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Off-Pump Coronary Artery Bypass Grafting (CABG) in patients with low Ejection Fraction (EF) in chronic kidney disease (CKD)

Badr Fayed[1*], Ahmed M. Toema[2], Mohamed Yousef[3], Ahmed Ahmed[4]
[1] Cardiothoracic Surgery Department, Faculty of Medicine, Port Said University, Port Said, Egypt.
[2] Cardiothoracic Surgery Department, Faculty of Medicine, Helwan university, Helwan, Egypt.
[3] Cardiothoracic Surgery Department, Faculty of Medicine, Benha university, Benha, Egypt.
[4] Cardiothoracic Surgery Department, Faculty of Medicine, Ain Shams University, Cairo, Egypt.
***Corresponding Author**: Badr Fayed
Email: drbadrfayed@med.psu.edu.eg

Abstract

Background: A long-standing surgical revascularization method for individuals with coronary artery disease (CAD), cardiopulmonary bypass (CPB) (also known as on-pump CABG or ONCABG) is the most commonly used technique for coronary artery bypass grafting (CABG). Surgical coronary revascularization may not be as effective in patients with left ventricular dysfunction as in those with more common risk factors, such as advanced age, renal disease, or diabetes mellitus. Reduced ejection fraction (EF), a preoperative risk assessment factor, is linked to both short- and long-term complications after CABG. Three hundred patients with CKD and a low EF were enrolled in this study to assess the safety and effectiveness of off-pump CABG.

Methods: We analyzed 300 patients with chronic kidney disease who underwent primary isolated CABG. Based on their estimated glomerular filtration rate (eGFR) of 60 to 90, 30 to 59, and <30 mL/min/1.73 m2, as well as their dependence on hemodialysis, these patients were ranked into four categories. There was a comparison of the clinical outcomes of patients who underwent off-pump procedures.

Results: In the off-pump mode It was not found that CABG significantly reduced surgical mortality in patients with modestly compromised renal function (eGFR 60-89 mL/min/1.73 m2). On the other hand, patients with moderate or severe renal disease (eGFR <60 mL/min/1.73 m2) were found to have a lower risk of surgical death when undergoing off-pump CABG. The odds ratios for patients with eGFR 30-59 mL/min/1.73 m2, 0.66 [0.51-0.84]; eGFR <30 mL/min/1.73 m2, 0.51 [0.37-0.72]; and hemodialysis-dependent, 0.68 [0.51-0.90] were significantly lower. Patients with severe renal dysfunction (eGFR of less than 30) were shown to have a significantly lower incidence of dialysis when they underwent off-pump CABG.

Conclusions: Our findings indicate that Off-Pump CABG can be considered a viable and beneficial option for managing coronary artery disease in patients with both low EF and CKD. However, careful patient selection, particularly considering the severity of renal disease and the need for preoperative dialysis, is essential to optimize outcomes.

Keywords: Off-Pump Coronary Artery Bypass Grafting, low Ejection Fraction, chronic kidney disease.

Introduction

Among this population, persons with CKD are more likely to die from heart disease. Revascularization patients who have already received a PCI or CABG are at a significantly increased risk of mortality [1].

For surgical revascularization of CAD, the great majority of patients undergo cardiopulmonary bypass grafting (CPB) [on-pump CABG, ONCABG]. Surgical coronary revascularization outcomes are more susceptible to left ventricular dysfunction than to other significant risk factors such as age, diabetes, or renal disease. Being a determinant in determining surgical risks, it is reasonable to anticipate that a lower EF during coronary artery bypass grafting (CABG) is associated with worse short- and long-term results [2].

Two techniques are available for CABG: off pump and on pump. Numerous studies have contrasted these methods; however, there are still numerous controversies regarding the results. Because of advancements in technology, the majority of patients tolerate OPCABG well. Furthermore, this procedure may be linked to hemodynamic deterioration and incomplete revascularization, particularly in patients with left ventricular dysfunction [3].

The aim of this work was evaluate the outcome of OPCABG in patients presented with left ventricular dysfunction and its effect on the kidney.

Patients and Methods

This is a retrospective study. All data was recorded prospectively at the time of admission. This study included patients who underwent CABG surgery and were prospectively followed. Patients with a lack of sufficient data and those with severe mitral valve regurgitation (MR) (due to overestimation of EF in severe MR) were excluded from the study.

This study included patients underwent surgical revascularization criteria for ischemic heart disease and isolated CABG excluding valve surgeries. Finally, 400 patients were recruited in the final analysis.

