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Received: 05 November, 2022
Accepted: 09 December, 2022
Published: 13 December, 2022

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CITATION

Erdil N, Akca B. Risk factors of postoperative atrial
fibrillation in patients undergoing beating heart coronary
artery bypass. AZJCVS. 2022;3(3):76-80. DOI: 10.5455/
azjcv.2022.11.018

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INTRODUCTION

New-onset atrial fibrillation (AF) is still the most common complication that affects about 10% to 65% of the patients who underwent coronary artery bypass graft (CABG) surgery (1,2). Thereafter CABG, development of AF is associated with a doubled increase in cardiovascular morbidity and mortality also associated with rising rates of stroke and heart failure related to repeated hospital admissions, longer hospital stays resulting with increased surgery costs (3,4).

The onset of AF after cardiac surgery is associated with

Risk factors of postoperative atrial fibrillation in patients undergoing beating heart coronary artery bypass

Abstract

Aim: This study aims to establish new-onset atrial fibrillation (AF) risk factors and postoperative outcomes after off-pump coronary artery bypass graft (CABG) surgery.

Material and Methods: Four hundred ninety patients who underwent off-pump CABG were enclosed in study. Patients divided into two groups in line with the development of new-onset AF as AF group (n=62) and non-AF group (n=428). Groups were compared in terms of preoperative clinical features and perioperative data, and multivariate analysis accomplished to identify independent clinical predictors of AF following off-pump CABG.

Results: AF was presented in 62 (12.7%) of the patients, and those were significantly older and had significantly higher additive EuroSCORE scores than without AF. Also patients with postoperative AF had significantly prolonged intensive care unit and longer hospital stays at postoperative period. In the multivariate logistic regression analysis performed, advanced age, mean Euroscore, Mild to moderate mitral regurgitation, Prolonged air leak from thorax drain, mean ventilation time, severe pleural effusion, need for inotropic drug support were found to be risk factors for postoperative AF.

Conclusion: Our study showed that age, high Euroscore, mild to moderate mitral regurgitation, prolonged ventilation time, severe pleural effusion and low cardiac output were risk factors of postoperative AF in patients underwent off-pump CABG. Also In patients who developed postoperative AF, prolonged intensive care unit and hospital stays were observed. Prospective randomized studies with larger patient series are recommended to support our study.

Keywords: Atrial fibrillation, Beating-heart, Coronary artery bypass grafting, Predictor, Risk factor

preoperative, intraoperative and postoperative factors like advanced age, gender, obesity, pulmonary disease, cardiac ischemia, and inflammation during surgery, also as prolonged mechanical ventilation, hemodynamic instability and infections after surgery (5,6).

The on-pump CABG seems related to a higher incidence of postoperative AF when compared with off-pump CABG but some studies have reported no significant difference in the incidence of AF whether or not the under cardiopulmonary bypass (6-8). The aim of this study is to determine the predictors and postoperative results of AF following off-pump CABG surgery.

MATERIAL AND METHODS

This study was conducted after the Institutional Ethics Committee approval of Inonu University (2022/4079)Written informed consent forms were taken from each patient before the surgery and the study was carried out considering the principles of the Helsinki Declaration. Hospital database was used for this retrospective study.

490 patients who underwent off-pump CABG were included in the study, and they were divided into two groups according to the development of postoperative AF as the AF group (n=62) the and non-AF group (n=428). Both groups were compared in terms of perioperative variables, and multivariate analysis was used to find independent clinical predictors of postoperative AF following off-pump CABG were determined. The exclusion criterias of this study were; 1. History of arrhythmia or paroxysmal/permanent AF before the surgery, 2. conversion from off-pump to on-pump CABG 3. Emergency surgery, redo operations 4. Patients had concomitant valve pathology /surgery or any kind of additional surgical procedures. Also, patients who had a thyroidal illness were excluded from the study.

