Effect of Cardiopulmonary Bypass on Glomerular Filtration Rate after Open Heart Surgery

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Abstract

Introduction: Cardiovascular diseases, especially coronary artery diseases, are among the most common diseases in the world. Different methods are used to treat patients with coronary artery disease, and coronary artery bypass surgery (CABG) is considered the most common treatment method in advanced coronary artery disease. Cardiopulmonary bypass (CPB) is one of the most common approaches, but it has complications, the most important of which is acute kidney failure. Therefore, the aim of this study is to investigate the effect of CPB on glomerular filtration rate after open heart surgery.

Material and Methods: This analytical cross-sectional study was conducted on patients who underwent open heart surgery using CPB. The data collection form includes demographic information (i.e., age, gender, weight, height, body surface area), underlying disease (i.e., diabetes, hypertension, cerebrovascular accident, hyperlipidemia, left ventricular failure), addiction history and laboratory information (urea, creatinine, Hemoglobin and fasting blood sugar) before surgery and up to three days after surgery (Urea and creatinine daily for the patient up to three days after surgery). Also, other data included the duration of use of pump, cross clamp, duration of anesthesia, duration of surgery, duration of mechanical ventilation, duration of hospitalization in the ward and ICU, the amount of blood products and Lasix (furosemide), usage in the operating room and ICU. All data were collected after reviewing the patients' medical records. Also, possible complications such as pulmonary complications, acute kidney failure, cardiac arrhythmia, reoperation due to bleeding, deep infection of the operation site, need for mechanical ventilation were extracted from the medical records. SPSS version 26 software was used for data analysis.

Results: In this study, 200 patients were studied, 62.5% of whom were men. The average age was 59.31 ± 10.21 years. The most common underlying diseases were hypertension (55.5%), diabetes (39.5%) and hyperlipidemia (13.5%). The average GFR of the patients after the operation was increased compared to before the operation. The amount of GFR was higher on the first (P=0.001), second (P=0.01) and third (P=0.002) days after surgery in the group receiving less than one hour of CPB compared to the group receiving more than one hour of CPB. Twenty-one patients had acute kidney injury, all of which belonged to the group receiving more than one hour of cardiopulmonary pump. Postoperative creatinine and urea were higher in patients with CPB for more than one hour than in patients with CPB for less than one hour. Patients who had a CPB duration of more than one hour needed to consume more blood products both in the operating room and in the ICU compared to patients with CPB of less than one hour.

Conclusion: The present study revealed that the use of CPB in all patients did not cause a decrease in mean GFR compared to before surgery, but longer use of CPB (more than one hour) was associated with higher levels of creatinine and urea after surgery. Overall, the findings of this study showed that long-term use of CPB may be linked to more kidney complications and bleeding.

Key words: Cardiopulmonary Bypass, Open Heart Surgery, Kidney Failure, Glomerular Filtration.

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INTRODUCTION

Cardiovascular diseases refer to a group of multiple failures in which the heart loses its normal function (1). Among these diseases, coronary artery disease is one of the most common heart complications and one of the main causes of death and disability in the world (2). Obesity, high blood pressure, high cholesterol, alcohol consumption and smoking are known as the most important causes of cardiovascular diseases (3, 4). Different methods have been used to treat patients with coronary artery disease, including drug treatments, angioplasty, and Coronary Artery Bypass

Graft (CABG) surgery (5).

CABG is usually performed in two ways, with or without the use of a cardiopulmonary pump (6). Cardiopulmonary bypass (CPB) is an extracorporeal blood circulation that temporarily takes over the function of the heart and lungs during surgery, maintaining circulation of blood during surgery (7). CPB causes the blood to be exposed to a large artificial surface and leads to the production and release of many chemical toxic substances and vascular activators, where the activation of neutrophils and their presence in the pulmonary circulation causes deep endothelial, epithelial and interstitial pulmonary damages.

This damage may be related to increased endothelial permeability, decreased lung capacity, and impaired gas exchange (8). Therefore, disturbance in gas exchange caused by acute lung tissue damage is one of the common and well-known complications of coronary artery bypass surgery (9). The use of cardiopulmonary pump is associated with other complications, including hemolysis, the need for blood products, capillary leak syndrome, and acute kidney injury (10-12).

