The Egyptian Cardiothoracic Surgeon

Vol. 2, No. 4, 155 - 161

Original Article

Off-pump coronary bypass grafting with or without the use of intracoronary shunts

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Abstract

Background: There is scarce literature comparing the role of the intracoronary shunt during off-pump coronary artery bypass grafting (CABG). This study aimed to compare off-pump CABG using intracoronary shunt versus the coronary clamp during distal coronary artery anastomosis.

Methods: We conducted this randomized study between January and June 2018. We randomized 30 patients into two groups. Group A (n= 15) included patients who had coronary clamping during off-pump CABG, and Group B (n= 15) included patients who had intracoronary shunt during off-pump CABG. Study endpoints were anastomosis time and postoperative cardiac enzyme levels.

Results: The mean age of the shunt group was higher than the mean age of the clamp group (61.06 ± 7.26 vs. 56.72 ± 12.44, respectively, p=0.03). Our study showed no statistical difference between the two groups regarding sex (p>0.99), hypertension (p>0.99), and diabetes (p=0.14). The distal anastomosis time was longer in the shunt group than in the clamp group (39.80±4.55 vs. 32.27±6.06 minutes, respectively, p=0.001). The postoperative troponin I (0.61±0.11 vs. 0.26±0.089 ηg/ml, p<0.001), and CK-MB levels (44.27±5.34 vs. 35.5±4.86 IU/L, p<0.001) were significantly higher in the clamp group.

Conclusion: The intracoronary shunt could be associated with lower cardiac enzyme release compared to the clamp technique. However, it was associated with a longer distal anastomosis time.

KEYWORDS

Coronary artery bypass grafting; Off-pump surgery; Intracoronary shunt; Coronary clamping

Article History

Submitted: 28 Apr 2020

Revised: 12 May 2020

Accepted: 22 June 2020

Published: 1 Oct 2020

Introduction

In patients with multivessel coronary artery diseases (CADs), the recommended intervention is Coronary artery bypass grafting (CABG). The use of cardiopulmonary bypass and cardioplegic arrest can induce a systemic inflammatory response, which has the potential for induction of multi-organ dysfunction [1]. In patients with severe left ventricular dysfunction, pulmonary, hepatic, and renal dysfunction, the off-pump CABG was found to be a safe alternative [2]. The off-pump technique is of particular importance in patients with significant aorta calcification and carotid stenosis, as well as patients with chronic respiratory and kidney disease [3].

The experience of the surgeon, anatomical positions of coronary arteries, and cardiac dimensions are major factors affecting the choice between on-pump or off-pump CABG [4]. The implementation of special devices such as local myocardial stabilization systems of vacuum or

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compression types and intracoronary shunts into clinical practice facilitated the development of techniques for myocardial revascularization on a beating heart [5].

The bloodless surgical site is essential for performing a good anastomosis. However, during distal anastomosis, continuous coronary blood flow may impair proper visualization. Surgeons may choose to use clamping or intracoronary shunting depending on their own experience or coronary artery anatomy, including the length and diameter of the target vessel [6].

The clamping of coronary arteries may trigger an ischemic reaction. In the case of adequate collateral blood flow, patients normally tolerate temporary occlusion of critically stenotic or occluded coronary arteries [7]. Additionally, beating-heart manipulation can result in hemodynamic and electrical instability. The intracoronary shunts have been configured to guarantee distal blood flow during the bypass process. Previous intracoronary models were quite rough, hard to install and remove, they tended to bend with the low blood flow parameter, and there were no small models available [8]. The latest generations are more convenient; they have atraumatic tips, improved blood flow specifications, and are available in different dimensions up to 1 mm small and 2.5 mm large to meet different coronary dimensions. It is useful to use temporary intracoronary shunts to prevent regional ischemia and air embolism as well as to make it possible to do bypass surgery on the dry surgical field [9]. The application of these shunts enables us to avoid left ventricular dysfunction during CABG and to generate a dry surgical field, thus eliminating complications associated with coronary artery wall damage when clamped. It is safe for patients with unstable angina, impaired left ventricular function, and, in the cases of the long-time anastomosis [10]. Furthermore, the use of intracoronary shunts is recommended for patients with thin walls where the shunt is used as a coronary artery stabilizer and prevents the seeding of its rear wall also into calcified coronary arteries where clamping may lead to coronary crushing, which can be ineffective in the development of a dry field [11,12].

