# Evaluation of right ventricular diastolic dysfunction after Coronary Artery Bypass Grafting (CABG) surgery

Maryam Faghani[1], Nakisa Khansari[1], Ali Fathi Jouzdani[1], Shahram Homayounfar[1], BABAK manafi[1], Seyed Kianoosh Hosseini[1], Mohammad Ali Seif Rabiee[1], and Fahimeh Ghasemi[1]

[1]Hamadan University of Medical Sciences Medical School

January 28, 2022

## Abstract

**Background**: Coronary artery bypass grafting (CABG) is a surgical procedure used in the treatment of coronary artery disease and to improve heart function. Right ventricular (RV) function is unclear based on myocardial velocities before and after coronary artery bypass graft surgery. RV dysfunction is a known cause of hypotension in early CABG surgery. The diastolic function has been shown to be a significant contributor to mortality and cardiac morbidity in recent years. Our study aimed to assess RV diastolic dysfunction after CABG surgery. **Methods:** Forty-four patients with the two-vessel disease (2 VD), small vessel disease (SVD) and three-vessel disease (3 VD) facial ischemia candidates for CABG surgery were studied. All patients underwent colour Doppler and RV strain echocardiography before and one month after CABG surgery, and patients' RV function indices were calculated. Data analysis was performed using SPSS 21 software and a value of $P<0.05$ was considered statistically significant. **Results:** Out of forty patients, the male to female ratio was 32:8 and their mean age was 65.17 $\pm$ 7.87 years and their mean body mass index was 25.59$\pm$ 3.20. Four patients were operated on without pumps. One month after CABG, systolic pulmonary artery pressure (SPAP), left ventricular ejection fraction (LVEF) and RV Diameter indexes increased significantly. Fractional area change (FAC), RV global longitudinal strain (GLS), Tissue Doppler imaging systolic wave (SM), RV myocardial perfusion imaging (MPI) and Tricuspid annular plane systolic excursion (TAPSE) decreased, which was less in the 3VD group than in the 1VD/2VD group ($P <0.001$). There was no significant difference between RV diastolic diameter (RVDD) and left ventricular diastolic diameter (LVDD) before and one month after CABG ($P <0.05$). Additionally, no significant correlation was detected between changes in RV strain and pump connection time. **Conclusion:** RV diastolic function is significantly reduced after CABG surgery. Surgery without the pump can certainly not eliminate this dysfunction and be effective in reducing its severity.

## Introduction

The incidence of coronary heart disease has increased in developing countries. Genetics, lifestyle, and diet play an essential role in developing diseases, especially cardiovascular diseases (1). These diseases are still the leading cause of death from cardiovascular disease; despite significant advances in reducing mortality, they are the leading cause of death in many countries (2). Studies from developed countries show that about 1-2 of every five deaths in these countries result from coronary artery disease (3, 4). The incidence of cardiovascular disease is on the rise in the Eastern Mediterranean and the Middle East, including Iran. Based on sporadic studies, Iran has a mortality rate from cardiovascular disease ranging from 25 to 45% (5). Coronary artery bypass graft (CABG) surgery is the low blood pressure is a typical result of RV dysfunction early after CABG surgery. RV dysfunction may develop during surgery and be stable in the early postoperative phase. The most common open-heart procedure is to treat advanced coronary artery disease patients. CABG is performed when at least 54% of the lumen of one or more coronary arteries is narrowed by stenosis, and also the angiographic image shows an artery. The number of CABGs performed to

treat coronary artery disease has increased more than fivefold since 1980 (6, 7). In patients with chronic heart failure, the right ventricular (RV) function is a significant indicator of symptoms and activity capacity and one of the most significant predictors of morbidity and mortality (8). The RV dysfunction is a known cause of low blood pressure after CABG surgery. RV dysfunction may develop during surgery and be stable in the early postoperative stages (9). To preserve hemodynamic stability and cardiac function in the early postoperative stage and determine the prognosis of the next stage, it is essential to properly diagnose and manage RV dysfunction after CABG (10). RVs have complicated structural and physiological characteristics due to their unfavourable position in the thoracic cavity, making them difficult to evaluate (11). Tissue Doppler Imaging is a new method of echocardiography to assess ventricular functions (12). Several factors can cause ventricular diastolic dysfunction, including hypertension, which triggers systolic and diastolic ventricular dysfunction, resulting from increased afterload (13). In this study, we evaluate RV diastolic disorders following CABG surgery.

