ORIGINAL ARTICLE

# EARLY EFFECTS OF CORONARY ARTERY BYPASS GRAFTING ON LEFT VENTRICULAR REGIONAL WALL MOTION ABNORMALITIES

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## ABSTRACT

**Objective:** To determine the early effects of Coronary Artery Bypass Grafting (CABG) on regional left ventricular wall motion abnormality in patients undergoing surgery for proven Coronary Artery Disease (CAD).

**Design:** Quasi-experimental study.

**Place and Duration of Study:** Department of Cardiac Surgery, National Institute of Cardiovascular Diseases, Karachi. from October 2005 to April 2006.

**Patients and Methods:** A total of a 100 adult patients who underwent elective CABG were selected. Pre-operative echocardiography was done to note if segmental left ventricular wall motion at basal, mid and apical levels were normal, hypokinetic, akinetic, dyskinetic, or aneurysmal. Postoperative echocardiography was done between $4^{th}$ and $6^{th}$ day and change in left ventricular segmental wall motion was noted.

**Results:** Seventy-five patients (n=75) were included in the analysis. These results showed that effect of CABG on anterior segmental wall motion abnormalities was insignificant (p=.609), the effect on the anterior IVS showed deterioration of segmental wall motion and this effect was significant (p=.001), effect is insignificant on anteriolateral segmental wall motion abnormalities (p=.078), normal pre-operative segments in posterior wall showed stability (p=.664) while disappearance of dyskinetic, reduction in akinetic segments postoperatively and inferior wall motion have same effects as of posterior wall. Comparison of pre-operative and postoperative echocardiographic data revealed early improvement in segmental wall motion of posterior and inferior wall, while alterations in segmental wall motion of anterior, anterior-lateral and septal wall.

**Conclusion:** Myocardial revascularization by CABG improves early left ventricular regional wall motion abnormalities where SVG is used as conduit for revascularization whereas no significant improvement occurs in early segmental wall motion in areas revascularized by LIMA.

**KEY WORDS:** *Early effect. CABG. Segmental wall motion.*

## INTRODUCTION

Coronary Artery Bypass Grafting (CABG) has proven utility to preserve and improve left ventricular function in patients with coronary artery disease.[1] Ischemia may result in myocardial scarring and commonly leads to myocardial stunning or hibernation with resultant reversible depression of left ventricular regional wall motion.[2] Coronary artery revascularization often results in improvement of myocardial depression.[3] It is most pronounced after 6-24 hours of surgery, primarily due to increased myocardial perfusion.[4] Improvement in segmental wall motion has been observed in areas of scarring from previous myocardial infarction, even 12 months after CABG.[5]

Improvement in regional wall motion is determined by three major factors. These include the severity of regional wall motion abnormality, completeness of revascularization in these areas of abnormal motion, and identification of ischemic perfusion territories for strategic surgical planning.[6]

Global left ventricular function is an index of left ventricular systolic function, which is commonly described as ejection fraction. Left ventricular regional wall motion analysis is usually based on grading of contractility of individual segments. For the purpose of analysis, the left ventricle is divided into basal, mid and apical levels. The basal and mid levels are each subdivided into 6 segments and the apical level is subdivided into 4 segments. All of these 16 segments can be visualized from different tomographic planes during surface echocardiography. On the basis of contractility of an individual segment, a numerical scoring system has been adopted in which higher scores indicate more severe wall motion abnormality, denoted by 1 for normal, 2 for hypokinesia, 3 for akinesia, 4 for dyskinesia and 5 for aneurysmal.[7] A Wall Motion Score Index (WMSI) is derived by the formula WMSI = sum of wall motion scores/ number of visualized segments.

These left ventricular segments or regions can be easily related to the coronary artery perfusion beds.[8]

Studies on the effect of coronary artery bypass grafting on

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regional left ventricular wall motion abnormalities with regard to Pakistani population is not available in the literature.

This study was, therefore, planned to determine the early effects of Coronary Artery Bypass Grafting (CABG) on regional left ventricular wall motion abnormality in local Pakistani population undergoing surgery for proven coronary artery disease.

