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Sequential Coronary Artery Bypass Grafting is a Safe Technique for Multi Vessels Disease Patients

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ABSTRACT
Background: Patients with multivessel coronary artery disease have shown the greatest improvement from coronary artery bypass graft (CABG) surgery, according to clinical trials.
Aim: To evaluate the effect of a sequential approach to coronary artery bypass grafting based on a prospective analysis of three-month mortality and morbidity rates, short-term outcomes, and findings**.**
Subject and Methods: This study included 113 patients with multi-vessel coronary artery disease for CABG. A cohort prospective study included 40 patients scheduled for sequential CABG at Al-Azhar University Hospitals**.** All patients were managed through three steps: Preoperative assessment, intra-operative assessment and post-operative assessment.
Results: Bleeding and need for re-exploration had the highest percent in post-operative hospital complications. New ECG changes had the highest percent in 90 days outcomes in all studied patients. Serum troponin and CK-MB levels in P1 and P2 were significantly different between the study populations. No significant variations in Echocardiographic parameters were found between the study and control groups. **Conclusion:** Clinical evidence showed that the sequential approach for coronary artery bypass grafting is a safe and effective treatment that may be used consistently in CABG, particularly for young patients without or with well-controlled diabetes in terms of short-term results and hospital mortality. The sequential approach reduced the risk of problems and hospitalization. Due to fewer aortic manipulations, sequential grafting gained popularity as minimally invasive direct coronary artery bypass grafting (MIDCAB).
Key Words: Sequential technique, CABG**,** MIDCAB.

INTRODUCTION

Clinical studies performed in 1980s and 1990s confirmed the effectiveness of coronary artery bypass graft (CABG) surgery in treating multivessel coronary artery disease, reducing angina symptoms and increasing the likelihood of survival [(1)].

In addition, CABG has shown better survival results than medication treatment, particularly in situations with triple vessel disease, and in patients with unstable angina and left ventricular failure. People who continue to suffer from ischemia after receiving various therapies for acute myocardial infarction [(2)] may potentially benefit from early CABG. Complete revascularization has been linked to less cardiac problems after CABG, although atherosclerosis-related thrombosis and intimal hyperplasia are major causes of graft failure in the long term [(3)].

Surgeons often conduct successive anastomoses on several coronary arteries using a single graft, such as the saphenous vein (SV), to reduce the risk of problems. Intraoperative studies have demonstrated that sequential grafting improves outcomes compared to single coronary grafts with end-to-side anastomosis due to enhanced blood flow and velocity in the proximal section of the graft. Patency rates after end-to-side and sequential anastomoses have been proven to be greater with postangiograms. These results imply that sequential bypass grafting is preferable than repeated bypass grafting because it results in a smoother flow and less spatial gradients of wall shear stress (WSS). These findings provide credence to the practice of sequential bypass grafting, which, in contrast to many end-to-side anastomoses, provides smoother flow and reduces spatial gradients of WSS [(4, 5)].

This study aimed to prospectively examine the short-term outcomes, results, and mortality/morbidity rates of sequential coronary artery bypass grafting procedure over the course of three months following surgery.

PATIENTS AND METHODS

This prospective study included 113 patients with multi-vessel coronary artery disease for CABG at Al-Azhar University Hospitals using vascular conduits from internal thoracic artery (ITA) and great saphenous vein (GSV) from one or both legs. The number of graft and harvested conduit ranged from 2-4 that vary according to the severity of coronary heart and the number of stenosed coronary vessels.

Inclusion criteria: Patients having multi vessel diseases. Patients having ejection fraction more than 35%. No age or sex limitation. Accepted risk factors (hypertension, DM, dyslipidemia and smoking).

Exclusion criteria: Patients having poor left ventricular function (less than 35 %). Patients having associated valve lesions. High risk factors (COPD, decompensated liver cell failure, chronic kidney disease and malignancy). Patients submitted to CABG previously (Re-do CABG). Patients who needed emergency CABG at the same day. Patients who have mechanical complications of MI. Post resuscitation patients.

