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Incidence of Acute Kidney Injury (AKI) for Patients Underwent CABG Operation Either On-Pump versus Off-Pump

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ABSTRACT

Background: Acute kidney injury (AKI) is described as an abrupt worsening of renal function, with a rise in serum creatinine levels and slow urine production. There is a high possibility to develop AKI about 30% after coronary artery bypass grafting (CABG) operation, 2% of them may need hemodialysis, which related with higher morbidity and mortality.

Objective: This study aimed to compare incidence of AKI between on pump versus off pump CABG.

Patients and Methods: A randomized retrospective observational comparative study that was done in Benisuef University. Patients' data was gathered from those who underwent CABG surgery through 5 years through the period from March 2017 to March 2022, where 100 patients had ischemic heart disease, underwent isolated CABG operation whether on pump or off pump in the department of Cardiothoracic Surgery, Faculty of Medicine, Benisuef University. Of them 50 had on pump CABG included in group A and the other 50 had off pump CABG included in group B. AKI incidence was compared between both groups.

Results: There was no statistically significant difference between both groups regarding patients' demographics, baseline clinical data and preoperative investigations results. Also, there was no statistically significant difference between both groups regarding operative data including urine output, intra-aortic balloon (IAB) pump and inotropic support usage intraoperatively. But, there was a statistically highly significant difference (< 0.01) between both groups regarding more intraoperative blood loss, blood transfusion, total surgery time and more arterial grafts other than left internal mammary artery (LIMA) that were used in group A. AKI occurred in 3 (6%) patients in group A of them 2 (4%) patients required temporary dialysis in the ICU and no patient required permeant dialysis in comparison with group B where 2 (4%) patients had AKI of them 1 (2%) patient required temporary dialysis in the ICU and no patient required permeant dialysis. So, there was no statistically significant difference between both groups. Regarding other postoperative morbidities, there was no statistically significant difference between both groups. Also, there was no difference in mortality where there was 1 (2 %) mortality in group A and 1 (2%) mortality in group B

Conclusions: There was no difference between on pump and off pump technique regarding the incidence of AKI and temporary and permanent dialysis. Also, there was no difference in the incidence rate of postoperative morbidity and mortality between both groups.

Keywords: AKI, Dialysis, Incidence, On pump, Off pump, CABG, Cardiopulmonary.

INTRODUCTION

AKI is characterized by a rapid decline in renal function accompanied by a rise in serum creatinine levels and a slow rate of urine production [1]. There is a high possibility to develop AKI about 30% after CABG operation, 2% of them may need hemodialysis [2], with increased rate of morbidity and mortality in those individuals with post-operative AKI [3, 4].

There are two schools for CABG and a lot of studies were done to compare the advantage and disadvantage of both techniques but still the short-, mid-, and long-term outcome of both techniques a controversial issue. Post-CABG AKI may occur with either an on- or off-pump technique. Renal hypoperfusion, hemolysis, hemodilution, inflammatory response and non-pulsatile flow that occurred in On-pump CABG was related with higher risk of post-operative AKI [5, 6].

Some studies showed that possible AKI that may occur for ischemic heart disease patients underwent off pump CABG operation may be due to technical difficulty of the procedure and excessive mobilization of the beating heart during graft positioning that may lead to hemodynamic instability, renal hypoperfusion and atheroemoblism from the side clamp that is applied on pressurized aorta [7]. In addition, some other studies showed that the on-pump CABG group had a greater incidence of AKI compared to the off-pump group [8, 9], but regarding, renal failure or mortality, there was no much difference between the two groups [8, 10, 11].

In this study, we compared the post-operative renal function, clinically and lab wise in patients who underwent CABG on pump versus off pump. The purpose of this study was to compare incidence of AKI between on pump versus off pump CABG.

PATIENTS AND METHODS

A randomized retrospective observational comparative study that was done in Beni-Suef University. Patients' data was gathered from those who underwent CABG surgery through 5 years from March 2017 to March 2022. 100 patients had ischemic heart disease, underwent isolated CABG operation whether on pump or off pump in the Department of

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Cardiothoracic Surgery, Faculty of Medicine, Benisuef University. Of them 50 had on pump CABG and the other 50 had off pump CABG.

Patients were divided into two groups based on the technique used in the surgery: Group A included 50 patients who were operated using on pump technique and group B that included 50 patients who were operated using off pump technique. Patients included in our study was selected to fulfill the following inclusion and exclusion criteria.