## PATIENTS AND METHODS

This was a quasi-experimental study done at the Department of Cardiac Surgery, National Institute of Cardiovascular Diseases (NICVD), Karachi. This study was carried out over a period of six months from October 2005 to April 2006. One hundred patients with proven coronary artery disease were selected without gender discrimination. The criteria for inclusion in the study were; age upto 70 years, presence of pre-operative regional left ventricle wall motion, abnormality on echocardiography and absence of mechanical support during weaning off Cardiopulmonary Bypass (CPB). The criteria for exclusion from the study were: patients requiring emergency coronary artery surgery, patients requiring an additional cardiac surgical procedure besides coronary bypass surgery, patients having cardiomyopathy other than ischemic cardiomyopathy, patients referred for CABG following Percutaneous Transcatheter Coronary Angioplasty (PTCA), patients who developed peri-operative myocardial infarction confirmed by postoperative electrocardiogram (ECG) and serial cardiac enzymes, patients undergoing redo CABG surgery and patients undergoing Off Pump Coronary Artery Bypass ( OPCAB) procedures.

All CABG procedures were done under general anesthesia with standard technique and continuous monitoring of Electrocardiography (ECG), arterial pressure, central venous pressure and arterial saturations. The internal mammary artery was used as a preferential conduit for grafting the left anterior descending artery. The great saphenous vein was used to bypass all other involved coronary arteries. No sequential grafts were done. Patients were kept in Intensive Care Unit (ICU) for approximately 48 hours postoperatively and then shifted to the surgical ward.

Pre-operative and postoperative echocardiography was done by the same experienced echo cardiographer. Postoperative echocardiography was done between 4-6 postoperative days. Guidelines provided by the American Society of Echocardiography (ASE) were followed while documenting regional wall motion. Tissue Harmonic Imaging (THI) was used. Left ventricular regional wall motion at three levels (basal level, mid level (papillary) and apical level) was noted. Basal and mid levels were each subdivided into 6 segments (anterior wall, anterior IVS (interventricular septum), IVS, anterio-lateral wall, posterior wall and inferior wall). The apical level was divided into four segments (anterior wall, IVS, anterio-lateral wall, posterior and inferior wall).

For purpose of analysis, a numerical scoring system was adopted on the basis of contractility, in which higher scores indicate more severe wall motion abnormality (1=normal, 2=hypokinesis, 3=akinesis, 4= dyskinesis, 5=aneurysmal) for all 16 segments. Systolic thickness of anterior IVS was measured to document the improvement or deterioration in this region. Left Ventricular End Diastolic Dimension (LVEDD), Left Ventricular End Systolic Dimension (LVESD) and Ejection Fraction (EF) were also noted. Comparison was done between findings of pre-operative and postoperative echocardiographic documented reports.

Data analysis was performed through SPSS version 10. Patients were divided into two groups on the basis of method of myocardial preservation used and Wall Motion Score (WMS) was calculated. Qualitative data including gender, left ventricular regional wall motion abnormality was presented by frequency and percentage; Mac Nemar test was applied to compare the proportions of anterior wall motion, anteriolateral wall and likelihood ratio was applied to compare the proportions of anterior IVS, IVS, posterior wall and inferior wall variables at $p<0.05$ level of significance. Age was presented by mean ± SD (standard deviation).

## RESULTS

In a 6 months period between October 2005 to April 2006, 100 patients undergoing coronary artery bypass grafting with pre-operative left ventricular regional wall motion abnormalities, were selected for the study. Out of these patients, 7 (7%) died, 2 of which had calcified aorta, which resulted in loss of cerebral function and they were unable to wake up postoperatively. Two patients who had pre-operative compromised renal function after CABG developed complete renal shutdown and died on the 5th postoperative day. One of the patients who expired on the operation day was diabetic and had endartrectomy of Right Coronary Artery and Left Coronary Artery (RCA and LCA) and developed intractable arrhythmias. Another patient had developed temponade due to postoperative bleeding which was not detected and the patient died within 24 hours postoperatively and 1 patient who had Chronic Obstructive Pulmonary Disease (COPD) pre-operatively was unable to wean off from ventilator and died on the 4th postoperative day due to respiratory failure. For purposes of completion, data was deficient in 18 of these patients. These patients were excluded from the scrutiny. Data was complete for 75 patients who were included in the analysis. In this group of patients, the average age was 52.28 ± 8.79 (range 36-71 years). Majority of the patients i.e. 72 (96%) were men. Pre-operative angiographic data revealed right main coronary artery (RCA) atherosclerosis in 51(68%) of which 21 (28%) were with 100% occlusion, 24 (32%) with 76-99% stenosis, 3 (4%) with 51-75% stenosis and 3 (4%) with 0-50% stenosis. The right dominant Posterior Descending Artery (PDA) was involved in 21(28%) patients and the posterior branch of left ventricle (PLV) in 6 (8%) patients.