Anesthesia and Surgical technique

The details about the management of general anesthesia and how it maintains also the perioperative medication strategies of patients were as defined in the previous study of our clinic (4). Isolated elective off-pump CABG performed by standard midline sternotomy to all patients. The decision for performing an off-pump / on-pump CABG was made by the surgeon according to the patients' characteristics, coronary artery anatomy and location of the lesion, comorbidities. Great saphenous vein and left internal mammary artery grafts were used as conduits. All operations were performed by the same team. Anticoagulation was provided with unfractionated heparin (150 IU/kg) which was given after harvesting internal mammary artery. Protamine sulfate was given in a 1:1 ratio for reversal of unfractionated heparin after the completion of all anastomoses. Mechanical stabilizer (Octopus, Medtronic Inc., Minneapolis, MN, USA) and heart positioner (Starfish or Urchin, Medtronic Inc.) was used to control motion of the beating heart. Intraoperative hemodynamic strategy can be summarized as; Hypotension managed with volume replacement and ephedrine used in case of need. Persistent hypertension managed with increasing the depth of anesthesia or nitroglycerin infusion. Tachycardia managed with increasing the depth of anesthesia or b-blockers like intravenous metoprolol or infusion of esmolol. Bradycardia managed with bolus theophylline infusion or with internal epicardial ventricular pacing.

Rhythm monitoring was done continuously for all patients during the ICU stay. A 12-lead electrocardiogram (ECG) was routinely documented for all patients' first, second, and fourth days postoperatively, and also ECG was documented in case of any arrhythmia suspicious during the hospital stay thus the diagnosis of AF was based on these findings.

Statistical analysis

Statistical analyses were used the SPSS software package (SPSS for Windows, version 16.0; SPSS, USA). SPSS The Shapiro-Wilk test was used for the normality assumption. Within each group, the preoperative and postoperative for each variable were compared using the Student t test. Data are presented as mean $\pm$ standard deviation. Categorical parameters were analyzed using the chi-square and Fisher's exact tests, where appropriate. If a parameter having a $p \leq 0.20$ in the univariate analysis, further analyzed with multivariate logistic regression analysis to detect postoperative AF risk factors. A p value less than 0.05 was considered significant.

RESULTS

Out of the 499 patients who underwent OPCABG in this institution during the study period were consecutively included in this study. The rate of AF observed in our study patients was 12.7% in the postoperative period.

Perioperative mortality was similar in both groups (Non-AF group 1.16% and AF group 1.61%, $p=0.839$). AF patients were significantly older than non-AF patients (60.14 ± 10.6 and 66.9 ± 8.1 years old, $p=0.001$). There was a statistically significantly higher Euroscore in the AF group (3.9 ± 2.4 and 4.8 ± 2.7 , $p=0.027$). There were more patients with low EF ($\leq 40\%$) in the AF group (29% and 41.2%). But there was not statistically significant for this difference ($p=0.079$). There was no significant difference in other preoperative data between the two groups (all p values >0.05 ; Table 1).

When intra and postoperative data were compared, the need for inotropic medication, prolonged air leak from thorax drain, severe pleural effusion, and prolonged mechanical ventilation time were higher in the AF group. There were no statistically significant differences between the AF and non-AF groups in the other perioperative variables (Table 2).

In the multivariate risk analysis performed to determine the risk factors for postoperative AF, advanced age (OR: 2.749), mean age (OR: 1.076), Euroscore (OR: 1.169), need for inotropic support (OR: 4.084), severe pleural effusion (OR: 3.420), prolonged air leak from thorax drain (OR: 5.625), mean ventilation time (OR: 1.177) were found to be risk factors (Table 3).

DISCUSSION

As being the most common arrhythmia after CABG surgery lots of investigations were performed for determining the risk factors of AF and prediction. AF was associated with preoperative, intraoperative, and postoperative factors so various risk factors were reported in different studies (5,6). One of the AF-associated risk factors was cardiopulmonary bypass usage and a lower incidence of AF has been marked as one of the advantages of off-pump CABG (9-11). Nevertheless, the literature contains conflicting reports regarding AF in patients who underwent off-pump CABG versus on-pump CABG (12,13).

