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ORIGINAL ARTICLE

TISSUE DOPPLER ECHOCARDIOGRAPHIC EVALUATION OF MYOCARDIAL FUNCTION AFTER UNCOMPLICATED CORONARY ARTERY BYPASS GRAFTING OPERATION.

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ABSTRACT

Background: CABG operation may affect myocardial function by inducing stunning.
Objective: evaluation whether myocardial function is affected by CABG in patients with preserved function.
Methods: : LV function evaluated by LVEF ,LV dimensions ,LA and Aortic root dimension ,Doppler mitral inflow velocities E and A waves and pulsed wave tissue Doppler of mitral annulus.
RV function evaluated by tricuspid annular plane systolic excursion, tricuspid valve inflow E and A waves, tissue Doppler echocardiography at the lateral side of the tricuspid annulus and myocardial Performance Index of RV
Results: Forty patients underwent CABG were included. 18 underwent conventional CABG , while 22 underwent off-pump surgery . Systolic LV function was not statistically significantly affected by CABG . LV diastolic function improved post CABG. Regarding RV function, IMP improved (i.e. values decreased) significantly when comparing the values from before CABG to after CABG. RV systolic function measured via TAPSE was significantly reduced 5 days after CABG and remained so three months postoperatively, and by using TDI systolic and diastolic RV function deteriorated post CABG.reduced TAPSE&RV S` with improved RIMP may indicate reduced regional RV function rather than reduced global function..
Conclusion: LV function did not deteriorate after CABG in patients with preserved preoperative systolic function. LV diastolic function improved after CABG. RV function reduced post CABG using TAPSE &TDI and improved using RIMP
Keywords: : Coronary artery bypass grafting ; Tissue Doppler echocardiography; Cardiopulmonary bypass; off-pump surgery.

INTRODUCTION

Surgical revascularization for CAD by CABG is indicated for patients with angina pectoris and amenable anatomy, especially patients with left main coronary artery or left main equivalent disease .[1] CABG proved to improve survival in patients with left main coronary artery disease and in specific subgroups with multi-vessel disease.[2]
The aim of revascularization is to restore myocardial oxygen supply to the myocardium and then improve symptoms of myocardial ischemia. Patients with dysfunctional, but viable, myocardium may regain regional and global contractile function after revascularization .[3] However, the time course of improvement in myocardial function after CABG is not describedcompletly . In patients with viable myocardium, the time needed to recover LV function is variable and may take weeks, months or even more .[4]
The liability of right ventricle (RV) to ischemic damage during the time of cross clamping increasingly recognized .Depressed RV

function has been proposed after CABG. The underlying causes leading to RV dysfunction still unclear.5

TDI represents quick and easy method for detecting systolic and diastolic dysfunction .Unlike conventional visual assessment of regional wall motion abnormalities it does not depend on subjective interpretation and can be objectively evaluated .6

AIM OF THE STUDY

To evaluate the effect of CABG on both left ventricular and right ventricular functions and using tissue Doppler imaging to determine whether any such effects differed between conventional on-pump CABG and off-pump surgery .

SUBJECTS & METHODS

This study was conducted from November 2015 to may 2019. Included 40patients who fulfilled the inclusion criteria.Recruited patients were assigned to either group A (which included 18 patients), who were subjected to CABG with use of cardiopulmonary bypass machine (On-pump CABG), and group B (which included 22 patients who were subjected to CABG without use of cardiopulmonary bypass machine (Off – pump CABG) . Written informed consent was obtained from all participants and the study was approved by the research ethical committee of Faculty of Medicine, Zagazig University. The work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans

Inclusion Criteria: Patients who had significant isolated CAD and EF > 50% who were accepted for CABG within two months of the diagnostic coronary angiography.

Exclusion Criteria: History of recent myocardial infarction in last 4 weeks or previous revasculaization**,** Presence of atrial fibrillation, significant valvular heart disease, Pulmonary hypertension (> 50 mmHg) and Ventricular aneurysm.

Tranthoracic echocardiography was performed before CABG (within 24 hour before surgery) as well as 5 days And 3 months after surgery. Myocardial tissue Doppler peak systolic (S ′), early diastolic (E ′)and late diastolic (A ′) velocities was measured (in cm/s) with the sample volume positioned at the septal and lateral angles of the mitral annular ring as well as on the lateral angle of the tricuspid valve.