Inclusion criteria: Patients with CAD who underwent isolated CABG operation whether on pump or off pump.

Exclusion criteria: Patients with borderline renal functions creatinine above 1.6 mg/dl. Patients with chronic kidney disease. Patients with EF below 40%. Re-do CABG surgery. Off pump CABG surgery converted to on pump. Minimal invasive CABG. Urgent or emergency operation. Patients with ischemic or non-ischemic mitral regurgitation. Patients with combined procedure e.g., other valves & aorta surgeries.

For every patient in both groups, preoperative evaluation information was gathered, including:

1. Medical history, clinical examination findings, and identified risk factors.
2. Demographic data: Name, age, sex, residency, BSA, and comorbidities.
3. Clinical data: Dyspnea (NYHA classification), angina, consciousness, blood pressure and pulse.
4. Full Laboratory study: full labs including (renal function)
5. Chest x ray result.
6. Electrocardiogram (ECG) result.
7. Transthoracic echocardiography findings: EF% , mitral valve (morphology, MVA, VC, regurgitation & etc.), other valves pathology, PASP, LA dimensions.
8. Cardiac catheterization.
9. ECG changes.
10. Spirometry result.

Pre-operative preparation and anesthesia technique:

The protocol of pre-operative preparation was the same for all patients in both groups.

Type of Anaesthesia used:

There was no significant difference between both groups where general anesthesia was utilized in all patients. Transesophageal echocardiography (TOE) was performed in all groups intraoperatively. All of our patients were transported to the ICU post-operatively on mechanical breathing.

Surgical technique:

All our study group patients were operated through full sternotomy incision:

- **Group "A" (on pump CABG):** Where heart lung machine was used with warm antegrade cardioplegia with mild hypothermia (temperature drafting to 34-35 °C).
- **Group "B" (off pump CABG):** Where octopus were used in all cases and intra-coronary shunt were used in some cases.

Operative data:

Data collected for both groups:

- Technique used on pump or off pump.
- Urine output.
- Operative time.
- TEE for assessment of EF.
- Need of inotropic supports & intra-aortic balloon (IAB).

Post-operative data:

Data collected for both groups:

- Urine output, renal function, AKI, and need of dialysis.
- Post-operative blood loss and time of ICT removal.
- Re-exploration or not (for bleeding or revision of the grafts).
- Post-operative hemodynamics.
- Adding or weaning of inotropes.
- Mechanical ventilation (MV) duration.
- ICU and hospital stay duration.
- Morbidity or mortality.
- Postoperative chest X-ray or ECHO abnormal findings.
- OPD abnormal clinical or laboratory findings (if available).

Ethical approval: The Ethics Committee of Beni-Suef University's Faculty of Medicine accepted the study. Following receipt of all information, signed consent was provided by each participant. The Helsinki Declaration was adhered to at every stage of the investigation.

Statistical analysis

Version 24.0 of SPSS was utilized to perform the statistical analysis. Quantitative data to be expressed as mean ± SD as age, BMI, and cardiopulmonary bypass time. Qualitative data to be expressed as numbers and percentage (%) as comorbidities, operative complications. P value $\leq$ 0.05 was considered significant in testing relationships between variables.

RESULTS

There was no statistically significant difference between both groups regarding demographic data (Table 1).

Table (1): Patients' demographics and baseline clinical data

		Group A (50)	Percentage	Group B (50)	Percentage	P value
Age (year)	Mean ±SD	58.3±11.2		59.4±10.9		0.2
Sex	Male	22	44%	23	46%	0.19
	Female	28	56%	27	54%	
BMI (kg/m^2)	Mean ±SD	28.1±2.4		27.9±2.5		0.22
Smoker	Smoker	37	74%	39	78%	0.21
Chest disease	Chronic (COPD, asthma)	14	28%	15	30%	0.27
Chronic disease	DM	35	70%	37	74%	0.19
	HTN	30	60%	31	62%	0.26
	Dyslipidaemia	16	32%	17	34%	0.28
	Previous MI	19	38%	17	34%	0.21
	Previous PCI	8	16 %	٦	١٢%	0.24
	Liver impairment	0	0%	0	0%	

BMI; Body Mass Index, DM diabetes mellitus, HTN hypertension, COPD chronic obstructive pulmonary disease, PCI percutaneous coronary intervention.

There was no statistically significant difference between both groups regarding pre-operative investigations (Table 2).

