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ORIGINAL STUDY

Assessment of the right ventricular function before and after coronary artery bypass surgery by conventional and tissue Doppler echocardiography

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Abstract

Aim of the work: **To study the extent of right ventricular (RV) dysfunction in ischemic patients after coronary artery bypass grafting (CABG).**

Patients and methods: **RV function was studied preoperatively and followed for 1 month postoperatively in 40 patients who were scheduled for elective coronary artery bypass surgery and in other 40 controls. We evaluated RV function by tissue Doppler study of the tricuspid annulus and the basal septum, tricuspid annular plane systolic excursion, and RV dimensions. Both LV dimensions, left atrium dimensions, and aortic root dimensions were also measured before and after surgery.**

Results: **RV function was significantly reduced after CABG as assessed by pulsed-wave tissue Doppler imaging in both the tricuspid annulus and the basal septum. There was also a significant reduction of tricuspid annular plane systolic excursion after CABG, but there was no significant difference in RV dimensions. Moreover, LVEDD was significantly reduced after CABG.**

Conclusion: **RV systolic function was reduced after CABG and remained depressed for 1 month postoperatively.**

Keywords: Tricuspid annular plane systolic excursion, Tissue Doppler Imaging, Right ventricle

1. Introduction

Although the mechanism of right ventricular (RV) dysfunction after cardiac surgery is not well understood, different mechanisms might interplay to produce effects such as cardiopulmonary bypass, perioperative myocardial ischemia, intraoperative myocardial damage, cardioplegia, and pericardial disruption or adhesions [1,2]. Although assessment of RV function is difficult owing to its complex geometry, this assessment could be achieved through two-dimensional echocardiography, transesophageal echocardiography, Doppler tissue imaging, and MRI [3,4].

In two-dimesnional echocardiography, RV enlargement is indicated by a diameter more than 42 mm at the base, a diameter more than 35 mm at the mid-level, or a longitudinal dimension more than 86 mm.

By tissue Doppler imaging, RV function could be assessed through measurement of the tricuspid annular motion − which provides an estimation of the RV ejection fraction − and the measurement of tricuspid annular velocity [5,6].

Tricuspid annular plane systolic excursion (TAPSE) is obtained from the apical 4-chamber view by M-mode in base of the RV free wall. The TAPSE is a method to measure the distance of systolic excursion of the RV annular segment. TAPSE less than 16 mm indicates RV systolic dysfunction [7].

1.1. Tricuspid annular plane systolic excursion

Fig. 1.

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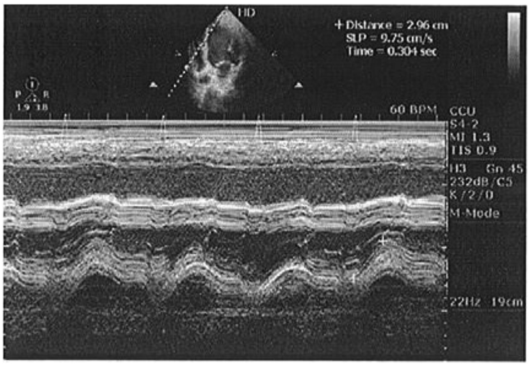

Fig. 1. Tricuspid annular plane systolic excursion.

2. Aim

The aim was to assess the effect of coronary artery bypass surgery on the RV function.

3. Patients and methods

The institutional committee's ethical criteria were followed during all proceedings. The National Heart institute's Local Medical Ethics Committee approved the study. Following an explanation of the purpose, procedures, and nature of the study to all participants, signed informed consent was obtained from each participant.

This study included 40 patients who were scheduled for coronary artery bypass surgery (group 1) and 40 healthy controls (group 2). Patients were assessed preoperatively and postoperatively. The preoperative assessments included clinical evaluation, echocardiography, and coronary angiography or PCI. The postoperative assessments included clinical evaluation and echocardiography.

The study population was recruited from the Cardiology Department and Cardiothoracic Surgery Departments at National Heart Institute (from April 2018 till September 2019). The study population was divided into two groups: group 1, which included 40 patients who were scheduled for coronary artery bypass grafting (CABG) during the study, and group 2, which included 40 healthy participants who had no history of cardiac disease and normal transthoracic echocardiography study.

