

Impact of Right Coronary Artery Bypass Grafting on Development of Atrial Fibrillation in Coronary Artery Bypass Grafting Surgery: A Retrospective Study

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ABSTRACT

Introduction: Previous studies suggest that the location of coronary artery disease cannot independently predict atrial fibrillation after coronary artery bypass grafting, but with little information, it has also been thought that simultaneous right coronary endarterectomy may cause this rhythm problem.

Objective: In this study, we aimed to evaluate the effect of right coronary artery bypass grafting on early postoperative atrial fibrillation.

Methods: Patients who underwent elective on-pump coronary artery bypass grafting operations in our hospital were included in the study, and patients who underwent a different open-heart surgery or those who had previously undergone open-heart surgery were not included. Patients included in the study were divided into Group 1 (patients who developed postoperative atrial fibrillation) and Group 2 (patients who did not develop postoperative atrial fibrillation) and compared

in terms of right coronary artery bypass grafting and other follow-up parameters.

Results: The mean age of a total of 158 patients included in the study was determined as 63.25 ± 10.07 years (range 44 - 85 years), 120 were male, and 96% of them had hypertension. Postoperative atrial fibrillation developed in 43 patients, and right coronary artery bypass grafting was performed in 123 patients.

Conclusion: We think that the frequency of postoperative atrial fibrillation development may be higher in cases where right coronary artery bypass grafting is performed, as it may play a role in processes related to the conduction system and right ventricular dysfunction, and multicenter studies with a large number of patients would be beneficial on this subject.

Keywords: Coronary Artery Disease. Coronary Artery Bypass. Atrial Fibrillation. Cardiac Conduction System Disease.

Abbreviations, Acronyms & Symbols

AF	= Atrial fibrillation
CABG	= Coronary artery bypass grafting
CAD	= Coronary artery disease
CPB	= Cardiopulmonary bypass
CRP	= C-reactive protein
DM	= Diabetes mellitus
EF	= Ejection fraction
Hgb	= Hemoglobin
HT	= Hypertension
MI	= Myocardial infarction
NSTEMI	= Non-ST-segment elevation myocardial infarction
RCA	= Right coronary artery
STEMI	= ST-segment elevation myocardial infarction

INTRODUCTION

Coronary artery bypass grafting (CABG) is reported as the recommended treatment method in patients with coronary artery disease (CAD), especially in those with diabetes mellitus or left main coronary disease^[1,2]. However, it is reported that the main complications that can be seen after CABG include myocardial infarction (MI), acute renal failure, stroke, pneumonia, atrial fibrillation (AF), low cardiac output, and mortality; and the incidence of AF, which is stated to be the most frequently observed rhythm problem in the postoperative period, is 10 - 40%^[1,2]. It is stated that this undesirable condition that may develop after CABG is an important reason for postoperative adverse events, and advanced age and low ejection fraction (EF) are among the known risk factors; surgical trauma, use of cardiopulmonary bypass (CPB), non-use of beta-blocking agents, and many factors such as hypoxia and electrolyte imbalance are also held responsible to the pathogenesis of new AF after CABG^[2,3]. It has been reported that this arrhythmia is generally benign, however, it can cause hemodynamic deterioration,

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Article received on March 27th, 2024.

Article accepted on October 22nd, 2024.

thromboembolic events, and prolonged hospitalization, and there is little consensus on its pathogenesis^[3]. It has been suggested in previous studies that the location of CAD cannot predict AF after bypass surgery, but with little information, simultaneous right coronary artery (RCA) endarterectomy is suspected to be the cause of this rhythm problem^[3]. It has also been reported that some studies conducted with patients undergoing non-cardiac surgery suggest that ischemia in the distribution of the RCA may be associated with a higher rate of new AF^[3]. In the literature, it is stated that the determinants of AF are advanced age, sex (male), and no postoperative beta-blocking treatment, and it has been reported that even a slight reduction in the incidence of AF after CABG can have an important impact on the postoperative clinical situation and shorten the length of hospital stay^[3].

Objective

In our study, we aim to evaluate the impact of RCA bypass grafting on early postoperative AF and mortality in isolated on-pump CABG patients and discuss it in light of the literature.

