

## Coronary vasculature and postoperative atrial fibrillation: a risk factor analysis

*Koroner damar yapısı ve ameliyat sonrası atriyal fibrilasyon: Risk faktör analizi*

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**Background:** This study aims to investigate the results of coronary artery bypass graft (CABG) surgeries in terms of the relation of postoperative atrial fibrillation, coronary vasculature, and the nature and extent of coronary artery disease.

**Methods:** Between January 2011 and May 2011, 94 consecutive CABG patients (68 males, 26 females; mean age 61.4±10.9 years; range 38 to 87 years) who were operated in our clinic were enrolled in this prospective observational study. Logistic regression analysis was performed for the factors influencing the occurrence of postoperative atrial fibrillation. The perioperative parameters (Gensini score, Rentrop score, number of revascularized vessels, dominant coronary artery system, revascularization of the dominant coronary artery system, left main coronary artery disease, clinical status on admission, left ventricular dysfunction, and left atrium diameter) were analyzed as independent variables.

**Results:** Twenty-three patients (24.5%) developed perioperative atrial fibrillation. Twenty patients returned to normal sinus rhythm with amiodarone therapy. In-hospital mortality was observed in three patients (3.2%). There was no statistically significant difference in mortality rates among the patients with and without atrial fibrillation. Left ventricular dysfunction (p=0.034) and left main coronary artery disease (p=0.019) were found to be significantly associated with the occurrence of postoperative atrial fibrillation. The rate of renal complications (p=0.030) and the need for sternal revision surgery (p=0.003) were not significantly different between both groups.

**Conclusion:** Postoperative atrial fibrillation is a frequently encountered complication of cardiac surgery. The left ventricular dysfunction is a significant risk factor for postoperative occurrence of atrial fibrillation. Although no significant association between coronary vasculature and atrial fibrillation, the left main coronary artery disease is a serious risk factor for postoperative atrial fibrillation.

**Key words:** Atrial fibrillation; complication; coronary artery bypass grafting; risk factor.

**Amaç:** Bu çalışmada koroner arter baypas greft (KABG) ameliyatlarının sonuçları, ameliyat sonrası atriyal fibrilasyon, koroner damar yapısı ve koroner arter hastalığının şekli ve genişliği ile ilişkisi açısından incelendi.

**Çalışma planı:** Ocak 2011 ve Mayıs 2011 tarihleri arasında kliniğimizde ameliyat edilen ardışık 94 KABG hastası (68 erkek, 26 kadın; ort. yaş 61.4±10.9 yıl; aralık 38-87 yıl) bu prospektif gözlem çalışmasına alındı. Ameliyat sonrası atriyal fibrilasyon gelişimini etkileyen faktörler için lojistik regresyon analizi yapıldı. Bağımsız değişkenler olarak ameliyat sırası parametreleri (Gensini skoru, Rentrop skoru, revaskülarize edilen damar sayısı, dominant koroner arter sistemi, dominant koroner arter sisteminin revaskülarizasyonu, sol ana koroner arter hastalığı, başvuru zamanı klinik tablosu, sol ventrikül disfonksiyonu ve sol atriyum çapı) analiz edildi.

**Bulgular:** Ameliyat sırası 23 hastada (%24.5) atriyal fibrilasyon gelişti. Yirmi hasta amiodaron tedavisi ile normal sinüs ritmine döndürüldü. Üç hastada (%3.2) hastane mortalitesi oldu. Atriyal fibrilasyon gelişen ve gelişmeyen hastalarda mortalite oranları açısından istatistiksel olarak anlamlı bir fark yoktu. Sol ventrikül disfonksiyonu (p=0.034) ve sol ana koroner arter hastalığı (p=0.019) ameliyat sonrası atriyal fibrilasyon gelişimi ile anlamlı olarak ilişkiliydi. Renal komplikasyon oranı (p=0.030) ve sternal revizyon cerrahisi gerekliliği (p=0.003) açısından iki grup arasında anlamlı bir farklılık yoktu.