Despite the theoretical advantages of intracoronary shunts, few studies had compared off-pump CABG with or without the use of intracoronary shunts. In this study, we aimed to compare off-pump CABG using intracoronary shunt and off-pump CABG using coronary clamp regarding the anastomotic time, postoperative complications, postoperative ejection fraction (EF) and troponin I level.

Patients and Methods:

Study design and patients:

We conducted this randomized study between January 2018 and August 2018 on 30 patients who underwent off-pump CABG. We randomly divided the patients into two groups. Group A included patients who had coronary clamping during off-pump CABG, and Group B included patients who had off-pump CABG with the use of an intracoronary shunt.

We included patients who had primary isolated CABG via a median sternotomy. We excluded patients with left ventricular ejection fraction (EF) less than 35%, ventricular aneurysm, renal insufficiency with a serum creatinine level >200 mg/L. Additionally, we excluded patients with re-operative CABG or CABG with concomitant procedures and those older than 80 years.

Data collected and outcomes:

Patients in both groups were compared regarding age, sex, presence of hypertension, and diabetes mellitus. Patients in both groups were also evaluated regarding preoperative and postoperative ejection fraction. Samples were taken for evaluation of 24 hours postoperative troponin I, CK and CKMB (the normal values for troponin is <.01 ng/ml, for CK 60-174 IU/L, for CKMB 5-25 IU/L) [13]. Both groups were evaluated regarding the postoperative need for inotropic support>24 hours, new ECG changes, the difference in proximal and distal anastomotic times.

Operative technique:

All patients had the same anesthetic technique. The left internal mammary artery (LIMA) was harvested before the pericardiotomy. Through changing the mattress temperature, systemic

Table 1: Comparison of the baseline characteristics, the need for inotropic support, and ECG new ischemia in both groups. Continuous data are presented as mean and SD and categorical data as number and percent

Variables	Clamp group (n= 15)	Shunt group (n= 15)	p value
Age (years)	56.72 ± 12.44	61.06 ± 7.26	0.036
Male	8 (53.3%)	8 (53.3%)	>0.99
Hypertension	10 (66.7%)	11 (73.3%)	>0.99
Diabetes	9 (60.0%)	4 (26.7%)	0.14
The need for inotropic support > 24 hours	7 (46.7%)	4 (26.7%)	0.45
ECG new ischemia	7 (46.7%)	3 (20.0%)	0.245

hypothermia was avoided. Partial anticoagulation was performed with 1 mg/kg heparin body weight.

Continuous follow-up of central venous pressure, heart rate, and systemic arterial pressure were carried out. LIMA to LAD bypass grafting was applied to every patient in both groups using the off-pump technique. Preparations for coronary arteriotomy were made following the exposure and stabilization of the LAD. During distal anastomosis, heart stabilizers were used. The soft silicone snares were placed 0.5 cm closer to the expected target for producing a bloodless anastomotic field following arteriotomy. After the last anastomosis suture, the LAD was declamped. Since opening the LAD artery, an intracoronary shunt was inserted into the coronary artery. Shunt size was measured before opening the coronary by analyzing the external appearance of the vessel. In the direct vision, shunts were inserted, and first, the proximal end was placed. Just before kneading the last suture, the shunt was extracted. An air blower device (Medtronic Inc. Minneapolis, MN, USA) with a saline aerosol aided invisibility. All distal anastomosis was done using 7/0 polypropylene sutures, while proximal anastomosis was done using 6/0 polypropylene.

