Clinical Medicine and Medical Research

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CMMR 04 (03) , 228–233 (2023)
Received 27 July 2023 | Revised 13 Aug 2023 | Accepted 24 Aug 2023 | Published Online 03 Sep 2023
https://doi.org/10.52845/CMMR/2023-4-2-1

CMMR JOURNAL
Open Access Journal

ISSN (O) 2693-499X

OPEN ACCESS JOURNAL

ORIGINAL- ARTICLE

Advantages of Beating Heart Bypass Surgery Without Use of Heart-Lung Machine in Baghdad

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Abstract

The location of the coronary arteries in the sub epicardium was one among other factors that stimulated cardiac surgeons to attempt revascularization without cardiopulmonary bypass (CPB). This study summarizes the experience with 163 patients who had coronary artery bypass grafting (CABG) without extra corporeal circulation (CPB) in Iraqi Center for Heart Diseases from September 1999 to July 2005. CABG on beating heart accounted for about 20% of the total number of coronary operations performed in the center at that time. 83.5% of patients were males and 16.5% were females. Age range was 31-78 years with a mean of 60 years. Majority of patients (70%) were presented with advanced functional class (FC) III and IV. Overall, 60% of patients had myocardial infarction and 8% had previous PTCA. Thirty six percent of patients had EF% below 50% with higher incidence in the elderly patients (high-risk group). All the patients were primary CABG and were done through median sternotomy. A total of 316 grafts were placed with a mean of 1.9 grafts/patient, (3 - 4) grafts per patient were placed in 21.5% of patients (substantially complete revascularization). Conversions to CPB were needed in four patients (2%), there were three mortalities (1.8%) after per-operative myocardial infarction (MI), and prolonged low cardiac output state. Mean 1CU stay was 24 hours and mean hospital stay was 5.5 days. Seventy two percent of patients reported complete relief of symptoms. Twenty two percent developed atypical chest pain with negative treadmill test and 5 patients (3.0%) had positive treadmill test in the follow- up period, which was 2-3 months after surgery. Post-operative complications were reported in 26% of patients, most commonly post-operative hypertensive crisis (6%) and low cardiac output (LCO) syndrome (4%).

Key words: There were significant improvements in post-operative functional class and LV function.

1 | INTRODUCTION

The three most important prognostic factors eterm-dined angiographically are the number of vessels involved, the location & severity of stenoses, & the ventricular function as measured by left ventricular ejection fraction. "Angiographically significant" steno-sis is considered present when the diameter is reduced by more than 50 percent corresponding to a reduction in cross-sectional area greater than 75 percent (•). Ventricular function usually is expressed,as the left ventricular ejection fraction, with 0.55 to 0.70 conside-red normal; 0.35 to 0.55, moderately depressed; and

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below 0.35, especially below 0.20 is severely depressed. An ejection fraction below 0.35 is often associated with intermittent congestive heart failure, and below 0.20 to 0.25, with severe heart failure [1].
Another important measurement to be obtained is the left ventricular end-diastolic pressure (LVEDP). The normal LVEDP is less than 12 mmHg. Pressures in the range of 12 to 20 mmHg represent moderate disease, while pressure of 20- 25mmHg or higher represent severe disease [2]. Related to this measurement is an important concept that delaying operation until symptoms are severe with high LVEDP often results in irreversible ventricular injury, which in turn can be a major cause of death in the first few years after a technically successful operation[3] [4]
PTCA and CABG are safe and both provide excellent relief of angina. Patients undergoing PTCA have less procedure-related pain, a shorter hospital stay, fewer periprocedural infarctions, and equal immediate relief of angina compared with CABG patient. PTCA may offer an early survival advantage over CABG in patient with single vessel disease and in some patients with double vessel disease with less than 95% stenosis of the left anterior descending artery. Revascularization is less complete with PTCA and restenosis is a significant problem leading to a higher need for subsequent procedures [5][6]. CABG provides more complete revascularization and better long-term relief of angina.

2 | MATERIALS & METHODS

2.1 | AIM OF STUDY

To evaluate the feasibility, advantages and drawbacks of coronary artery bypass grafting without cardiopulmonary bypass depending on the significant predictors of outcome.

Clinical presentations include the following (Fig.1):
1- Chronic stable angina: Seventy percent (114/163) of patients were included in this group, 98 out of 114 (86%) had a history of previous MI and the rest (14%) were non-infarcted.
2. Unstable angina: Twenty eight percent (46/163) of patients were included in this group, all of them were non-infarcted.
3. Cardiogenic shock: three patients (1.8%) operated upon while they were in cardiogenic shock.