## Methods

This cross-sectional study was performed from 2018 to 2019 on forty patients (32 males and 8 females) with small vessel disease (SVD), two-vessel disease (2VD) and three-vessel disease (3VD) that were referred to the cardiac surgery ward of Farshchian Hospital in Hamadan, Iran as CABG candidates. The protocol of the present study was evaluated and approved by the Ethics Committee of Hamadan University of Medical Sciences (IR.UMSHA.REC.1399.293). All participants provided their informed consent.

Color Doppler Echocardiography and RV Strain examinations were performed on all patients before and one month after surgery. Also, LVDD, RVDD, RV Diameter, TAPSE, FAC, PAP, LVEF, MPI, TDI indices were measured for all patients. A checklist was used to gather demographic data regarding the patients, including age, gender, diabetes history, blood pressure, smoking history, Vascular Grafts, and Pump Time.

Thirty-six patients underwent CABG using the cardiopulmonary pump (on-pump) and four patients did not use the pump (off-pump). Among 40 patients, 20 SVD and 2VD patients without severe stenosis in the right coronary artery (RCA) territory and 20 3VD patients with severe stenosis in the RCA territory were examined. Figure 1 shows the frequency distribution of graft types used in RCA territory. Paired t-test and Friedman test were used in data analysis. SPSS software version 21 was used for all statistical analyses and $P<0.05$ was considered statistically significant.

## Results

In accordance with Table 1, the mean age of patients was 67.15±7.87 years, and the mean body mass index was 25.59±3.20. Twenty-eight (70%) patients had a history of hypertension and twenty-six (65%) had a history of diabetes and twenty-eight (70%) had a history of smoking. The distribution of graft types performed in RCA patients can be seen in Figure 1.

**Table 1. Basic characteristics of patients.**

| | |
|---|---|
| Age | 67.15±7.87 |
| Average body mass index (BMI) | 25.59±3.20 |
| Sex (Male: Female) | 32:8 |
| Hypertension | 28 (70%) |
| Diabetes | 26 (65%) |
| Smoking | 28 (70%) |
| Hyperlipidemia | 18 (45%) |

The mean connection time to the pump during surgery was totally 49.87±5.2 in the SVD group and 49.00±4.47 minutes in the 2VD group and 50.75±5.64 minutes in the 3VD group ($P = 0.296$). (Figure 1)

