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Research Article

RV Dysfunction after Coronary Artery Bypass Grafting (CABG), Single Center Experience

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Abstract

Aim: To assess the change and analyze the possible predictors in RV function post CABG

Methods and Results: This cross-sectional retrospective study enrolled all patients undergoing isolated CABG and compared those with postoperative RV systolic dysfunction versus patients without RV dysfunction. We included 164 patients underwent CABG with a mean age of 56.1 ± 12.2 years old. Those patients were classified in to two groups: Group I (64.6%) patients with postoperative RV dysfunction and group II (35.4%) without RV dysfunction postoperatively. We summarize our data as followings: 1) Demographic and clinical data: group I patients had prevalence of DM and obesity were compared to group II patients (p = 0.02 and 0.05 respectively), otherwise all other clinical predictors didn't differ between the groups. 2) Echocardiography, angiography and operative data: patients of group I had higher rates of preoperative larger LV, LV systolic dysfunction, reduced TAPSE values and severe diseased coronaries compared to group II patients. 3) Change in RV function after CABG and prognosis: There was significant deterioration of RV function post CABG in early follow up postoperative period (13% preoperatively VS 65% postoperatively; p = 0.04). Patients who had better preoperative RV function maintained it postoperatively compared to patients with baseline RV dysfunction, p = 0.04. RV dysfunction in our study is not associated with increased in-hospital mortality.

Conclusion: CABG has negative impact on RV function. Obesity and uncontrolled DM show role in RV dysfunction post operatively. Evaluation of RV function in perioperative period is of future challenging.

Keywords: *RV Dysfunction; CABG; Predictors*

Introduction

It has well-proved that coronary artery bypass grafting (CABG) surgery is the treatment of choice for multi-vessel coronary artery disease and its improvement in not only survival but also symptoms and functional capacity [1].

Ventricular function post- CABG procedure shows marked discrepancy from the left ventricle to the right ventricle. Many studies suggested that LV systolic function following CABG surgery is maintained especially those with baseline reduced function, whereas LV diastolic function doesn't show the same results [2-5]. On the other hand, the right ventricle systolic and diastolic function may both be impaired in the early and midterm follow up [5].

Right ventricular Function is measured by trans-thoracic echocardiography (TTE) and expressed by tricuspid annular plane systolic excursion (TAPSE) and tissue Doppler imaging (RV S') [6].

A variety of factors may affect cardiac function and morphology in health and disease. Right ventricular functional is small yet significant change with age and gender [7]. Obesity clearly affects the left ventricle, few studies have examined the impact of obesity on the right ventricle [8]. Several studies have suggested that mitral regurge severity is associated with right ventricular ejection fraction [9].

Aim of the Study

We aim to assess the change in RV function post CABG and to determine the predictors that may be associated with its dysfunction post cardiac surgery.

Methods

It is a cross sectional, retrospective single center study, in which 164 patients who underwent CABG at cardiac center- King Abdullah Medical City (KAMC) from 1 Jan 2016 to 6 June 2017 were included.

Inclusion criteria: Patients operated for elective and isolated CABG at KAMC.

Exclusion criteria: Patients with atrial fibrillation, severe pulmonary hypertension, cardiogenic shock, another valve intervention in addition to CABG and those didn't have post-operative echocardiography follow up.

Demographic (age, gender, body mass index (BMI), etc.), clinical characteristics (diabetes mellitus (DM), hypertension (HTN), renal impairment, old history of ischemic heart disease (IHD), left ventricular ejection fraction (LVEF), etc.) and surgical data (ischemic time, bypass time and right coronary artery (RCA) vascularization) were obtained from medical records.

Surgical principals: Via median sternotomy with aorto-caval (single/bicaval). Cardio protection through antegrade mixed with retrograde or direct into the vein after distal anastomosis and topical hypothermia to achieve complete protection of the myocardium. Surgical procedure was done with cardioplegia every 20 minutes, wean off bypass. Trans- esophageal echocardiography (TEE) was done for assessment of wall motion and ventricular function after revascularization.