Table 1-4. *Important Preoperative Variables*

Pre-operative Variables	< 65 years (143)	> 65 years (20)	Overall 100% (163)
Male Gender	84.6% (121)	75% (15)	83.4% (136)
Female Gender	15.3% (22)	25% (5)	16.5% (27)
Presentation:			
SA:			
Class I	5.6% (8)	5% (1)	5.5% (9)
Class II	23.7% (34)	30% (6)	24.5% (40)
Class III	34.3% (49)	30% (6)	33.7% (55)
Class IV	6.3% (9)	5% (1)	6.3% (10)
UA	28% (40)	30% (6)	2 8.2% (46)
C.S	2.1% (3)	0% (0)	1.8%(3)
Risk Factors:			
Smoking	35.6% (51)	35% (7)	35.58% (58)
HT	31.4% (45)	75% (15)	36.8% (60)
DM:			
Insulin dependent	6.2% (9)	0% (0)	5.5% (9)
Oral hypoglycemic	29.3% (42)	30% (6)	29.4% (48)
Hypercholesterolemia			
Diet control	8.3%(12)	10% (2)	8.5% (14)
Drug control	5.5% (8)	5% (1)	5.5% (9)
Comorbidities:			
CVA	1.3% (2)	0% (0)	1.2%(2)
Previous Extra cardiac operation	0% (0)	5% (1)	0.6%(1)
Peripheral thromboembolism	2% (3)	0%(0)	1.8%(3)
COPD	4.1% (6)	5% (1)	4.2% (7)

Table 5. *shows several variables of the patient at time of presentation and from history of the patient.*

ECG	Arrhythmia	8.3% (12)	0% (0)	7.3% (12)
	MI:			
	Present	60% (86)	60% (12)	60% (98)
	Absent	35% (50)	75% (15)	39.8% (65)
Cardiomegaly		37% (53)	65% (13)	40.4% (66)
PTCA (Previous)		9% (13)	0% (0)	8% (13)

SA = Stable Angina; UA = Unstable Angina; C.S = Cardiogenic Shock; HT = Hypertension; DM = Diabetes Mellitus; CVA = Cerebrovascular Accident; COPD = Chronic Obstructive Pulmonary Disease; ECG = Electrocardiography; MI = Myocardial Infarction; Rx = Treatment; PTCA = Percutaneous Transluminal Coronary Angioplasty

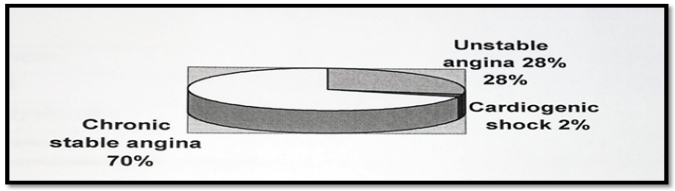

Fig1. *Percentage of patient according to clinical presentation 2-2 Echocardiography:*

All patients had two-dimensional (2-D) echocardiography studies pre and post-operatively and some of them had Doppler study with color flow estimation.(Table 6).

Table 6. *Pre-operative Echocardiography Data.*

Echocardiography Data	< 65 year	> 65 years	Mean
EF	0.50 ±0.20	0.50 ±0.10	0.50 ±0.15
Apical movement: Normal	8.4% (12)	30% (6)	11% (18)
Hypokinetic	3 3.6% (48)	40% (8)	3 4.3% (56)
Akinetic	30.8% (44)	10% (2)	2 8.2% (46)
Mildly dyskinetic	21.7% (31)	20% (4)	21.5% (35)
Apical aneurysmi	5.5% (8)	0% (0)	5% (8)

2-3 Angiographic Studies:

Pre-operative angiographic study was done for all patients and significant data were estimated (Table 7) which revealed; ninety patients (55%) had 3 vessels disease including eight patients (5%) with critical left main coronary artery stenosis. Twenty patients (12%) had LAD and RCA disease. Thirteen patients (8%) had LAD and Cx. And 40 patients (25%) had only the LAD involved in the disease.