All patients included in the study were subjected to a preoperative clinical evaluation that included a detailed history taking, complete physical examination, 12-lead ECG, and routine laboratory workup as well as assessment of the risk factors such as diabetes mellitus, hypertension, and smoking. The laboratory workup was in the form of full blood count, liver function tests (AST and ALT) and kidney function tests (urea and creatinine).

The echocardiographic measurements included left ventricular end diastolic and end systolic dimensions (LVESD and LVEDD), aortic root dimensions, and left atrial dimensions.

The systolic tricuspid regurgitation pressure gradient between RV and right atrium was calculated by the simplified Bernoulli equation, and accordingly, pulmonary artery systolic pressure was estimated by adding the right atrial pressure.

TAPSE was obtained from the apical 4-chamber view by M-mode in base of the RV free wall.

Two-dimensional echocardiography-derived RV dimensions were determined from the apical 4-chamber view; three basic measures were taken in end-diastole RV length, the basal and mid-cavity RV diameters, as well as the RV longitudinal dimension.

Using tissue Doppler study, the systolic (Sm) and early and late diastolic (Em and Am) tricuspid annular motion velocities were measured at the lateral free wall (TV lat) and basal septum obtained from the apical four-chamber view using a pulsed-wave Doppler. The averages of 3 TDI signals from different cardiac cycles were employed for data analysis. The peak systolic velocity ranges from 10 to 19 cm/s. When the systolic velocity is less than 10 cm/s, it should raise the suspicion of abnormal RV function. The E TDI peak velocity ranges from 8 to 20 cm/s. When the E TDI is less than 8 cm/s, it indicates RV diastolic dysfunction. The ATDI peak velocity ranges from 7 to 20 cm/s.

Coronary angiography was analyzed for significant stenosis in any of the major coronaries or its branches.

Operative details for group I included type of graft (arterial or venous), operative ischemic time, if a prosthetic valve was implanted, in addition to the CABG surgery and the size and type of the valve. The same clinical, laboratory, and echocardiographic parameters measured in the preoperative assessment were reassessed postoperatively.

Data analysis was done, where the included preoperative data obtained in group 1 were compared with the data of the control group. Preoperative data were compared with postoperative data in group 1 regarding echocardiographic measurements (LVEDD, LVESD, LA, and AOR), RV dimensions, TAPSE, and tissue Doppler imaging of the tricuspid annulus and the basal septum.

4. Results

The study was performed over a period of 19 months from April 2018 till September 2019 and included 40 patients (group 1) who had CABG, with a mean age of 59.3 ± 5.858 years. A total of 30 patients

Table 1. Baseline patient characteristics.

Variables	Control group (n = 40)	Cases (n = 40)
Age in years	59.3 ± 5.858	58.3 ± 5.49
Male	32 (80)	30 (75)
Smoker	4 (10)	20 (50)
DM	16 (40)	24 (60)

were males, representing 75% (Table 1). The study also included 40 healthy individuals, with a mean age of 58.3 ± 5.49 years. Overall, 32 (80%) were males in the control group. Only 18 (45%) patients were hypertensive in the control group, whereas 26 (65%) persons were hypertensive in the patient group. Moreover, 16 (40%) patients were diabetics in the control group and 24 (60%) patients were diabetics in the patient group (Table 1 and Figs. 2 and 3).

4.1. Clinical characteristics in group 1

Table 2.

4.2. Echocardiographic data in the patient and control groups

As noted in Table 3, the control group had significantly lower left ventricular, left atrial, and

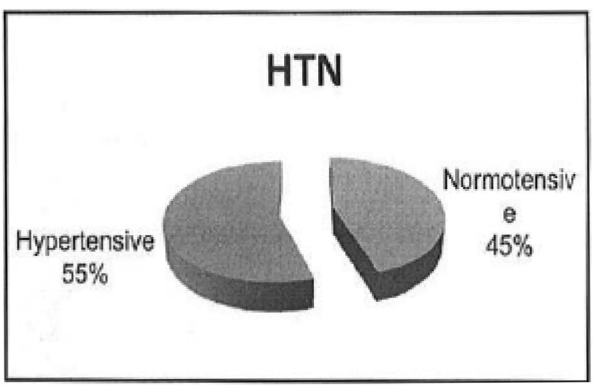

Fig. 2. Prevalence of hypertension among cases.

