Comparison of Graft Flow in Off-pump and Conventional Coronary Artery Bypass Grafting

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Objective: **Patency of the anastomosis is a concern in patients undergoing off-pump coronary revascularization. Transient time flow is a tool for measurement of graft flow and assessing the patency of anastomosis .The aim of this study is to compare graft flow between off-pump and conventional coronary artery bypass grafting using transient time flow technique.**

Methods: **Transient time flow was measured in 28 and 25 cases that underwent conventional coronary artery bypass grafting (CCABG) and off- pump coronary artery bypass (OPCAB) technique respectively. Graft patency was assessed by flow curve, mean flow and pulsatility index (PI). Average flow was compared between individual grafts in both groups.**

Results: **No statistical significant difference was found in graft flow between these two techniques. Average flow was 34.25+19.28 ml/min in LIMA to LAD graft, 21.40+4.60 ml/min in radial artery to OM /Diag. graft and 19.65 + 8.9 ml/min in SVG to RCA /PDA graft in CCABG and 31.07 + 17.18 ml/min, 22.21 + 5.7 ml/min and 20.11 + 10.70 ml/min in OPCAB group.**

Conclusion: **No significant difference was found in graft blood flow in CABG performed with either conventionally or using off-pump-technique. Transient time flow is a useful tool in operative room to assess the graft patency in coronary artery bypass grafting surgery.**

Off – pump coronary artery bypass surgery (OPCAB) has become a widely accepted procedure. Many trials report better outcomes in OPCAB compared with conventional coronary artery bypass grafting (CCABG). OPCAB reduces morbidity, need for blood transfusion and intensive care and hospital stay compared to CCABG (1)(2). However, there is a concern about the quality of anastomosis and graft patency because of the technical difficulty in performing anastomosis in OPCAB procedures (3). Transient time ultrasound principle for flow measurement was introduced recently into cardiac surgery. It is an accurate method that is available in operative room (OR), easy to use and can be used for assessment of graft blood flow. (4)(5)(6). The aim of this study is to compare graft flow by transit time flow method between OPCAB and CCABG.

Patents and Methods

Patient population

Transient flow measurement records were collected and analyzed in consecutive 53 patients who were scheduled for elective first time multivessel single coronary artery bypass grafting during the period from January 2004

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to February 2005. Twenty-eight cases were operated upon using CCABG and 25 patients using OPCAB technique. All cases received standardized perioperative and anesthetic care. Cardiac enzyme release was routinely done at the day of surgery and at postoperative day one. Analysis of creatine kinase and creatine kinase MB fraction release at day of surgery was done.

Surgical Technique

Conventional CABG (CCABG)

CCABG operations were performed in moderate hypothermia (32oC) using roller, non-pulsatile cardiopulmonary bypass (CPB) (Cobe-Century-USA), and membrane oxygenator (Capiox, Sx-Terumo-Corp.Tokyo-Japan). Cold antegrade multidose blood cardioplegia was used for cardiac diastolic arrest.

The OPCAB procedures were done via median sternotomy and each coronary artery was stabilized in turn using the Medtronic Octopus III Tissue Stabilization System (Medtronic, Inc, Minneapolis, MN). Starfish repositioner (Medtronic Inc., Minneapolis, MN) or a deep pericardial stitch was used for repositioning and exposing the target vessels.

Intracoronary shunts (Clear View, Arteriotomy shunts, Medtronic Inc., USA) were used in all patients to aid visualization during the distal anastomosis of the grafts. Surgical blower (Medtronic Inc., Minneapolis, MN, USA) was used routinely to aid visualization during performing anastomosis. Norepinephrine and volume expansion were used to maintain hemodynamics during positioning of the heart for anastomosis of the target vessels.

Types of the Conduits

Conduits used for bypass included left internal mammary (IMA) and right internal mammary artery (IMA) which were used as non-pedicled in situ grafts, left radial artery (RA), and saphenous vein grafts (SVG). The left internal mammary artery was anastomosed end-to-side to the left anterior descending (LAD) coronary artery. The right mammary artery was used for revascularization of right coronary artery (RCA) or posterior descending artery (PDA) .