Statistical analysis:

We performed a statistical analysis using the statistical package of social science (SPSS, windows version 22, IBM Corp, Chicago, IL, USA). All continuous data were presented as mean, and standard deviation (SD) and categorical data were presented as frequencies and percentages. We used student t-test to compare means from both groups and paired t-test for related outcomes. Categorical variables were compared using Chi-square or Fisher exact test when appropriate. A p-value of less than 0.05 is considered significant.

Results

Demographics and Clinical characteristics:

The mean age of the shunt group was higher than the mean age of the clamp group (61.06 ± 7.26 vs. 56.72 ± 12.44, respectively, p=0.03). Our study showed no statistical difference between the two groups regarding sex (p>0.99), hypertension (p>0.99), and diabetes (p=0.14). Moreover, seven cases of the clamp group needed inotropic support postoperatively versus four cases of the shunt group (p=0.45). In addition, seven cases of the clamp group had ECG new ischemic changes, and three cases of the shunt group had ECG new ischemic changes (p=245). (Table 1)

Study Outcomes:

In the shunt group, there was no significant difference between pre- and postoperative EF (p=0.17). However, the levels of troponin I, CK, and CK-MB significantly increased postoperatively (p=0.001). Similarly, there was no significant difference between pre- and postoperative EF in the clamp group (p=0.706). The elevation in the levels of troponin I, CK, and CK-MB was statistically significant (p<0.001). Regarding the comparison between shunt and clamp groups, there was no significant difference between both groups in terms of the preoperative EF (p=0.736), CK (p=0.561), CK-MB (p=0.139). Additionally, there was no significant difference between both groups in terms of postoperative EF (p=0.659). On the other hand, a significant elevation was observed in the clamp group than the shunt group in terms of postoperative troponin I, CK, and CK-MB (p<0.001). (Table 2)

Table 2: Comparison between the ejection, Troponin I. CK, and CK-MB pre and postoperatively in the clamp and shunt groups. Data are presented as mean and SD.

Variables	Clamp group		P-value	Shunt group		P-value	P-value*
	Preoperative	Postoperative		Preoperative	Postoperative		
EF (%)	58.60±4.97	59.20±3.55	0.706	58.01±3.5	59.7±2.96	0.17	0.659
Troponin I (ng/ml)	0.00±0.00	0.61±0.11	<0.001	0.00±0.00	0.26±0.089	0.001	<0.001
CK (IU/L)	68.73±6.22	861.67±40.11	<0.001	66.8±11.1	671.9±52.35	0.001	<0.001
CK-MB (IU/L)	17.80±2.27	44.27±5.34	<0.001	16.1±3.8	35.5±4.86	0.001	<0.001

*P-value of postoperative levels between both groups

Furthermore, we found that the distal anastomosis time was longer in the shunt group than in the clamp group (39.80±4.55 vs. 32.27±6.06, respectively, p=0.001) On the other hand, the proximal anastomosis time was similar in both groups (p>0.99). In addition, there were no statistical differences between the numbers of grafts between the two groups (p=0.382). (Table 3)

Discussion

The intracoronary shunt is used to revascularize the LAD and proximal right coronary artery (RCA) more frequently than other vessels. The circumflex and distal RCA are theoretically more difficult to insert shunt in them with a higher risk of endothelial denudation; additionally, proximal RCA ischemia is empirically proven to cause arrhythmia, including atrioventricular block [14,15].

Endothelial cells are well known to play a critical role in controlling vascular homeostasis [16]. The endothelium is impaired by some mechanical interaction [17]. There is evidence connecting the use of intracoronary shunts with mechanical damage to the coronary artery endothelium [18]. In surgery, however, the damage to the endothelium can also be caused by the use of locking sutures around coronary arteries, clamping the artery with a bulldog clamp and clips, and gas insufflation in the anastomosis region [19]. These aspects should be considered during the construction of the coronary anastomosis [20].