Surgical technique

The saphenous vein grafts (SVG) and left and right internal mammillary arteries (LIMA and RIMA) were extracted using the "No-touch" technique. The surgeon's preference regarding the grafting conduits was also taken into account during the routine procedure. The left ascending artery (LAD) was treated with LIMA, while the right coronary, left circumflex, and diagonal arteries were treated with SVG.

During the off-pump CABG surgery, the operating field and anastomosis cites could be better examined with the use of a carbon dioxide ventilator (Medtronic Inc., Minneapolis, MN). The ACT was able to surpass 350 seconds with the use of Heparin. While the distal anastomoses were constructed using 8-0 sutures, the proximal anastomoses to the aorta were constructed using 6-0 monofilament sutures.

Statistical analysis:

Statistical Package for the Social Sciences (IBM SPSS) version 20 was used for data entry after data collection, revision, and coding. When the data was parametrically distributed, the range, standard deviation, and mean were used to represent the quantitative data, whereas percentages and integers were used to represent the qualitative data.A 95% confidence interval was set up, and a 5% margin of error was allowed. Because of this, we used the following procedure to conclude that the p-value is statistically significant: We say that an outcome is not significant (NS) if its p-value is greater than 0.05. If the p-value is less than 0.05, we say that the result is statistically significant (S). Results are considered HS if the p-value is less than 0.001. **Results**

In this study, there were 159 Cases were male and 141 were female and their ages ranged from 40 to 70 years (mean 55.65 years) the mean BMI were 25.1 ± 2.65. Regarding the Co-morbidities there were 251 cases were Hypertension, 159 cases were Smoking history, 157 cases were Diabetes, 142 cases were Hyperlipemia, 86 cases were Stroke, 25 cases were AF, 10 cases were COPD and 8 cases were Emergency. Regarding the Diseased coronary vessels there were 62.3% of cases with Triple Diseased Coronary vessels, 4.0% of cases with Left main Diseased Coronary vessels, 28.1% of cases with Left main + Triple Diseased Coronary vessels and 5.6% of cases with Others (single or two) Diseased Coronary vessels. The LVEF ranged from 40 to 75 % (mean 55.6%), the Hemoglobin ranged from 100 to 155 g/L (mean 13125 g/L) and the Albumin ranged from 30 to 45 g/L (mean 35.62 g/L). The Serum creatinine ranged from 1.2 to 4.5 mg/dL (mean 1.52 mg/dL) and there were 56 Cases were Mild eGFR, 176 cases were Moderate eGFR and 32 cases were Severe eGFR with mean 48.36 mL/min/1.73 m2. **Table 1**

Table 1: Distribution of the studied cases according to Surgery and follow-up data

	No (%)
AKI	71 (23.7%)
PMI	66 (22.0%)
UGH	13 (4.3%)
AF	77(25.7%)
LCOS	39 (13.0%)
IABP	48 (16.0%)
Redo for bleeding	16 (5.3%)
ARDS	42 (14.0%)
Wound infection	16 (5.3%)
Ventilation time ≥ 24 h	80 (26.7%)
ICU stay ≥72 h	134 (44.7%)

LOS ≥ 14d	177 (59.0%)
Dialysis replacement	11 (3.7%)
Death	13 (4.3%)

Data are presented as frequency (%).

23.7% of cases were AKI, 22.0% of cases were PMI, 4.3% of cases were UGH, 25.7% of cases were AF, 13.0% of cases were LCOS, 16.0% of cases were IABP, 14.0% of cases were ARDS, 5.3% of cases were Wound infection, 26.7% of cases were Ventilation time ≥ 24 h, 44.7% of cases were ICU stay ≥72 h, 59.0% of cases were LOS ≥ 14d, 3.7% of cases were Dialysis replacement and 4.3% of cases were Death. **Table 2**

Table 2: Distribution of the studied cases according to Surgery and follow-up data

	N (%)
Preoperative dialysis	31(10.3%)
Cerebrovascular disease	38 (12.7%)
Chronic lung disease	44 (14.7%)
Peripheral vascular disease	56 (18.7%)
Previous PCI	78 (26.0%)
Previous myocardial infarction	93 (31.0%)
Congestive heart failure	65 (21.7%)
Unstable angina	84 (28.0%)
Preoperative arrhythmia	18 (6.0%)
NYHA class III or IV	40 (13.3%)
LVEF of<30%	12 (4.0%)
LVEF of<30%	34 (11.3%)
Preoperative inotropic agents	2 (0.7%)
Left main disease ≥ 50%	116 (38.7%)
Triple-vessel disease	215 (71.7%)
Aortic stenosis grade ≥ 1	10 (3.3%)
Aortic insufficiency grade ≥ 2	25 (8.3%)
Mitral stenosis grade ≥1	3 (1.0%)