We prospectively evaluated Left ventricular function by LV ejection fraction by modified Simpson method, left ventricular dimensions, left atrium and Aortic root dimension, Doppler mitral inflow velocities including E and A wave peak velocities (cm/s) and pulsed wave tissue Doppler of mitral annulus.

We prospectively also evaluated right ventricular function by RV Systolic function, right ventricular dimensions, tricuspid annular plane systolic excursion, tricuspid valve inflow E and A waves, tissue Doppler echocardiography at the lateral side of the tricuspid annulus and myocardial Performance Index (MPI) of RV

Statistical analysis

Values presented as mean p standard deviation. Comparisons between groups were made using Student's t test or Mann—Whitney U test as appropriate. Repeated measure analysis of variance (ANOVA) followed by post-hoc comparisons using paired t-tests with Bonferroni correction were used to compare tissue Doppler parameters before and at different time points after surgery. For al l analyses a p value<0.05 was considered non significant.

RESULTS

Patient characteristics:

Forty consecutive patients (35 male, 52 ±10 years) underwent elective CABG in zagazig university hospitals were included in this study. Of the 40 patients enrolled, 18 underwent conventional CABG (16 male, 55 ± 8 years), while 22 patients underwent off-pump surgery (19 male, 50 ±10 years).

Angiograhic data :

Thirty patients had three vessels CAD ,while 8 patients had 2-vessel disease, two patients had distal left main and osteal LAD, and 35 patients had right coronary artery disease. Some patients had more than one segment stenosed in the same vessel.

Operative details:

Overall, grafts number was not significantly different between On-pump and off-pump CABG (median = 3 in both). Most patients received three b grafts (range 1—4), 6 patients received sequential grafts and in all patient LIMA to the LAD bypass graft was used.

Echocardiographic Left ventricular function before and after CABG:

In our study, a non significant decrease in LV systolic function with CABG was observed in patients with normal pre-operative LVEF, While decrease in LVEF was small (mean 3% reduction at 3 months post CABG compared to preoperative value),which may not have any clinical significance(p value>0.05). The other LV indices that changed after CABG operation were decreased LVIDd (p value<0.01) and increased Left atrial diameter (p<0.001).

Transmitral diastolic indices:

Not significantly changed after CABG operation E wave changes (0.67 before operation vs 0.68 &0.70 post operatively respectively 5 days and 3 months with non significant p value), A wave changes (0.67 before operation vs. 0.59 &1.1 post operatively respectively 5 days and 3 months with non significant p value) and E/A changes (1.1 before operation vs. 1.2 &2.24 post operatively respectively 5 days and 3 months with non significant p value).

Right ventricular myocardial function before and after CABG :

Right ventricular index of myocardial performance (RIMP):

RIMP significantly improved when comparing the values from before CABG to after CABG (0.45±0.12 before CABG vs 0.39±0.09 and 0.42±02.87 postoperatively 5 days and 3 months respectively with P = 0.013). The improvement after CABG was due to a reduction in ICT and IVRT.

RV systolic function by tricuspid annular motion (TAPSE):

Our study results showed RV systolic function measured via TAPSE was significantly reduced 5 days after CABG and remained so three months postoperatively (TAPSE changes 22.9mm before CABG vs 16.6mm&18.62mm postoperatively 5 days and 3 months respectively with *P* value < 0.001).

Trantricuspid pulsed-wave indices:

E wave changed from 0.43±0.08 before operation vs 0.46±0.13&0.44±0.12 post operatively 5 days and 3 months respectively with non significant p value for post operative changes as compared to baseline values, A wave changed from 0.39±0.08 before operation vs. 0.5±0.76&0.45±0.12 post operatively 5 days and 3 months respectively with non significant p value for post operative changes as compared to baseline values and E/A changed from 1.2±0.34 before operation vs. 1.2±0.39&1.2±0.36 post operatively 5 days and 3 months respectively with non significant p value for post operative changes as compared to baseline values.

Right ventricular dimension before and after CABG.