All patients were managed through three steps:

Preoperative assessment: History taking including personal history (Age, sex and special habits), family history of ischemic heart diseases and history of patient's present complaint to determine the anginal functioning class according to (CCS & NYHA) classifications. **Physical examination** including

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general examination, cardiac examination, ECG, echocardiography, cardiac catheterization, radiology & advanced investigations. Laboratory investigations including CBC, ESR, C-RP, electrolyte panel, blood glucose, liver function & enzymes profile. Kidney function profile, ABG, cardiac profile (if there was acute ischemia event) and coagulation profile (PT, PC, INR, and PTT).

Intra-operative assessment: Total operation time, cardiopulmonary bypass time, cross clamp time, number of grafts, preoperative usage of inotropic support, and usage of intra-aortic balloon pump.

Postoperative assessment: ICU data and medications including inotropic support requirements.

Ethical Approval: The study received ethical approval from The Ethics Committee of Al-Azhar University, granting permission to proceed. Prior to their inclusion in the study, all participants were supplied with pertinent study materials. Each study participant provided written consent by signing a consent form. Stringent adherence to the World Medical Association's (WMA) Code of Ethics for Human Studies (Declaration of Helsinki) was ensured. The utmost ethical standards were upheld throughout the research.

Statistical analysis: Data entered and analyzed using Microsoft Excel software then imported into Statistical Package for the Social Sciences (SPSS version 22.0) software. Quantitative data were described using range (minimum and maximum), mean, standard deviation and median. Differences between quantitative independent multiple were tested by t-test. P value was set at ≤ 0.05 for significant results & ≤ 0.001 for high significant result.

RESULTS

The current study included 133 patients, 67.5% were males. Their age ranged between 35-73 years with mean value of 55.5 ± 6.9 years. 39.8% were smokers, 35.6% had hyperlipidemia, 34.5% had hypertension and 20.3% were diabetics as shown in table (1).

Table (1): basic characteristic data of included patients

	N=113	
Age (years)		
Range	35 – 73	
Mean ± SD	55.5 ± 6.9	
BMI (kg/m^2)		
Range	25.7 – 39.8	
Mean ± SD	31.22 ± 4.92	
Gender		
Male	76	67.5%
female	37	32.5%
Comorbidities		
Smoking	45	39.8%
Diabetes mellitus	23	20.3%
Systemic hypertension	39	34.5%
Dyslipidemia	40	35.6%

Regarding the operative details, the operation duration ranged between 3.5-5.3 hours with mean value of 4.6 ± 0.4 h. The by-pass time ranged between 115-181.6 minutes and the cross clamp time ranged between 75.2-91.4 minutes. Five handered cronary anastomosis were done and ranged between 3-6 arteries with mean value of 4.5 ± 0.7 per patients. Among our studied patients: 6 of them need 3 grafts, 60 patients need 4 grafts, 40 patients need 5 grafts and 7 patients need 6 grafts. Mammary artery graft was used for all patients, saphenous vein graft was used in 110 patients while in 3 patients radial artery graft was used. The majority of cases had one top end 94.7% while the remaining had two top ends. All patients were on pump during the procedure; 55.8‹% were on warm cardioplegia fluid while the remaining were on Custodial as shown in table (2).

Table 2: Operative data of included patients

	N=113	
Operation duration (hours)		
Range	3.5 – 5.3	
Mean ± SD	4.6 ± 0.4	
Bypass Time (min)		
Range	115.4 – 181.6	
Mean ± SD	125.9 ± 44.6	
Cross Clamp Time (min)		
Range	75.2 – 91.4	
Mean ± SD	85.3 ± 14.8	
The total number of coronary anastomoses	500	
Range	3 – 6	
Mean ± SD (per patient)	4.5 ± 0.7	
No. of coronary anastomosis		
3 grafts	6 patients	5.3%
4 grafts	60 patients	53.1%
5 grafts	40 patients	35.4%
6 grafts	7 patients	6.2%
The used conduit		
Mammary artery graft	113	100%
Saphenous vein graft	110	97.3%
Radial artery graft	3	2.7%
Number of top ends		
1 top end	107	94.7%
2 top ends	6	5.3%
Pump use		
On pump	113	100%
Off pump	0	0%
Cardioplegia fluid		
Custodial	50	44.2%
Warm Cardioplegia	63	55.8%
Number of leg incision		
1	60	53.1%
2	53	46.9%

Post-operative complications included superficial wound infection in 22 patients, bleeding that needed re-exploration in 6 patients, arrythmia (AF) in 3 cases, mild renal impairement in 2 cases, MI, IAPB due to low CO and stroke without residual deficiet in 1 case for each. All patients survived with no mortality. On follow up, 6 patients developed new EEG changes, 5 patients developed hypotension, chest pain and rlevated cardiac enzymes were reported in 3 patients for each, need for diagnostic CA and re-infarction were reported in 2 patients for each, lastely AF was reported in 1 patient as shown in tables (3)and (4).