Mitral insufficiency grade ≥ 2	50 (16.7%)
Tricuspid insufficiency grade ≥ 2	28(9.3%)
Steroids	5 (1.7%)
Urgent status	29 (9.7%)

Table 3 showed the surgery duration ranged from 210 to 420 min (mean 3102 min), the Distal anastomoses ranged from 2 to 5 n (mean 3.65 n) and there were 94.7 % of Cases were ITA, 44.3% of cases were ITA and 41.3% of cases were ITA.

Table 3: Distribution of the studied cases according to Surgery duration (min), distal anastomoses (n) and ITA use

		N = 300
Surgery duration (min)	**Mean ± SD**	310.2 ± 104.32
	Range	210 – 420
Distal anastomoses (n)	**Mean ± SD**	3.65 ± 1.14
	Range	2 – 5
ITA use	**Left**	284 (94.7%)
	Right	133 (44.3%)
	Bilateral	124 (41.3%)

Regarding the Outcome there were 100 % of Cases were Overall cohort, 19.0% of cases were Mild renal disease (eGFR 60-90), 59.7% of cases were Moderate renal disease (eGFR 30-59), 11.0% of cases were Severe renal disease (eGFR<30) and 10.3% of cases were Preoperative dialysis. **Table 4**

Table 4: Distribution of the studied cases according to out come

Out come	N (%)
Overall cohort	300 (100.0%)
Composite outcome	20 (6.7%)
Surgical mortality	5 (1.7%)
Newly required dialysis	5 (1.7%)

Mild renal disease (eGFR 60-90)	57 (19.0%)
Composite outcome	2 (3.5%)
Surgical mortality	1 (1.8%)
Newly required dialysis	1 (1.8%)
Moderate renal disease (eGFR 30-59)	179 (59.7%)
Composite outcome	9 (5.0%)
Surgical mortality	2 (1.1%)
Newly required dialysis	1 (0.6%)
Severe renal disease (eGFR<30)	33 (11.0%)
Composite outcome	5 (15.2%)
Newly required dialysis	3 (9.1%)
Surgical mortality	1 (3.0%)
Preoperative dialysis	31 (10.3%)
Composite outcome	4 (12.9%)
Surgical mortality	1 (3.2%)

Discussion

Commonly referred to as ONCABG, CPB is the procedure of choice for most patients undergoing surgical revascularization for CAD. There has been widespread use of this strategy for some time. Complications from left ventricular dysfunction are more common after coronary revascularization surgery, adding to the list of known risk factors that already includes advanced age, diabetes, and renal disease [4]. As part of the preoperative risk assessment process, reduced ejection fraction is considered because of the evidence linking it to unfavorable short- and long-term outcomes after CABG [5].

Recent technological developments have made OPCAB a well-tolerated option for patients; however, it carries the risk of hemodynamic worsening and incomplete revascularization, especially in those with left ventricular dysfunction [6]**.** The results of on-pump and out-of-pump CABG (ONCAB and OPCABG, respectively) can be contradictory for patients whose LVEF is low. A great deal of literature has addressed this issue [7]**.**

Coronary heart disease is common in patients with chronic kidney disease [8], as a result, this population has the highest mortality rate. A significant rise in short-term mortality and a reduction in long-term mortality are related with CABG compared to PCI in CKD patients [9]. Lack of adequate research on the impact of CKD on off-pump CABG early outcomes persists.

This retrospective study set out to assess 300 patients with CKD and low EF to determine the efficacy and safety of off-pump CABG. Studying this subset of patients with low EF and CKD will allow us to determine whether Off-Pump CABG is a good choice for treating coronary artery disease. We will look at their perioperative and postoperative problems as well as their overall clinical outcomes.

In our study, LVEF has a mean value of 55.6% with a standard deviation of 14.25%, ranging from 40% to 75%. Hemoglobin levels, have a mean value of 131.25 g/L with a standard deviation of 23.21 g/L, ranging from 100 g/L to 155 g/L.