CPB can play a role in the pathogenesis of renal failure through systemic inflammatory response syndrome (SIRS), changes in blood flow and changes in the vasomotor tone of the kidneys, as well as microembolism (13).

SIRS occurs mainly through the contact of blood with the artificial surface of the bypass pathway, and an increase in inflammatory factors such as TNF-α, interleukin 6 and interleukin 8 has been seen in the pathophysiology of renal failure after CPB (14). The use of a CPB may reduce the effective renal perfusion pressure by 30%, which occurs through changes in renal vasomotor tone and reduced oxygen supply to the renal parenchyma, resulting in ischemic damage (15). The use of renal replacement therapy, including dialysis, may be necessary for the treatment of renal failure after heart surgery using a CPB, and 1 to 2.9% of patients may need it (16).

The need for dialysis is one of the predictors of mortality, so that the 30-day mortality rate of people who need dialysis after CPB is reported to be 42% (17). Therefore, understanding the mechanism of renal failure and its related factors after using a CPB is very important for preventing this consequence and its timely management.

Considering the high prevalence of cardiovascular diseases and subsequent CABG, it seems essential to consider the best treatment approaches with the least negative consequences for patients. According to some studies, the use of CPB has been associated with some degree of renal failure, on the other hand, the results of all studies are not consistent with each other. Therefore, the aim of this study is to cross-sectionally investigate the effect of CPB on glomerular filtration rate (GFR) after open heart surgery.

Materials and Methods

This analytical cross-sectional study was conducted on patients who underwent open heart surgery using CPB in the first half of 2021 at Shafa Medical Education Center in Kerman, Iran. Patients who met the inclusion and exclusion criteria were included in the study.

Inclusion criteria included: patients who are candidates for open heart surgery, having informed consent. Exclusion criteria included: having a previous history of CABG, dialysis, history of kidney transplant and patients with valvular heart disease.

Procedure

The data collection form includes demographic information (i.e., age, gender, weight, height, body surface area), underlying disease (i.e., diabetes, hypertension, cerebrovascular accident, hyperlipidemia, left ventricular failure), addiction history and laboratory information (urea, creatinine, Hemoglobin and fasting blood sugar) before surgery and up to three days after surgery (Urea and creatinine daily for the patient up to three days after surgery). Also, other data included the duration of use of pump, cross clamp, duration of anesthesia, duration of surgery, duration of mechanical ventilation, duration of hospitalization in the ward and ICU, the amount of blood products and Lasix (furosemide), usage in the operating room and ICU. All data were collected after reviewing the patients' medical records. Furthermore, complications such as pulmonary complications, acute kidney failure, cardiac arrhythmia, re-operation due to bleeding, deep infection of the operation site, the need for mechanical ventilation was extracted and recorded from the medical records. In this study, glomerular filtration rate (GFR) was calculated based on the Cockcroft-Gault formula.

$$FR = \frac{(140 - \text{age}) \times \text{weight} \times (\text{women in } 0.85\ )}{\text{Serum creatinine} \times 72}$$

Data analysis

Descriptive indices including frequency and frequency percentage were used for qualitative variables and mean and standard deviation for quantitative variables. To compare glomerular filtration before and after surgery, T-test and equivalent non-parametric tests were used if needed. SPSS version 26 software was used for data analysis and P-value <0.05 was considered to be statistically significant.

Ethical Considerations

The information of all patients was kept confidential with the project manager. This study was approved by the Ethics Committee of the University of Medical Sciences. The study was conducted after receiving written informed consent and code of ethics, IR.KMU.AH.REC.1401.005. The study was conducted according to the World Medical Association Declaration of Helsinki.

RESULTS

A total of 200 patients were included in the study. The subjects consisted of 125 male patients (62.5%) and 75 female patients (37.5%). The average age of the studied patients was equal to 59.31±10.21 years, ranging from 40 to 78 years. The most common underlying disease was high blood pressure (55.5%), followed by diabetes (39.5%), hyperlipidemia (13%) and a history of CVA (3.5%). The results showed that 31.5% of patients had a history of smoking and 44.5% had a history of opium use. Out of 200 patients examined, 100 patients underwent CPB in CABG surgery for less than one hour and 100 patients for more than one hour.

Comparing the qualitative variables of these two groups showed that there was no significant difference between the two groups in terms of gender, opium consumption, hyperlipidemia, hypertension, and CVA. However, the difference between the two groups was significant in terms of diabetes (P=0.014), smoking (P=0.001) and ASA use (P=0.025) (Table 1).