**Sonuç:** Ameliyat sonrası atriyal fibrilasyon kalp cerrahisinde sık karşılaşılan bir komplikasyondur. Sol ventrikül disfonksiyonu, ameliyat sonrası atriyal fibrilasyon gelişimi açısından anlamlı bir risk faktörüdür. Koroner damar yapısı ve atriyal fibrilasyon gelişimi arasında anlamlı bir ilişki olmasa da, sol ana koroner arter hastalığı ameliyat sonrası atriyal fibrilasyon için ciddi bir risk faktörüdür.

**Anahtar sözcükler:** Atriyal fibrilasyon; komplikasyon; koroner arter baypas greftleme; risk faktör.



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The incidence of postoperative atrial arrhythmias has been reported to be between 5% and 65% after cardiac surgery,<sup>[1,2]</sup> and new-onset postoperative atrial fibrillation (AF) has been seen at rates ranging from 10-40% after coronary artery bypass grafting (CABG) operations.<sup>[3]</sup> In an analysis of more than 17,000 CABG patients over a 10-year period, Attaran et al.<sup>[4]</sup> reported a postoperative AF incidence rate of 28.7%, with corresponding higher morbidity and mortality rates in the AF group. In another analysis by the same authors, postoperative AF was found to be associated with increased postoperative complications in on-pump operations only.<sup>[5]</sup>

In this study, we analyzed the outcome results of consecutive CABG operations to determine the relationship between coronary vasculature, the nature and extent of coronary artery disease (CAD), and postoperative occurrence of AF. Postoperative mortality and morbidity were also compared.

## PATIENTS AND METHODS

The study was conducted by the Cardiovascular Surgery Department and Cardiology Department at the Bağcılar Research and Training Hospital. The institutional ethics committee approved the study, and written consent was obtained from the participants. Ninety-four consecutive coronary bypass patients (68 males, 26 females; mean age 61.4±10.9 years; range 38 to 87 years) were enrolled in this prospective observational study between January 2011 and May 2011. The author responsible for the data collection was completely blinded to the operation decisions, and the occurrence of postoperative AF was recorded prospectively in a database. The preoperative characteristics of the patients are outlined in Table 1. Preoperatively, the mean ejection fraction (EF) of the patients was lower in the AF group; however, the number of patients with left ventricular dysfunction (LVD) was similar (Table 1). All patients were being treated with beta (β) blockers (metoprolol) before the surgery.

The collateral flow before revascularization was graded using the following classification system developed by Rentrop et al.<sup>[6]</sup>

Grade 0= No visible filling of any collaterals

Grade 1= Filling of the side branches of the infarct artery with no dye reaching the epicardial segment

Grade 2= Partial filling of the epicardial vessel

Grade 3= Complete filling of the epicardial vessel by collaterals.

The analysis of Rentrop scores was done by classifying the patients according to degree of

collateralization, with scores of 0 and 1 representing poor collateralization and scores of 2 and 3 representing good collateralization. In addition, we also used the modified Gensini score, a well-known scoring system for coronary artery occlusions that has been validated, to measure the range and degree of coronary atherosclerosis.<sup>[7]</sup> Coronary arteries are divided into eight segments, and the most severe degree of occlusion in each of these segments is graded from 1 to 4 (grade 1, 1-49% reduced lumen diameter; grade 2, 50-74% stenosis; grade 3, 75-99% stenosis; grade 4, 100% occlusion). Total scores range between 0 and 32.

All patients were operated via median sternotomy, and the left internal thoracic artery (LITA) was harvested in 86 patients (91.5%). For the on-pump procedures, aortic arterial and two-stage venous cannulations were instituted. Distal anastomoses were performed using a cross-clamp, and the proximal anastomoses were performed by side clamping the ascending aorta. The procedures were then completed in a standardized fashion. In the off-pump CABG operations (OPCAB), an Octopus® II myocardial stabilizer (Medtronic, Minneapolis, MN, USA) and intracoronary shunts were used. Heparin was neutralized both in the on-pump and OPCAB operations. The patients were monitored with continuous telemetry in the surgical ward. Those with postoperative AF received amiodarone infusions (900 mg in 24 hours), and this therapy was continued orally (2x400 mg) in case sinus rhythm resumed. In refractory cases, electrical conversion was performed in the intensive care unit (ICU) with sedation (midazolam 5 mg). Patients that failed to respond both to pharmacological and electrical conversion were accepted as having persistent AF. Rate control therapy was then instituted and tailored to meet the individual needs of each patient.