Echocardiography

All patients had a baseline 2- dimension (2-D) echocardiogram and tissue doppler (DTI) before and after surgery. Subsequently, study participants were monitored for at least few months after CABG, in specific regard to their right ventricular (RV) function.

Preoperative transthoracic echocardiography (TTE) were collected as well as TTE performed after surgery. Echocardiography was performed with a vivid 7 ultrasound system. Parasternal and apical views were obtained. Left ventricular (LV) end diastolic, end systolic dimensions, ejection fraction (EF), right atrial (RA) and right ventricular (RV) size all were assessed by 2-D echocardiography. Pulsed wave and color doppler were also used to assess LV-diastolic function and valvular regurge successively. RV systolic function was evaluated by means of tricuspid annular plane systolic excursion (TAPSE) and tissue Doppler imaging (RV S'). Tricuspid annular plane systolic excursion (TAPSE) was obtained from the apical four-chamber view. The difference in the displacement of the right ventricular base from end-diastole to end-systole at the junction of the tricuspid valvular plane was used to determine TAPSE. Tissue Doppler imaging S (RV S') was measured using a pulsed wave Doppler sampling gate of 6–6 mm and a sweep of 100 mm/s. A value of TAPSE < 16 mm, and/or RV S' < 10 cm was considered abnormal and defined RV dysfunction [10].

The study population was divided in to two groups representing patient with RV dysfunction and those without RV dysfunction post-surgery.

Statistical analysis

Statistical analysis was performed by use of the SPSS software package (SPSS Inc.; Chicago, Ill), version 21.0. Data are presented as mean± SD, or as median and range according to the type of distribution of each variable Chi square test was used to compare the existence of ventricular dysfunction pre-and post-operatively. Logistic DM, HTN, Smoking, dyslipidemia, renal impairment, LVEF, LV size, TAPSE, RV size). Linear regression analysis was performed. For all analyses a p value < 0.05 was considered significant and not significant if it is > 0.05).

Our study is designed to be the part of the standard of patient care and has received approval of the ethics committee/institutional review board of the King Abdullah Medical City.

Results

For the total (164) operated patients at cardiac center-King Abdullah Medical City (KAMC), mean age of (56.1 ± 12.2 years old) and BMI (27.8 ± 5.9) respectively. From the whole cohort, 114 (69.5%) were men, 104 (63%) diabetic, 115 (70%) hypertensive, 70 (43%) obese, only 28 (17%) had chronic Kidney disease (CKD), and 97 (59%) had an old history of IHD. Eighty four percent of the patients presented with positive troponin and 28% had high natriuretic peptide (BNP) preoperatively.

Baseline left ventricular dysfunction (LVD)was observed in 110 patients (67%), however, preoperative right ventricular dysfunction (RVD) was also observed in 13% of the patients. The mean cardiopulmonary by-pass time and cross-clamp time for all our patients were (139.41 ± 71.03 and 91.09 ± 37.5 minutes respectively). Regarding to postoperative complications, 27% of the patients were in need for intra-aortic balloon pump (IABP), 72% had inotropic support in early postoperative period and 18% developed atrial fibrillation (AF) (Table 1).

Variable	Number	%
Age Mean ± SD	56.1 ± 12.2	
Male	114	69.5%
BMI Mean ± SD	27.8 ± 5.9	
DM	104	63.4%
HTN	115	70.1%
Smoking	51	31.1%
Dysliedmia	82	50%
CKD	28	17.1%
Old IHD	97	59.1%
Obesity	70	42.7%
Clinical presentation:		
STEMI	26	15.9%
NSETMI	43	26.2%
UA	31	18.9%
Other presentations	64	39%
HBG level Mean ± SD	10.1 ± 2.2	
High initial S. Cr	37	22.6%
High BNP	46	28%
+VE Troponin	137	83.5%
Preoperative LV dysfunction	110	67%
Preoperative RV dysfunction	21	13%
Cardiopulmonary bypass time Mean ± SD	139.41 ± 71.03	
Cross clamp time Mean ± SD	91.09 ± 37.5	
Postoperative IABP	44	27%
Postoperative inotropes	118	72%
Postoperative AF	30	18%
Mortality	13	8%