Table 1: Comparison of qualitative variables of patients according to the duration of CPB

Variable		Cardiopulmonary pump under 1 hour	Cardiopulmonary pump above 1 hour	P-value
		Frequency	Frequency	
sex	Female	44	31	0.058
	Male	56	69	
Underlying disease	Diabetic	48	31	0.014
	Hyperlipidemia	12	14	0.674
	Hypertension	56	55	0.887
	CVA	4	3	0.7
Opium consumption	Yes	40	49	0.2
	No	60	51	
smoking	Yes	20	43	0.001
	No	80	57	
ASA intake	Yes	72	85	0.025
	No	28	15	

The comparison of the quantitative variables of the patients according to the duration of the CPB showed that,

The variable of age in the use of cardiopulmonary pump under one hour is equal to (52.24±9.87), weight is equal to (67.64±9.85) kg, height is equal to (166.88±9.12) cm and body cross-sectional area is (1.72±0.16)

The variable of age in using cardiopulmonary pump for more than one hour is equal to (59.39±10.6), weight is equal to (69.28±13.72) kg, height is equal to (168.36±9.05) cm and body cross-sectional area is (1.75±0.19).

Statistically, there was no significant in terms of the duration of CPB (p<0.05). Table 2 shows the comparison of two groups of patients based on hospitalization and operating room data. The duration of mechanical ventilation, the length of stay in the ward and the length of stay in the ICU were not significantly different in the two groups (P>0.05). While the duration of anesthesia, duration of surgery and Clamp-time in patients who used cardiopulmonary pump for more than one hour were significantly higher than the other group (P=0.001).

The average duration of using the pump in patients that was less than one hour and more than one hour was statistically significant (P=0.001).

Table 2: Comparison of data related to hospitalization and operating room of patients according to the duration of CPB

Variable	Cardiopulmonary pump under 1 hour		Cardiopulmonary pump above 1 hour		P-value
	Mean	SD	Mean	SD	
duration of anesthesia	4.27	0.46	6.48	1.7	0.001
Duration of surgery	3.87	0.44	6.04	1.65	0.001
Duration of mechanical ventilation	15.2	7.2	16.25	11.13	0.427
Duration of stay in the department	3.56	1.82	3.51	1.67	0.859
Length of stay in ICU	4.04	2.15	4.33	2.87	0.42
Pump-time	50.48	9.49	85.3	18.62	0.001
Clamp-time	25.6	6.32	43.09	15.9	0.001

Examining the laboratory markers of the patients according to the duration of the cardiopulmonary pump showed that the creatinine of the patients who were under the CPB for more than one hour was significantly higher on the first, second and third day after the operation than the patients who were under the CPB for less than one hour (P=0.001), while no significant difference was found between the creatinine levels of the two groups before the operation. The level of urea on the second and third day after the operation was significantly higher in the pump group for more than one hour than in the pump group for less than one hour (P=0.001). While the level of urea before the operation did not differ between the two groups.

In the pump group, the level of hemoglobin above one hour was also higher on the first (P=0.036), second (P=0.001), and third (P=0.01) days after the operation than the other group, and it was not different from before the operation.

The level of fasting blood sugar before surgery was significantly higher in the pump group under one hour (P=0.001), and this level was also significantly higher on the second day after surgery than the other group (P=0.002), but no significant difference was found between two groups on the first and third days after surgery.

Table 3: Comparison of laboratory markers of patients according to the duration of CPB

Variable		Cardiopulmonary pump under 1 hour		Cardiopulmonary pump above 1 hour		P-value
		Mean	SD	Mean	SD	
Creatinine	Before the operation	1.06	0.38	1.04	0.33	0.783
	The first day after the operation	0.79	0.28	1.02	0.28	0.001
	The second day after the operation	0.79	0.28	0.95	0.35	0.001
	The third day after the operation	0.74	0.23	0.87	0.23	0.001
urea	Before the operation	36.88	14.55	37.06	11.94	0.924
	The first day after the operation	35.76	16.07	38.18	13.32	0.248
	The second day after the operation	33.24	15.29	41.16	16.98	0.001
	The third day after the operation	31.28	12.32	39.88	20.26	0.001
hemoglobin	Before the operation	13.01	1.78	12.54	3.44	0.233
	The first day after the operation	9.68	1.22	10.09	1.48	0.036
	The second day after the operation	9.32	1.18	10.16	1.56	0.001
	The third day after the operation	9.58	1.07	1.89	1.28	0.01
fasting blood sugar	Before the operation	180.68	97.17	134.87	56.25	0.001
	The first day after the operation	191.84	62.21	190.6	65.88	0.891
	The second day after the operation	152.4	44.14	134.2	37.87	0.002
	The third day after the operation	139.72	51.96	134.82	47.16	0.49