Grunenfelder and colleagues investigated the correlation between the volumetric flow rate and the pressure in the coronary artery through an in vitro shunt study. They demonstrated that the flow rate through a 1.5 mm shunt was 40 ml/min against a systemic pressure of 75 mm Hg and more than 40 ml/min with larger shunts. According to those results, even at a blood pressure of 75 mm Hg, 1.5- and 2.0-mm shunts will provide sufficient myocardial perfusion [21].

In accordance with our findings, Rivetti and associates stated that clamping in the target coronary arterial territory causes ischemia, and late-term stenosis may occur due to endothelial damage with subsequent ischemia.

Table 3: Comparison between the number of grafts, the proximal and the distal anastomosis times in the clamp, and shunt groups. Data are presented as mean and SD.

	Clamp group (n= 15)	Shunt group (n= 15)	P-value
Number of grafts	3.27±0.70	3.47±0.52	0.382
Distal anastomosis time (minutes)	32.27±6.06	39.80±4.55	0.001
Proximal anastomosis time (minutes)	13.47±3.60	13.47±3.34	>0.99

Local thrombosis and rupture of atherosclerotic plaque may also occur and demonstrated that the use of intraluminal shunt reduced coronary ischemia [11].

Hangler and colleagues reported the significance of using intracoronary shunt in patients with serious ischemia. In addition, Bozok and coworkers showed lower rates of postoperative troponin I and lower levels of myocardial edema in beating heart CABG with intracoronary shunting, pointing out that this elevation may be perceived as a reversible injury rather than frank myocardial necrosis, so they suggested the use of shunting in patients susceptible to transient ischemia [12,22].

Based on cardiac enzymes and an echocardiographic examination, Emmiler and collaborators compared the shunt group with a shunt-less group. Their observations were in agreement with Bozok and colleagues' findings [22,23]. Likewise, Menon and associates and Gandra and coworkers reported that the application of intracoronary shunt decreased ischemia in the coronary artery and abnormalities in wall motion [24,25].

Postoperative troponin release was lower in the shunt group, while distal anastomosis was longer. Our findings were in agreement with other studies [26]. Gurbuz and colleagues found higher troponin I level in patients without intracoronary shunting, and Bozok and coworkers recorded longer intracoronary shunt anastomosis time with intracoronary shunt usage [22,27]. These findings may be due to the time taken to insert and remove the shunt, which requires extra careful handling to prevent damage to the intima [28]. In contrast, Hangler and collaborators demonstrated that the use of intracoronary shunt caused distal coronary artery endothelial damage and indicated that this technique should only be used in selected cases [6].

Yeatman and colleagues measured hemodynamic parameters in patients with multiple coronary artery lesions undergoing off-pump CABG with or without intracoronary shunts. Before and after the application of distal anastomoses, hemodynamic parameters were measured. Major reduction in stroke volume, cardiac index, and blood pressure in the second group were also associated with the application of anastomosis to LAD [29]. The most prominent hemodynamic changes, such as a decrease in stroke volume, cardiac index, systemic blood pressure, and an increase in central venous pressure, were observed in both groups during the application of the anastomosis on the circumflex branch of the left coronary artery. These changes returned to their initial values after the heart was placed back in its anatomical position while stroke volume and cardiac index remained reduced in the second group [30].

Study limitations

The major limitation of the study is the small sample size. Despite randomization, there was an unequal distribution of age between groups. The study is a single-center experience, and generalization of our findings to other centers may not be applicable. A larger study is recommended to confirm our findings.

Conclusion

The intracoronary shunt could be associated with lower cardiac enzyme release compared to the clamp technique. However, it was associated with a longer distal anastomosis time.

Conflict of interest: Authors declare no conflict of interest.

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