Basal right ventricular dimension(RVD1) changes from3.2±0.47 cm before CABG vs 3.08±0.45cm & 3.1±0.46 cm postoperatively 5 days and 3 months respectively with P value >0.05, Mid right ventricular dimension(RVD2) changes from 2.39±0.4cm before CABG vs 2.44±0.45 cm&2.40±0.47postoperatively 5 days and 3 months respectively with P value >0.05, Base to apex of right ventricular dimension (RVD3) changes from 4.98±0.8 cm before CABG vs 5.00±0.78&5.00±0.65 cm postoperatively 5 days and 3 months respectively with P value >0.05.

Tissue Doppler echocardiographic evaluation:

Left ventricular tissue Doppler parameters:

Systolic left ventricular function was not significantly affected by CABG As systolic tissue Doppler velocities (S') changes in off-pump cases from 8.2±2.7 before CABG vs 8±2.4&8.1±2.4 post operatively 5 days and 3 months respectively with non significant p value . (S') changes in on-pump cases from 8.3±2.1before CABG vs 8.1±2.5& 8±1.9 post operatively 5 days and 3 months respectively with non significant p value . Tab.(1)&fig.(1)

regardless of the unchanged conventional pulsed-wave Doppler indices obtained from mitral valve flow, Diastolic peak left ventricular early diastolic function (E'), improved significantly at 5 days after CABG in the septal area compared to preoperative values . After 3 months E' values at the septal and lateral mitral annulus were not significantly different from the preoperative value.

As diastolic peak left ventricular early diastolic function (E'), in off-pump cases changed from 9.9±3.3 before CABG vs 10.8±2.9&10.5±2.6 post operatively 5 days and 3 months respectively with significant p value . (E') changed in on-pump cases from 8.5±2.6 before CABG vs 9.1±3.2 & 9.7±2.7 post operatively 5 days and 3 months respectively with significant p value. Tab.(2)&fig.(2)

Right ventricle tissue Doppler parameters:

In the right ventricle tissue Doppler measures of systolic (S') and early diastolic function (E') decreased significantly at 5 days after CABG compared to preoperative values ($p < 0.05$ for each, Fig.). Even after 3 months E' and S' values at the lateral tricuspid annulus were significantly lower compared to preoperative value ($p = 0.008$) .

As systolic tissue Doppler velocities at lateral annulus of tricuspid valve (S') changed in off-pump cases from 13±2.9 before CABG vs 9.2±2.6&8.1±2.3 post operatively 5 days and 3 months respectively with significant p value . (S') changed in on-pump cases from 13.2±2.4 before CABG vs 8.7±3.1& 8.8±2.9 post operatively 5 days and 3 months respectively with significant p value. Tab.(3)&fig.(3)

Early diastolic function (E') changed in off-pump cases from 10.8±4.1 before CABG vs 7.5±1.6 &6.5±1.8 post operatively 5 days and 3 months respectively with significant p value . (E') changed in on-pump cases from 10.9±3.4 before CABG vs 7.2±3.8& 7.1±2.9 post operatively 5 days and 3 months respectively with significant p value .

Off-pump versus on-pump CABG:

There was no significant difference between the changes in left and right ventricular systolic or diastolic function between patients undergoing on- or off-pump surgery. Comparisons were made by repeated measure ANOVA and paired t test with Bonferroni correction, respectively. The p value for interaction between time point and type of surgery was non-significant.

Table(1) : Systolic (S'), early diastolic (E') and late diastolic (A') tissue Doppler velocities recorded at the lateral angle of the mitral annulus by pulsed wave tissue Doppler echocardiography before CABG, as well as 5 days and 3 months after CABG (mean ± SD)

		Baseline	Post CABG	
		Before CABG	5 days	3 months
Left ventricular longitudinal function				
S' (cm/s)	Off pump	8.2±2.7	8±2.4	8.1±2.4
	On pump	8.3±2.1	8.1±2.5	8±1.9
E' (cm/s)	Off pump	9.9±3.3	10.8±2.9	10.5±2.6
	On pump	8.5±2.6	9.1±3.2	9.7±2.7
A' (cm/s)	Off pump	9.8±3.2	9.9±2.7	9.2±3.6
	On pump	9.8±2.9	9.8±2.8	9.6±3.1

Table(2) : Systolic (S'), early diastolic (E') and late diastolic (A') tissue Doppler velocities recorded at the septal angle of the mitral annulus by pulsed wave tissue Doppler echocardiography before CABG, as well as 5 days and 3 months after CABG (mean ± SD)