The radial artery was usually anastomosed to branches of the circumflex artery, i.e. obtuse marginal branches (OM) or diagonal branches (Diag.). One or more saphenous vein grafts (SVG) were used to complete revascularization of the remaining stenosed coronary arteries. In all patients, single conduit was used for grafting of each stenotic coronary artery .The Order of anastomosis, anastomotic technique and type of sutures used did not differ in the two groups.

Transient Time Flow Measurement

Flow was measured (milliliters per minute {ml/min}) by the transient time method with the Veri Q System (CM 4008, Medi Stem AS, Oslo, Norway). Probes size 2 to 5 mm (Quik Fit Probe) to fit with the actual vessel size were used. (Fig. 1)

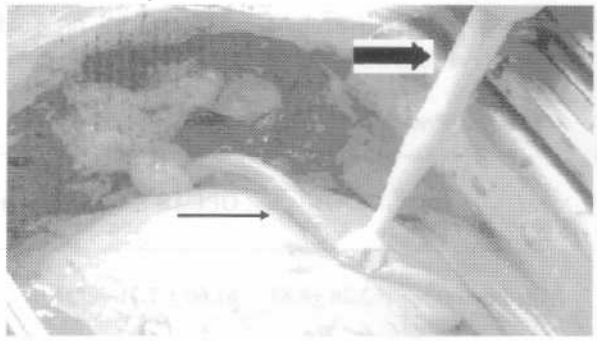


Fig. 1 measurement of the flow Measurement of graft flow using probe size 3 mm (thick arrow) in vein graft to posterior descending coronary artery (thin arrow)

Graft flow was measured in arterial and venous grafts and recorded after completion of proximal and distal anastomosis, weaning of patients from CPB and before heparin reversal.Flow was assessed by flow curve, mean flow rate and pulsatility index (PI) (Fig. 2)

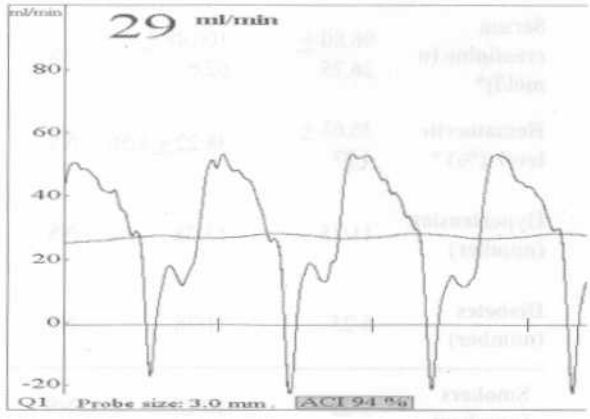


Fig. 2 Transient time flow measurement
Transient Time Flow measurement of left internal mammary artery (LIMA) to left anterior descending coronary artery (LAD).Shown are bypass flow (QI),flow curve , mean flow (29ml/min), pulstility index (PI)(2.6), probe size used(3.0 mm) , and percentage of probe contact with the graft (ACT) (94%).

Graft flow less than 10 ml/min or PI more than 5 usually was a sign that necessitates revision of the graft.

Statistical Analysis

Values are expressed as mean + standard deviation (SD). Comparisons between the two groups were performed using t-test. A P-value of 0.05 or less was considered significant. Analysis was done using SPSS program (SPSS, 7.5 for windows, Minu Tab, USA).

Results

The preoperative characteristics of all the studied patients are shown in Table 1.