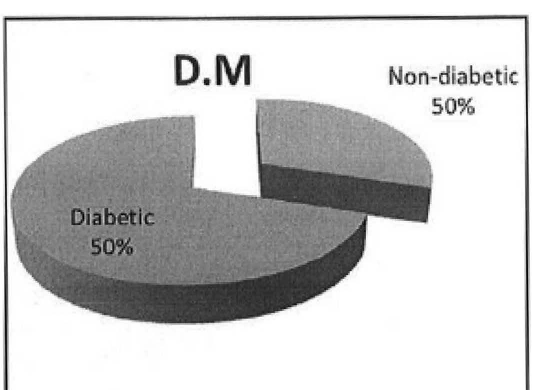

Fig. 3. Prevalence of diabetes mellitus among cases.

Table 2. Clinical characteristics of the patients (group 1).

Variables	(N = 40) n (%)
Chronic stable angina	14 (35)
Unstable angina	10 (25)
Myocardial infarction	22 (55)
Coronary angiography	36 (90)
After PCI	12 (30)

aortic dimensions; however, the RV transverse dimensions did not differ, and the RV longitudinal dimension was actually lower in group 1 than in the controls, although both were in the normal range. Moreover, the S wave recorded in the basal septum was lower in group 1. The other TDI data showed no significant difference other than RV dimensions (Figs. 4–6).

4.3. The coronary angiographic data of the study population

Table 4.

4.4. Left main artery

The left main coronary artery was involved in six cases (15% of cases). Two had ostial disease, whereas the other four had distal significant disease.

4.5. Echocardiographic data in patients preoperatively and postoperatively

As shown in Table 5, the preoperative and postoperative echocardiographic diameters of the left ventricle, aortic root, and left atrium were

Table 3. Echocardiographic data analysis compared between preoperative data of cases (group 1) and controls (group 2).

Variables	Cases (40)	Controls (40)	P value
LVESD (cm	3.9 ± 0.44	3.2 ± 0.88	0.001
LVEDD (cm)	5.7 ± 0.69	4.2 ± 0.46	0.008
LA (cm)	4.2 ± 0.66	3.7 ± 0.45	0.04
AOR (cm)	3.1 ± 0.36	2.8 ± 0.41	0.02
RVD3 (cm)	4.1 ± 0.811	5.7 ± 1.14	0.001
TDISS (m/s)	0.07 ± 0.23	0.08 ± 0.01	0.03
TAPSE (cm)	2.48 ± 0.38	2.6 ± 0.47	0.4
TDIAS (m/s)	0.13 ± 0.03	0.15 ± 0.023	0.063
TDIAE (m/s)	0.12 ± 0.03	0.13 ± 0.03	0.347
TDIAA (m/s)	0.15 ± 0.388	0.14 ± 0.04	0.46
TDISE (m/s)	0.09 ± 0.02	0.098 ± 0.19	0.148
TDISA (m/s)	0.08 ± 0.02	0.08 ± 0.01	0.78

A, late diastolic tricuspid velocity; A, late diastolic basal septal velocity; AOR, aortic root; E, early diastolic basal septal velocity; E, early diastolic tricuspid annular velocity; LA, left atrium; LVEDD, left ventricular end-diastolic diameter; LVESD, left ventricular end-systolic diameter; RVD3, base to apex right ventricular dimension; S, systolic tricuspid annular velocity; S, systolic basal septal velocity; TAPSE, tricuspid annular plane systolic excursion; TDIA, tissue Doppler image in tricuspid annulus; TDIS, Tissue Doppler imaging in basal septum; TDIS, Tissue Doppler S velocity at basal septum.

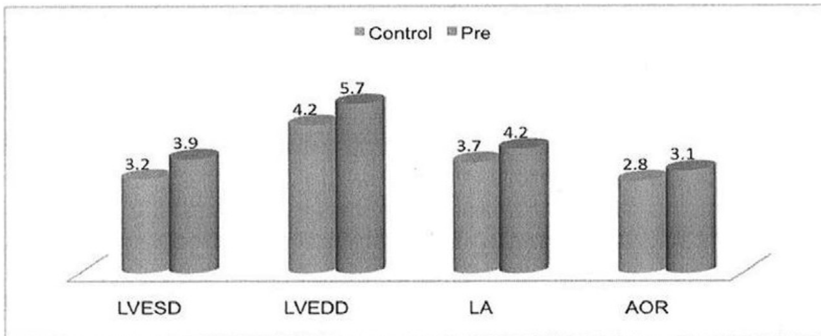

Fig. 4. Preoperative data of the patients group compared with the control group. All parameters showed a significant difference between both groups (P < 0.05).

