Effects of Coronary Bypass Surgery on Myocardial Performance Index (MPI or Tei index)

Majid Maleki, MD, Peiman Malek Marzban, MD, S. Zahra Ojaghi Haghighi, MD and F. Noohi, MD

Abstract

Background- Coronary artery bypass grafting (CABG) is a common surgical procedure performed in the world. Coronary artery disease (CAD) has become prevalent in Iran, and the aim of this study is to assess the effects of CABG on LV systolic and diastolic function indices. We also attempted to disclose the CABG effect on the myocardial performance (Tei) index.

Methods- 50 patients were enrolled in this study, all of whom were given instructions about the research program. They were admitted to our center electively for CABG; the first echocardiography was taken just prior to surgery, and the second TTE was performed between 1 and 43 weeks after surgery (mean=11 weeks).

Results- CABG had dramatic effects on the patients, as their mean left ventricular ejection fraction (LVEF) rose from 48.88% to 52.54% (P<0.001). It was more obvious in patients with preoperative LVEF less than 40%, Tei index<0.49, male gender and those with complete revascularization. LVEF had no change in the case of incomplete revascularization. MPI (Tei) decreased significantly after CABG from 0.4992 to 0.4462 (P=0.001), which was more pronounced in those whose preoperative Tei index was equal or more than 0.49 and in patients with triple vessel or left main CAD. Diastolic function recovery had a time-dependent manner with no change or even deterioration during the first few days after CABG, but after 4 weeks nearly half of the patients had normal diastolic function. History of systemic hypertension and old age (>60 years old) are both associated with more preoperative diastolic dysfunction and are negative predictors for diastolic function recovery after CABG. Isovolumetric relaxation time (IVRT), E-wave deceleration time (EDT), peak E-wave velocity (PEV) and peak A-wave velocity (PA) all show significant improvement after CABG. There was no mortality in our series.

Conclusion- CABG has important positive and significant effects on many LV systolic and diastolic indices including LVEF, LVESV, IVRT, PEV, PAV and EDT as well as on the myocardial performance (Tei) index ***(Iranian Heart Journal 2005; 6 (1,2): 26-30).***

Key words: coronary artery bypass surgery Ë myocardial function Ë ejection fraction

Abbreviations: CABG: coronary artery bypass grafting. CAD: coronary artery disease, LVEF: left ventricular ejection fraction, MPI: myocardial performance index (Tei), LVEDD: left ventricular end diastolic dimension, LVESD: left ventricular end systolic dimension, LVEDV: left ventricular end diastolic volume, IVRT: isovolumetric relaxation time, BEF: basal ejection fraction, FS: fractional shortening , EDT:E-wave deceleration time, TTE: transthoracic echocardiography

An essential subject in managing CAD patients is to improve LV function, so one of the most important attributes of CABG is its ability to increase blood supply for the myocardium in order for it to overcome dysfunction if it has not been damaged irreversibly by CAD.

CABG has dramatic effects on most left ventricular (LV) systolic and diastolic function indices, and numerous studies carried out in different centers consistently show significant improvement in the above-mentioned indices.

Also, there is a recently described index (MPI or Tei index), which reflects global (both systolic and diastolic) cardiac function. This index can be derived from mitral inflow Doppler spectral and is equal to the sum of isovolumetric relaxation time (IVRT) and isovolumetric contraction time (IVCT), divided by ejection time (ET). Any pathologic event which may compromise LV systolic or diastolic function prolongs IVCD and IVRT, and shortens ET; consequently, MPI increases. There is some controversy among authors for the normal range of MPI, but most agree that values between 0.32 and 0.42 are normal.

This index has some correlation with LVEF, and LVEF can be calculated roughly using MPI:

From the Dept. of Cardiology, Shaheed Rajaie Cardiovascular Medical Center, Mellat Park, Vali Asr Avenue, Tehran, Iran.
Correspondence to M. Maleki, MD, Shaheed Rajaie Cardiovascular Medical Center, Mellat Park, Vali Asr Avenue, Tehran, Iran
Email: Maleki@rhc.ac.ir Tel : (021) 2055594 Fax: (021) 2055594

LVEF = 0.60–(0.34 X MPI), although this formula mildly underestimates EF, when assessed by radionuclide ventriculography.[1]

There are several studies suggesting a close relation between MPI and BNP level in heart failure, with 86% sensitivity and 82% specificity by considering 0.47 cut-off point. This research is one of the few studies on the effects of CABG on MPI.

