Early postoperative outcomes of coronary artery bypass grafting patients on-pump versus off-pump

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Coronary artery bypass grafting (CABG) is defined as "open-heart surgery in which a section of a blood vessel is grafted from the aorta to the coronary artery to bypass the blocked section of the coronary artery. Cardiac surgery became more feasible in the late 1930s with the development of the heart-lung machine by Dr. John Gibbon which enabled cardiopulmonary bypass (CPB). This study aimed at comparing early postoperative outcomes between patients undergone CABG on-pump versus off-pump. The study was done on 40 patients, 20 of them was done by on-pump technique and the other 20 was done by off-pump technique. All the patients were transferred to intensive care unit and were observed for the following criteria: Early postoperative bleeding, Cardiac support (Medical or Mechanical), Different types of Arrythmias, Renal function and Hospital stay. Early postoperative bleeding: appears to be more with On-pump technique in the first 3 post operative days. Cardiac support (Medical or Mechanical): No significant difference with both techniques. Different types of Arrythmias: No significant difference with both techniques. Renal function: No significant difference with both techniques except of only one patient needed renal dialysis was done by on-pump technique. Hospital stay: No significant difference with both techniques with mean days of hospital stay for all patients of 8 days. In conclusion, our trial did not show any overall advantage to the use of the off-pump as compared with the on-pump cardiac surgical approach for coronary bypass grafting.

Keywords: CABG, cardiopulmonary bypass, IHD, OPCAB, ONCAB.

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Introduction

First introduced in the mid-1960s, coronary artery bypass grafting (CABG) is the gold standard treatment for patients with extensive coronary artery disease [1]. The first successful open-heart operation using cardiopulmonary bypass (CPB) was carried out in 1952 [2]. The development and success of this approach has undoubtedly contributed to the decline in deaths owing to coronary artery disease that has occurred in developed countries during the past five decades [1]. However, coronary revascularization on CPB with its attendant aortic manipulation has been implicated in various complications, including increased risk of stroke [3,4] and stimulation of a systemic inflammatory response [5]. This led in the mid-1980s to renewed interest in performing CABG on the beating heart[6] helped by the development of various stabilizing devices[7] like tissue stabilizer and coronary clamping, which offer an applicable option for optimal visualization during off-pump CABG [8], despite the increased difficulty of this approach [5]. Since that time, there has been ongoing debate as to which technique is superior, including several meta-analyses that have not fully answered the question [3,4,9,10]. A good illustration of the dichotomy is the fact that 95% of CABGs in India are performed off-pump [5], whereas the figure in the United Kingdom is ~ 20% [11]. The most important factor governing the choice of whether to choose on-pump or off-pump is the long-term outcomes. Until now, these have been difficult to assess owing to the lack of long-term reporting from randomized controlled trials. Some resolution to this problem has recently occurred with the publication of the 5-year outcomes of two of the largest randomized controlled trials to date, namely, the ROOBY (Randomized On/Off Bypass) [12] and CORONARY (CABG Off or On-Pump Revascularisation Study) [13] trials. However, the debate is still unsolved, with no overall advantage for one technique over the other. In this study, we tried to compare both techniques regarding a group of postoperative variables.

Aim

Overall goal This study aimed at comparing early postoperative outcomes between patients undergone CABG on-pump versus off-pump.

Objectives

The objectives are to assess the following postoperative outcomes:

(1) Early postoperative bleeding.
(2) Cardiac support (medical or mechanical).
(3) Different types of arrhythmias.
(4) Renal function.
(5) Hospital stay.

Patients and methods

Patients

This study is a retrospective descriptive study conducted on all patients with Coronary artery disease (CAD) presented by recurrent attacks of chest pain and diagnosed with multivessel CAD and meeting inclusion and exclusion criteria at duration from May 2017 to April 2018 at Cardiothoracic Surgery Department, Assuit University Hospital, by one surgical team.

Inclusion criteria

All patients who presented to cardiothoracic unit for undergoing elective CABG were included, except for those mentioned in the exclusion criteria.