Comparison of the glomerular filtration rate of patients was determined according to the duration of CPB. Average glomerular filtration before operation (22.4±72), first day after operation (92.44±34.46), second day after operation (97.16±34.75), third day (28.44±102), after operation (74.42±22.85), the first postoperative day (76.82±25.68), the second postoperative day (±84.97±31.74) and the third postoperative day (89.49±2.89). The results demonstrated that the amount of glomerular filtration depends on the duration of the CPB. No significant difference was found in GFR between the two groups (P=0.45). While on the first (P=0.001), second (P=0.01) and third (P=0.002) days after the operation, the GFR level in the group that received less than one hour of CPB was higher than the group receiving over an hour of CPB.

The mean and standard deviation of GFR before surgery in all studied patients was equal to 73.21 ± 22.6, which was 84.63 ± 31.3 on the first day after surgery, 91.06 ± 33.75 on the second day, and 95.84 ± 29.06 on the third day, which this rate was significant compared to pre-operation in all three days (P=0.001).

The mean and standard deviation of creatinine before surgery in all studied patients was found to be 1.05 ± 0.35, which was 0.91 ± 0.31 on the first postoperative day, 0.88 ± 0.33 on the second postoperative day, and 0.88 ± 0.33 on the third day. In addition, it was determined to be 0.81 ± 0.24 after the operation, which was statistically significant compared to the time before the operation in all three days (P=0.001).

Table 4 shows the blood products and drugs received in the operating room and ICU in patients according to the duration of CPB use. The use of Pack cell, FFP and platelets in the operating room was significantly higher in patients who had a CPB of more than one hour, while the use of Lasix in the operating room was more in the group that had a CPB of less than one hour. Inotrope consumption in the operating room did not differ between the two groups.

In the ICU, Pack cell, FFP, and platelet consumption was significantly higher in the group with a pump for more than one hour, while inotrope consumption in the ICU was significantly higher in patients with a pump for less than one hour, and no significant difference was found in the prescription of Lasix in the ICU between two groups.

Table 4: Comparison of blood products and drugs received according to the duration of CPB

Variable		Cardiopulmonary pump under 1 hour	Cardiopulmonary pump above 1 hour	P-value
		Frequency	Frequency	
surgery room	Pack cell	56	73	0.012
	FFP	36	61	0.001
	PLT	4	35	0.001
	Laxis	20	3	0.001
	Inotrope	12	19	0.171
ICU	Pack cell	52	69	0.014
	FFP	4	17	0.003
	PLT	8	21	0.009
	Laxis	60	72	0.079
	Inotrope	52	36	0.023

Table 5 shows the comparison of GFR in all patients on different days according to receiving blood products and drugs in the operating room. As shown, the patients who received Pack cell in the operating room had significantly lower GFR on the first day after the operation than the patients who did not receive Pack cell in the operating room.

There was no significant difference in GFR from the first to the third days after the operation of the patients according to the consumption of FFP, platelets and Lasix in the operating room (P>0.05).

Table 5: Comparison of GFR according to blood products and drugs received in the operating room

