence in the stated study was slightly higher than that of the present research; nonetheless, in both studies, the surgical method had no effect on the incidence of AKI.

A cohort study by Onk et al. (2016) in Turkey assessed a total of 375 patients undergoing CABG surgery and reported that 45 (12%) patients had AKI. In comparison with people without kidney injury, a statistically significant relationship was observed with the three factors of protein NGL, hematocrit, and interleukin 6 (20) The reported prevalence of AKI in the mentioned research was three times higher than that in the present research. On the other hand, in this study, other factors related to the incidence of AKI were discussed, which warrant further investigation in the future.

The reported prevalence of AKI differs between countries, estimated at 26.3% in the United States, 54% in South America, 48.5% in Brazil, 14.7% in Belgium, and 27.9% in China. This exhibits different rates of prevalence in various nationalities (21-22). Moreover, inconsistent with the results of the present study, the male gender and smoking were reported as factors related to AKI (21). Contradictory results have been obtained in studies on AKI, which may be due to the different definitions of renal failure adopted in previous studies. The International Association of Thoracic Surgeons defines AKI as serum creatinine levels greater than 2 mg/dL and the need for postoperative dialysis (23).

Conclusion

As evidenced by the results of the present study, the recognition of the factors that aggravate kidney failure is of great help in treatment planning. It is recommended to hold timely consultation with a kidney specialist. Furthermore, patients with high levels of urea need to visit a kidney specialist preoperatively to be evaluated for such factors as dehydration, hypovolemia, and sweating that lead to prerenal azotemia. A few days give break to non-emergency CABG patients of angiography would be very useful in this group.

The maintenance of a stable hemodynamic situation and blood pressure control during CABG procedure will help to keep renal function normal. This logic would continue not only during operation but also in the ICU ward; therefore, after the surgery, the management of hydration and electrolysis of these patients will markedly reduce postoperative morbidity and mortality, as well as the cost of treatment and hospital stay.

References

1. Weinstein MC, Coxson PG, Williams LW, Pass TM, Stason WB, Goldman L. Forecasting coronary heart disease incidence, mortality, and cost: the Coronary Heart Disease Policy Model. Am J Public Health. 1987 Nov;77(11):1417-26. https://doi.org/10.2105/AJPH.77.11.1417PMid:3661794 PMCid:PMC1647098
2. Delahaye F, Roth O, de Gevigney G. Epidemiology of acute coronary syndrome. Rev Prat. 2003; 53(6):607-10.
3. Brown JR, Kramer RS, Coca SG, Parikh CR. Duration of acute kidney injury impacts long-term survival after cardiac surgery. Ann Thorac Surg. 2010;90(4):1142-8. https://doi.org/10.1016/j.athoracsur.2010.04.039https://doi.org/10.1016/j.athoracsur.2012.04.065
4. Vellinga S, Verbrugghe W, De Paep R, Verpooten G, Janssen van Doorn K. Identification of modifiable risk factors for acute kidney injury after cardiac surgery. Neth J Med. 2012;70(10):450-4.
5. Gude D, Jha R. Acute kidney injury following cardiac surgery. Ann Card Anaesth. 2012;15(4):279-86. https://doi.org/10.4103/0971-9784.101874PMid:23041685
6. Karkouti K, Wijeysundera DN, Yau TM, Callum JL, Cheng DC, Crowther M, et al. Acute kidney injury after cardiac surgery: focus on modifiable risk factors. Circulation. 2009;119(4):495-502. https://doi.org/10.1161/CIRCULATIONAHA.108.786913PMid:19153273
7. Mao MA, Thongprayoon C, Wu Y, Tejwani V, Vela-Ortiz M, Dearani J, et al. Incidence, severity, and outcomes of acute kidney injury in octogenarians following heart valve replacement surgery. Int J Nephrol. 2015;2015:237951. https://doi.org/10.1155/2015/237951PMid:26090225 PMCid:PMC4458288
8. Coppolino G, Presta P, Saturno L, Fuiano G.