The left main coronary artery had 76-99% stenotic disease in 12 (16%) patients, and 0-50% stenosis in 3 (4%) patients. The Left Anterior Descending artery (LAD) was involved in all patients (100%), with totally occlusive disease in 15 patients (20%), 76-99% stenotic disease in 54 patients (72%), and 51-75% stenosis in 6 patients (8%). The diagonal branches of the LAD (DIAG 1 and 2) were diseased in 51 patients (68%). The main circumflex (CIRC) system was found to have 100% occlusion in 9 patients (12%), 76-99% stenosis in 36 patients (48%), and <75% stenosis in 9 patients (12%). Obtuse marginal arteries OM-1, OM-2, and OM-3 were diseased in 56%, 36% and 8% patients respectively. The Ramus Intermedius had 76-99% proximal stenosis in only 3 patients (4%).

All patients underwent surgery on cardiopulmonary bypass. The total number of proximal anastomosis were 162 (mean 2.16 ± 0.78). The total number of distal anastomosis were 216 (mean 2.88 ± 0.77).

Systemic cooling down to a core body temperature of 32°C in 12 patients and 28°C in 63 patients was used for further myocardial protection. Topical cooling with cold saline to complement this was employed in all the patients.

The mean cardiopulmonary bypass time was 97.83 minutes (varying from 40 - 212 minutes) and mean aortic cross clamp time was 38.66 minutes (varying from 15 - 83 minutes).

The distal RCA was grafted in 30 patients (40%) and the RCA-PDA in 15 patients (20%).

All the (100%) patients had their LAD grafted. The mid LAD was grafted in 72 patients (96%) and distal LAD in 3 patients (4%). DIAG-1, and DIAG-2 were grafted in 33(44%) and 3(4%) patients respectively. The Ramus Intermedius was grafted in 3 patients (4%).

OM-1, OM-2, and OM-3 arteries were grafted in 39(52%), 18(24%), and 3 patients (4%) respectively.

The Left Internal Mammary Artery (LIMA) was used to bypass the LAD in 60 patients (80%) and the Great Saphenous Vein (SVG) in 15 patients (20%). All other vessels were grafted using SVG as a conduit.

Endarterectomy of the RCA was carried out in 12 (16%) patients, of the LAD in 3 (4%) patients. On the basis of pre-operative and postoperative echocardiography findings, Wall Motion Score Index (WMSI) was 1.25 pre-operatively and 1.23 postoperatively.

There was no significant difference between pre- and postoperative left ventricular WMSI. This indicates that CABG had no significant early effect on the WMSI.

There was no change in the Left Ventricular Ejection Fraction (LVEF) in pre-operative and postoperative echocardiography findings, which showed that CABG has no early effect on the LVEF.

The mode of myocardial preservation was antigrade cold blood cardioplegia in 39 patients (52%) and intermittent cross clamping with fibrillation in 36 patients (48%). The early effect of CABG on the left ventricular regional wall motion abnormality was same in the patients in which two different methods of myocardial preservation was used in Group A with antegrade cold blood cardioplegia and in Group B with intermittent cross clamping with fibrillation. Both groups of patients showed increase in wall motion score (WMS) in anterior, anterior IVS and IVS. Anterolateral wall in Group A revealed a decrease in WMS while group B showed no significant change. While WMS decreased in both groups A and B in posterior and inferior wall segments, Table I .

Effect of CABG on left ventricle wall motion is shown in Table II. These results showed that effect of CABG on anterior segmental wall motion abnormalities was insignificant (p=.609), the effect on the anterior IVS showed significant deterioration of segmental wall motion (p=.001), and the anteriolateral segmental wall motion abnormalities were insignificantly changed (p=.078). The normal pre-operative segments in posterior wall showed stability (p=.664), while disappearance of dyskinetic, reduction in akinetic segments postoperatively and inferior wall motion have the same effects as of posterior wall.

**Table I:** Results comparing two different methods of myocardial preservation.

| Segmental wall | Group A (n=39) Pre-operative WMS | Group A (n=39) Postoperative WMS | Group B (n=36) Pre-operative WMS | Group B (n=36) Postoperative WM |
|---|---|---|---|---|
| Anterior wall | 208 | 211 | 190 | 191 |
| Anterior IVS | 186 | 211 | 171 | 195 |
| IVS | 107 | 131 | 100 | 124 |
| Ant-lat wall | 201 | 190 | 182 | 181 |
| Posterior wall | 215 | 206 | 197 | 184 |
| Inferior wall | 160 | 146 | 181 | 139 |

Wall motion score(WMS) = Sum of wall motion score.