		Baseline	Post CABG	
		Before CABG	5 days	3 months
Septal ventricular longitudinal function				
S' (cm/s)	Off pump	7.1±2.6	7.3±2.9	6.9±1.8
	On pump	7.3±2.6	7.1±2.9	7.2±2.7
E' (cm/s)	Off pump	6.8±2.5	7.3±3.0	6.4±1.6
	On pump	6.1±2.6	6.8±2.2	7.1±2.3
A' (cm/s)	Off pump	9.4±2.6	9.1±3.1	9.0±3.0
	On pump	9.3±2.5	9.2±2.9	9.2±1.7

Table (3): Systolic (S'), early diastolic (E') and late diastolic (A') tissue Doppler velocities recorded at the lateral tricuspid annulus by pulsed wave tissue Doppler echocardiography before CABG, as well as 5 days and 3 months after CABG (mean± SD).

		Baseline	Post CABG	
		Before CABG	5 days	3 months
Right ventricular longitudinal function				
S' (cm/s)	Off pump	13±2.9	9.2±2.6	8.1±2.3
	On pump	13.2±2.4	8.7±3.1	8.8±2.9
E' (cm/s)	Off pump	10.8±4.1	7.5±1.6	6.5±1.8
	On pump	10.9±3.4	7.2±3.8	7.1±2.9
A' (cm/s)	Off pump	11.8±3.7	8.4±2.8	8.1±2.1
	On pump	10.9±2.9	9.1±2.8	8.7±2.1

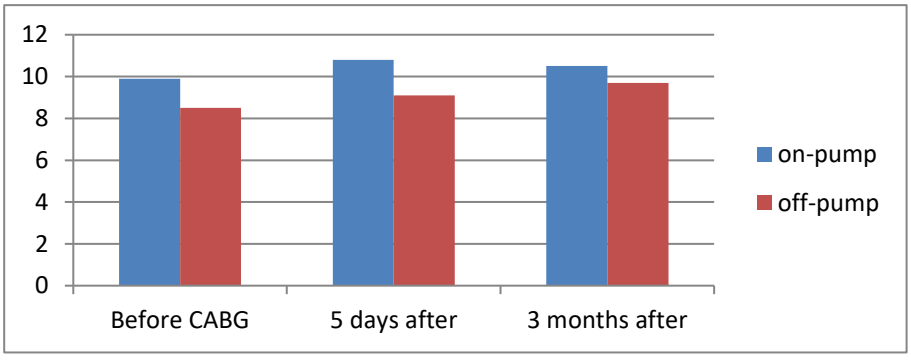

Figure (1): Early diastolic (E') tissue Doppler velocities recorded at the lateral angle of the mitral annulus by pulsed wave tissue Doppler echocardiography before CABG, as well as 5 days, and 3 months after CABG .

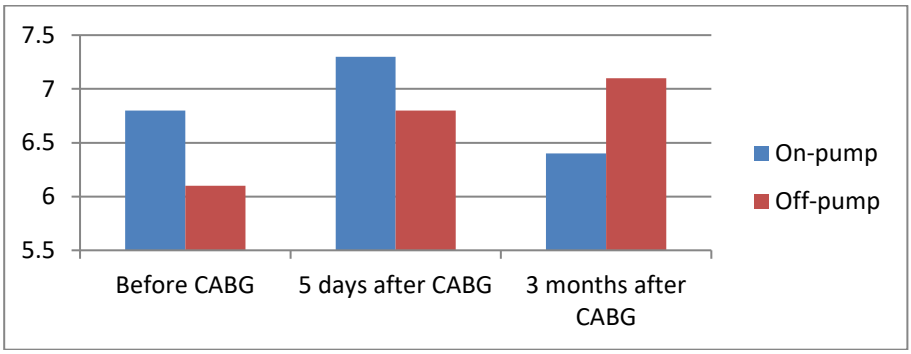

Figure (2): Early diastolic (E') tissue Doppler velocities recorded at the septal angle of the mitral annulus by pulsed wave tissue Doppler echocardiography before CABG, as well as 5 days, and 3 months after CABG .