Table (2): Patients' preoperative investigations results

		Group A (50)	Percentage	Group B (50)	Percentage	P value
Complete blood count	Chronic Anaemia	3	6%	2	4%	0.3
ECHO	LVEF (40-50%)	10	20%	11	22%	0.35
Coronary angiography (number-percentage)	Number of CAD 1 vessel disease 2 vessels disease 3 vessels disease LM disease	 2(4%) 7(14%) 41(82%) 15(30%)	 3(6%) 8(16%) 39(78%) 14(28%)			0.2 0.31
Euroscore II	Mean ±SD	2.1±1.3		2.2±1.2		0.2

LVEF left ventricular ejection fraction, CAD coronary artery disease, LIMA left internal mammary artery.

There was no significant difference between both groups regarding urine output, IAB pump and inotropic support usage intraoperatively. There was a statistically highly significance difference between both groups regarding more intraoperative blood loss, blood transfusion, total surgery time and more arterial grafts other than LIMA were used in group A (Table 3).

Table (3): Operative data

	Group A	Group B	P value
Urine output (ml /hour) (mean ± SD)	121.4±42.3	110.5±35.2	0.41
IAB pump (number-percentage)	1(2%)	2(4%)	0.34
Inotropic support	10(20%)	12(24%)	0.28
Blood loss (ml) (mean ± SD)	320.4±101.2	152.4±50.3	< 0.01
Blood transfusion (units) (mean ± SD)	2.4±0.8	1.1±0.3	< 0.01
Total surgery timetable (mean ± SD) (min.)	248.9 ± 49.2	181.2 ± 39.1	<0.01
Arterial grafts used (number-percentage) LIMA RIMA RADIAL Artery	 50(100%) 15(30%) 14(28%)	 50(100%) 2(4%) 1(2%)	 <0.01 <0.01

IAB intra-aortic ballon pump, LIMA left internal mammary, RIMA right internal mammary.

During surgery while weaning from cardio-pulmonary bypass, 5 (10%) patients required DC shock and 1 (2%) patient required temporary pacemaker in group A in comparison with group B where 3 (6%) patients required DC shock and 1 (2%) patient required temporary pace maker during surgery, which showed no statistically significant difference between both groups. Concerning MV, every patient in both groups was sent to the ICU. There was a statistically significant difference between the two groups regarding the duration of MV and timing of extubation, post-operative blood loss and transfusion, re-exploration for bleeding and ICU stay (Table 4).

Table (4): Mechanical ventilation duration, blood loss, blood transfusion, total ICU stay and re-exploration for bleeding

	Group A	**Group B**	**P value**
MV duration (hours) Mean ± SD	6.7±1.1	3.6±0.5	0.02
Blood loss (ml) Mean ± SD	510±93.4	202±45.7	0.02
Blood transfusion (unit), Mean ± SD	2.9±0.5	1.3±0.4	0.02
ICU stay (day) Mean ± SD	2.4±0.58	1.2±0.3	0.03
Re-exploration for bleeding or graft revision	4 (8%)	1 (2%)	0.02

AKI occurred in 3 (6%) patients in group A of them 2 (4%) patients required temporary dialysis in the ICU and no patient required permeant dialysis in comparison with group B where 2 (4%) patients had AKI of them 1 (2%) patient required temporary dialysis in the ICU and no patient required permeant dialysis. So, there was no statistically significant difference between both groups. Between the two groups, there was no statistically significant difference in any postoperative morbidities. Additionally, there was no difference in mortality between groups A and B, with 1 (2%) fatality in each group (Table 5).

Table (5): Morbidity and mortality

	Group A (95)	**Group B (124)**	**P value**
Morbidity			
Renal complication			
AKI	3(6%)	2(4%)	0.2
Dialysis			
Temporary	2(4%)	1(2%)	0.22
Permanent	0	0	0.21
IABP ICU application	2(4%)	1(2%)	0.22
Superficial wound infection	3(6%)	2(4%)	0.2
Deep wound infection	2(4%)	1(2%)	0.22
Arrhythmias	1(2%)	3(6%)	0.3
Stroke	1(2%)	1(2%)	0.92
Pneumonia (ARDS)	2 (4%)	2 (4%)	0.84
ICT insertion for pleural effusion	2(4%)	4(8%)	0.35
Mortality	1 (2%)	1 (2%)	0.92

DISCUSSION

So, we planned to compare the incidence of AKI between on pump versus off pump CABG by comparing the post operative renal function, clinically and lab wise.