Table 1. Preoperative demographic, patient and disease-related parameters predisposing to post-CABG AF. (Data expressed as mean $\pm$ SD or n(%))

Variables	Non-AF group(n =428)	AF group(n = 62)	p Value
Age (years)	60.14 $\pm$ 10.6	66.9 $\pm$ 8.1	0.0001
Age $\geq$ 65 years	158(36.9%)	38(61.7%)	0.0001
Female	121(28.3%)	16(25.8%)	0.686
Diabetes mellitus	95(22.2%)	8(12.9%)	0.093
Hypertension	119(27.8%)	17(27.4%)	0.184
Obesity bmi $\geq$ 30	78(18.2%)	8(12.9%)	0.303
BSA (m ²)	1.78 $\pm$ 0.19	1.78 $\pm$ 0.14	0.808
BMI (kg/m ²)	27.1 $\pm$ 4.03	26.6 $\pm$ 4.2	0.450
History of smoking	203(47.4%)	32(61.6%)	0.538
Family history of CAD	109(25.5%)	10(16.1%)	0.109
Prior stroke	4(0.9%)	2(3.2%)	0.125
Hyperlipidemia	156(36.6%)	22(34.6%)	0.999
Unstable angina	74(17.3%)	13(21%)	0.479
COPD	63(14.7%)	12(19.4%)	0.343
Peripheral vascular disease	9(2.1%)	2(3.2%)	0.577
Carotid artery disease	28(6.5%)	6(9.7%)	0.364
Prior myocardial infarction	249(58.2%)	39(62.9%)	0.480
Prior PTCA	68(15.9%)	12(19.4%)	0.490
Renal insufficiency	10(2.3%)	1(1.6%)	0.719
Mild to moderate mitral regurgitation	15(3.5%)	7(11.3%)	0.006
Emergency operations	16(3.7%)	1(1.6%)	0.393
LMCA disease	2(0.5%)	1(1.6%)	0.280
Low LV EF ($\leq$ 40)	124(29%)	26(41.2%)	0.079
EuroSCORE	3.9 $\pm$ 2.4	4.8 $\pm$ 2.7	0.027
RCA disease	136(31.8%)	27(43.5%)	0.066
BUN (mg/dl)	18.51 $\pm$ 8.02	19.61 $\pm$ 8.26	0.402
Creatinine (mg/dl)	1.02 $\pm$ 0.60	1.05 $\pm$ 0.28	0.713
LV EF	47.6 $\pm$ 10.02	45.3 $\pm$ 10.94	0.121

BSA: Body Surface Area. BMI: Body Mass Index. CAD: Coronary Artery Disease. COPD: Chronic Obstructive Pulmonary Disease. PTCA: Percutaneous Transluminal Coronary Angioplasty. LMCA: Left Main Coronary Artery. LV EF: Left Ventricular Ejection Fraction. RCA: Right Coronary Artery. BUN: Blood Urea Nitrogen

Table 2. Treatment-related parameters predisposing to post-CABG AF

Variables	Non-AF group (n = 428)	AF group(n = 62)	p Value
Perioperative Mortality	5(1.16%)	1(1.62%)	0.839
Usage of LIMA	390(91.1%)	57(91.9%)	0.832
Usage of Radial artery	23(5.4%)	1(1.6%)	0.200
Coronary endarterectomy	0(0%)	2(3.2%)	0.016
Coronary patch plasty	4(0.9%)	2(3.2%)	0.125
Inotropic Support	9(2.1%)	5(8.1%)	0.008
Intraaortic balloon pump	2(0.5%)	1(1.6%)	0.280
Prolonged air leak from thorax drain	8(1.9%)	6(9.7%)	0.001
Re-exploration (bleeding/tamponade)	2(0.5%)	0(0%)	0.590
Serious Pleural effusion	13(3%)	6(9.7%)	0.011
Number of grafts per operation	1.56 $\pm$ 0.59	1.68 $\pm$ 0.62	0.158
Mechanical ventilation time (h)	6.5 $\pm$ 2.65	9.5 $\pm$ 10.14	0.001
ICU stay (days)	2.16 $\pm$ 0.63	3.40 $\pm$ 1.19	0.001
Hospital stay (days)	6.26 $\pm$ 1.58	7 $\pm$ 1.64	0.004

LIMA: Left Internal Mammary Artery. CPB: Cardio Pulmonary Bypass. ICU: Intensive Care Unit

Table 3. Results of multivariate analysis for prediction of independent risk factors