Table (1): Preoperative data:

	CCABG	OPCAB	Significance
Age (Years) *	62.28 ±8.83	61.60 ± 7.71	**NS
Body Mass Index (kg/m²) *	26.05 ± 4.03	25.55 ± 3.54	NS
EuroSCORE (standard) *	2.35 ±2.51	2.63 ± 0.78	NS
EuroSCORE (logistic %) *	3.08 ±2.36	2.96 ± 1.51	NS
Ejection fraction (%) *	49.60 ± 10.40	48.00 ± 10.99	NS
Serum creatinine (u mol/l)*	96.80 ± 26.75	106.48 ± 62.6	NS
Hematocrite level (%) *	36.63 ± 4.27	38.22 ±3.56	NS
Hypertension (number)	11/25	13/28	NS
Diabetes (number)	8/25	11/28	NS
Smokers (number)	9/25	10/28	NS

** Data were presented as mean + SD*
*NS** = Non significant*

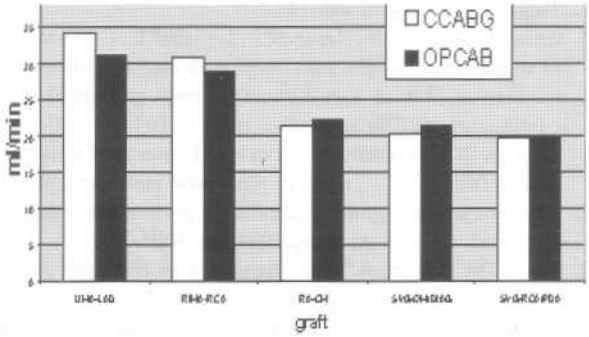
The preoperative characteristics of all the studied patients are shown in Table 1. No significant differences were found between these two groups (CCABG and OPCAB). Intraoperative data showed increased number of grafts per patient in CCABG group compared to OPCAB group. This difference was statistically significant. It also showed that there was a significant increase in number of patients who needed norepinephrine in OPCAB patients compared to CCABG patients (Table 2).

Table (2): Intraoperative variables

	CCABG	OPCAB	Pvalue
No. of distal anastomosis / patient	3.39 ± 0.81	2.72 ± 0.84	0.006
Use of Norepinephrine	6/28 (21%)	18/28 (64.3%)	0.00
Cross clamp time (minutes)	63.67 ±20.57	-	-
Total bypass time (minutes)	95.85 ±25.28	-	-

Total number of grafts was 95 in CCABG group versus 68 in OPCAB group. LIMA was grafted to LAD in all patients in both groups except one patient in OPCAB group; in that case LIMA was grafted to a reasonable diagonal artery. RA was used in 20/28 (85%) in CCABG group and in 16/25 (64 %) in OPCAB group. RIMA was used in 8/28 (28%) in CCABG and 10/25 (40%) OPCAB groups respectively.

Saphenous vein was used to complete revascularization in both groups. Comparison of individual graft flow between patients who underwent revascularization using CCABG and those who underwent OPCAB did not show statistical significance difference in these two techniques. The mean flow in LIMA to LAD anastomosis was 34.25 ± 19.28 versus 31.07 ±17.18 ml/min, RIMA to RCA/PDA 30.88 ± 9.43 versus 29.00 ±9.21 ml/min, RA to OM/Diag. 21.40 ± 4.60versus 22.21 +5.7 ml/min, and SVG to RCA/PDA were 19.65 ± 8.9 versus 20.11 ±10.70 ml/min in CCABG and OPCAB groups respectively (Table 3 and Fig. 3).



Two grafts were revised in the CCABG group duo to high PI and low flow, one graft was kinked and raanastomosis was done for the second graft. Flow measurement was satisfactory after that. A statistical significant difference was found in between the two groups regarding greater amount of blood loss and longer period of mechanical ventilation postoperatively in CCABG group. Patient that underwent OPCAB had lesser cardiac enzyme release, shorter stay in intensive care unit and hospital stay compare with those who underwent CCABG. (Table 4)