Table 1: *Characteristic data for the whole patient group.*

AF: Atrial Fibrillation; BMI: Body Mass Index; CKD: Chronic Kidney Disease; DM: Diabetes Mellitus; HTN: Hypertension; IABP: Intra-Aortic Balloon Pump; IHD: Ischemic Heart Disease; LV: Left Ventricle; STEMI: ST- Elevation Myocardial Infraction; NSTEMI: Non-ST Elevation Myocardial Infraction; UA: Unstable Angina; S.Cr: Serum Creatinine; BNP: Pro B-type Natriuretic Peptide.

Cross section retrospective cohort analysis effect of CABG on RV function

There was significant deterioration of RV function post CABG in early follow up postoperative period (13% preoperatively VS 65% postoperatively; *p* = 0.04). Three (14%) out of 21 patients with baseline RV function was improved after CABG, while 18 (86%) was further deteriorated. However, 63% of patients with baseline normal RV function showed significant deterioration after CABG (Table 2, 3 and Figure 1).

Variable	Preoperative RV dysfunction	Postoperative RV dysfunction	P- value
N (%)	21 (13%)	106 (65%)	0.04
RV: Right Ventricle			

Table 2: *Change in RV function post CABG.*

Changes		Improved/preserved	Deteriorated	p-value
Baseline RV dysfunction	21 (13%)	3 (14.3%)	18 (85.7%)	0.04
Normal baseline RVF	143 (87)	53 (37.1%)	90 (62.9%)	

Table 3: *Follow up of RV function after CABG.*

RV: Right Ventricle; RVF: Right Ventricular Function.

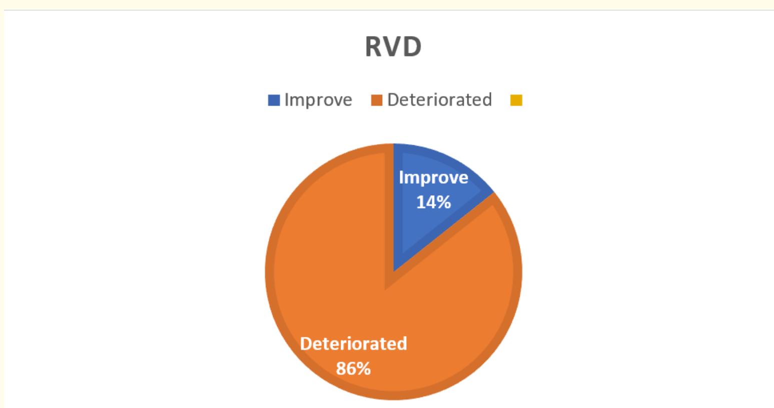

Figure 1: *Change in RV function post CABG in patients with baseline RV dysfunction.*

We classified our patient into two groups: Group I: 106 patients (64.6%) with RV Dysfunction post operatively and Group II: 58 patients (35.4%) without RV Dysfunction post operatively. We compare between the two groups of patients in all predictor as the followings.

Demographics and risk factors

Patients of group I showed higher prevalence of DM and obesity compared to patients of group II (70% and 48%VS 52% and 33%; *p* = 0.02 and 0.05 respectively).

There were also higher prevalence rates of hypertension, chronic kidney disease, smoking, dyslipidemia and history of old IHD among patients of group I compared to group II patients with no significant difference (Table 4).