METHODS

The study was conducted on patients who underwent CABG surgery in our hospital between February 2022 and April 2023. Declaration of Helsinki criteria were complied with, and ethics committee approval (20.11.2023/17) was obtained for the study. Patients who underwent isolated on-pump CABG surgery in our hospital whose study data were available were included in our retrospective study, and patients who underwent emergency CABG surgery, patients who underwent off-pump CABG, patients who underwent major vascular surgery simultaneously with the CABG operation, patients who underwent another open-heart surgery, patients who had previous open-heart surgery, and patients with known AF in the preoperative period were not included. Preoperative and postoperative medical data (preoperative clinical characteristics, comorbidities, laboratory parameters, intraoperative data such as coronary artery distal anastomoses, and postoperative AF development) of the patients included in the study were examined and recorded from hospital records, and statistical evaluations were made. CHA2DS2-VASc score — which is calculated with history of heart failure, 1 point; hypertension (HT), 1 point; age ≥ 75 years, 2 points; age between 65 and 74 years, 1 point; diabetes, 1 point; female sex, 1 point; stroke/transient ischemic attack, 2 points; and peripheral vascular disease, 1 point^[4-6] — was used as a predictor of postoperative AF risk. A total of 158 patients included in the study were divided into Group 1 (patients who developed postoperative AF) and Group 2 (patients who did not develop postoperative AF) and compared. The medical treatment of the patients included oral beta-blockers (unless strictly contraindicated) in the preoperative and postoperative periods. Patients had fasting (six to eight hours) blood tests when they were hospitalized for surgery, and after receiving surgery approval from the Anesthesiology and Reanimation Department, the patients were taken to CABG surgery without waiting for an extra-specific period. CABG surgeries were generally performed with a standard median sternotomy, and myocardial protection was provided by giving cold blood cardioplegia from the aortic root (a single dose, antegrade) and the coronary sinus (intermittent, retrograde). After the surgery, the patients were taken to the cardiovascular surgery

intensive care unit and monitored for 24 hours with a standard D2 lead; they were extubated when they were adequately alert, breathed spontaneously, and there were no abnormalities in their blood gas parameters and hemodynamic status. Patients received blood transfusions when necessary (if the hematocrit level was $< 24 - 25\%$). Newly developed AF was defined as an AF episode lasting > 5 minutes, detected while hospitalized (by monitoring or 12-lead electrocardiogram).

Statistical Analysis

All statistical analyses were performed using the IBM Corp. Released 2015, IBM SPSS Statistics for Windows, Version 23.0, Armonk, NY: IBM, Corp. Continuous variables are shown as mean $\pm$ standard deviation. Categorical variables were evaluated using the chi-square test and Fisher's exact test. Normally distributed continuous variables were evaluated using the independent samples *t*-test, and non-parametric data were evaluated using the Mann-Whitney U test. A *P*-value of ≤ 0.05 was considered statistically significant.

RESULTS

The mean age of 158 patients (120 of whom were male) included in the study was 63.25 ± 10.07 years (range 44 - 85 years), and 96% of them have HT. Demographic data of patients are shown in Table 1. Postoperative AF rhythm developed in 43 of the patients, RCA bypass grafting was performed in 123 patients, and the intraoperative data of the patients are shown in Table 2. Early postoperative mortality was found to be 8.2%, and postoperative AF development rate was 30% and 17% in cases with and without RCA bypass grafting, respectively ($P = 0.000$); the postoperative events are shown in Table 3. The CHA2DS2-VASc scores of the patients in the AF and non-AF groups were found to be 2.74 ± 1.36 and 2.38 ± 1.15 , respectively ($P = 0.157$), and the comparison of perioperative data of the groups is shown in Table 4. The mean preoperative C-reactive protein (CRP) value in the patient group that developed early postoperative mortality was found to be higher than that in the patient group that did not develop early postoperative mortality (19.10 ± 27.39 and 11.58 ± 15.1 , respectively, $P = 0.005$).