Pulmonary morbidity is defined as the need for prolonged ventilation and reintubation in conjunction the use of bronchodilators and extensive chest physiotherapy. Renal morbidity is characterized by significant increases in serum urea/creatinine levels or the need for dialysis. In addition, neurological morbidity has been described as any postoperative cerebrovascular event (stroke or transient ischemic attack) and transient neurological dysfunction, and bleeding is denoted by postoperative drainage from the chest tubes that exceeds 1000 cc/day on the day of surgery. Revision for bleeding was performed when it exceeded 3 mL kg<sup>-1</sup> h<sup>-1</sup> in the first three hours or for persistent chest tube drainage >200 mL h<sup>-1</sup>.

All statistical analyses were conducted using the SPSS version 11.0 statistical software package (SPSS

**Table 1. Preoperative characteristics**

Parameter	All patients (n=94)				AF group (n=23)			Non-AF group (n=61)			p1	p2
	n	%	Mean±SD	Min.-max.	n	%	Mean±SD	n	%	Mean±SD		
Gender	68	72.3			18	78.3		50	70.4		0.457	0.357
Age (years)			61.4±10.9	38-87			64.0±10.3			60.6±11.0	0.189	0.359
Concomitant												
Valve disease	13	13.8			4	17.4		9	12.7		0.577	
Ascending aortic aneurysm	2	2.1			0	0		2	2.8		1.000	
Carotid stenosis	1	1.1			0	0		1	1.4		1.000	
Ejection fraction (%)			51.7±8.9	30-70			48.3±9.0			52.8±8.7	0.035	
Left ventricular dysfunction	16	17.0			7	30.4		9	12.7		0.061	0.034
Left atrium (cm)			3.8±0.5	3.0-5.6			3.9±0.3			3.8±0.5	0.402	0.224
CRP (mg/L)			13.7±23.2	0.02-173.7			12.5±15.7			14.2±25.5	0.782	
NYHA Class											0.120	
Class I	64	68.1			17	73.9		47	66.2			
Class II	17	18.1			2	8.7		15	21.1			
Class III	9	9.6			4	17.4		5	7.0			
Class IV	4	4.3			0	0		4	5.6			
Canada class											0.783	
Class I	22	23.4			5	21.7		17	23.9			
Class II	37	39.4			9	39.1		28	39.4			
Class III	12	12.8			4	17.4		8	11.3			
Class IV	5	5.3			2	8.7		3	4.2			
Class V	18	19.1			3	13.0		15	21.1			
Clinical state											0.714	0.116
SAP	57	60.6			12	52.2		45	53.4			
USAP	29	30.9			8	34.8		21	29.6			
NSTEMI	6	6.4			2	8.7		4	5.6			
STEMI	2	2.1			1	4.3		1	1.4			
Gensini score			66.6±31.2	20-160			65.0±28.8			67.1±32.1	0.773	0.435
Rentrop score											0.079	0.316
0	42	44.7			11	47.8		31	43.7			
1	24	25.5			9	39.1		15	21.1			
2	25	26.6			2	8.7		23	32.4			
3	3	3.2			1	4.3		2	2.8			
Collateralization											0.065	0.054
Poor	66	70.2			20	87.0		46	64.8			
Good	28	29.8			3	13.0		25	35.2			
Left main disease	8	8.5			4	17.4		4	5.6		0.101	0.019
Dominant coronary system											0.259	0.360
Circumflex	22	23.5			3	13.0		19	26.8			
Right coronary	71	75.5			20	87.0		62	73.2			
COPD	3	3.2			0	0		3	4.2		1.000	
Tobacco use	72	76.6			19	82.6		53	74.6		0.422	
Renal dysfunction	9	9.6			3	13.0		6	8.5		0.684	
EuroSCORE												
Standard			2.6±2.3	0-10			3.4±2.0			2.3±2.4	0.061	
Logistic (%)			2.6±2.8	0.9-18.2			3.0±1.8			2.4±3.1	0.446	

AF: Atrial fibrillation; SD: Standard deviation; p1: Independent t-test or Chi square test; p2: Logistic regression; CRP: C-reactive protein; NYHA: New York Heart Association; SAP: Stable angina pectoris; USAP: Unstable angina pectoris; NSTEMI: Non-ST elevation myocardial infarction; STEMI: ST elevation myocardial infarction; COPD: Chronic obstructive pulmonary disease; EuroSCORE: European System for Cardiac Operative Risk Evaluation.