Table (3): Description of post-operative hospital complications in all studied patients

		Studied patients (N = 113)	
Post-operative hospital complications	**Bleeding and need for re-exploration**	6	5%
	Cerebrovascular event (stroke recovered without residual deficit).	1	0.8%
	Arrhythmia (AF return to NSR e amiodarone & no need for DC shock).	3	2.7%
	Wound infection (superficial) sternal wound infection)	22	19.5%
	MI	1	0.8%
	Renal complications (mild cases no need for dialysis)	2	1.8%
	IAPB due to low CO	1	0.8%
	Post-op mortality	0	0%

Table (4): Description of 90 days outcomes in all studied patients

		Studied patients (N = **113**)	
90 days outcomes	**V/D odds (hypotension)**	5	4.4%
	typical chest pain	3	2.7%
	new ECG changes	6	5%
	Cardiac enzymes Odds	3	2.7%
	Need for diagnostic CA (SVG to RCA was occluded ttt by PCI)	2	1.8%
	Re-infarction	2	1.8%
	Repeat revascularization (Redo- CABG)	0	0%
	Arrhythmia (AF)	1	0.8%
	CVA	0	0%
	Death	0	0%

Follow up of cardiac enzyme for 90 days post-operative demonstrated statistically significant decline in serum troponin and CK-MB level early post-operative and after 90 days of the procedure in comparison with pre-operative levels as shown in **table (5).**

Table (5): Comparison of echocardiography and cardiac enzymes throughout the study

		Throughout the study			P-value
		Pre-op (n = 113)	**Before discharge (n = 113)**	**After 90 days (n = 113)**	
EF (%)	**Mean**	51.8	52.4	51.4	**P1 = 0.333NS**
	±SD	4.5	4.8	5.1	**P2 = 0.806 NS** **P3 = 0.262 NS**
Serum troponin	**Mean**	1.65	0.87	0.72	**P1 = <0.001 HS**
	±SD	1.8	0.43	0.36	**P2 = <0.001 HS** **P3 = 0.555 NS**
CK-MB	**Mean**	31.1	11.24	8.93	**P1 = <0.001 HS**
	±SD	12.1	8.93	4.84	**P2 = <0.001 HS** **P3 = 0.098 NS**

S: p-value < 0.05 is considered significant. NS: p-value > 0.05 is considered non-significant

Post-operative echocardiography follow up showed insignificant changes in ejection fraction%, right and left ventricular dimensions and pulmonary artery pressure between post-operative and pre-operative values as shown in table (6).

Table 6: Echocardiography data of the studied population

	Pre-operative		**Post-operative**		**t**	**p-value**
LVESD	3.04	0.57	3.03	0.59	0.259	0.795
LVEDD	4.94	0.58	4.39	0.71	1.159	0.246
EF%	51.8	4.5	52.4	4.8	0.969	0.333
RVD	3.27	0.35	3.25	0.37	0.417	0.676
PASP	26.76	6.88	25.78	6.12	1.131	0.259

DISCUSSION

CABG improves survival in individuals with unstable angina and LV failure, particularly those with triple vessel disease. Patients with persistent ischemia after previous treatments may benefit from early CABG for acute myocardial infarction. Complete revascularization reduces post-CABG unfavourable cardiac events [6].

The current study included 133 patients, 67.5% were males. The average age was 55.5 ± 6.9 years, with a range of 35-73 years. 39.8% were smokers, 35.6% has hyperlipidemia, 34.5% has hypertension and 20.3% were diabetics. This is in agreement with **Reham *et al.*** [7] who assessed the usefulness and results of successive grafting for bypassing several coronary arteries. Patients' ages varied from 45 to 63, with a mean of 53.9 ± 8.5 years; however, just two of the patients were female. The average BMI was 29.0 ± 0.8.