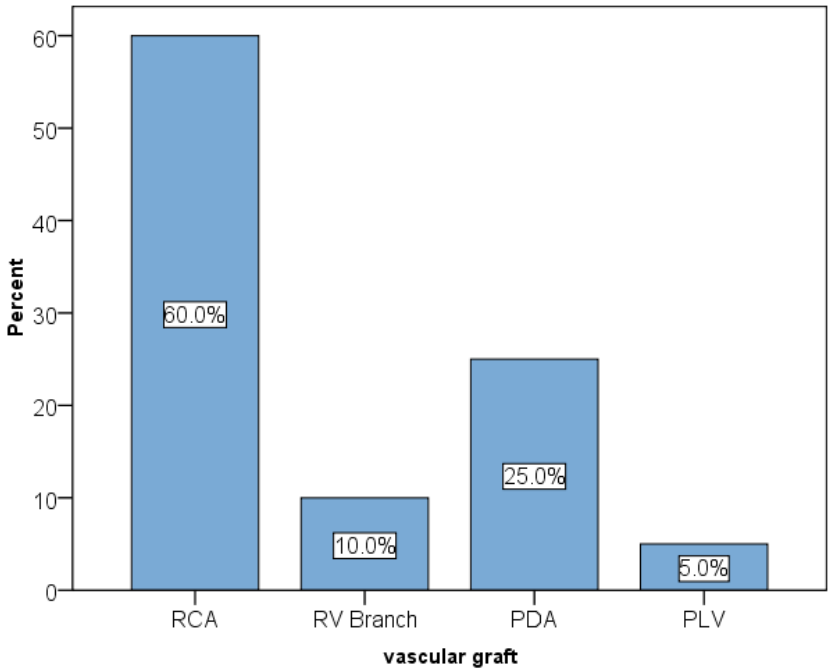


**Figure 1: Graft types in patients in the 3VD group**

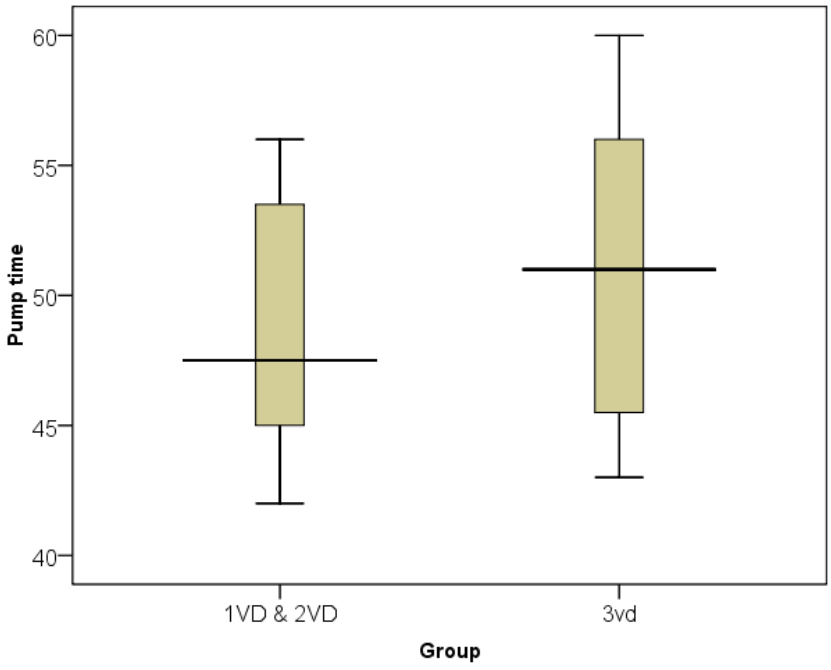


**Figure 2: Connection times of pumps vary with the number of vessels in patients during coronary artery surgery**

As shown in Table 2, A significant difference can be seen between the first and second groups in terms of the number of RV strain changes (P <0.001) and RV function in the second group (3 VD) decreased than the first group.

**Table 2: The rate of RV Strain change in patients undergoing coronary artery surgery based on the number of vessels involved.**

| Number of vessels involved | Mean | Standard deviation | P-value |
|---|---|---|---|
| SVD, 2 VD | -7.62 | 0.93 | P<0.0001 |
| 3 VD | -6.33 | 0.76 | P<0.0001 |

2 VD: Two-vessel disease, SVD: small vessel disease, 3 VD: Three-vessel disease. Paired t-test was used for comparison between groups.

As shown in Table 3, there was no significant difference in RVDD or LVDD indices between SVD, 2 VD, and 3 VD patients before and after surgery (P <0.05). Moreover, RVDD and LVDD index changes were not significantly different before and after CABG in all patients (P <0.05).

**Table 3: Comparison of RVDD and LVDD indices before and one month after surgery between the groups.**

| Evaluation time | Grade | SVD & 2VD | 3VD | P-value |
|---|---|---|---|---|
| RVDD before surgery | Normal | 4 | 5 | 0.846 |
| | Mild | 12 | 10 | |
| | Moderate | 4 | 5 | |
| | Severe | 0 | 0 | |
| | Total | 20 | 20 | |
| RVDD after surgery | Normal | 3 | 5 | 0.231 |
| | Mild | 11 | 12 | |
| | Moderate | 6 | 3 | |
| | Severe | 0 | 0 | |
| | Total | 20 | 20 | |
| LVDD before surgery | Normal | 5 | 3 | 0.475 |
| | Mild | 11 | 12 | |
| | Moderate | 4 | 5 | |
| | Severe | 0 | 0 | |
| | Total | 20 | 20 | |
| LVDD after surgery | Normal | 4 | 5 | 0.820 |
| | Mild | 13 | 10 | |
| | Moderate | 3 | 5 | |
| | Severe | 0 | 0 | |
| | Total | 20 | 20 | |

2 VD: Two-vessel disease, SVD: small vessel disease, 3 VD: Three-vessel disease. RVDD: Right ventricular diastolic dysfunction, LVDD: Left ventricular diastolic dysfunction. Friedman test was used for comparison between groups.

**Discussion**

The RV dysfunction following heart surgery is a well-known phenomenon that occurs immediately following CABG. The RV contraction and filling are impaired after surgery, but the exact mechanism remains unknown.