Variables	p Value	Odds Ratio (95% CI)
Age (years)	0.0001	1.076(1.043-1.109)
Age ≥65 years	0.0001	2.749(1.573-4.802)
EuroSCORE	0.029	1.169(1.016-1.345)
Mild to moderate mitral regurgitation	0.006	3.504(1.369-8.973)
Prolonged air leak from thorax drain	0.001	5.625(1.883-16.808)
Serious Pleural effusion	0.011	3.420(1.250-9.361)
Inotropic Support	0.008	4.084(1.322-12.613)
Mechanical ventilation time(h)	0.001	1.177(1.072-1.292)

LV EF: Left Ventricular Ejection Fraction, COPD: Chronic Obstructive Pulmonary Disease,
RCA: Right Coronary Artery, BUN: Blood Urea Nitrogen, CPB: Cardio Pulmonary Bypass, LV; Left Ventricle

In this study, the rate of AF was 12.7% in patients who underwent off-pump CABG. Our result is similar to the study of Bohatch Júnior et al. who reported AF rate of 13.43% in the off-pump group. However, in the same study Bohatch Júnior et al. found no significant difference in the incidence of AF between the off-pump group and the on-pump group (19.79%) (6). In a recent study, Chooriyil N et al. reported the rate of AF was 18% in patients who underwent off-pump CABG, and also a similar AF rate of 19.3% was reported in a study by Lewicki et al. conducted in off-pump CABG patients. (14,15).

Among a lot of risk factors that have been reported in previous studies, increased age is a major risk factor of AF and increased age is frequently accepted as a significant predictor (2,4,6,16). In this study, the patients with AF were significantly older than non-AF patients ($p=0.001$), and also the multivariate risk analysis revealed that the advanced age (OR: 2.749) and mean age (OR: 1.076) parameters were determined as the risk factors for postoperative AF. Euroscore was detected statistically significant higher in the AF group ($p=0.027$), and also as similar to our previous studies Euroscore (OR: 1.169) was found a risk factor of AF (2,4,17).

In this study, mechanical ventilation time was significantly longer in AF group ($p=0.001$), and mean ventilation time (OR: 1.177) was found a risk factor of AF. In a study Edgerton, et al. reported that immediate extubation reduces AF independent from comorbidities (18). Also, Straka, et al. reported an incidence of 21% AF in the early extubation group, on the other hand they did not use a control group (19). In a study, Ascione et al. could not show any relationship between AF onset and mean mechanical ventilation time, even they did not check for early extubation in particular (20). In our opinion, mechanical ventilation brings out changes in intrathoracic pressure and lung volume that affect preload, afterload, heart rate, and myocardial contractility, which are reasoned with increased right atrium pressure and increased sympathetic activity that causes AF.

In a study conducted on patients undergoing off-pump CABG,

Chooriyil et al. reported a significant association of perioperative inotrope use in patients developing AF (14). Similarly in our study, the need for inotropic medication was higher in the AF group, and the need for inotropic support (OR: 4.084) was found a risk factor for postoperative AF.

Interestingly, prolonged air leaks from the thorax drain (OR: 5.625) and severe pleural effusion (OR: 3.420) parameters were found to be risk factors for AF. As we all know these parameters prolonged the hospital stay and we think that intrathoracic pressure, lung volume changes, and also electrolyte imbalance during this period may cause AF.

This study has several limitations. First the study is not multicentered and performed in one institution with a single center data. The second one is the retrospective nature of study. Also asymptomatic AF in a short time period may be missed. Moreover, mid-term and long-term patient outcomes were not included in our study.

CONCLUSION

Our study showed that age, high Euroscore, mild to moderate mitral regurgitation, prolonged ventilation time, severe pleural effusion and low cardiac output were independent risk factors of postoperative AF in patients undergoing beating-heart CABG. In addition, patients who developed AF in the postoperative period had longer intensive care unit and hospital stays. Prospective randomized studies with larger patient series are recommended to support our study.

Patient informed consent: Written informed consent forms were taken from each patient before the surgery and the study was carried out considering the principles of the Helsinki Declaration. Hospital database was used for this retrospective study.

Conflict of Interests: The author declares that there are no conflict of interests.

Financial Disclosure: There are no financial supports.

Ethics committee approval: This study was conducted after the Institutional Ethics Committee approval of Inonu University (2022/4079).

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