Exclusion criteria

The exclusion criteria were as follows:

(1) Re-do patients.
(2) Patients with valve affection.
(3) Patients admitted on emergency basis.
(4) Patients undergone intraoperative shift from off-pump to on-pump.

Methods

The study was done on patient presented to Assuit University Heart Hospital between May 2017 and April 2018.

The operations were done under general anesthesia by using fentanyl and cisatracurium besylate injection and insertion of endo-tracheal tube. The operative technique was started by median sternotomy, followed by harvesting the internal mammary artery and other conduits; in case of on-pump technique, initiation of CPB was done, and in case of off-pump technique, the tissue stabilizer was used.

All the patients were transferred to intensive care unit and were observed for the following parameters:

(1) Early postoperative bleeding.
(2) Cardiac support (medical or mechanical).
(3) Different types of arrhythmias.
(4) Renal function.
(5) Hospital stay.

Risk benefits assessment

Information collected by this study may contribute to the care of patients in the future who have the same lesions as those that participate in this study. The information may also improve the future management of study participants. On the other hand patients will benefit from the clinical and radiological follow up postoperatively. There are no known risks associated with participation in this study. Patients' treatment and follow up will not be altered by any means.

Confidentiality

The investigators will review the charts retrieved through above mentioned CPT codes to determine there eligibility. This will be done in a private area at the cardiothoracic department to ensure confidentiality. The data from the eligible charts will be kept in locked cabinets. Each patient will be assigned a specific study number which will then be used to enter the data into the computers for analysis and statistical purposes. The computers will be password protected and no one would have access to the cabinets, study coding numbers, or computers except the investigators. Identifiable data will be accessed only by the investigators and will not be shared with any other investigators

Informed consent

For the all the patients, since they will be contacted for follow-up, the procedures of the research will be discussed with patients and an informed consent will be taken.

Results

Our study was conducted on 40 patients with CAD presented by recurrent attacks of chest pain and diagnosed with multivessel CAD.

Overall, 20 (50%) of the patients were done by using off-pump technique and the other 20 (50%) patients were done by using the on-pump technique (Table 1).

Mean age of the selected patients was 57 years.

A total of 31 (75%) patients were male and nine (25%) were female (Table 2).

Bleeding

On monitoring the 40 patients of the study in the first

3 postoperative days regarding the amount of bleeding from the intercostal drains and mediastinal drains, the results are as follows.

On-pump technique

A total of 20 patients done by on-pump technique showed mean amount of bleeding in the first postoperative day of 885.50 ml with median (range) of 900 ml (260–1700 ml); on the second postoperative day of 637.00 ml, with median (range) of 625 ml (300–950 ml); and on the third postoperative day of 457.00 ml, with median (range) of 410 ml (100–1250 ml).

Off-pump technique

A total of 20 patients from the study done by off-pump technique showed a mean amount of bleeding in the first postoperative day of 517.00 ml, with median (range) of 425 ml (200–1400 ml); on the second postoperative day of 258.50 ml, with median (range) of 225 ml (0–950 ml), and on the third postoperative day of 127.50 ml, with median (range) of 75 ml (0–500 ml) (Table 3).

Table 1 Age (years)

Age (years)	Off-pump (*n*=20)	On-pump (*n*=20)	*P*
Mean±SD	57.00±6.60	57.80±9.59	1.000
Range	42.0-71.0	42.0-84.0	

Table 2 Sex

Sex	Off-pump (*n*=20) [*n* (%)]	On-pump (*n*=20) [*n* (%)]	*P*
Male	16 (80.0)	15 (75.0)	1.000
Female	4 (20.0)	5 (25.0)	

Table 3 Bleeding

Bleeding	Off-pump (*n*=20)	On-pump (*n*=20)	*P*
First day			0.001*
Mean±SD	517.00±335.29	885.50±296.21	
Median (range)	425 (200-1400)	900 (260-1700)	
Second day			0.000*
Mean±SD	258.50±213.18	637.00±186.89	
Median (range)	225 (0-950)	625 (300-950)	
Third day			0.000*
Mean±SD	117.50±123.84	457.00±277.19	
Median (range)	75 (0-500)	410 (100-1250)	