Methods

In this study, we compared pre-CABG LV function with indices such as LVEF, left ventricular end-diastolic volume (LVEDV), left ventricular end-systolic volume (LVESV), left ventricular end-diastolic dimension (LVEDD), left ventricular end-systolic dimension (LVESD), basal ejection fraction (BEF), fractional shortening (FS) and also peak E-wave velocity (PEV), peak A-wave velocity (PAV), E-wave deceleration time (EDT), isovolumetric relaxation time (IVRT) and mitral inflow pattern (MPI) pre-CABG with postoperative values by echocardiography. Fifty patients were enrolled in this study, all of whom were examined 1 or 2 days before CABG, and the second TTE was performed 1 to 43 weeks after CABG (mean =11 weeks, median=7 weeks).There was no mortality in our study group.

Results

Of the 50 patients, 21 (42%) were female, and 29 (58%) were male. Twenty-two (44%) had systemic arterial hypertension, and 18 (36%) had diabetes mellitus. From the angiographic point of view, 40 patients (80%) had three-vessel or left main coronary artery disease, 8 patients (16%) had two-vessel disease and 2 patients (4%) had single-vessel disease. LVEF was 44.69%, but echocardiographic LVEF calculated by the Simpson method was 48.88%, mean (P=0.001). All angiographic LVEF reports were based on eye-ball estimation.

Table I. Effect of CABG on LV function indices

Variable	Pre-CABG	Post-CABG	change	P-value
EF	48.88%	52.54%	↑3.51%	<0.001
MPI(Tei index)	0.4992	0.4462	↓0.053)	0.001
IVRT	113.56	96.78	↓16.78	<0.001
PEV	0.71	0.80	↑0.09	0.002
PAV	0.84	0.0.74	↓0.1	<0.001
EDT	232.84	200	↓32.84	0.001
LVESD	3.48	3.57	↑0.09	0.241(n)
BEF	57.68%	53.72%	↓ 3.96%	0.041
FS	31.22%	28.24%	↓2.98%	0.019
LVEDV	98.04	96.46	↓1.58	0.595(n)
LVESV	50.68	46.20	↓4.48	0.02
LVEDD	5.03	4.96	↓ 0.07	0.331(n)

n= non-significant

As evident from the data of Table I, LVEF and PEV both significantly increased (3.51% and 0.09m/s, respectively), and LVESV, PAV, IVRT, EDT, BEF and FS all significantly decreased (4.48ml, 0.1m/s, 16.78msec, 32.84msec, 3.96%, 2.98%) after CABG. In addition, CABG significantly reduced MPI from a mean preoperative level of 0.4992 to 0.4462, which was more pronounced in patients whose preoperative MPI was equal to or more than 0.49 and in patients with triple-vessel or left main CAD.

LVEF rose from 48.88% to 52.54%, and the increment was more obvious in patients with preoperative LVEF less than 40%, MPI < 0.49; 3 male gender and finally those with complete revascularization; LVEF did not increase in patients with incomplete revascularization.

In some subgroups, LV function indices changed differently; for example males had lower preoperative LVEF and enjoyed more LVEF rise after CABG than females. MPI, however, decreased in both, which was more significant in females.

Table II. Gender difference on CABG results

variable	Pre-CABG		post-CABG		change	P-value		
	male	female	male	female	male	female	male	female
EF	47.096	51.738	51.379	54.143	↑4.310	↑2.405	0.001	0.019
MPI(Tei)	0.5045	0.4919	0.4595	0.4286	↓0.0455	↓0.0633	0.050	0.005
IVRT	115.41	111.00	100.07	92.24	↓15.34	↓18.76	0.002	0.020
PEV	0.6534	0.7895	0.7672	0.8471	↑0.1138	↑0.0576(n)	0.003	0.216(n)
PAV	0.7786	0.9152	0.7234	0.7695	↓0.0552	↓0.1457(n)	0.50	<0.001
EDT	230.07	236.67	204.14	193.19	↓25.93	↓43.48	0.038	0.015

↓0.09

Hypertensive patients had a significant rise in their LVEF (3.477%, P<0001) and PEV ($0.1105_{m/s}$, P=0.026) and also significant decrease in MPI (0.06, P=0.012), IVRT ($24.27_{msec,}$ P=0.003), PAV ($0.16_{m/s,}$ P<0.001) and EDT (30.68_{msec}, P=0.045). In contrast, normotensives had an insignificant decrease of PAV ($0.038_{m/s}$, P=0.15), but all other indices showed significant improvement.