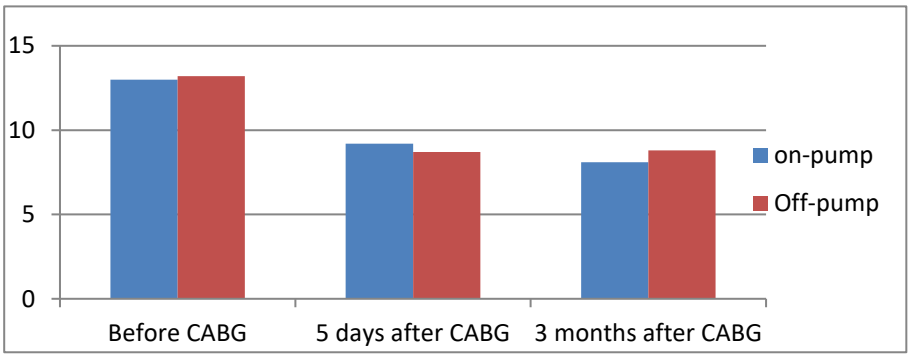

Figure (3): Systolic tissue Doppler velocities (S') recorded at the lateral angle of the tricuspid lannulus by pulsed wave tissue Doppler echocardiography before CABG, as well as 5 days,and 3 months after CABG.

DISCUSSION

In our study we could not demonstrate any significant reduction in systolic left ventricular function as an early or long-term effect of cardiac surgery. On the contrary, left ventricular diastolic function improved early after surgery.

This finding is consistent with data published by **Hedman et al.,**[7] which use TDI to evaluate effect of CABG on myocardial function.

And is in discordance with **Ryan J et al.,**[8] in patients undergoing CABG, pre-operative LVEF determinant the change in LV function following surgery. Patients with preoperative LVEF <50% had an improvement in LV systolic function whereas those with normal pre-operative LVEF had a significant decline in LV systolic function. Proposed explanation may be improvement in function due to improved blood supply is more than depression caused by CABG operation in patient with LVEF<50% .

Right ventricular function deteriorated as a consequence of cardiac surgery with only incomplete recovery during long-term follow-up. This finding is consistent with previous reports. This is in accordance with the study

Roshanali et al .,[9]RV tissue velocity decreased one year after from14.0 to 7.0 cm/s; p<0.001).
In another study, done by **Casula RP et al .,**[10] pulsed wave Doppler tissue showed reduction in RV systolic velocities compared with preoperative values.
AL-ahdal F, et al., [11] Tricuspid annular plane systolic excursion decreased post operatively (TAPSE 2.38±0.388 versus 1.82±0.39; p value=0.000).In another study done by **Hedman A, Alam M et al .,** [12]a tricuspid annular motion was significantly reduced 3 months after.
In our study, we found a significant improvement in the RIMP after CABG, although RV systolic tissue Doppler wave and TAPSE were diminished. The results might be interpreted as an improvement in RV function secondary to a postoperative adaptation to different contraction/relaxation phases.
The improvement in the RIMP was mainly due to a decrease in isovolumic time intervals. These changes are attributable to a better myocardial perfusion of the RV after CABG. Our observations suggest that RIMP is a valuable indicator of the global RV performance.
In study done by **Z.Ojahi MD et al .,**[13] RV myocardial performance index was significantly increased one week after CABG (0.35 vs 0.77,p<0.001) and remained unchanged one month postoperatively.

CONCLUSIONS

In this study we had found patients with normal pre-operative LVEF had a non significant decline in LV systolic function after CABG.Other LV parameters that changed post surgery decreased LVIDd, and increased LAD. LV diastolic function improves after CABG.
Right ventricular systolic and diastolic functions decreased after coronary artery bypass surgery (in patients underwent off- or on-pump surgery) with only incomplete recovery over time.

Study limitations

The sample size was predominately males and the follow up period was relatively short. The echocardiographic window was difficult in some patient due to sternotomy and closed dressing.and Lack of other independent imaging, to assess the global RV functions such as magnetic resonance. .

Summary

In this study we conclude that LV systolic function did not deteriorate after CABG,diastolic function of LV improves e after CABG, returning to preoperative values during follow up . Right ventricular function decreases after CABG with partial recovery with time. RV function deteriorated in patients who did off- pump or on-pump CABG.
Authors admitted no conflict of interest-no financial disclosures.

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