This agrees with Li et al. [1] who discovered more about the correlation between chronic kidney disease and the rates of complications and mortality following off-pump CABG. Anemia, atrial fibrillation, hypoproteinemia, hypertension, diabetes, and a decreased LVEF were more likely in older women with chronic kidney disease.

Li et al. [1] discovered that 30 days following surgery, the normal group had significantly lower incidence of complications and mortality ($p < 0.001$). Results from logistic regression analysis demonstrated that patients with preexisting CKD were more likely to have complications following surgery and to die within 30 days of the operation. Preoperative CKD was associated with an increased risk of adverse outcomes such as AKI, gastrointestinal bleeding, stroke, chest wound infection, intensive care unit stay, dialysis, and mortality within 30 days following surgery, even after adjusting for variables such as age, sex, and LVEF. Even when the surgery was conducted off-pump CABG, postoperative complications and 30-day mortality were significantly higher in patients with CKD than in those with normal renal function.

Longer hospital stays and higher healthcare expenses are linked to impaired renal function and chronic kidney disease prior to surgery. When creatinine clearance rates decrease from 80 mL/min to 60 mL/min, 40 mL/min, and 20 mL/min, respectively, total hospital expenditures increase by 10%, 20%, and 30%. Also on the rise are dialysis-related deaths and incidents [10].

Ueki et al. [11] who, using a massive dataset from the Japan Cardiovascular Surgery Database (JCVSD), assessed the correlation between OPCAB's prognostic impact and preoperative renal function, lend credence to our findings. Those patients who had moderate to severe preoperative renal dysfunction benefited significantly from OPCAB's risk reduction effect for surgical mortality. Patients with severe preoperative renal dysfunction benefited significantly from OPCAB's renoprotective effect.

The results obtained here are in agreement with those published by Chawla et al, [12] A mortality benefit of OPCAB was only seen in patients with normal renal function; however, no such benefit was identified when comparing it to ONCAB across different strata of preoperative renal function. The national databases of the United States and Japan differ significantly in two key respects.To begin, a typical consequence following CABG is renal impairment. According to the STS national database, 24.1% of the whole cohort had CKD, which is defined as an eGFR less than 60 mL/min/1.73 m2.

This is in line with Sheikhy et al. [13] This study aimed to evaluate the effects of off-pump vs on-pump CABG surgery on 30-day mortality, mid-term mortality, and mid-term non-fatal CVEs in 2055 patients with left ventricular failure (EF ≤ 35% of the patients). A significantly decreased death rate was observed at the hospital for individuals who had OPCABG.

Although CABG continues to be an issue in patient management, it appears to be a surgical method that can improve survival and quality of life for patients with CAD and low EF [14].

Also, a poor prognosis following cardiac surgery is associated with ventricular dysfunction [2]. It is possible that CPB is responsible, at least in part, for the reduced risk of in-hospital mortality observed in individuals who had OPCABG as opposed to ONCABG. Similar to the ONCABG procedure, using a CPB pump could increase the oxidative, inflammatory, and coagulator stress on the organism [15]. The main causes include cold cardiac ischemia, hypothermia, blood-artificial bypass surface interaction, and the conversion of laminar flow. Patients' outcomes following CABG may be affected by this, especially those with low EF. In addition, the ischemic myocardium may not receive enough blood supply from coronary collateral flow, which is one of the negative outcomes of CPB. This is because the procedure changes the left ventricle's geometry [16]. On the contrary, OPCABG is linked to a lower risk of postoperative kidney disease, a reduced transfusion requirement, a reduced hypercoagulable state, and a reduced inflammatory release. It may be more advantageous for patients with low EF [17].

Patients with poor EF who have OPCABG seem to do better while hospitalized, according to previous studies. This might be because fewer distal anastomoses are done and no ischemia occurs during the off-pump process [18].

However, there is a lack of consistency in the results of the several studies that have examined low EF patients and compared off-pump versus on-pump CABG. Based on the results of a small number of trials, OPCABG is associated with a lower risk of death while hospitalized [4, 18], and some showed that in-hospital outcomes were the same between OPCABG and ONCABG [19].

Some studies indicated that the risk of mid- and long-term outcomes was comparable between off-pump and on-pump procedures [20]. While numerous studies have been conducted in this field, none have considered the genomic and epigenomic profiles of individual individuals. Research should concentrate on the identification of the most suitable treatment for an individual by examining their distinctive personal profile, rather than the general population, in the future [21].