Pack cell	Pack cell consumption		No Pack cell consumption		
	Mean	SD	Mean	SD	
Preoperative GFR	72.28	24.07	74.88	19.7	0.438
GFR on the first postoperative day	81.36	32.01	90.57	29.27	0.046
GFR on the second day after surgery	89.83	36.15	93.3	28.99	0.487
GFR on the third day after surgery	93.05	30.7	100.8	25.36	0.072
FFP	FFP consumption		Not consuming FFP		p.v
	Mean	SD	Mean	SD	
Preoperative GFR	72.41	24.06	73.96	21.22	0.63
GFR on the first postoperative day	80.9	28.85	88.14	33.21	0.1
GFR on the second day after surgery	88.08	28.65	93.87	37.86	0.22
GFR on the third day after surgery	93.5	27.58	98.11	30.39	0.26
Platelet	Platelet consumption		No platelet consumption		p.v
	Mean	SD	Mean	SD	
Preoperative GFR	80.34	19.33	71.48	23.05	0.028
GFR on the first postoperative day	81.6	17.39	85.36	33.83	0.5
GFR on the second day after surgery	90.74	21.87	91.14	36.1	0.94
GFR on the third day after surgery	90.82	21.54	97.08	30.57	0.22
Lasix	Taking Lasix		No taking Lasix		P-VALUE
	Mean	SD	Mean	SD	
Preoperative GFR	74	16.16	73.1	23.34	085
GFR on the first postoperative day	87.34	19.45	84.27	32.55	0.66
GFR on the second day after surgery	93.6	20.57	90.73	35.13	0.7
GFR on the third day after surgery	97.17	15.03	95.66	30.46	0.81

Table 6 shows the comparison of GFR in all patients on different days according to receiving blood products and drugs in ICU. Patients who received Pack cell in ICU had significantly lower GFR on the third postoperative day than patients who did not receive Pack cell in ICU. No statistically significant difference was found in GFR from the first to the third days after the operation of the patients according to the consumption of FFP and platelets in the ICU. Patients who required Lasix in the ICU had significantly lower GFR on the first to third postoperative days than patients who did not receive Lasix in the ICU (Table 6).

Table 6: Comparison of GFR according to blood products and drugs received in ICU

Pack cell	Pack cell consumption		No Pack cell consumption		P-value
	Mean	SD	Mean	SD	
Preoperative GFR	72.18	22.55	74.78	22.73	0.42
GFR on the first postoperative day	81.12	28.93	90	34.13	0.05
GFR on the second day after surgery	88.84	33.49	94.48	34.08	0.24
GFR on the third day after surgery	92.1	29.16	101.43	28.18	0.02
FFP	FFP consumption		No FFP consumption		P-value
	Mean	SD	Mean	SD	
Preoperative GFR	68.09	28.94	73.81	21.76	0.27
GFR on the first postoperative day	82	32.78	84.94	31.21	0.68
GFR on the second day after surgery	94.38	41.24	90.67	32.88	0.63
GFR on the third day after surgery	91.47	32.93	96.36	28.63	0.46
platelet	platelet consumption		No platelet consumption		P-value
	Mean	SD	Mean	SD	
Preoperative GFR	80.89	15.4	71.9	23.39	0.04
GFR on the first postoperative day	85.48	23.38	84.48	32.15	0.87
GFR on the second day after surgery	96.27	33.26	96.18	33.85	0.37
GFR on the third day after surgery	99.07	25.64	95.28	29.65	0.51
Lasix	taking Lasix		No taking Lasix		P-value
	Mean	SD	Mean	SD	
Preoperative GFR	71.4	21.99	76.72	23.52	0.115
GFR on the first postoperative day	78.63	24.42	96.27	39.2	0.001
GFR on the second day after surgery	86.38	33.11	100.16	33.37	0.006
GFR on the third day after surgery	89.7	27.92	107.48	27.77	0.001

Postoperative complications in patients receiving CPB for less than one hour were not significantly different from patients receiving CPB for more than one hour (P=0.056; Table 7).

Table 7: Comparison of postoperative complications of patients according to the duration of CPB

Variable	Cardiopulmonary pump under 1 hour	Cardiopulmonary pump above 1 hour
	Frequency	Frequency
AF	4 (16.7%)	3 (7.3%)
Sepsis	8 (33.3%)	18 (43.9%)
Agitation	12 (50%)	11 (26.8%)
AF + Sepsis + Agitation	0 (0%)	3 (7.3%)
AF + sepsis	0 (%)	6 (14.6%)

DISCUSSION

CABG surgery is the most common treatment method in advanced stages of coronary artery disease. The use of cardiopulmonary pump during this surgery has been used for a long time, but despite its usefulness in establishing blood circulation during surgery, it has also been associated with several complications (18). Considering that acute kidney injury is one of the most important side effects of this surgical procedure, this study evaluated the effect of CPB on glomerular filtration rate as well as laboratory markers, use of blood products and other related side effects.