In our study there was no statistically significant difference between both groups regarding patients' demographics, baseline clinical data and pre-operative investigation results. Also, there was no statistically significant difference between both groups regarding operative data including urine output, IAB pump and inotropic support usage intraoperatively. But, there was a statistically highly significant difference (< 0.01) between both groups regarding more intraoperative blood loss, blood transfusion, total surgery time and more arterial grafts other than LIMA were used in the on-pump group. AKI occurred in 3 (6%) patients in the on-pump group of them 2 (4%) patients required temporary dialysis in the ICU and no patient required permanent dialysis in comparison with the off-pump group where 2 (4%) patients had AKI of them 1 (2%) patient required temporary dialysis in the ICU and no patient required permanent dialysis. So, there was no statistically significant difference between both groups. Between the two groups, there was no statistically significant difference in any post-operative morbidities. Additionally, there was no difference in mortality between the on-pump group and the off-pump group, with 1 (2%) fatality in each case.

Our result is consistent with **Wang *et al.*** [12] result that was also a retrospective study where 932 patients were operated through the period from January 2012 to December 2016 who were divided equally in both groups. It showed no significant difference in incidence of AKI or mortality between on-pump (group A) and off-pump (group B) group, but they had a higher overall incidence of AKI (40.3% of all CABG patients) (197 in A group and 179 in B group) because their study included only patient ≥ 70 years undergoing CABG and there was a higher new onset of dialysis in 2.3% of all patients, with decreased survival rate [12]. Also, our result is consistent with the result of the German off pump CABG on elderly patients (GOPCABE)," by **Reents *et al.*** [13] where their study group included patients ≥ 75 years undergoing on-pump and off pump CABG. So, mostly the high incidence of AKI and new onset of dialysis may refer to the old age of the study group or their preoperative renal dysfunction, which are separate risk factors for AKI post CABG [14].

Mariscalco *et al.* [15] showed new onset of renal dialysis post-cardiac surgery at rate ranging from 1 to 6%. But, in Veterans Affairs Randomized On/Off bypass (ROOBY) study they had 0.9% incidence of new renal dialysis in the first 30 days postoperatively [16]. **Garg *et al.*** [17] analysed in details the kidney function of the CORONARY patient and showed that 1.2% of their study group had new renal dialysis post CABG.

Coronary is one of the largest randomized trials, it showed 4.1% reduction of incidence of AKI in the off-pump group in stage 1 AKI than on-pump group, without significant differences between both groups in more than stage 1 AKI or new renal dialysis incidence [18].

None of our group had chronic renal failure nor chronic dialysis but that happened in other studies, which showed progression of AKI to CKD and chronic dialysis [19]. Which may have negative effect on the long-term survival specially in elderly patients, which did not happen in our study group [20].

There was a still big controversy between on pump and off-pump and their effect and incidence of AKI and kidney injury as some studies say that CPB can affect renal function through impairing the normal renal physiology, which did not occur with off pump technique, but that issue still debatable with different outcome in different studies [15, 21]. **Wijeysundera *et al.*** [22] conducted an analysis of 22 risk-adjusted observational studies (n = 293,617) and 37 randomized controlled trials (n = 3449) and reported that the advantage of off-pump CABG was only shown in observational studies, with no meaningful difference in aggregate randomized trials.

Our study group showed that there was no statistical significance difference between both groups in occurrence of AKI and post-operative temporary dialysis, which may refer to short bypass time for on pump group, which decrease haemolysis incidence and time [23], with less inflammatory response [24, 25]. Maintaining high perfusion pressure in all the on-pump group all through the time, which maintain high perfusion pressure for all the body organs including the kidney [26]. Total revascularization in the on-pump group, which provide faster and better recovery for the heart, circulation, and renal circulation. Also, in off-pump group short transient renal hypoperfusion may occur during performing lateral wall grafts due to transient hypotension and hypoperfusion. In both groups the risk of atheroemoblism during aortic manipulation for proximal anastomosis is the same in both groups. So, the risk in both groups were nearly the same.

Till now there is no medication that can decrease the risk of incidence or to treat AKI that may happen after CABG. So, preoperative proper investigation and check-up should be done during patient preparation for CABG aiming to reduce the incidence rate of AKI post-CABG.

CONCLUSION

There was no difference between on-pump and off-pump technique regarding the incidence of AKI and temporary and permanent dialysis. Also, there was no difference in the incidence rate of postoperative morbidity and mortality between both groups.

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