Inc., Chicago, IL, USA). All continuous variables were expressed as mean ± standard deviation using ranges, and all discrete variables were presented as frequencies and percentages. Comparisons of the continuous and discrete variables were done with either an independent t-test, chi-square test, or Fisher's exact test where appropriate. Logistic regression analyses were performed for the factors that affected the occurrence of postoperative AF. The perioperative parameters (Gensini score, Rentrop score, number

of revascularized vessels, dominant coronary artery system, revascularization of the dominant coronary artery, left main CAD, clinical status at admittance [stable angina pectoris, unstable angina pectoris, non-ST elevation myocardial infarction (NSTEMI) and ST-segment elevation myocardial infarction (STEMI)], LVD (EF <40%), and left atrium diameter] were analyzed as independent variables. The analysis was also adjusted for gender and age. P values of <0.05 were accepted as being statistically significant.

**Table 2. Comparison of operative details**

Parameter	AF group (n=23)			Non-AF group (n=71)			p
	n	%	Mean±SD	n	%	Mean±SD	
Concurrent procedures	0			7	9.9		0.188
Off-pump coronary artery bypass	2	8.7		9	12.7		1.000
Use of LITA graft	22	95.7		64	90.1		0.674
Blood transfusion in ICU	23	100		60	84.5		0.06
Aortic cross-clamp time			53.4±21.8			63.3±39.1	0.131
Cardiopulmonary bypass duration			93.5±31.7			103.6±49.3	0.180
Number of bypassed vessels			2.6±0.9			2.5±0.8	0.607
Troponin-T-0			0.67±0.74			1.91±3.33	0.160
Troponin-T-1			0.51±0.71			1.10±1.40	0.084
Troponin-T-2			0.54±0.76			0.90±1.04	0.203

AF: Atrial fibrillation; SD: Standard deviation; LITA; Left internal thoracic artery; ICU: Intensive care unit; Troponin-T-0: Troponine T on the day of operation; Troponin-T-1: Troponine T on the first postoperative day; Troponin-T-2: Troponine T on the second postoperative day.

## RESULTS

Postoperatively, 23 patients (24.5%) had AF. Twenty of these patients were converted to normal sinus rhythm via amiodarone infusion therapy, and the remaining three did not respond to medical therapy and were discharged with AF. Seven patients (7.4%) had more than one concurrent procedure (Table 2). Three had ascending aortic replacement, three others underwent aortic valve replacement, two had mitral reconstruction, and one underwent a carotid endarterectomy. A comparison of operative details did not result in statistically significant differences between the AF and non-AF groups. In addition, the differences in the frequency of off-pump procedures were not statistically significant, although the absolute numbers varied widely.

Three of the study participants (3.2%) had in-hospital mortality, with two of these patients having undergone concomitant procedures (aortic valve replacement and ascending aortic replacement). The etiology was multi-organ failure in one and bleeding in the other two. Additionally, one of the three patients had AF in the postoperative period. The mortality rates were similar

in the AF and non-AF groups (4.3% vs. 2.8%;  $p=1.000$ ).

The average number of bypassed coronary arteries was  $2.5\pm0.8$  (range, 1-5). A regression analysis revealed no significant association between the occurrence of postoperative AF and number of bypassed vessels ( $p=0.377$ ). Furthermore, the revascularization of the dominant system was not significantly associated ( $n=58$ ; 61.7%;  $p=0.360$ ) with AF occurrence. The preoperative measures are outlined in Table 1. However, there was a significant correlation between left ventricular dysfunction [OR=4.4; 95% confidence interval (CI): 1.1-16.9;  $p=0.034$ ] and left main CAD (OR=13.3; 95% CI: 1.5-114.5;  $p=0.019$ ) as they related to postoperative AF. This significance persisted even after the analysis was adjusted for age and gender.