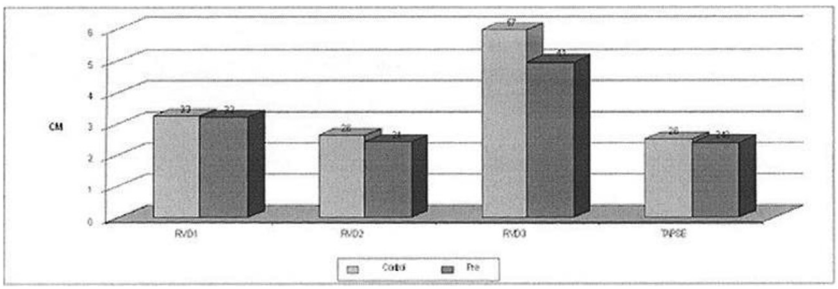

Fig. 5. Comparison between cases and controls, RVDI: basal right ventricular dimension, RVD2: mid right ventricular dimension, RVD3: base to apex of right ventricular dimension. There was a significant (P = 0.001) difference between the cases and controls in RVD3.

compared. There was a significant difference ($P < 0.05$) between the preoperative and post-operative LVEDD data of patients (Fig. 7).

As noted from Table 6, there were significant differences ($P < 0.05$) between the preoperative and postoperative tissue Doppler data. The tricuspid annular and basal septal values were significantly reduced postoperatively, and TAPSE was more significantly decreased postoperatively.

4.6. Surgical details

(1) A total of 26 patients were operated upon off-pump, with a percentage of 65%, whereas the remaining 14 patients were operated upon on-pump, with a percentage of 35%.
(2) The type of cardioplegia was warm antegrade cardioplegia with each dose from 15- to 20-min interval.

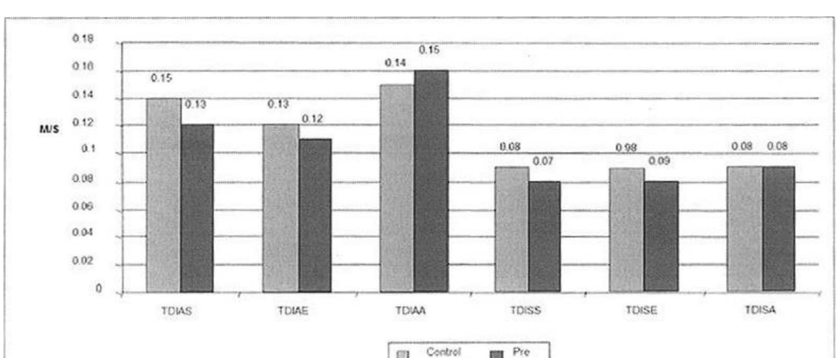

Fig. 6. Comparison between cases and controls regarding tissue Doppler data. TDIA: tissue Doppler image at tricuspid annulus, S: systolic tricuspid annular velocity, E: early diastolic tricuspid annular velocity. A: late diastolic tricuspid velocity. TDIS tissue Doppler imaging in basal septum, S: systolic basal septal velocity, E: early diastolic basal septal velocity, A: late diastolic basal septal velocity. There was a significant difference (P < 0.05) between cases and controls in tissue Doppler imaging in systolic basal septal velocity.

Table 4. Angiographic data: involvement of the different segments in each artery.

Variables $N = 40$	RCA (75%) No. 30	LAD (95%) No. 38	LCX (70%) No. 28
Proximal	24 (80)	28 (73)	18 (64)
Middle	4 (13)	8 (21)	8 (28)
Distal	2 (7)	2 (6)	2 (8)

(3) The types of grafts used were LIMA graft for LAD and saphenous venous grafts for OM, PDA, and diagonal branches.
(4) A total of 30 patients required venous graft anastomosis with PDA-RCA, whereas only 28 patients required venous grafts anastomosis with OM and 38 patients required LIMA anastomosis with mid-LAD. The number of patients who had significant left main disease and required graft anastomosis with both LAD and OM was only six.
(5) The type of vessel by-passed had no statistically significant effect on the degree of RV dysfunction.