Variable	Group I with RV dysfunction N = 106	Group II without RV dysfunction N = 58	p- value
Age M ± SD Age >70y	55.65 ± 12.6 10 (9%)	56.98 ± 11.7 10 (17%)	.144 0.144
Male	77 (73%)	37 (64%)	0.239
DM	74 (70%)	30 (52%)	0.021*
HTN	75 (71%)	40 (69%)	0.811
Smoking	34 (32%)	17 (29%)	0.715
HB level	9.945 ± 2.2	10.407 ± 2.2	0.287
Dyslipidemia	55 (52%)	27 (47%)	0.606
CKD	19 (18%)	9 (16%)	0.695
Obesity	51 (48%)	19 (33%)	0.057*
Old IHD	59 (56%)	38 (66%)	0.918
High BNP	30 (28%)	16 (28%)	0.918
+VE Troponin	91 (86%)	46 (79%)	0.280
High initial S.Cr	25 (24%)	12 (21%)	0.671
Dilated LV	25 (24%)	7 (12%)	0.075
Dilated RV	18 (17%)	10 (17%)	0.928
Mild/moderate MR	40 (38%)	14 (24%)	0.149
Mild/moderate TR	19 (18%)	16 (28%)	0.073
Diastolic dysfunction grade II/III	7 (7%)	3 (5%)	0.331
LV dysfunction pre-OP	73 (69%)	37 (64%)	0.509
reduced TAPSE pre-OP	15 (14%)	6 (10%)	0.486
3-vessel disease in coronary angiography	57 (54%)	28 (48%)	0.764
LM disease	55 (52%)	35 (60%)	0.298
Bypass time	141.05 ± 71.31	127.24 ± 62.15	0. 588
Ischemic time	92.3 ± 37.8	90.0 ± 40.8	0.491
RCA disease	57 (54%)	28 (48%)	0.764
RCA revascularization	41 (39%)	15 (26%)	0.149
Postoperative IABP	34 (32%)	10 (17%)	0.03*
Postoperative inotropes	83 (78%)	35 (60%)	0.01*
Postoperative AF	21 (20%)	9 (15%)	0.55
In-hospital Mortality	10 (9%)	3 (5%)	0.334

Table 4: *Comparison of demographic, clinical, operative and mortality data between the two groups.*

AF: Atrial Fibrillation; CKD: Chronic Kidney Disease; DM: Diabetes Mellitus; HTN: Hypertension; IABP: Intra-Aortic Balloon Pump; IHD: Ischemic Heart Disease; S.Cr: Serum Creatinine; BNP: Pro B-type Natriuretic Peptide; MR: Mitral Regurgitation; TR: Tricuspid Regurgitation; RVSP: Right Ventricular Systolic Pressure; TAPSE: Preoperative Tricuspid Annular Plane Systolic Excursion; LV: Left Ventricle; LA: Left Atrium; RCA: Right Coronary Artery; RV: Right Ventricle; RA: Right Atrium; LM: Left Main Coronary Artery.

Echocardiographic and angiographic characteristics

Preoperative echocardiographic data showed that patients of group I who developed RV dysfunction later had baseline dilated LV more than patients of group II (24% VS 12%; $p = 0.075$). Similarly, patients who developed RV dysfunction postoperatively had more prevalence of preoperative LV systolic dysfunction (73 VS 37; $p = 0.51$), dilated RV and reduced TAPSE in their baseline echocardiography compared to those without postoperative RV dysfunction. Also, group I patients had severe CAD findings including higher rate of RCA involvement detected in coronary angiography compared to group II patients without significant difference (Table 4).

CABG and follow up

Coronary artery bypass grafting was done with higher rate of RCA revascularization and potentially longer recorded both bypass time and ischemic time among group I patients compared to group II patients with no significant difference. Also, postoperative inotropic support ($p = 0.01$) and intra-aortic balloon pump insertion ($p = 0.03$) were significantly more frequent in patients with RV dysfunction compared to patients without RV dysfunction. Similarly, patients with postoperative RV dysfunction showed higher mortality rate compared to those without postoperative RV dysfunction with no significant difference ($p = 0.33$) (Table 4).

Discussion

RV function reduces after cardiac surgery and it is reported by most of investigators [11]. It starts once the pericardium is incised and its reversal to normal is not documented [12]. Indeed, RV function is often impaired after cardiac surgery owing to in-effective myocardial protection (i.e. retrograde cardioplegia), air embolism and pulmonary vasoconstriction related to protamine. In our study, baseline RV dysfunction was observed in 13% of the patients and postoperative function of RV reduces significantly to 65%, $p = 0.04$. Patients who had better preoperative RV function maintained it postoperatively compared to patients with baseline RV dysfunction, $p = 0.04$. Similarly, in a recent study fair number of patients with LV dysfunction undergoing CABG present with RV dysfunction and patients with better preoperative RV function preserved it postoperatively too [13]. However, there is a single study that documented improvement in RV function following CABG [14].