Diabetic patients had a significant improvement in most indices, including MPI (0.057, P=0.11), LVEF (3.47%, P=0.004), IVRT (21.72_{msec}, P=0.009) and PAV ($0.16_{m/s}$, P=0.001), but PEV and EDT both decreased insignificantly. In patients without diabetes, all the indices improved significantly after CABG, LVEF ↑3.531%, P=0.003; MPI ↓0.0506, P=0.024; IVRT ↓14.00_{msec}, P=0.006; PEV ↑$0.1319_{m/s}$,

P=0.001; PAV ↓0.0559, P=0.032; EDT ↓37.69, P=0.003].

Patients with preoperative LVEF less than 40% had a greatest increase in their LVEF (↑4.750%, P=0.001) and showed a significant improvement in IVRT (↓34.63, P=0.003), PEV (↑$0.22_{m/s}$, P=0.024) and PAV (↓$0.095_{m/s}$, P=0.047) after CABG. MPI and EDT both improved insignificantly. Those with preoperative LVEF more than 40% showed a significant improvement in all the indices (LVEF ↑3.274%. P=0.001; MPI ↓0.0502, P=0.002; IVRT ↓13.38_{msec}, P=0.004; PEV ↑$0.0655_{m/s}$, P=0.025; PAV ↓$0.0929_{m/s}$, P=0.001; EDT ↓34.93_{msec}, P=0.002).

In patients with preoperative MPI equal or greater than 0.49, all the indices improved significantly after CABG, (LVEF ↑2.769%, P=0.003; MPI 65, P=< 0.001; IVRT ↓22.54_{msec}, P=0.001; PEV ↑$0.1062_{m/s}$, P=0.001; PAV ↓$0.1081_{m/s}$, P=< 0.001; EDT ↓45.38_{msec}, P=0.009). This subgroup had the greatest improvement in MPI postoperatively. In contrast, patients with preoperative MPI less than 0.49, had a significant improvement only in LVEF (↑4.313%, P=0.004) and PAV (↓$0.0771_{m/s}$, P=0.046). The rise in LVEF in the latter subgroup is more prominent than that in the former, so MPI may have some correlation with myocardial viability, and this issue should be addressed in future studies.

Discussion

This study compares the effects of CABG on systolic and diastolic functions before and after surgery.

Most echocardiographic LV systolic indices such as LVEF, LVESV and MPI improve significantly after CABG, although BEF and FS both significantly decrease after CABG, which translates into the inability of the LV posterior wall's exaggerated excursion to compensate for the interventricular septum's (IVS) abnormal anterior motion, appearing after pericardiotomy. LVEDD also decreases significantly during the first few days after surgery but returns to preoperative values thereafter. LVEF had no change when revascularization was incomplete. MPI significantly improves after CABG, especially in patients with triple-vessel or left main lesions and those with preoperative MPI equal to or more than 0.49. Similarly, LVEF improves more significantly when preoperative MPI is less than 0.49, and this finding may relate to some degree between MPI and myocardial viability.

Diastolic function recovery has a time- dependent manner with no change or even deterioration during the first few days after CABG, but after 4 weeks, nearly half of the patients will recover normal diastolic function. Past history of systemic hypertension and old age (>60 years old) are both associated with more preoperative diastolic dysfunction, and they are negative predictors for diastolic function recovery after CABG.

Diabetes mellitus in itself has no major influence on the early results of CABG and LV function recovery, unless associated with systemic arterial hypertension, which may have detrimental effects on LV diastolic function recovery.
MPI is greater in patients with triple-vessel or left main disease and is reduced more after CABG compared to patients with two or single-vessel disease. Furthermore, improvement of IVRT, PAV, EDT and PEV is more prominent in the former group.
Those with preoperative LVEF less than 40% and male gender have a larger LVEF and PEV increase after CABG; all the patients of the former group had diastolic dysfunction preoperatively, but 17% of the patients with preoperative LVEF equal to or more than 40% had normal diastolic function before CABG.
Old age (>60 years) is associated with a greater improvement in MPI, EDT and PAV in comparison to younger patients, but both have a significant LVEF improvement following complete revascularization.
This study shows MPI to be a safe, noninvasive, reproducible and reliable index in evaluating the effects of CABG on LV function.

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