DISCUSSION

It has been reported that the pathophysiology of AF in the general population has been extensively studied but is not yet fully understood^[4]. Also, that AF, which is stated to be the most frequently observed (10 - 40%) rhythm disorder in the postoperative CABG period^[1,2], is a cause of mortality and morbidity. The stated known risk factors include advanced age and low EF, and many factors such as surgical trauma, use of CPB, non-use of beta-blocking agents, and electrolyte imbalance are also held responsible for its pathogenesis^[2,3]. Previous studies reported that the location of CAD cannot independently predict AF after bypass surgery, but with limited information, it is suggested that simultaneous RCA endarterectomy may predispose to this rhythm problem^[3,5]. It has also been reported that some studies conducted with patients undergoing non-cardiac surgery suggest that ischemia in the distribution of the RCA is also associated with a high incidence of AF^[3]; in addition, in a study aimed to evaluate the results of patients who underwent RCA endarterectomy, the authors reported that they have noticed a high rate of rhythm disturbances, including

Table 1. Demographic characteristics of patients.

Variable	n = 158	%
Age (years)	63.25 ± 10.07	
Sex (male)	120	75.9
DM	88	55.7
Preoperative EF	55.67 ± 8.31	
Preoperative Hgb (g/dl)	13.14 ± 1.79	
Preoperative creatinine (mg/dl)	1.05 ± 1.00	
Preoperative CRP (mg/l)	12.19 ± 16.44	

CRP=C-reactive protein; DM=diabetes mellitus; EF=ejection fraction; Hgb=hemoglobin

Table 2. Intraoperative data of patients.

Variable	n = 158	%
CPB duration (min.)	133.88 ± 37.37	
Aortic cross-clamping duration (min.)	92.17 ± 29.82	
Number of mean distal anastomoses	3.89 ± 0.89	
Number of right coronary artery distal anastomoses	123	78

CPB=cardiopulmonary bypass

Table 3. Postoperative events.

Variable	n = 158	%
Postoperative AF	43	27.2
Postoperative mortality	13	8.2

AF=atrial fibrillation

Table 4. Comparison of the perioperative data of the groups.

Variable	AF Group	Non-AF Group	P-value
	n = 43	n = 115	
Age (years)	64.48 ± 9.53	62.79 ± 10.27	0.479
Male sex	0.79 ± 0.41	0.74 ± 0.43	0.248
DM	0.58 ± 0.49	0.54 ± 0.49	0.410
Mean number of distal anastomoses	4.07 ± 1.05	3.82 ± 0.81	0.081
Mean number of RCA anastomoses	0.86 ± 0.35	0.75 ± 0.43	0.001
CPB duration (min.)	144.76 ± 39.06	129.81 ± 36.06	0.383
Aortic cross-clamping duration (min.)	100.37 ± 31.74	89.10 ± 28.61	0.763
Preoperative EF	54.83 ± 8.86	55.98 ± 8.11	0.399
CHA2DS2 VASc score	2.74 ± 1.36	2.38 ± 1.15	0.157
Preoperative Hgb (g/dl)	12.94 ± 1.75	13.21 ± 1.81	0.962
Preoperative CRP (mg/l)	11.63 ± 17.63	12.41 ± 16.05	0.552

AF=atrial fibrillation; CPB=cardiopulmonary bypass; CRP=C-reactive protein; DM=diabetes mellitus; EF=ejection fraction; Hgb=hemoglobin; RCA=right coronary artery

atrioventricular block and ventricular fibrillation, and that they thought that the reason for this may be ischemia that may develop in the conduction system secondary to early occlusion of the RCA bypass graft^[6]. A study reported that previous studies suggested that intraoperative ischemia in the distribution of the RCA may be important in the pathogenesis of rhythm problems^[3], and in another publication, it is stated that the combination of RCA occlusion and proximal left anterior descending CAD was not a risk factor for AF in CABG patients^[3,7].