*Significant p-value

Table 4 Cardiac support

Cardiac support	Off-pump (*n*=20) [*n* (%)]	On-pump (*n*=20) [*n* (%)]	*P*
Adrenalin	19 (95.0)	20 (100.0)	1.000
GTN	20 (100.0)	17 (85.0)	0.231
Noradrenalin	13 (65)	11 (55.0)	0.519
IAB	1 (5.0)	3 (15.0)	0.605
Dobutamine	0 (0.0)	3 (15.0)	0.231
Dopamine	0 (0.0)	2 (10.0)	0.147

GTN, glyceryl trinitrate; IAB, intra-aortic balloon.

Cardiac support

All of the 40 patients included in this study had received different types of cardiac support (chemical and mechanical) on discharge from the operative theater as follows.

Off-pump

Of the 20 patients done by off-pump technique, 19 (95%) patients were supported by adrenalin, 20 (100%) patients by glyceryl trinitrate, 13 (65%) patients by noradrenalin, and one (5%) patient by intra-aortic balloon (IAB).

On-pump

Of the 20 patients done by on-pump technique, 20 (100%) patients were supported by adrenalin, 17 (85%) patients by glyceryl trinitrate, 11 (55%) patients by noradrenalin, three (15%) patients by IAB, three (15%) patients by dobutamine, and two (10%) patients by dopamine (Table 4).

Arrhythmia

Of all the 40 patients in this study, only four patients developed postoperative arrhythmia.

Of the 20 patients done by off-pump technique, two (10%) patients developed postoperative arrhythmia: one of them developed rapid atrial fibrillation (AF) and was managed by amiodarone intravenous infusion successfully to normal sinus rhythm, and the other patient developed also rapid AF and was managed by intravenous digoxin successfully to normal sinus rhythm; both patients had normal sinus rhythm preoperatively.

Of the 20 patients done by on-pump technique, two (10%) patients had developed arrhythmia: one of them developed frequent ventricular ectopics, which were managed by intravenous shots of lidocaine and magnesium sulfate successfully to normal sinus rhythm, and the other patient had developed rapid AF and was managed successfully by intravenous infusion of amidarone to normal sinus rhythm; both patient had normal sinus rhythm preoperatively (Table 5).

Renal function

All 40 patients in this study had normal renal functions preoperatively.

Of the 20 patients done by off-pump technique, three (15%) patients had slightly impaired renal functions. All of these three patients were managed by good hydration and restriction of nephrotoxic drugs, with no renal dialysis needed; all of the three patients were discharged with normal renal functions.

Table 5 Arrhythmia

Arrhythmia	Off-pump (*n*=20) [*n* (%)]	On-pump (*n*=20) [*n* (%)]	*P*
Yes	2 (10.0)	2 (10.0)	1.000
No	18 (90.0)	18 (90.0)	

Table 6 Renal function

Renal function	Off-pump (*n*=20) [*n* (%)]	On-pump (*n*=20) [*n* (%)]	*P*
Within normal	17 (85.0)	16 (80.0)	1.000
Impaired	3 (15.0)	4 (20.0)	

Table 7 Hospital stay

Hospital stay (days)	Off-pump (*n*=20)	On-pump (*n*=20)	*P*
Mean±SD	8.30±2.11	8.75±2.12	0.670
Range	4.0-12.0	6.0-14.0	

Of the 20 patients done by on-pump technique, four (20%) patients had impaired renal functions; three of these patients were managed by good hydration and restriction of nephrotoxic drugs, and the fourth patient needed renal dialysis and showed improvement after only two settings of dialysis. All four patients were discharged with normal renal functions (Table 6).

Hospital stay

The hospital stay of the 40 patients included in this study was calculated from the day of operation to the day of discharge to home.

The 20 patients done by off-pump technique showed mean hospital stay of 8.30 days, with range of 4–12 days.

The other 20 patients done by on-pump technique showed mean hospital stay of 8.75 days with, range of 6–14 days (Table 7).