All patients undergoing heart surgery are likely to experience RV dysfunction regardless of a cardiopulmonary pump, the duration of aortic clamping, or the method used for cardioplegia or myocardial protection (14). Although most studies have reported decreased RV function after CABG surgery or during the immediate recovery period, long-term results have not been studied. A significant reduction in the systolic displacement of the tricuspid annulus has been observed immediately after CABG that have indicated RV dysfunction, and the reduction persists for up to 6 months after surgery. Tissue doppler velocity is a relatively new way of evaluating myocardial function. The diastolic and systolic velocities of the tricuspid annulus are recorded by tissue Doppler velocity. They reveal RV systolic and diastolic function, respectively, which decreases following RV infarction or cardiomyopathy (14, 15). Charlie J et al. examined the effects of pericardial incision on RV systolic function in twenty-four patients who underwent elective on-pump CABG. At three times during surgery after sternotomy immediately before pericardiotomy, after pericardiotomy and placement of pericardial sutures, and after chest closure at a follow-up visit for cardiopulmonary bypass, color tissue Doppler-derived isovolumic acceleration (IVA), Speckle tracking-derived TAPSE, S', free wall systolic strain, RV outflow tract strain, and two-dimensional RV dimensions and fractional area change (FAC) were measured. As a final result of this study, the evidence suggested that pericardial opening does not influence RV systolic function indexes from speckle tracking or tissue color Doppler. All RV systolic functions, including RV free wall strain TAPSE, and RV SM were significantly reduced post-pericardiotomy, compared with pre-pericardiotomy, while RVOT Strain and RV Diameter remained unchanged (16). We obtained similar results in RVSM, TAPSE, and RV Strain in this study, but our study was conducted after one month following CABG, and the RV diameter changes were not the same as in our study. Gozdzik et al. reported that after CABG surgery, Global longitudinal strain echocardiographic parameters in the left ventricle were reduced significantly six months after surgery in 63 patients (17). Our follow-up period was three months instead of 6 months. We had a smaller sample size than Gozdzik et al. and also the strain method was not used to estimate LVEF in the present study. LVEF values were measured globally, which increased significantly after surgery, and there was no difference between LVDD and RVDD between patients before and after CABG. Lue et al. demonstrated that the index of LVDD indexes before and after CABG did not differ significantly, which is compatible with the results of this study (18). On the other hand, in a study by Bord et al that looked at changes in RV function after off-pump CABG, patients' RVDD grade was normal before surgery but significantly different after surgery (19). The reason for the discrepancy between the results can be because, in the present study, most patients underwent on-pump surgery; on the other hand, the second evaluation of patients was done one month after surgery, while in this study, the second evaluation was performed when patients were transferred to the ward.

The study had limitations because there was no access to a larger sample size because of the COVID-19 pandemic and the reduction in surgical candidates because of the current pandemic.

## Conclusion

The RV diastolic function is significantly reduced after CABG surgery. It is certain that without the pump, surgery cannot compensate for this disorder and can't reduce its severity. Doppler tissue can be used to evaluate RV function after surgery in a simple and non-invasive procedure.

## Acknowledgement

The present study was funded by Hamadan University of Medical Science (No: 9606073688). The authors acknowledge the Vice Chancellor for Research and Technology of Hamadan University of Medical Sciences and the Clinical Research Development Unit of Farshchian Hospital in Hamadan, Iran. In addition, the authors state there were no conflicts of interest with the study's results.

## References

1. Matthan NR, Welty FK, Barrett PHR, Harausz C, Dolnikowski GG, Parks JS, et al. Dietary hydrogenated fat increases high-density lipoprotein apoA-I catabolism and decreases low-density lipoprotein apoB-100 catabolism in hypercholesterolemic women. Arterioscler Thromb Vasc Biol. 2004;24(6):1092-7.

2. Mirmiran P, Ramezankhani A, Hekmatdoost A, Azizi F. Effect of nutrition intervention on non-communicable disease risk factors among Tehranian adults: Tehran Lipid and Glucose Study. Ann Nutr Metab. 2008;52(2):91-5.

3. Roger VL, Go AS, Lloyd-Jones DM, Benjamin EJ, Berry JD, Borden WB, et al. Executive summary: heart disease and stroke statistics—2012 update. Circulation. 2012.