Table 7. *Catheterization Data*

Catheterization Data	< 65 years	>65 years	Overall 100%
No. of vessels involved:			
1	21% (30)	50% (10)	25% (40)
2	20.3% (29)	20% (4)	20% (33)
3	58.7% (84)	30% (6)	55% (90)
-Type of vessels involved			
3VD (Including 5% left main)	56% (80)	50% (10)	55% (90)
LAD + RCA	12. 6% (18)	10% (2)	12% (20)
LAD + C_x	6.3% (9)	20% (4)	8% (13)
LAD	25.1% (36)	20% (4)	25% (40)
-EF%			
< 25%	2.8% (4)	30% (6)	6.1% (10)
25% - 50%	28% (40)	50% (10)	30.7% (50)
> 50%	69.2% (99)	20% (4)	63.2% (103)
-LVEDP (mmHg).			
<12	12. 6% (18)	10% (2)	12.3% (20)
12-20	56.6% (81)	60% (12)	57% (93)
>20	30.8% (44)	30% (6)	30.7% (50)
-Associated valve lesion	3.5% (5)	5% (1)	3.6% (6)

3VD = Three Vessel Disease; LAD = Left Anterior Descending; RCA=Right Coronary Artery; Cx =Circumflex; EF%=Ejection Fraction LVEDP = Left Ventricular End Diastolic Pressure.

2-4 Pre-operative Preparation:

Aspirin ingestion was stopped at least one week before surgery and compatible blood was prepared.

On the day of operation, the patient received oral beta-blockers to slow down the heart rate to facilitate anastomosis and provide additional protection against myocardial ischaemia by reducing oxygen consumption.

The patients were pre-medicated with morphine or diazepam on the early morning of surgery.The pump was stand by but not primed and the perfusionist was informed to be around during surgery.

2-5 Operative Procedure:

Our whole 163 patients were primary CABG and all were done through median sternotomy.The selection of our patients in this study was done after the evaluation of the anginographic study; however, the final decision regarding the number of grafts inserted may be criticized in the operating room. (Table 8)

All surgical procedures were performed in the Iraqi Center for Heart Diseases under general anesthesia using the standard techniques and drugs (including diazepam and fentanyl with intermittent administration of pancuranium to provide muscle relaxation). Intravenous nitroglycerin was added to control ischaemia or to induce vasodilatation whenever indicated.

A total of 316 grafts were placed with 1-4 grafts per patient (mean = 1.9 graft/patient) as follows; 116 patients (71%) had LIMA anastomosed to LAD, six patient (3.6%) had LIMA anastomosed to DG, one patient (0.6%) had LIMA anastomosed to OM, 57 patients (35%) had SVG anastomosed to LAD, thirty (18.4%) had SVG anastomosed to RCA. Forty patients (24.5%) had SVG anastomosed to DG and 50 patients (30.6%) had SVG anastomosed to OM. Sixteen patients (9.8%) had SVG anastomosed to PDA (Fig. 9) In four patients only the decision was made intra-operatively to go on bypass, after completion of LIMA anastomosis to LAD, the reason for that was ST-segment elevation that appeared on the monitor when the RCA was snared.

Table 8. *operative complications*

Operative Variables	Group I < 65 years	Group II ≥ 65 years	Overall 100%
1- Emergency operation	4.9% (7)	0% (0)	4.3% (7)
2- No. of grafts			
1	29.3% (42)	40% (8)	30.7% (50)
2	47.6% (68)	50% (10)	47.8% (78)
3	19.6% (28)	10% (2)	18.5% (30)
4	3.5% (5)	0% (0)	3% (5)
3- Type of graft			
LIMA-LAD	75.5% (108)	40% (8)	71.1% (116)
SVG-LAD	31.4% (45)	60% (12)	35% (57)
SVG-RCA	11.1% (16)	70% (14)	18.4% (30)
SVG-DG	28% (40)	0%(0)	24.5% (40)
SVG-OM	33.5% (48)	1 0% (2)	30.6% (50)
SVG-PDA	11.1(16)	0%(0)	9.8% (16)
LIMA-OM	0.7 %((1)	0% (0)	0.6% (1)
LIMA-DG	4.2% (6)	0% (0)	3.6% (6)
5-Need for CPB	2.8% (4)	0%(0)	2.4% (4)
6- IABP	22.3% (32)	40% (8)	24.5% (40)
7- Inotropes	46.8% (67)	50% (10)	47.2% (77)
8- Total operative time	180 ± 30	160 ± 30	170 ± 30
9- Per-operative MI	2% (3)	0% (0)	1.8%(3)

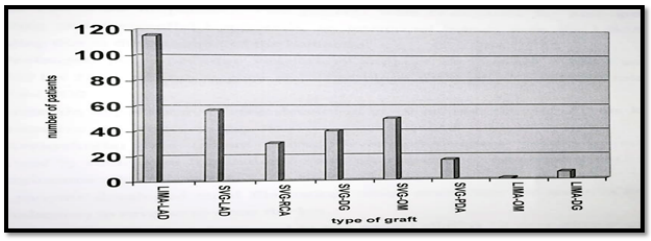

Fig 2. *Distribution of patients according to type of graft*

2-6 Post-operative complications: (Table 9)