In this study, we demonstrated also that presence of some cardiovascular risk factors explained a proportion of variance observed in RV function measured by echocardiography in a cohort of 164 ischemic patients who underwent CABG surgery.

Patients with high BMI associated with structural abnormality in the cardiac chamber due to hyperdynamic circulation and high metabolic requirements. In previous studies obesity was found to be associated with abnormalities in RV structure and function [15,16]. Same reported in our study as increasing BMI is significantly associated with RV dysfunction post CABG. On the other hand, some studies revealed no relation between obesity and RV function [17,18].

104 (63%) patients in our cohort had diabetes and it was reported by some investigators that diabetes mellitus could influence the RV function even in absence of coronary artery disease [19,20]. Our results indicate the DM is a significant predictor for the presence of RV dysfunction in ischemic patients who underwent CABG surgery. This has been highlighted by results of a recent study that assessed RV function post ST- elevation myocardial infarction (STEMI) but with cardiac magnetic resonance imaging (CMRI) and concluded that DM is strongly associated with RV dysfunction [21].

RV and LV dysfunction

From our interesting findings that RV function post-surgery is independent on LV systolic function. On the other hand, Garatti., *et al.* studies 324 patients with previous myocardial infarction and assessed RV function with echocardiography after surgery. They found that there was no significant difference in LVEF between the group of RV dysfunction and the group without RV dysfunction of fully matched population [22]. However, a recent study showed that patients with RV dysfunction postoperatively had significantly reduced preoperative LVEF compared to patients without RV dysfunction [13]. This discrepancy can be explained by different sample population and severity of LV dysfunction in different studies as part of RV function is coming from left ventricle and so patients with LV failure are associated with poor preoperative RV function which could persist in early postoperative period.

RV dysfunction and short term outcome

Indeed, patients with RV dysfunction showed larger LV volumes, higher rate of MR, diastolic dysfunction and reduced preoperative TAPSE values. However, it is notable that all those variables didn't reach significant level. Also, in the present study, RV dysfunction is not associated with increased in-hospital mortality, despite these patients experiencing higher postoperative rates of inotropic support and IABP insertion. Similar results were reported in a study which assessed impact of RV dysfunction in outcome in patients who underwent cardiac surgery [22]. However, in a recent study, RV dysfunction is known to be associated with all-cause mortality in cardiac surgery population [23]. This discrepancy could be explained by small cohort sample population and short term observation. Moreover, the LVEF didn't significantly differ in both groups and most of hospital outcome measures are more related to function of LV.

Conclusion

This study confirmed that there is remarkable decline of RV systolic function after coronary artery bypass grafting and this dysfunction is not associated with short term mortality. Preoperative LV dysfunction and operative ischemia might have a role in this negative surgical impact on RV. Moreover, presence of DM and higher BMI seem to be associated with RV dysfunction post CABG. This result might help to identify patients who could be at risk for postoperative RV dysfunction. Further research on larger population with longer follow up is required to elucidate the etiology, predictors and recovery of RV dysfunction in cardiac surgery.

Study Limitations

TAPSE and TDI (RV S') are rough indicators of RV function. However, the complex geometry of the right ventricle makes it difficult to assess the systolic function of this cardiac chamber. Cardiac magnetic resonance imaging is the gold standard for quantifying RV size and function; however, access to the technology is limited. Indeed, although it measures longitudinal function, it has shown good correlation with more complex techniques estimating RV global systolic function such as radionuclide-derived RV EF. Moreover, this study evaluates RV function in early postoperative period. However, it is expected to change even up to one year follow up. Also, limited number of patients included due to the nature of single center. Corroboration in multicenter larger population with longer follow-up is recommended.

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