Acute kidney injury in patients undergoing cardiac surgery. J Nephrol. 2013;26(1):32-40 https://doi.org/10.5301/jn.5000215PMid:23042436

9. Freeland K, Jahromi AH, Duvall LM, Mancini MC. Postoperative blood transfusion is an independent predictor of acute kidney injury in cardiac surgery patients. J Nephropathol. 2015;4(4):121-6.
10. Ried M, Puehler T, Haneya A, Schmid C, Diez C. Acute kidney injury in septua- and octogenarians after cardiac surgery. BMC Cardiovasc Disord. 2011;11(1):52https://doi.org/10.1186/1471-2261-11-52PMid:21835003 PMCid:PMC3163622
11. Hu Y, Li Z, Chen J, Shen C, Song Y, Zhong Q. The effect of the time interval between coronary angiography and on-pump cardiac surgery on risk of postoperative acute kidney injury: a meta-analysis. J Cardiothorac Surg. 2013;8(1):178. https://doi.org/10.1186/s13019-023-02274-6https://doi.org/10.1186/1749-8090-8-178PMid:23915489 PMCid:PMC3750660
12. Chen SW, Chang CH, Fan PC, Chen YC, Chu PH, Chen TH, et al. Comparison of contemporary preoperative risk models at predicting acute kidney injury after isolated CABGing: a retrospective cohort study. BMJ Open. 2016;6(6):e010176. https://doi.org/10.1136/bmjopen-2015-010176PMid:27354068 PMCid:PMC4932284
13. Li XH, Xiao F, Zhang SY. Investigation of risk factors of acute kidney injury after off-pump ing and 3 years' follow-up. Beijing Da Xue Xue Bao Yi Xue Ban. 2017;49(1):131-6.
14. Oezkur M, Wagner M, Weismann D, Krannich JH, Schimmer C, Riegler C, et al. Chronic hyperglycemia is associated with acute kidney injury in patients undergoing CABG surgery: a cohort study. BMC Cardiovasc Disord. 2015;15(1):41. https://doi.org/10.1186/s12872-015-0028-y PMid:25964053 PMCid:PMC4443518
15. Spunda R, Valek M, Salmay M, Prskavec T, Pecha O, Lindner J, et al. Differential impact on acute kidney injury incidence between on-and off pump coronary artery bypass grafting in octogenarians. Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub. 2015;159(3):449-54. https://doi.org/10.5507/bp.2014.023PMid:24881588
16. Thakar CV, Liangos O, Yared JP, Nelson D, Piedmonte MR, Hariachar S, et al. ARF after open-heart surgery: Influence of gender and race. Am J Kidney Dis. 2003 Apr;41(4):742-51. https://doi.org/10.1016/S0272-6386(03)00021-0PMid:12666060
17. Schopka S, Diez C, Camboni D, Floerchinger B, Schmid C, Hilker M. Impact of cardiopulmonary bypass on acute kidney injury following coronary artery bypass grafting: a matched pair analysis. J Cardiothorac Surg. 2014 Jan 18;9:20.
18. Kumada Y, Yoshitani K, Shimabara Y, Ohnishi Y. Perioperative risk factors for acute kidney injury after off-pump coronary artery bypass grafting: a retrospective study. JA Clin Rep. 2017;3(1):55. https://doi.org/10.1186/s40981-017-0125-2 PMid:29457099 PMCid:PMC5804651
19. Ghanei E, Hogat SA, Orouji Jokar T, Kolahi AA. Coronary Artery Bypass Surgery and Acute Kidney Injury: Impact of the Off-Pump Technique. Iran Red Crescent J. 2012; 14(2): 65-9.
20. Onk OA, Onk D, Ozcelik F, Gunay M, Turkmen K. Risk Factors for Acute Kidney Injury after Coronary Artery Bypass Surgery and Its Detection Using Neutrophil Gelatinase-Associated Lipocalin. Cardiorenal Med. 2016 May;6(3):216-29. https://doi.org/10.1159/000444099PMid:27275158 PMCid:PMC4886083
21. Kakili H, Gachkar L. Check cystatin c and efficiency cut-off point for the diagnosis of coronary artery disease in patients admitted for elective coronary angiography artery in Modares hospital in 2013. Medical Thesis.
22. Pournosrat K, Soleimannejad K, Yaghmaei P. The Inflammatory Role of Myeloperoxidase and Its Increased Level in Patients with Coronary Artery Disease. sjimu. 2014; 22 (5) :168-178
23. Deb, S; Wijeysundera, HC; Ko, DT; Tsubota, H; Hill, S; Fremes, SE. Coronary artery bypass graft surgery vs percutaneous interventions in coronary revascularization: a systematic review. JAMA 2013; 310 (19): 2086-95.doi:10.1001/jama.2013.281718. PMID 24240936https://doi.org/10.1001/jama.2013.281718PMid:24240936