1. Post-operative bleeding: Blood loss was in the range of 150-500 ml/patients (mean 250 ± 50 ml/ patient).
2. Prolonged post-operative ventilatory support was needed in three patients: (1.8%) for 18 hours due to poor results of blood gas analysis with Co2 retention and low P02.
3. Systemic hypertensive crisis developed in 10 patients (6.1%) (All are known hypertensive patients).
4. Arrhythmia: One patient (0.6%) developed frequent ventricular ectopics followed by ventricular fibrillation 3 hours after operation responded to D.C. shock and xylocaine administration.
5. Pericardial effusion: developed in one patient (0.6%) 10 days after operation, pencardiocentesis done for him with uneventful course after that.
6. Wound infection: One patient only developed wound infection, wound debridement performed with good results.
7. Pulmonary atelectasis.
8. Ischemic chest pain: As will be explained later on.

Table 9. *Post-operative complications*

Complications	Total(163) 100%	< 65 years (143) 87.7%	≥ 65 years (20) 12.3%
1 - Bleeding and tomponade	1.2% (2)	0% (0)	10% (2)
2- Prolonged ventilatory support	1.8% (3)	1.4% (2)	5% (1)
3- Systemic hypertensive crisis	6.1% (10)	4.2% (6)	20% (4)
4- Ventricular arrhythmia	0.6% (1)	0.7% (1)	0% (0)
5- Atrial fibrillation	6.1% (10)	2% (3)	35% (7)
6- Wound infection	0.6% (1)	0%(0)	5% (1)
7- Pulmonary atelectasis	1.8% (3)	0% (0)	15% (3)
8- Pericardial effusion	0.6% (1)	0.7% (1)	0% (0)
9- Ischemic chest pain	3.6% (6)	2% (3)	15% (3)
10- LCO syndrome	3.6% (6)	3.5% (5)	5% (1)

LCO = low cardiac output

3 | RESULTS

Previous attack of myocardial infarction was found in 60% of patients with no significant differences between the two subgroups. There was low incidence (8%) of patients with previous PTCA, all within the first subgroup. Angiographically, 55% of patients (most of them in the first age group) had triple vessel disease, while 20% and 25% of patients had double vessel disease and single vessel disease respectively. (36.8%) of patients had pre-operative ejection fraction below 50%, with higher incidence in the elderly patients.
Regarding pre-operative LVEDP, there were 87% of patients with LVEDP above 12 mm Hg with no significant difference between the two subgroups. Over all, four grafts per patients were placed in 3% of patients, three grafts per patients were placed in 18.5% of patients while two and one graft were placed in 47.8% and 30.7% of patients respectively.Conversion to CPB occurred in four patients (2.4%) only, whey were within the first subgroup.IABP was used in 24.5% of patients more frequently in elderly, while inotropic support was needed in 47.2% of patients with no significant different between the two subgroups. Mean operative time was 170 ± 30 minutes. Post-operative blood loss was in the range of 150-500 ml per patient and the incidence has been recognized statistically to be higher in patients with larger number of anastomosis sites. Mean post-operative intubation time was 8 ± 1.5 hours.
ICU stay was in the range of 18 hours to 5 days with

mean 26 hours and hospital stay was in the range of 4 - 7 days (mean = 5±1 days). (Fig 5).

4 | DISCUSSION

Depending on the patient and on the surgeon, we can probably say for an average coronary patient with good left ventricle and no additional diseases the early operative mortality and morbidity are already so low that it is difficult to make them lower, and we should keep in mind the issue of late patency of grafts anastomosed on the beating heart. Short hospital stay of those patients is the most apparent advantage.Regarding our patients in this study, the majority (70%) presented with advanced functional class (III and IV) versus 30% with class I and II, compared to another study(7) where the patients presented earlier with 50% of patients in class I and II, High prevalence (60%) of our patients with previous MI were found compared to other study (8), where 40% of patients were infarcted, might be attributed to late presentation of our patients in proper pre-operative management and subsequent late referral.

Majority (88%) of our patients had elements of LV dysfunction (LVEDP > 12 mmHg), this is higher incidence compared to another study Three grafts per patient were placed in 18.5%) of patients and four grafts per patients were placed in 3% of patients because not all vessels were graftable. The key to successful beating heart coronary artery surgery is mechanical stabilization [(9)].