It has been reported that a study suggests that right-sided cardiac dysfunction is associated with AF and supraventricular tachycardia^[4,8,9], and right ventricular dysfunction can lead to right atrial dilatation and remodeling, which can alter conduction and increase susceptibility to postoperative AF^[4,10]. Furthermore, it is stated in the same study that the results of the study are consistent with the observation that right ventricular function, which may also improve in the postoperative period, is associated with the development of AF^[4]. Another angiography-based study stated that RCA disease was detected in 21.4% of patients who did not develop AF and 71.4% of patients who developed AF after MI ($P < .0001$)^[11].

In our study, RCA bypass grafting was performed in 123 of 158 patients who underwent on-pump CABG surgery. The rate of postoperative AF development was found to be 27.2%, and when the patient groups were examined according to the development of postoperative AF, the rate of RCA bypass grafting was found to be 86% (37/43 patients) in the group that developed AF and 75% (86/115 patients) in the group without AF, and that was statistically significant ($P = 0.001$). Again, according to our study results, the average number of distal anastomoses was found to be 4.07 ± 1.05 in the group that developed AF and 3.82 ± 0.81 in the group without AF ($P = 0.081$). No statistically significant difference was detected between the two groups in terms of our other study parameters, and when patients who underwent and did not undergo RCA bypass grafting were evaluated, the postoperative AF development rate was found to be 30% (37/123 patients) and 17% (6/35 patients), respectively ($P = 0.000$).

It is stated in the literature that there is no widely accepted risk model to predict AF after cardiac surgery, and various models have been created and validated on this subject^[12]. The CHA2DS2-VASc score has been validated both prospectively and retrospectively in predicting AF after cardiac surgery^[12-16]. In our study, the CHA2DS2-VASc score was calculated to predict the risk of postoperative AF, and the CHA2DS2-VASc scores of the patients in the AF and non-AF groups were found to be 2.74 ± 1.36 and 2.38 ± 1.15 , respectively; although this score was higher in the AF group, no statistically significant difference was detected ($P = 0.157$).

The optimal timing of CABG after MI is still a controversial issue, and early CABG is not clearly defined in most publications in the literature, but the majority of statistics in studies on this subject are based on a CABG time limit of 24 or 48 hours^[17,18]. Some studies in the literature report that the mortality rate in CABG operations performed in the early period (one day, two days, or one week) after MI is higher than in those performed in the late period. Some other studies have shown that CABG timing does not affect mortality in patients with ST-segment elevation myocardial infarction (STEMI) or non-ST-segment elevation myocardial infarction (NSTEMI)^[17,19-23]. In a meta-analysis conducted on the relationship between CABG timing and mortality in the literature, the mortality rate in patients who underwent CABG in the first 24 hours was found

to be between 4.0 and 24.6% (average 10.5%), and the mortality in patients who underwent CABG after 24 hours (late) was found to be between 1.8 and 11.4%. In the same study, it is stated that the mortality in patients who underwent CABG in the first 48 hours was found to be between 3.6 and 42.9%, and the mortality in patients who underwent (late) CABG after 48 hours was found to be between 1.8 and 5.5%^[17]. It is stated in the literature that early CABG after acute MI, in the high stage of CRP, may further increase this systemic inflammatory response and negatively affect the prognosis^[17,24]. The mortality rate in our study was found to be approximately 8%. In our study, the preoperative mean CRP levels of patients with mortality were found to be statistically significantly higher than those without mortality (19.10 ± 27.39 and 11.58 ± 15.1 , respectively, $P = 0.005$). Since some of the patients in our study underwent CABG surgery in the early period after MI, we think that this may have contributed to the relatively high mortality rate.

Limitations

Our study has some limitations, such as its retrospective design, being single-center and hospital registry-based study, failure to classify patients as STEMI or NSTEMI, and having a short follow-up period.

CONCLUSION

We think that the incidence of postoperative AF development may be higher in cases where RCA bypass grafting is performed, as it may play a role in the processes related to the conduction system and right ventricular dysfunction. In our opinion, it would be useful to conduct multicenter studies with a large number of patients on this subject.

No financial support.

No conflict of interest.