**Table II:** Comparison between pre-operative and postoperative echocardiography of left ventricular segmental wall motion.

| Segmental wall motion | Basal (n=75) | Mid (n=75) | Apical (n=75) | Basal (n=75) | Mid (n=75) | Apical (n=75) | P-value |
|---|---|---|---|---|---|---|---|
| **Anterior wall** | | | | | | | |
| u Normal | 42 | 36 | 30 | 39 | 33 | 33 | 0.609[a] |
| u Hypokinesia | 15 | 18 | 21 | 21 | 21 | 21 | 1.00[b] |
| u Akinesia | 18 | 21 | 24 | 15 | 21 | 21 | 0.23[c] |
| **Anterior IVS** | | | | | | | |
| u Normal | 54 | 36 | 33 | 42 | 27 | 27 | .0001[a] |
| u Hypokinesia | 18 | 24 | 30 | 18 | 21 | 27 | .0001[b] |
| u Akinesia | 03 | 15 | 12 | 09 | 21 | 18 | .0001[c] |
| u Dyskinesia | | | | 06 | 06 | 03 | |
| **IVS** | | | | | | | |
| u Normal | 54 | 51 | | 39 | 36 | | .0001[a] |
| u Hypokinesia | 15 | 18 | - | 27 | 27 | | .001[b] |
| u Akinesia | 06 | 06 | - | 03 | 06 | - | |
| u Dyskinesia | | | | 06 | 06 | | |
| **Anteriolateral wall** | | | | | | | |
| u Normal | 42 | 45 | 30 | 42 | 39 | 33 | .078[a] |
| u Hypokinesia | 18 | 15 | 24 | 27 | 29 | 21 | .664[b] |
| u Akinesia | 15 | 15 | 21 | 06 | 09 | 18 | .0001[c] |
| u Dyskinesia | | | | | | 03 | |
| **Posterior wall** | | | | | | | |
| u Normal | 45 | 44 | 24 | 45 | 45 | 36 | .664[a] |
| u Hypokinesia | 09 | 06 | 15 | 15 | 18 | 15 | .0001[b] |
| u Akinesia | 21 | 24 | 33 | 15 | 15 | 24 | .002[c] |
| u Dyskinesia | | 03 | 03 | | | | |
| **Inferior wall** | | | | | | | |
| u Normal | 30 | 30 | | 33 | 27 | | .0001[a] |
| u Hypokinesia | 12 | 12 | | 21 | 24 | | .0001[b] |
| u Akinesia | 30 | 30 | | 21 | 24 | | .0001[b] |
| u Dyskinesia | 03 | 03 | | | | | |

[a] pre vs. post echocardiography of normal segmental wall motion,
[b] pre vs. post echocardiography of hypokinetic segmental wall motion abnormality,
[c] pre vs. post echocardiography of akinetic segmental wall motion abnormality,
[d] pre vs. post echocardiography of dyskinetic segmental wall motion abnormality.

## DISCUSSION

The first pioneering operation to revascularize the myocardium was reported by Baily in 1957.[9,10] Coronary Artery Bypass Grafting (CABG) is a treatment of choice for patients with multi-vessel disease.[11] Patients with Coronary Artery Disease (CAD) and impaired left ventricular function, who have had surgical revascularization, have a better prognosis compared to patients who had Percutaneous Coronary Intervention

(PCI).[12-15] These patients represent a population that gains a survival advantage with surgical revascularization and shows a significant improvement in segmental and global myocardial function.[16-18]

Left ventricular segmental wall motion abnormality, which is another term for left ventricular dysfunction, is a condition which may be caused by myocardial hibernation.[19,20] Hibernating myocardium may be associated with chronic hypoperfusion, or result from repetitive episodes of ischemia which can have a cumulative effect on contractile function. Myocardial hibernation leads to reversible ultra structural changes in the myocytes, including the loss of myofilaments and accumulation of glycogen. Due to these structural changes, the affected myocytes do not start contracting as soon as myocardial revascularization has been carried out, but may resume normal contractile activity within a short span of time.[13] Timing to see the resumption of normal contractile activity in hibernating myocardium after revascularization has always been dissimilar in various studies. As in this study, to appreciate early effects, 2D echocardiography has been used between 4-6 postoperative days, to monitor changes in segmental wall motion. While Hirata *et al.* studied changes in segmental wall motion immediately after myocardial re-vascularization and one month postoperatively, using Cyclic Variation (CV) of ultrasonic Integrated Backscatter (IB), as a predictor of the success of revascularization.[21] In another study, Rubenson *et al.* have studied changes in segmental wall motion, at one week and one and-a-half month post-operatively, using two-dimensional (2D) echocardiography.[22]