There was very low incidence (2.4%) of conversion to CPB compared to other studies (9%) [(10)]

IABP was used in 24.5% of patients while inotropic support needed in 47.2%. Mean operative time was 170 ± 30 minutes, which is comparable to other studies [(11)], [(12)] It is much shorter than other procedures using CPB [(10)] with mean operative time = 3 15 ± 1 8.20 minutes.

There was significant improvement in the functional class of our patients post-operatively during the follow-up period. (Fig. 7)

ICU and hospital stay were much shorter than other studies (13) using CPB where mean ICU and hospital stay was 28 ± 2.5 hours and 8 ± 2 days respectively.

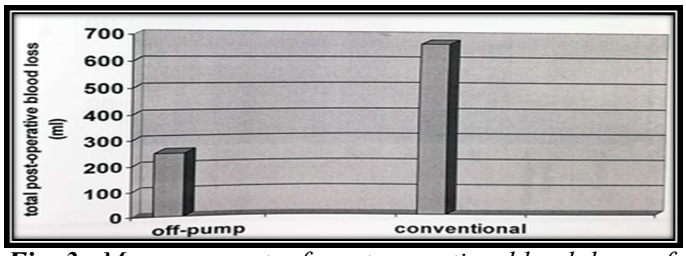

Fig 3. *Mean amount of post-operative blood loss of patients with CABG without CPB compared to conventional CABG*

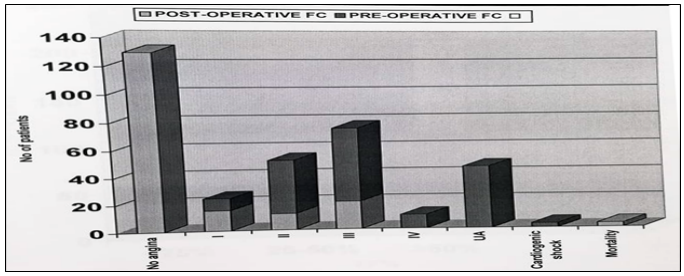

Fig 4. *Pre-operative and post -operative functional class*

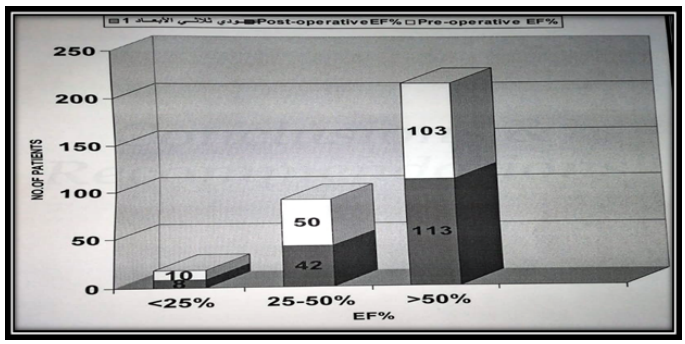

Fig 5. *Distribution of patients according to their preoperative and postoperative EF%*

5 | CONCLUSIONS AND RECOMMENDATIONS

1. As long as there is not yet an ideal method of myocardial protection during CPB the beating heart might become the future way of performing CABG operations.
2. The surgeons experience is especially beneficial in determining which patients will get benefit.
3. Special attention and care should be paid to those patients with pre-operative advanced functional classes.
4. In cases in which the left anterior descending artery and the right coronary artery are to be bypassed, it is preferable to perform the anastomosis to the left anterior descending artery first in order that the patient may better tolerate subsequent manipulation to the heart.
5. With the advancement of mechanically stabilized beating heart coronary surgery all branches of the circumflex territory, which was the more challenging

part of the procedure can be revascularized.
6. Reduction of post-operative morbidity and consequent hospital stay are very important end points especially when the cost containment is crucial for health care delivery system.
7. CABG on beating heart can reduce blood transfusion requirements most likely due to a less pronounced postoperative reduction of platelet count.
8. G. We believe that beating heart coronary surgery is going to be used more frequently in the future as a technique of myocardial revascularizati-on in selected cases although we recognize that longer follow up and more experience is needed that will eliminate the learning curve, allowing for predictable results.

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How to cite this article: Hussein Hashin Eissa et al. Advantages of Beating Heart Bypass Surgery Without Use of Heart –Lung Machine in Baghdad Clinical Medicine and Medical Research, 4(03), 22 –233. https://doi.org/10. 52 845 /CMMR/2023-4 -3-1