The mean durations of ICU and hospital stays were  $4.3\pm4.8$  days (range, 1-31 days) and  $8.3\pm4.5$  days (range, 1-31 days, respectively). When compared comparison was made between the AF and non-AF groups, the AF group was shown to have significantly longer ICU stays than the non-AF group ( $7.4\pm6.7$  vs.  $3.3\pm3.6$  days, respectively;  $p=0.0001$ ), and the hospital stays were also

**Table 3. Postoperative morbidity**

Morbidity	All patients		Postoperative AF		No AF		p
	n	%*	n	%**	n	%***	
Pulmonary	16	17.0	7	30.4	9	12.7	0.061
Renal	6	6.4	4	17.4	2	2.8	0.030
Bleeding	3	3.2	2	8.7	1	1.4	0.147
Neurological	1	1.1	1	4.3	0		0.245
Need for inotropic support	16	17.0	6	26.1	10	14.1	0.200
Low cardiac output	1	1.1	1	4.3	0		0.245
Revision surgery for bleeding or dehiscence	6	6.4	5	21.7	1	1.4	0.003

AF: Atrial fibrillation; \* % in the whole population; \*\* % in patients with postoperative atrial fibrillation; \*\*\* % in patients without postoperative atrial fibrillation.

more prolonged ( $10.8 \pm 5.8$  vs.  $7.5 \pm 3.7$  days, respectively;  $p=0.012$ ).

The postoperative morbidity is shown in Table 3. There were complications encountered in 25 patients (26.6%). Intraaortic balloon pump (IABP) counterpulsation was used in two patients, and inotropic support was used in 16 others (17.0%). When these complications (other than AF) were analyzed, 11 of them occurred in the AF group. A comparison of the AF and non-AF group showed that 47.8% of the postoperative AF patients and 19.7% of non-AF patients had postoperative morbidity, and the difference was statistically significant ( $p=0.01$ ).

## DISCUSSION

The main focus of this study was to analyze the association of coronary vasculature parameters along with the clinical presentation and postoperative AF. Gensini scores were used to analyze the effect of the extent of CAD, and Rentrop scores were utilized to evaluate collateral circulation. There was no significant relationship between the Gensini and Rentrop scores and the development of postoperative AF, and no significant differences were seen when the AF and non-AF groups were compared. However, the presence of left main disease was associated with postoperative AF at a high odds ratio.

In addition, we analyzed the coronary vasculature for the dominant coronary system and searched for probable correlations. Along with the comparison of the dominant systems, involvement of the dominant coronary artery or its branches and the effect of its revascularization on the occurrence of postoperative AF were also investigated. However, no significant connections could be found. The nodal arterial involvement was previously analyzed by Al-Shanafey et al.<sup>[8]</sup> when they examined the effect of the presence of diseased nodal vessels on the genesis of postoperative AF<sup>[8]</sup> and discovered that the incidence rate of atrioventricular (AV) node disease was similar in both the AF and non-AF (78% vs. 74%) patients. However, the incidence of sinoatrial nodal artery involvement was higher in the AF group (34% vs. 21%). Taking into account the results of their study, it is possible that AV nodal arterial involvement may not be a significant factor in the development of postoperative AF. In this study, we chose to take a more general approach in our evaluation of the nodal blood supply correlation.

Magee et al.<sup>[3]</sup> conducted an extensive analysis using predictive risk algorithms in their study comprised of 19,620 patients and found an AF incidence of 21.5%. Furthermore, they reported a higher incidence of left main disease and lower EF in the patients with AF.

Villareal et al.<sup>[9]</sup> analyzed the outcome results of 994 isolated CABG patients who had postoperative AF and compared these results with 5,481 non-AF cases. The AF incidence was 16%. Postoperative AF cases had higher hospital mortality (7.4% vs. 3.4%) and lower four-years survival rates (74% vs. 87%) when compared to non-AF group. On the other hand, in a more recent report, a connection was found between postoperative AF and long-term mortality in isolated CABG patients. However, a similar relationship was not seen between the same group of patients and hospital mortality.<sup>[10]</sup> In a study by Bramer et al.<sup>[11]</sup> in which the patients were enrolled for a longer period of time, it was determined that preoperative AF was an independent risk factor for hospital mortality in CABG patients. The incidence of AF in our study group was 24.5%, and the mortality rates between the two groups were not significantly different. However, pulmonary and renal complications occurred more frequently in the postoperative AF patients.