4. Chen W-W, Gao R-L, Liu L-S, Zhu M-L, Wang W, Wang Y-J, et al. China cardiovascular diseases report 2015: a summary. Journal of geriatric cardiology: JGC. 2017;14(1):1-10.

5. Mirmiran P, Mohammadi F, Allahverdian S, Azizi F. Association of educational level and marital status with dietary intake and cardiovascular risk factors in Tehranian adults: Tehran lipid and glucose study (TLGS). Nutr Res. 2002;22(12):1365-75.

6. Farhangi MA, Najafi M, Jafarabadi MA, Jahangiry L. Mediterranean dietary quality index and dietary phytochemical index among patients candidate for coronary artery bypass grafting (CABG) surgery. BMC Cardiovasc Disord. 2017;17(1):1-8.

7. Riley RF, Don CW, Powell W, Maynard C, Dean LS. Trends in coronary revascularization in the United States from 2001 to 2009: recent declines in percutaneous coronary intervention volumes. Circ Cardiovasc Qual Outcomes. 2011;4(2):193-7.

8. Hashemi N, Brodin L-Å, Hedman A, A Samad B, Alam M. Improved right ventricular index of myocardial performance in the assessment of right ventricular function after coronary artery bypass grafting. Interact Cardiovasc Thorac Surg. 2018;26(5):798-804.

9. Joshi SB, Roswell RO, Salah AK, Zeman PR, Corso PJ, Lindsay J, et al. Right ventricular function after coronary artery bypass graft surgery—a magnetic resonance imaging study. Cardiovasc Revasc Med. 2010;11(2):98-100.

10. Chinikar M, Rafiee M, Aghajankhah M, Gholipour M, Hasandokht T, Imantalab V, et al. Right ventricular dysfunction and associated factors in patients after coronary artery bypass grafting. ARYA atherosclerosis. 2019;15(3):99.

11. Pouleur A-CM, Rousseau MF, Ahn SA, Amzulescu M, Demeure F, de Meester C, et al. Right ventricular systolic dysfunction assessed by cardiac magnetic resonance is a strong predictor of cardiovascular death after coronary bypass grafting. The Annals of thoracic surgery. 2016;101(6):2176-84.

12. Caso P, Galderisi M, Cioppa C, Severino S, De Simone L, Izzo A, et al. Regional diastolic function in normotensive versus hypertensive subjects: comparison using Doppler myocardial imaging. G Ital Cardiol. 1997;27(9):901-7.

13. Galderisi M, Petrocelli A, Alfieri A, Garofalo M, de Divitiis O. Impact of ambulatory blood pressure on left ventricular diastolic dysfunction in uncomplicated arterial systemic hypertension. The American journal of cardiology. 1996;77(8):597-601.

14. Fazlinejad A, Mohammadi A, Mottahedi B, Esfahanizadeh J. Right Ventricular Function before and after an uncomplicated Coronary Bypass Graft as Assessed by Pulsedwave Doppler Tissue Imaging of the Tricuspid Annulus. medical journal of mashhad university of medical sciences. 2009;52(4):203-8.

15. Alam M, Wardell J, Andersson E, Samad BA, Nordlander R. Right ventricular function in patients with first inferior myocardial infarction: assessment by tricuspid annular motion and tricuspid annular velocity. Am Heart J. 2000;139(4):710-5.

16. Bitcon CJ, Tousignant C. The effect of pericardial incision on right ventricular systolic function: a prospective observational study. Canadian Journal of Anesthesia/Journal canadien d'anesthésie. 2017;64(12):1194-201.

17. Gozdzik A, Letachowicz K, Grajek BB, Plonek T, Obremska M, Jasinski M, et al. Application of strain and other echocardiographic parameters in the evaluation of early and long-term clinical outcomes after cardiac surgery revascularization. BMC Cardiovasc Disord. 2019;19(1):1-8.

18. Liu J, Tanaka N, Murata K, Ueda K, Wada Y, Oyama R, et al. Prognostic value of pseudonormal and restrictive filling patterns on left ventricular remodelingand cardiac events after coronary artery bypass grafting. The American journal of cardiology. 2003;91(5):550-4.

19. Borde D, Joshi P, Joshi S, Asegaonkar B, Apsingekar P, Khade S, et al. Changes in Right Ventricular Function After Off-Pump Coronary Artery Bypass Grafting. J Cardiothorac Vasc Anesth. 2021;35(3):811-9.