In the present study, 200 patients were examined, most of them were men (62.5%). This finding is in line with other previous studies that have reported the incidence of cardiovascular diseases and subsequent CABG surgery in men. For example, Lawton has stated in a report that almost 70% of CABG surgeries were performed in men (19). One of the important reasons for these observations is the protective role of sex hormones, because estrogen plays a role in inhibition of the sclerotic plaque formation, blood pressure regulation, as well as anti-inflammatory and antioxidant effects (20).

This study also showed that the average age of the patients was 59.31 years, ranging from 40 to 78 years. Epidemiological studies also demonstrated that the average age of coronary artery disease and heart attack in the Middle East is approximately 51 years, which is about 12 years lower than the average age in European countries (21). Coronary artery diseases in men usually occur between the ages of 50 and 60 and appear with an average of ten years difference in women (22).

The findings of the present study also showed that blood pressure (55.5%), diabetes (39.5%) and hyperlipidemia (13%) were the most common underlying diseases of the studied subjects. High blood pressure is one of the main risk factors for the occurrence of coronary artery diseases, so cross-sectional studies on more than one million people have shown that the risk of death from coronary artery disease increases significantly with increased blood pressure (23).

Diabetes and dyslipidemia are also among the most important risk factors for heart diseases, for example, de Jong et al. showed that a history of diabetes is associated with a 2.33-fold increase in the incidence of heart attack in women and 1.81-fold in men (24). Other reports have also stated that having diabetes increases the chance of coronary artery disease by 2 to 4 times (25). Hedayat Nia et al also showed that dyslipidemia was associated with a 2.71-fold increase in myocardial infarction (26).

In this study, we compared the duration of CPB use with outcomes and laboratory markers. For this purpose, 100 patients who were used CPB for more than one hour and 100 patients who were used CPB for less than one hour were compared. The average use of the pump in the first and second groups was 85.3±18.62 and 50.48±9.49 minutes, respectively.

The current study howed that, on average, the GFR of all patients after surgery (first, second and third days) not only did not decrease compared to before surgery, but also had an upward trend in these three days. Loef et al also showed in their study that patients who underwent heart surgery with CPB had an increase in GFR one week after surgery compared to before surgery (27). Therefore, according to the results of the present study, the use of CPB did not cause a decrease in GFR on average. In terms of the duration of using the pump, the findings of this study showed that 21 patients (10.5%) had some degree of acute kidney injury after surgery according to the AKIN criteria, and 100% of these cases belonged to the group that received a CPB for more than one hour.

Khademi et al also reported that the incidence of acute renal failure after CPB was equal to 18% until 48 hours after the operation (28). Arif et al also reported the incidence of acute renal failure after CPB to be 7.69% (29).

The findings of the present study also showed that creatinine levels were lower on all three days after surgery in the group receiving less than one hour of CPB compared to the group receiving more than one hour of CPB. Similar observations regarding urea were observed for the second and third days after surgery. These findings indicate that longer use of CPB may be associated with increased markers of renal function, on the one hand, since all cases of acute kidney injury occurred in the group receiving more than one hour of CPB. Longer use of CPB may be associated with decreased renal function. Similar to the findings of this study, Arif et al also showed in a research that patients receiving a longer duration (more than 90 minutes) of CPB had higher levels of postoperative creatinine than patients receiving a shorter duration (less than 90 minutes) of CPB (29).

Axtell et al also reported that longer duration of cardiopulmonary pump use has a significant relationship with the incidence of acute renal failure (30). In this regard, Perez and colleagues have also found that the duration of cardiopulmonary pump use is associated with the risk of acute renal failure (31).

The results of the present study also showed that patients receiving CPB for more than one hour needed to consume more blood products both in the operating room and in the ICU compared to patients with CPB for less than one hour. Therefore, the findings of the present study showed that the long-term use of the CPB may be associated with an increase in the need for blood products. Consistent with the findings of this study, Abbaszadeh et al showed that patients undergoing CPB received more blood, albumin and fresh plasma and platelets (32). Nuttall et al also showed that the use of CPB was linked to increased bleeding and increased need for blood products (33). Sandoughdaran et al. suggested the use of CPB as one of the predictive factors of the need for blood transfusion (34). The researchers considered the increased bleeding and the need for blood products in the use of the CPB to be caused by the proximity of blood to synthetic substances and non-endothelial surfaces, causing hemostatic disorders in the thrombolytic and fibrinolytic system (32).