Amar et al.<sup>[12]</sup> analyzed 1,851 CABG operations in order to devise and validate a clinical prediction rule for postoperative AF and found a postoperative AF incidence rate of 33%. Old age, a prior history of AF, prolonged P-wave duration, and postoperative low cardiac outputs were significantly correlated with postoperative AF risk in their study.

Postoperative AF is often a short-lived condition. Between 15% and 30% of patients convert to sinus rhythm in two hours, and 25% to 80% accomplish this within 24 hours solely through the correction of electrolyte imbalances.<sup>[13,14]</sup> Three patients (3.2%) in our study could not be converted to sinus rhythm, but rate control was still achieved. These patients were discharged and treated with amiodarone and warfarin.

Previous studies have sought to determine whether the type of procedure has an effect on the development of postoperative AF,<sup>[15,16]</sup> but these have failed to show any differences between the OPCAB and on-pump groups of patients. One of the interesting features in one of these reports was that the OPCAB group used fewer internal thoracic artery grafts and performed fewer distal anastomosis procedures.<sup>[16]</sup> The number of internal thoracic artery graft used in our study was similar in the AF and non-AF patient groups (Table 2), and no significant differences were seen between the OPCAB and on-pump patients.

Patients who undergo CABG have been reported to have a higher AF incidence rate when concomitant valvular operations are performed.<sup>[15]</sup> Seven patients (7.4%) had concurrent procedures in our study, and

mortality was higher in these patients. However, no correlation to AF was detected. Çiçekçioğlu et al.<sup>[17]</sup> showed that the need for inotropic support and IABP counterpulsation was associated with postoperative AF, and the mortality rate for these patients was also higher. Our results differed for that study as we detected no similar findings between our two patient groups.

Age has been the most consistent risk factor in various studies.<sup>[16,18-21]</sup> The aging process is known to have degenerative and inflammatory effects on the atrial myocardium which leads to changes in the electrical properties of the atria.<sup>[22]</sup> The connection between inflammation and postoperative AF has also been explored.<sup>[23]</sup> We evaluated the effects of age and left atrium size on the development of postoperative AF and found no significant correlations in the regression analysis. Gökşin et al.<sup>[21]</sup> reported that age is an independent risk factor and that the use of  $\beta$  blockers and statins may prevent the postoperative occurrence of AF. Edgerton et al.<sup>[24]</sup> reported that postoperative ventilator usage, gender, and previous CABG are associated with an increased risk of postoperative AF. However, we found no significant correlations between gender and age and the development of postoperative AF in our study. Atrial fibrillation may cause significant morbidity and increased hospital costs.<sup>[3]</sup> We compared the postoperative troponine levels between our two groups, and although the absolute numbers were quite different, especially on the day of operation and the following day, there was no statistical significance. The most striking difference was detected in the rates of renal complications and sternal revisions, but these could be explained by the increased morbidities in the AF patients.

The main limitation of this study was the low number of patients, which may have caused us to not identify some significant results between the groups. For example, it is possible that the variance in troponine levels could have resulted in a significant difference had we had a higher sample size, but considering that the numbers of patients who required inotropic or IABP support were similar, this should not be assumed. The small patient sample also limited the number of parameters we could analyze. However, our focus was on the extent of CAD and vasculature, and we expected to find significant correlations by using the Gensini and Rentrop scores to evaluate postoperative AF. The lack of significance in those scores along with the significance of left main disease was unexpected. Therefore, more detailed analyses should be performed to clarify these points.

In conclusion, postoperative AF is a frequently encountered complication of cardiac surgery, but most

cases can be converted to normal sinus rhythm. The presence of left ventricular dysfunction is a significant risk factor for postoperative AF. Furthermore, although we found no significant correlations with coronary vasculature, the presence of left main disease is another significant risk factor for postoperative AF. Hence, these patients must be accepted as being at high risk for postoperative AF, and aggressive preventive measures should be considered.

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