Figs. 8 and 9.

5. Discussion

As the RV has low oxygen demand and high degree of collateralization of blood supply [8], RV function is not affected significantly after acute coronary syndrome and myocardial infarction unless the inferior wall is specifically involved.

The aim of this study was to assess the effect of CABG surgery on the RV.

We proceeded by comparing the echocardiographic features of the right and left ventricles of patients who were planned to have CABG with those of age- and sex-matched healthy controls.

However, controls had lower left ventricular dimensions (end-systolic dimension and end-diastolic dimension of 3.05 ± 0.391 and 4.808 ± 0.469 cm, respectively, vs. 3.79 ± 0.75 and 5.5 ± 0.69 cm, respectively, with $P = 0.001$ and 0.008, respectively), and the RV dimensions did not differ significantly. Only the RV longitudinal dimension was slightly less than that of healthy controls (5.97 ± 1.143 cm vs. 4.98 ± 0.811 cm, $P = 0.001$), and this led us to conclude that IHD affected the LV more than the right.

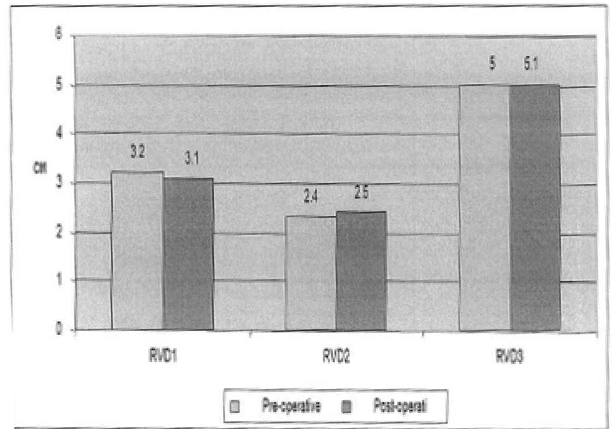

Fig. 7. Right ventricular dimensions preoperatively and postoperatively showed no significant difference (P > 0.05).

When comparing RV annular velocities, only the basal septal velocities were lower in the patients than in the control group (0.08 ± 0.016 vs. 0.07 ± 0.237 cm/s, with $P = 0.031$), and this may be due to the influence of the LV portion of the septum.

Comparison between preoperative and postoperative data in the patient group showed a significant improvement in LV size and function. The left ventricular end-diastolic diameter improved (5.7 ± 0.69 vs. 5.23 ± 0.57, $P = 0.037$). This is in contrast to the findings in a previous study done by Hamouratidis et al. [9], where there was no significant change in left ventricular diastolic diameter.

The RV dimensions did not change significantly ($P > 0.05$) postoperatively neither did the pulmonary artery systolic pressure.

In our study, we found that all tricuspid annular velocities as assessed by TDI showed significant difference between preoperative and postoperative

Table 5. Preoperative and postoperative tissue Doppler data.

Variables	Preoperative (no = 40)	Postoperative (no = 40)	P value
LVESD (cm)	3.9 ± 0.45	3.85 ± 0.612	0.58
LVEDD (cm)	5.7 ± 0.69	5.2 ± 0.571	0.03
LA (cm)	4.2 ± 0.65	3.9 ± 0.42	0.10
AOR (cm)	3.1 ± 0.36	2.9 ± 0.478	0.16

LVEDD: Left ventricular end diastolic dimension, LVESD: Left ventricular end systolic dimension, L.A.: Left atrium, AOR: Aortic root, EF:Ejection fraction.
Preoperative and postoperative data of only the LVEDD showed a statistically significant reduction ($P < 0.05$).

Table 6. TDI parameters of tricuspid annulus and basal septum preoperatively and postoperatively.