In this study, early significant improvement in segmental wall motion was noted in the posterior and inferior wall regions, these are the areas where the saphenous vein was used as a conduit for revascularization, whereas no significant improvement was seen in segmental wall motion in the regions which were revascularized by the LIMA. To verify the effect of CABG on segmental wall motion abnormalities, Voci *et al.* noted that segmental wall motion analysis before CABG surgery in patients revealed that 170 (66%) of 256 myocardial segments were subnormal, of which 115 (67%) improved and 102 (60%) returned to normal immediately after CABG surgery. Eleven myocardial segments that were hyperkinetic before CABG surgery returned to normal after CABG surgery. Pre-operatively, 162 (63%) of 256 myocardial segments had systolic wall thickening less than 30%, which increased from 11.8% ± 8.9% to 24.3% ± 14.3% (mean ± SD) ($p < 0.01$) postoperatively. Conversely, a reverse trend was found when systolic wall thickening was greater than 30% before CABG surgery, the thickening decreased from 46.2% ± 13.8% to 33.4% ± 14.8% after CABG surgery ($p < 0.01$). They concluded that immediately after CABG surgery, there was a recovery of function in some myocardial segments and a reduction in function of others.[23] Similar results were obtained by Rubenson *et al.*[22] who studied 20 patients with coronary artery disease with two-dimensional echocardiography, the day before saphenous vein bypass graft surgery. Serial studies were obtained 7.4 ± 2.5 (± SD) and 43.4 ± 13.1 days postoperatively to qualitatively assess the effect of bypass surgery on regional wall motion. There was a significant worsening in the septal motion (apical and basal) and a significant improvement in posterior wall motion (apical and basal) after bypass surgery. Anterior and lateral wall motion was not significantly changed. The motion of septal segments, however, generally worsened postoperatively irrespective of being normal or abnormal pre-operatively.

The present study also confirms results which were obtained by Friesewinkel *et al.*[8], who expressed no doubts about the superior long-term patency of LIMA in comparison to saphenous vein grafts, however, he opined that the early postoperative results were controversial. In his study, 33 patients who underwent elective myocardial revascularization were examined. In addition to vein grafts, bilateral IMA grafts were used in 8 patients and unilateral ones in 25 patients. Myocardial segmental wall motion was assessed by transesophageal echocardiography perioperatively. Anterior wall motion [left IMA grafts to left anterior descending artery (LAD)] was decreased early postoperatively (30 minutes) in both groups. Posterior wall motion was decreased in the bilateral IMA group (right IMA to right coronary artery) and remained unchanged in the unilateral IMA patients (vein grafts to RCA). Internal mammary artery revascularization may result in deterioration of segmental myocardial function in the early (< 4 hours) postoperative period. He concluded that bilateral IMA grafts should, therefore, be used with caution in patients with impaired ventricular function.

However, Podgoreanu, *et al.*[24] suggested that using echo-cardiography for interpretation of regional wall motion abnormalities is subjective and experience dependent. In his view delayed contraction in the ejection phase (tardokinesis) and regional systolic asynchrony, which are sensitive markers of myocardial ischemia, cannot be accurately assessed visually. He used color kinesis (CK), a technique that evaluates spatiotemporal patterns of endocardial motion, to objectively detect regional wall motion abnormalities in patients undergoing coronary bypass surgery, and he compared it with conventional assessment of grayscale images by less experienced reviewers; he used expert grading as the gold standard for comparison. Quantitative CK analysis agreed more closely with expert grading than less experienced reviewers.

During postoperative echocardiography it was painful for the patient to change posture and to have images by surface echocardiography from anterior chest wall close to the wound, which may have affected the echocardiography results.

## Conclusion

Myocardial revascularization by CABG improves early left ventricular regional wall motion abnormalities, where SVG is used as conduit for revascularization, whereas no significant improvement occurs in early segmental wall motion in areas revascularized by LIMA.

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