Authors' Roles & Responsibilities

SY	Substantial contributions to the conception of the work; revising the work critically for important intellectual content; final approval of the version to be published
EA	Substantial contributions to the acquisition and analysis of data for the work; drafting the work; final approval of the version to be published
SZ	Substantial contributions to the acquisition and analysis of data for the work; drafting the work; final approval of the version to be published
ETY	Substantial contributions to the conception of the work, revising the work critically for important intellectual content, final approval of the version to be published
AÇ	Substantial contributions to the acquisition and analysis of data for the work; drafting the work; final approval of the version to be published

REFERENCES

- Engin M, Ozsin KK, Savran M, Guvenc O, Yavuz S, Ozyazicioglu AF. Visceral adiposity index and prognostic nutritional index in predicting atrial fibrillation after on-pump coronary artery bypass operations: a prospective study. *Braz J Cardiovasc Surg.* 2021;36(4):522-9. doi:10.21470/1678-9741-2020-0044.
- Topal D, Korkmaz UTK, Velioglu Y, Yuksel A, Donmez I, Uçaroğlu ER, et al. Systemic immune-inflammation index as a novel predictor of atrial fibrillation after off-pump coronary artery bypass grafting. *Rev Assoc Med Bras (1992).* 2022;68(9):1240-6. doi:10.1590/1806-9282.20220295.
- Mendes LA, Connelly GP, McKenney PA, Podrid PJ, Cupples LA, Shemin RJ, et al. Right coronary artery stenosis: an independent predictor of atrial fibrillation after coronary artery bypass surgery. *J Am Coll Cardiol.* 1995;25(1):198-202. doi:10.1016/0735-1097(94)00329-0.
- Shimony A, Afilalo J, Flynn AW, Langleben D, Agnihotri AK, Morin JF, et al. Usefulness of right ventricular dysfunction to predict new-onset atrial fibrillation following coronary artery bypass grafting. *Am J Cardiol.* 2014;113(6):913-8. doi:10.1016/j.amjcard.2013.11.048.
- Pattison CW, Dimitri WR, Williams BT. Dysrhythmias following coronary artery surgery. A comparison between cold cardioplegic and intermittent ischaemic arrest (32 degrees C) with the effect of right coronary endarterectomy. *J Cardiovasc Surg (Torino).* 1988;29(5):601-5.
- Göl MK, Yilmazkaya B, Göksel S, Sener E, Mavitaş B, Taşdemir O, et al. Results of right coronary artery endarterectomy with or without patchplasty. *J Card Surg.* 1999;14(2):75-81. doi:10.1111/j.1540-8191.1999.tb00954.x.
- Caretta Q, Mercanti CA, De Nardo D, Chiarotti F, Scibilia G, Reale A, et al. Ventricular conduction defects and atrial fibrillation after coronary artery bypass grafting. Multivariate analysis of preoperative, intraoperative and postoperative variables. *Eur Heart J.* 1991;12(10):1107-11. doi:10.1093/oxfordjournals.eurheartj.a059845.
- Aziz EF, Kukin M, Javed F, Musat D, Nader A, Pratap B, et al. Right ventricular dysfunction is a strong predictor of developing atrial fibrillation in acutely decompensated heart failure patients, ACAP-HF data analysis. *J Card Fail.* 2010;16(10):827-34. doi:10.1016/j.cardfail.2010.05.004.
- Matyal R, Mahmood F, Hess P, Zhao X, Mitchell J, Maslow A, et al. Right ventricular echocardiographic predictors of postoperative supraventricular arrhythmias after thoracic surgery: a pilot study. *Ann Thorac Surg.* 2010;90(4):1080-6. doi:10.1016/j.athoracsur.2010.05.019.
- Mariscalco G, Engström KG, Ferrarese S, Cozzi G, Bruno VD, Sessa F, et al. Relationship between atrial histopathology and atrial fibrillation after coronary bypass surgery. *J Thorac Cardiovasc Surg.* 2006;131(6):1364-72. doi:10.1016/j.jtcvs.2006.01.040.