Conclusion

The present study revealed that the use of CPB in all patients did not cause a decrease in mean GFR compared to before surgery, but longer use of CPB (more than one hour) was associated with higher levels of creatinine and urea after surgery. Overall, the findings of this study showed that long-term use of CPB may be linked to more kidney complications and bleeding.

References

Hanson MA, Fareed MT, Argenio SL, Agunwamba AO, Hanson TR. Coronary artery disease. Prim Care Clin Off Pract. 2013;40(1):1–16.

Mack M, Gopal A. Epidemiology, traditional and novel risk factors in coronary artery disease. Heart Fail Clin. 2016; 12(1): 1–10.

Sarrafzadegan N, Mohammmadifard N. Cardiovascular disease in Iran in the last 40 years: prevalence, mortality, morbidity, challenges and strategies for cardiovascular prevention. Arch Iran Med. 2019; 22(4): 204–10.

Gharakhanlou R, Farzad B, Agha-Alinejad H, Steffen LM, Bayati M. Anthropometric measures as predictors of cardiovascular disease risk factors in the urban population of Iran. Arq Bras Cardiol. 2012; 98: 126–35.

Alexander JH, Smith PK. Coronary-artery bypass grafting. N Engl J Med.

2016; 374(20): 1954–64.

Imantalab V, Sedighinejad A, Jouryabi AM, Biazar G, Kanani G, Haghighi M, et al. Glycemic Control in Coronary Artery Bypass Graft Surgery: A Different Perspective. Anesthesiol Pain Med. 2021; 11(6).

Jorairahmadi S, Javaherforooshzadeh F, Jannatmakan F, Soltani F, Zadeh LS. Evaluation of the Relationship Between Changes in Potassium Concentration and Arrhythmia During Coronary Artery Bypass Grafting Surgery. Anesthesiol Pain Med. 2022; 12(1).

Hendrix RHJ, Ganushchak YM, Weerwind PW. Oxygen delivery, oxygen consumption and decreased kidney function after cardiopulmonary bypass. PLoS One. 2019; 14(11): e0225541.

Benjamin EJ, Blaha MJ, Chiuve SE, Cushman M, Das SR, Deo R, et al. Heart disease and stroke statistics—2017 update: a report from the American Heart Association. Circulation. 2017; 135(10): e146–603.

Pickering JW, James MT, Palmer SC. Acute kidney injury and prognosis after cardiopulmonary bypass: a meta-analysis of cohort studies. Am J Kidney Dis. 2015; 65(2): 283–93.

Ono M, Joshi B, Brady K, Easley RB, Zheng Y, Brown C, et al. Risks for impaired cerebral autoregulation during cardiopulmonary bypass and postoperative stroke. Br J Anaesth. 2012; 109(3): 391–8.

Bronicki RA, Hall M. Cardiopulmonary bypass-induced inflammatory response: pathophysiology and treatment. Pediatr Crit Care Med. 2016;17(8):S272–8.

Ng RRG, Chew STH, Liu W, Ti LK. Persistent kidney injury at hospital discharge after cardiac surgery with cardiopulmonary bypass in patients with normal preoperative serum creatinine and normal estimated glomerular filtration rate. J Cardiothorac Vasc Anesth. 2014; 28(6): 1453–8.

Neugarten J, Sandilya S, Singh B, Golestaneh L. Sex and the risk of AKI following cardio-thoracic surgery: a meta-analysis. Clin J Am Soc Nephrol. 2016; 11(12): 2113–22.

Toda Y, Sugimoto K. AKI after pediatric cardiac surgery for congenital heart diseases–recent developments in diagnostic criteria and early diagnosis by biomarkers. J intensive care. 2017; 5(1): 1–7.

Fu H-Y, Chou N-K, Chen Y-S, Yu H-Y. Risk factor for acute kidney injury in patients with chronic kidney disease receiving valve surgery with cardiopulmonary bypass. Asian J Surg. 2021; 44(1): 229–34.

Ortega-Loubon C, Fernández-Molina M, Pañeda-Delgado L, Jorge-Monjas P, Carrascal Y. Predictors of postoperative acute kidney injury after coronary artery bypass graft surgery. Brazilian J Cardiovasc Surg. 2018; 33: 323–9.