Table (4): Postoperative outcomes

Variable	CCABG	OPCAB	P value
Blood loss (ml)	959.82 ± 448.01	703.32 ±214.48	0.012
Ventilation time (hours)	19.14 ± 8.21	11.92 ± 5.78	0.001
Creatine kinase (umol/l.)	28.82 ± 29.21	15.66 ± 26.05	0.091
Creatine kinase MB(umol/l)	3.95 ± 2.57	1.65 ±2.29	0.002
Intensive Care Unit stay (Days)	2.46 ±1.17	2.12 ±0.52	0.182
Length of stay (Days)	10.07 ±4.17	7.52 ±1.15	0.005

Discussion

Cardiopulmonary bypass has been used for decades in CABG. It offers bloodless field and motionless heart that enables surgeon to perform a precise microvascular anastomosis of conduits to the coronary arteries (7). OPCAB or beating heart surgery is getting popular due to documented advantages on reducing morbidity, need for blood transfusion, hospital stay and simplicity (2,8). Despite many techniques (silastic snares or sutures, coronary concluders, intracoronary shunts and use of surgical blower) to control bleeding at arteriotomy sites and to facilitate bloodless field, there is still concerns about anastomotic quality and hence graft patency (9,10). Absence of hemodynamic compromise and probing of the anastomosis were used by surgical team to confirm the graft patency. Other methods have also been used to assess the quality of grafting and evaluate any technical errors while the patient is still in OR and the sternum is opened. Intraoperative angiography, although it is considered as gold standard technique in evaluating graft patency, has several limitation as it is invasive, time consuming and not always accessible in the operative room (3). Other methods such as thermal angiography and electromagnetic graft flow measurement can be used but they are difficult in interpretation and inaccurate (11, 12, 13). Epicardial ultrasound is a promising technique that may prove to be noninvasive, rapid and inexpensive technique for intraoperative assessment of anastomotic quality (14) .The transient time flow method for measurement of graft flow is based on the Doppler principle that directly measure mean blood volume flow. Several studies have demonstrated that this method is reliable and easy to perform (4, 5, 7, 15). In this study total graft flow in OPCAB group was found to be comparable with CCABG. When comparing individual grafts, LIMA to LAD graft in OPCAB had a non-significant lower mean flow compared to CCABG; this difference may be attributed vasoconstrictor effect of norepinephrine that was usually needed when performing OPCAB procedure to maintain hemodynamic stability. Schmitz and colleagues (11) demonstrated a significantly lower flow in cases done using OPCAB technique. They explained the lower mean graft flow in LIMA graft based on the absence of vasodilator effect of global ischemia in on-pump CABG and the use of vasoconstrictors during off- pump CABG. The mean flow in other grafts was not significantly different in between the two groups. This is in contrast to the finding of Schmitz et al. (10), who used SVG as a sequential graft to the rest of the stenotic coronary arteries while no sequential grafts were used in the current study. Kjaergard et al. (16) detected no difference between arterial or venous graft flow. Interestingly they also did not found any significant differences between men and women .The mean flow rate in arterial grafts (LIMA-LAD flow was 33.7 +2.0ml/min in CCABG and 34.4+2.9 ml/min in OPCAB) and venous grafts

(SVG-anastomosis flow was 30.4 ml/min in CCABG and 37.8 +5.4 ml/min in OPCAB) were similar to those of other studies (17). In a recent study, no statistical significant difference was found between conventional and off-pump CABG regarding arterial or venous grafts. The mean flow in all cases in LIMA to LAD graft flow was 37.4 + 23.5 ml/min and in SVG anastomosis graft it was 21.2+ 36.0 ml/min. (18). Graft patency was shown to be similar one year after surgery using angiography evaluation in conventional CABG and off- pump technique (19). To confirm accuracy of transient time flow technique as method of assessment of graft patency and assure that there no difference in graft patency in coronary artery grafting with or without the cardiopulmonary bypass still need further large studies .

Conclusion

No .difference was found in graft blood flow in CABG performed with either conventionally or using off-pump-technique. Transient time flow measurement is a helpful tool that can be used in assessing the graft patency in both on and off- pump CABG beside other clinical and laboratory markers.

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