Discussion

In this study, we tried to be more specific in comparing on-pump and off-pump techniques in elective CABG surgery to determine the early postoperative outcomes of both techniques.

Bleeding is a common and severe condition after cardiac operations associated with increased resource utilization. Severe anemia and use of blood products are recognized as determinants of morbidity and death after cardiac operations [13]. In our study, results showed significant difference between on-pump and off-pump techniques with incidence of more rate of bleeding with the use of CPB machine. These results are consistent with many trials that showed that 50% of patients undergoing CPB-dependent cardiac surgery require blood transfusion, with variability among centers [14]. Unexpected excessive bleeding occurs in a smaller percentage of CPB patients, with ~ 10% requiring substantial transfusion following surgery [14,15].

Comparing the incidence of early postoperative arrhythmias with both techniques, our study showed no significant difference between the two techniques. Many studies about the development of post-CABG arrhythmias stated that incidence of arrhythmia is more with the use of CPB owing to the increased amount of inflammation [16].

Renal function is an important factor to determine postoperative morbidity following cardiac surgery. In our study, comparison between off-pump and on-pump technique in patients with normal preoperative renal functions showed no overall significance for the avoidance of CPB; however, many studies stated that among patients who undergo elective CABG, off-pump coronary artery bypass (OPCAB) significantly reduces surgical mortality in patients with moderate or severe preoperative renal dysfunction. It is essential to consider the preoperative renal function of enrolled patients when interpreting the results of randomized trials that evaluated the risk reduction effect of OPCAB. Further comparison of OPCAB versus on-pump coronary artery bypass (ONCAB) with a particular focus on this high-risk patient cohort is needed [17].

Delivery of postsurgical critical care is a common component of cardiac surgery practices, and the use of positive inotropic support is a very important part in these practices; in our study, we found that the use of inotropic support is common in almost all patients included in the study, obviously the most frequently used was adrenaline in 100% of patients done by on-pump technique and 95% of patients done by off-pump technique, a finding corresponding with the study done by Kastrup *et al.* [18].

Post-CABG intensive care not only requires the use of sophisticated equipment but also highly skilled and dedicated nursing and medical staff. As such, the ICU takes up a significant proportion of the total cost associated with the patients' overall hospital stay, and therefore, patients with prolonged ICU stays can have serious cost implications. Furthermore, patients with prolonged ICU stay can also lead to a shortage of ICU beds and result in operations being canceled. As a result, we studied the length of postoperative hospital stay of patients included in our study with the results showing no significant difference between patients operated upon by using off-pump technique

who showed a mean number of hospital stays of 8.30 ± 2.11 days and those operated upon by using on-pump technique who showed a mean number of hospital stays of 8.75 ± 2.12. Several studies have identified risk factors for prolonged ICU stay with varying definitions. Wong and colleagues examined 885 CABG patients and defined prolonged ICU stay as greater than 48 h. Moreover, unlike our study, they examined postoperative factors. The risk factors identified included increased age, female sex, preoperative myocardial infarction, postoperative use of IAB pump, inotropes, bleeding, atrial arrhythmia, and renal insufficiency [19]. Other studies claimed that ischemic effect of CPB increases the risk of morbidity and therefore hospital stay [20].

Conclusion

In our study and according to the variables that we discussed earlier, we have found that on-pump CABG is associated with increased rate of bleeding, and this could be owing to the effect of CPB and its effect on the blood components, namely, the platelets and coagulation factors.

Other variables that were put for comparison between the two techniques, including arrhythmia, renal functions, cardiac support, and hospital stay, showed no significant difference.

In conclusion, away from postoperative bleeding that was found to be more with the use of CPB, our trial did not show any overall advantage to the use of the off-pump as compared with the on-pump cardiac surgical approach for coronary bypass grafting.

More studies are recommended to be conducted on bigger sample sizes for the sake of exploring more indicators of postoperative mortality and the surgical method of choice of management of each indicated case.

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Conflicts of interest

There are no conflicts of interest.

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