- Alasady M, Abhayaratna WP, Leong DP, Lim HS, Abed HS, Brooks AG, et al. Coronary artery disease affecting the atrial branches is an independent determinant of atrial fibrillation after myocardial infarction. *Heart Rhythm.* 2011;8(7):955-60. doi:10.1016/j.hrthm.2011.02.016.
- Burgos LM, Ramírez AG, Seoane L, Furmento JF, Costabel JP, Diez M, et al. New combined risk score to predict atrial fibrillation after cardiac surgery: COM-AF. *Ann Card Anaesth.* 2021;24(4):458-63. doi:10.4103/aca.ACA_34_20.
- Lip GY, Lane DA. Modern management of atrial fibrillation requires initial identification of "low-risk" patients using the CHA2DS2-VASc score, and not focusing on "high-risk" prediction. *Circ J.* 2014;78(8):1843-5. doi:10.1253/circj.cj-14-0584.
- Chua SK, Shyu KG, Lu MJ, Lien LM, Lin CH, Chao HH, et al. Clinical utility of CHADS2 and CHA2DS2-VASc scoring systems for predicting postoperative atrial fibrillation after cardiac surgery. *J Thorac Cardiovasc Surg.* 2013;146(4):919-26.e1. doi:10.1016/j.jtcvs.2013.03.040.
- Kashani RG, Sareh S, Genovese B, Hershey C, Rezentes C, Shemin R, et al. Predicting postoperative atrial fibrillation using CHA2DS2-VASc scores. *J Surg Res.* 2015;198(2):267-72. doi:10.1016/j.jss.2015.04.047.
- Yin L, Ling X, Zhang Y, Shen H, Min J, Xi W, et al. CHADS2 and CHA2DS2-VASc scoring systems for predicting atrial fibrillation following cardiac valve surgery. *PLoS One.* 2015;10(4):e0123858. doi:10.1371/journal.pone.0123858.
- Lang Q, Qin C, Meng W. Appropriate timing of coronary artery bypass graft surgery for acute myocardial infarction patients: a meta-analysis. *Front Cardiovasc Med.* 2022;9:794925. doi:10.3389/fcvm.2022.794925.
- Chen HL, Liu K. Timing of coronary artery bypass graft surgery for acute myocardial infarction patients: a meta-analysis. *Int J Cardiol.* 2014;177(1):53-6. doi:10.1016/j.ijcard.2014.09.127.
- Kaul TK, Fields BL, Riggins SL, Dacumos GC, Wyatt DA, Jones CR. Coronary artery bypass grafting within 30 days of an acute myocardial infarction. *Ann Thorac Surg.* 1995;59(5):1169-76. doi:10.1016/0003-4975(95)00125-5.
- Parikh SV, de Lemos JA, Jessen ME, Brilakis ES, Ohman EM, Chen AY, et al. Timing of in-hospital coronary artery bypass graft surgery for non-ST-segment elevation myocardial infarction patients results from the National cardiovascular data registry ACTION Registry-GWTG (acute coronary treatment and intervention outcomes network registry-get with the guidelines). *JACC Cardiovasc Interv.* 2010;3(4):419-27. doi:10.1016/j.jcin.2010.01.012.
- Davierwala PM, Verevkin A, Leontyev S, Misfeld M, Borger MA, Mohr FW. Does timing of coronary artery bypass surgery affect early and long-term outcomes in patients with non-ST-segment-elevation myocardial infarction? *Circulation.* 2015;132(8):731-40. doi:10.1161/CIRCULATIONAHA.115.015279.
- Khan AN, Sabbagh S, Ittaman S, Abrich V, Narayan A, Austin B, et al. Outcome of early revascularization surgery in patients with ST-elevation myocardial infarction. *J Interv Cardiol.* 2015;28(1):14-23. doi:10.1111/joic.12177.
- Bianco V, Kilic A, Gleason TG, Aranda-Michel E, Wang Y, Navid F, et al. Timing of coronary artery bypass grafting after acute myocardial infarction may not influence mortality and readmissions. *J Thorac Cardiovasc Surg.* 2021;161(6):2056-64.e4. doi:10.1016/j.jtcvs.2019.11.061.
- Fransen E, Maessen J, Dentener M, Senden N, Geskes G, Buurman W. Systemic inflammation present in patients undergoing CABG without extracorporeal circulation. *Chest.* 1998;113(5):1290-5. doi:10.1378/chest.113.5.1290.