	Variable	Preoperatively	Postoperatively	P value
ECHO	TAPSE	2.48 ± 0.38	1.8 ± 0.39	0.001
(TDI)	TDIAS (m/s)	0.13 ± 0.03	0.1 ± 0.02	0.014
	TDIAE (m/s)	0.12 ± 0.03	0.08 ± 0.02	0.001
	TDIAA (m/s)	0.15 ± 0.3	0.08 ± 0.04	0.001
	TDISS (m/s)	0.07 ± 0.2	0.06 ± 0.01	0.05
	TDISE (m/s)	0.09 ± 0.02	0.08 ± 0.01	0.017
	TDISA (m/s)	0.08 ± 0.02	0.07 ± 0.02	0.045

TAPSE, tricuspid annular plane systolic excursion.

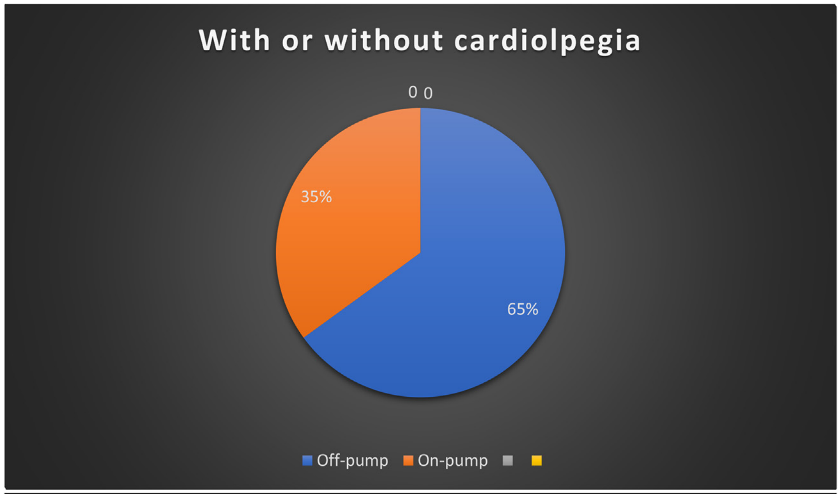

Fig. 8. Percentage of patients who were operated upon both off-pump and on-pump.

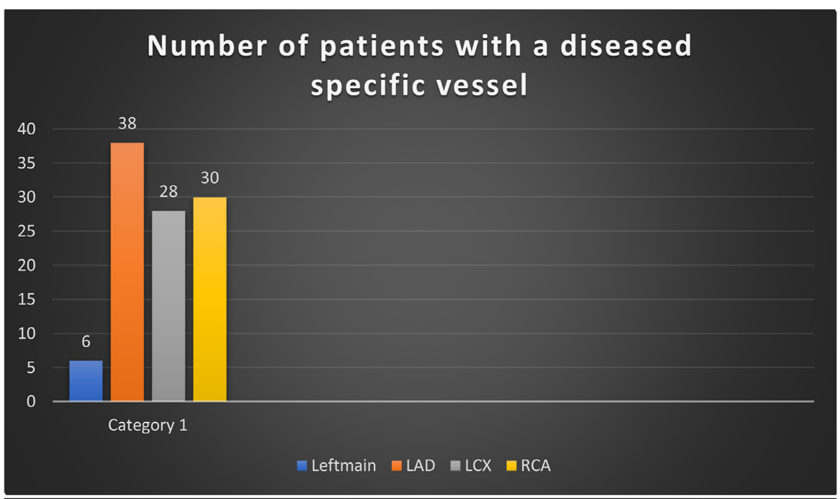

Fig. 9. The number of patients with a diseased-specific vessel.

studies, such as systolic velocity (0.13 ± 0.03 vs. 0.011 ± 0.029, $P = 0.014$), early diastolic velocity (0.012 ± 0.032 vs. 0.08 ± 0.024, $P = 0.001$), and late diastolic velocity (0.15 ± 0.38 vs. 0.08 ± 0.04, $P = 0.0001$).

This is in accordance with the study done by Roshanali and Ali [10]. Baseline echocardiography was performed for their study patients who were scheduled for coronary artery bypass surgery, and follow-up echocardiography was done for these patients 1 year after CABG. RV tissue velocity decreased from 14.0 to 7.0 cm/s; $P < 0.001$).

Another study done by Alam et al. [1]2003) concluded that both systolic and early diastolic tricuspid annular velocities (TVA) were significantly reduced 1 month after CABG ($P < 0.001$ for both), and there was no improvement in the diastolic TVA in the follow-up period. Moreover, the systolic TVA showed no improvement 3 months after CABG but partial recovery at 1 year.