Ortega-Loubon C, Fernández-Molina M, Carrascal-Hinojal Y, Fulquet-Carreras E. Cardiac surgery-associated acute kidney injury. Ann Card Anaesth. 2016; 19(4): 687.

Lawton JS. Sex and gender differences in coronary artery disease. In: Seminars in thoracic and cardiovascular surgery. Elsevier; 2011. p. 126–30.

Iorga A, Cunningham CM, Moazeni S, Ruffenach G, Umar S, Eghbali M. The protective role of estrogen and estrogen receptors in cardiovascular disease and the controversial use of estrogen therapy. Biol Sex Differ. 2017; 8(1): 1–16.

Almahmeed W, Arnaout MS, Chettaoui R, Ibrahim M, Kurdi MI, Taher MA, et al. Coronary artery disease in Africa and the Middle East. Ther Clin Risk Manag. 2012; 8: 65.

Beltrame JF, Dreyer R, Tavella R. Epidemiology of coronary artery disease. INTECH Open Access Publisher London, UK; 2012.

Blacher J, Levy BI, Mourad J-J, Safar ME, Bakris G. From epidemiological transition to modern cardiovascular epidemiology: hypertension in the 21st century. Lancet. 2016; 388(10043): 530–2.

De Jong M, Woodward M, Peters SAE. Diabetes, glycated hemoglobin, and the risk of myocardial infarction in women and men: a prospective cohort study of the UK Biobank. Diabetes Care. 2020; 43(9): 2050–9.

Rathore V, Singh N, Mahat RK, Kocak MZ, Fidan K, Ayazoglu TA, et al. Risk factors for acute myocardial infarction: a review. EJMI. 2018; 2(1): 1–7.

Hedayatnia M, Asadi Z, Zare-Feyzabadi R, Yaghooti-Khorasani M, Ghazizadeh H, Ghaffarian-Zirak R, et al. Dyslipidemia and cardiovascular disease risk among the MASHAD study population. Lipids Health Dis. 2020; 19(1): 1–11.

Loef BG, Henning RH, Navis G, Rankin AJ, Van Oeveren W, Ebels T, et al. Changes in glomerular filtration rate after cardiac surgery with cardiopulmonary bypass in patients with mild preoperative renal dysfunction. Br J Anaesth. 2008; 100(6): 759–64.

Khademi S, Mehr LS, Janati M, Jouybar R, Dehghanpisheh L. Association of urine output during cardiopulmonary bypass and postoperative acute kidney injury in patients undergoing coronary artery bypass graft. Perfusion. 2022; 02676591211068973.

Arif A, Niazi AK, Muneeb M, Umer KS, Ali A, Shahbaz A. Correlation of prolonged Cardiopulmonary Bypass time with Postoperative Complications-A prospective review. Pakistan J Med Heal Sci. 2022; 16(04): 23.

Axtell AL, Fiedler AG, Melnitchouk S, D'Alessandro DA, Villavicencio MA, Jassar AS, et al. Correlation of cardiopulmonary bypass duration with acute renal failure after cardiac surgery. J Thorac Cardiovasc Surg. 2020; 159(1): 170–8.

Pérez T, Candela-Toha AM, Khalifi L, Muriel A, Pardo MC. Individualized prediction for the occurrence of acute kidney injury during the first postoperative week following cardiac surgery. J Clin Anesth. 2022; 77: 110596.

Abbaszadeh Ghanavati M, Mehrani F, Boloorian A, Jazayeri Gharehbagh E. Comparison of bleeding and transfusion in patients who undergo coronary artery bypass grafting with and without cardiopulmonary bypass. Payavard Salamat. 2011; 5(1): 32–9.

Nuttall GA, Erchul DT, Haight TJ, Ringhofer SN, Miller TL, Oliver Jr WC, et al. A comparison of bleeding and transfusion in patients who undergo coronary artery bypass grafting via sternotomy with and without cardiopulmonary bypass. J Cardiothorac Vasc Anesth. 2003; 17(4): 447–51.

Sandoughdaran S, Sarzaeem MR, Bagheri J, Jebelli M, Mandegar MH. Predictors of blood transfusion in patients undergoing coronary artery bypass grafting surgery. Int Cardiovasc Res J. 2013; 7(1): 25.