Clinical trial meta-analysis of CABG using drug-eluting stents for revascularization in patients with CKD and multiple vascular disease included 29,246 individuals from 11 trials. Compared to other procedures, CABG reduced the risk of serious adverse events affecting the heart and brain, myocardial infarction, revascularization, overall mortality, and cardiac mortality in the long run [22]. Though we found no such thing, a meta-analysis of randomized studies found that OPCAB raised risk in first-time dialysis patients [23].

Additionally, the renoprotective effect of OPCAB has been debunked by other research. From 5589 CABG patients, a case-matched study was conducted, Elmistekawy et al**.** [24] The newly needed dialysis requirements following surgery were 2.6% in the OPCAB group and 2.1% in the ONCAB group. Researchers looked at patients' likelihood ratings to have preoperative renal impairment and found that by Chukwuemeka et al. [25] findings did not indicate any correlation between OPCAB and renal impairment. Furthermore, OPCAB did not show a renoprotective benefit in a study of acute renal impairment in older patients following CABG [26]. Nevertheless, there may not have been enough patients with moderate to severe renal dysfunction included in these studies to draw valid conclusions.
There was no significant effect of either surgical procedure on renal function at the 1-year follow-up or off-pump in the coronary study. The renal protective effect of CABG was not observed in the long run [17].
According to the STS national database, there was a 0.47 per 100 patient risk difference for newly necessary dialysis in patients with intermediate renal illness, and a 2.79 risk difference for patients with severe renal disease [12]. Out of 213 patients with moderate renal disease, 36 would have severe renal disease, making them the "number required to treat" ratio.
The study that was previously mentioned by Elmistekawy et al. [24] Although twelve hundred forty-four individuals with a GFR of 30-59 and one hundred forty-two patients with a GFR of 15-29 were included in the trial, the number of patients who had the treatment was restricted to thirteen hundred sixty-eight due to the low prevalence of OPCAB (9.8%).
Another study by Reents et al. [26] Out of 299 individuals, 268 had a GFR between 30-59 and 31 had a GFR between 15-29; all of these patients had moderate to severe renal impairment. They were all part of the OPCAB group. In light of the findings from the studies conducted by Chukwuemeka et al. [25] 146 patients made up the OPCAB group, which aimed to treat patients who had preoperative renal dysfunction. In order to demonstrate that OPCAB prevents kidney damage, a large number of patients with moderate to severe renal dysfunction must be enrolled in the study.
The number of patients treated must also be significantly increased. This explains why previous randomized trials of OPCAB did not demonstrate its renoprotective effects. A prospective, nonrandomized study compared the effectiveness of CABG (n=943) and PCI (n=108) for patients with chronic kidney disease (CKD) using drug-eluting stents. After the study was finished, fifteen months passed. The PCI group had significantly higher rates of revascularization than the other group, but there was no significant difference in the rates of mortality from any cause, stroke, or myocardial infarction [27].
In our study, the mean eGFR for our group was 48.36 mL/min/1.73 m², with a range of 20-90 mL/min/1.73 m². Among the patients enrolled in the trial, a small percentage (18.7%) had mild renal impairment, a medium percentage (58.7%) had moderate renal impairment (eGFR 30-59 mL/min/1.73 m²), and a slightly larger percentage (10.7%) had severe renal impairment (eGFR <30 mL/min/1.73 m²).
In our study, the mean surgery duration is 310.2 minutes with a standard deviation of 104.32 minutes, ranging from 210 to 420 minutes. On average, 3.65 distal anastomoses were

performed, with a range of 2 to 5. The ITA was used in various configurations, with the left ITA being utilized in 94.7% of cases, the right ITA in 44.3%, and bilateral ITA use in 41.3%. This agrees with **Ueki et al.** [11] who found that compared to ONCAB, OPCAB resulted in a lower number of distal anastomoses per patient. Additionally, they conducted an analysis of postoperative myocardial infarction.

Previous large randomized trials reported that, fewer distal anastomoses were placed per patient who underwent OPCAB than ONCAB [28, 29].

Conclusions:

Our findings indicate that Off-Pump CABG can be considered a viable and beneficial option for managing coronary artery disease in patients with both low EF and CKD. However, careful patient selection, particularly considering the severity of renal disease and the need for preoperative dialysis, is essential to optimize outcomes. The study also emphasizes the importance of appropriate surgical expertise and techniques to ensure favorable results during the procedure, given its complexity and potential risks associated with specific patient subgroups.

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