Even in those without any preexisting heart conditions, a high WBC count has been found to forecast the emergence of cardiovascular issues in the future. Patients presenting with unstable angina pectoris, acute coronary syndrome (ACS), and acute myocardial infarction (MI), as well as patients undergoing percutaneous coronary interventions (PCIs) or coronary artery bypass grafting (CABG), have all been shown to have an increased risk of mortality if their white blood cell (WBC) count is high. Additionally, cerebral ischemia and stroke are linked to increased total white blood cell, neutrophil, and monocyte numbers [8]. **Adam *et al.*** [9] showed that When comparing laboratory data, group A had substantially larger MPV (10.63 vs 10.15 fL, p< 0.001) but significantly lower WBC (8.58 vs 13.74 ×103/µL, p < 0.001). Serum levels of alanine transaminase (ALT; p=0.02), aspartate transaminase (AST; p=0.001), blood urea nitrogen (BUN; p =0.009), creatine kinase (CK; p=0.006), and troponin-I were all considerably greater in group B than in group A.

This study illustrated that there were 99 patients (87.5%) in need for low doses inotropic support and 14 patients (5%) in need for Intra-Aortic Balloon Pump (IABP), there were 6 cases needed intraoperative IABP. There were 31 patients (27.5%) showed serial ECG changes (PVCs, ischemia and AF). The mean ventilation time for all patients studied was 17.3 ± 21.3% hours, with a minimum of 6 hours and a maximum of 96 hours. Regarding total ICD drainage, the mean quantity in all patients studied was 560 ± 206.1 cc, at least 300 and no more than 1050. Regarding postoperative ICU stay, the mean ICU stay for all patients studied was 5.1 ± 1.01 days, with a minimum of 3 days and a maximum of 7 days.

In a study conducted by **Reham *et al.*** [7], post-operative outcomes were examined, revealing that the average duration of ventilation was 11.5 ± 5.3 hours, with only 3 cases (6%) requiring ventilation for less than 24 hours. Inotropes were administered for an average duration of 17.2 ± 10.1 hours, and 3 cases (6%) necessitated the use of an (IABP). Prolonged inotropic support, lasting less than 48 hours, was observed in 7 cases (14%). Troponin levels measured 6 hours after the operation averaged at 0.95 ± 0.8 ng/ml, with no indications of ischemia on the electrocardiograms. The average length of stay in the Intensive Care Unit (ICU) was 2.3 ± 0.8 days, but 4 patients (8%) required a prolonged ICU stay of 10 days. Two patients (4%) experienced high drainage and required reopening, while 2 others developed superficial wound infections. Additionally, 3 patients (6%) exhibited atelectasis, and 6 patients (12%) experienced renal impairment (defined as a post-operative creatinine level exceeding 2 mg/dl or a significant increase from pre-operative levels). Notably, there were no instances of severe wound infections or in-hospital deaths.

In this study the follow up of cardiac enzymes for 90 days post-operative demonstrated statistically significant decline in serum troponin and CK-MB level early post-operative and after 90 days of the procedure in comparison with levels as shown in table 5. Post-operative echocardiography follow up showed insignificant changes in ejection fraction%, right and left ventricular dimensions and pulmonary artery pressure between post-operative and pre-operative values.

Reham *et al.* [7] showed that the mean left ventricular ejection fraction (LVEF) was 59.2%, LVEDD was 5.3 ±0.6, LVESD was 3.6±0.6, and LA was 3.8±0.4.

CONCLUSION

Clinical evidence suggests that the sequential approach for coronary artery bypass grafting is safe and effective treatment that may be used consistently in CABG, particularly for young patients without or with well-controlled diabetes in terms of short-term results and hospital mortality. Hospital mortality, short-term results, and post-operative complications (such as wound infection, lung difficulties, atrial fibrillation, myocardial infarction, haemorrhage, and reduced cardiac output) are all positively affected by the sequential approach. Due to fewer aortic manipulations, sequential grafting gained popularity as minimally invasive direct coronary artery bypass grafting (MIDCAB).

DECLARATIONS

- **Consent for publication:** All authors have agreed to submit the work.
- **Availability of data and material:** Available
- **Competing interests:** None
- **Funding:** No fund
- **Conflicts of interest:** No conflicts of interest.

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