Basal septal systolic, early, and late diastolic velocities decreased postoperatively (systolic velocity = 0.07 ± 0.014 vs. 0.06 ± 0.23, $P = 0.05$, early diastolic = 0.09 ± 0.018 vs. 0.08 ± 0.021, $P = 0.017$, and late diastolic = 0.08 ± 0.02 vs. 0.07 ± 0.021, $P = 0.045$).

In another study done by Casula et al. [11], pulsed-wave Doppler tissue was used as means of assessing RV function. One month after surgery, the transthoracic echocardiographic data showed a 55 ± 12% ($P < 0.0001$) reduction in RV systolic velocities compared with preoperative values.

TAPSE also decreased postoperatively (TAPSE 2.48 ± 0.388 vs. 1.82 ± 0.39; $P = 0.001$). This finding is in accordance with the study done by Roshanali et al. [10].

In another study done by Ojaghi et al. [12], TAPSE and peak Sm velocity was significantly reduced 1 week after CABG and remained so after 1 month.

5.1. Conclusion

RV function assessed by tissue Doppler imaging in tricuspid annulus and basal septum is significantly reduced 1 month after CABG.

RV function by TAPSE was also depressed compared with the preoperative data. The RV dimensions were apparently not affected.

Compared with healthy controls, preoperative data did not differ except for systolic basal septal velocity. It was lower in the patients studied than in controls. RV longitudinal dimension was also slightly less than in healthy controls.

Conflict of interest

Authors declare no conflict of interest.

References

[1] Alam M, Hedman A, Nordlander R, Samad B. Right ventricular function before and after an uncomplicated coronaryaftery bypass graft as assessed by pulsed wave Doppler tissue imaging of the tricuspid annulus. Am Heart J 2003;146:520–6.

[2] Brookes CI, White PA, Bishop AJ, Oldershaw PJ, Redington AN, Moat NE. Validation of a new intraoperative technique to evaluate load-independent indices of right ventricular performance in patients undergoing cardiac operation. J Thorac Cardiovasc Surg 1998;116:468–76.

[3] David JS, Tousignant CP, Bowry R. Tricuspid annularvelocity in patients undergoing cardiac operation using transesophageal echocardiography. J Am Soc Echocardiogr 2006;19:329–34.

[4] Kwak YL, Oh YJ, Jung SM, Yoo KJ, Lee JH, Hong YW. Change in right ventricular function during off-pump coronary artery bypass graft surgery. Eur J Cardio Thorac Surg 2004;25:572–7.

[5] Tuller D, Steiner M, Wahl A, Kabok M, Seiler C. Systolic right ventricular function assessment by pulsed wave tissue Doppler imaging of the tricuspid annulus. Swiss Med Wkly 2005;135:461–8.

[6] Nikitin NP, Witte KK. Application of tissue Doppler imaging in cardiology. Cardiology 2004;101:170–8.

[7] Guidelines for the echocardiography assessment of the right Heart in adults: and the Canadian society of echocardiography. J Am Soc Echocardiogr 2010;23:685–731.

[8] Dima C, Yang EH. Right ventricular infarction. Updated: Mar 29,2011, emedicine. medscape.com.

[9] Hamouratidis D, Handle CE, Pipilis A, Fiandra A, Deverall PB, Yates AK. Effects of coronary anery surgery on left ventricular performance, segmental wall movement, and exertional ischaemia, Department ofCardiology, Guy>s Hospital, London. Br Heart J 1988;60:23–9.

[10] Roshanali F, Ali M. Decreased right ventricular function after coronary artery bypass grafting. Tex Heart Inst J 2008;35: 2505.

[11] Casula RP, Andreas A, Kyriacou AA, Yadav H, Chukwuemeka A, Cherian A, et al. The right ventricular annular velocity reduction caused by CABG occurs at the moment of pericardial incision. Am Heart J 2010;159:314322.

[12] Ojaghi Z, Moaref A, Noohi F. Echocardiography; endorsed by the European maleki M. Mohebbi A.: evaluation of right association of echocardiography, a registered ventricular function after coronary artery branch of the European society of cardiology, bypass grafting. Iran Heart JJ 2007;8:13.