

Atrial fibrillation following off-pump versus on-pump coronary artery bypass grafting: Incidence and risk factors

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Abstract

Background: Postoperative atrial fibrillation (AF) is a common arrhythmia that occurs after coronary artery bypass grafting (CABG). New surgical techniques, particularly off-pump coronary artery bypass (OPCAB), are thought to be less invasive and results in fewer complications, i.e. AF, but available data are inconsistent. The aim of this study is to present the incidence and risk factors of AF in patients operated on with or without cardiopulmonary bypass.

Methods: We studied 1836 consecutive patients with stable coronary artery disease who were operated on with (CABG) or without (OPCAB) cardiopulmonary bypass. The patients were monitored using a continuous electrocardiogram monitoring system until the sixth postoperative day.

Results: Atrial fibrillation occurred in 18.3% and 19.3% of CABG and OPCAB patients, respectively ($p = 0.3$). The peak incidence of arrhythmia was observed between the second and third postoperative day in both CABG and OPCAB patients (36% and 41%, respectively). Patient's age and history of hypertension were significant predictors of postoperative AF (OR 1.38, 95% CI 1.01–1.76, $p = 0.0002$; and OR 1.38, 95% CI 1.01–1.76, $p = 0.008$, respectively). Patients who developed AF vs. without AF had significantly higher rates of complications such as death (3.1% vs. 1.2%, $p = 0.01$), reoperation (5.2% vs. 2.8%, $p = 0.02$), and the need to utilize intra-aortic balloon pump (IABP) (6.8% vs. 3.4%, $p = 0.002$). Use of IABP and reoperation were significant perioperative predictors of the arrhythmia (OR 2.1, 95% CI 1.27–3.4, $p = 0.003$; and OR 1.9, 95% CI 1.09–3.30, $p = 0.02$, respectively). AF was also associated with a prolonged stay in an intensive care unit (72.5 ± 78.8 for patients with AF vs. 34.6 ± 25.2 for patients with sinus rhythm, $p = 0.000001$).

Conclusions: In patients undergoing CABG, postoperative AF is a common arrhythmia independent of the type of surgical procedure. (Cardiol J 2016; 23, 5: 518–523)

Key words: atrial fibrillation, cardiopulmonary bypass, coronary artery bypass grafting, off-pump coronary artery bypass

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Introduction

Postoperative atrial fibrillation (AF) is the most common arrhythmia complicating coronary artery bypass grafting (CABG). It is reported in 15–33% of patients undergoing coronary bypass surgery [1–5]. A comprehensive review of data concerning postoperative AF was published by Banach et al. [6].

Although in some studies it has been considered a benign and self-limiting complication, some data suggest serious morbidity and an increase in outcomes in patients who developed AF postoperatively [7, 8]. In a large study, Mariscalco et al. [9] found that long-term mortality rates were significantly higher in patients with postoperative AF. The arrhythmia significantly increases the risk of stroke [10]. A hypothesis that off-pump coronary artery bypass (OPCAB) is associated with less frequent postoperative AF and improved outcomes have been tested in several studies but available data are inconsistent [11–15].

The aim of the study was to evaluate the incidence and predictors of AF in patients operated with or without cardiopulmonary bypass.

Methods

We studied 1836 consecutive patients with documented stable coronary artery disease (CAD) operated in the Department of Cardiac Surgery, Medical University of Gdansk, over a 63-month period. The study protocol was approved by the local bioethics committee. The inclusion criteria were: (1) angiographically documented stable CAD referred for cardiac surgery; and (2) sinus rhythm (SR) in a standard 12-lead electrocardiogram (ECG) performed before the surgery upon hospital admission.

The exclusion criteria included persistent/permanent AF or a history of paroxysmal AF before the surgery, permanent cardiac pacemaker implanted before the surgery, concomitant valvular heart disease, other surgical procedure than isolated CABG or OPCAB, and an acute coronary syndrome.

Patients were divided into two groups depending on whether they were operated with CABG or OPCAB technique. The decision for using or not using OPCAB technique was made by a surgeon performing the procedure and was related to specific clinical and anatomical conditions.

The same surgical staff presenting a comparable level of experience performed both CABG and OPCAB procedures.

All patients were managed using a similar perioperative protocol. Beta-blockers were administered before the surgery in the majority of patients and continued immediately after the surgical procedure. No other antiarrhythmic protocol was used in the prevention of postoperative AF.

A median sternotomy was performed in both CABG and OPCAB groups. A modified Saint Thomas cardioplegic solution was used in the CABG group.

Arrhythmia analysis

Atrial fibrillation was assessed by the use of continuous ECG monitoring system (Hewlett Packard, USA) with the possibility of rhythm disturbance analysis during the patient stay in an intensive care unit (ICU). Subsequently, during the first 24 h after leaving the ICU, each patient was monitored using the Space Lab system (Space Lab, USA). A standard 12-lead ECG was performed once a day and in the cases of clinical manifestations of an arrhythmia. The analysis took into account all AF events lasting longer than 10 min or requiring medical treatment due to clinical instability. The period of analysis was restricted to 6 postoperative days.

Statistical analysis

Results are expressed as mean values and standard deviation. The EuroSCORE data are median values and ranges and were compared using the Kruskal-Wallis test. Categorical variables were evaluated with the χ^2 test, normally distributed continuous variables with the Student *t* test, and non-normally distributed continuous variables with the Mann-Whitney U test. Odds ratios (OR) were calculated using logistic regression model. $P < 0.05$ was considered statistically significant. Statistical analyses were performed using the Statistica 10.0 (Statsoft) software.

Results

The mean patient age was 61.6 years and men comprised the majority (75.5%) of the study population. More than half of patients had a history of hypertension. In the study group, 1051 (57.2%) patients were operated with cardiopulmonary bypass (CPB) and 785 (42.8%) patients were operated without CPB.

Preoperative data of 1836 patients were divided into two groups depending on the type of the procedure are shown in Table 1.

The OPCAB group had a higher proportion of women (27.4% vs. 22.3%, $p = 0.008$), patients with

Table 1. Comparison of perioperative data of 1836 patients according to the type of the procedure.

	CABG (n = 1051)	OPCAB (n = 785)	P
Age [years]	60.8 ± 8.9	62.6 ± 10.2	0.2
Gender:			0.008
Male	817 (77.7%)	234 (22.3%)	
Female	570 (72.6%)	215 (27.4%)	
Body mass index [kg/m ²]	27.5 ± 4.03	27.2 ± 3.7	0.6
Previous myocardial infarction	536 (50.9%)	478 (60.9%)	0.00002
Hypertension	620 (58.9%)	541 (68.9%)	0.00003
Diabetes	216 (20.5%)	184 (23.4%)	0.2
Chronic obstructive pulmonary disease	25 (2.4%)	28 (3.5%)	0.1
Peripheral arterial disease	86 (8.2%)	112 (14.2%)	0.00004
Neurologic deficit	72 (6.8%)	32 (4.1%)	0.08
Beta-blocker	845 (80.6%)	674 (85.8%)	0.3
Angiotensin converting enzyme inhibitor	662 (62.9%)	511 (65.1%)	0.6
Statin	736 (70.0%)	573 (72.9%)	0.8
EuroSCORE [median (min; max)]	3 (0;11)	3 (0;10)	0.2
Left ventricular ejection fraction [%]	53.6 ± 11.7	53.4 ± 11.1	0.7
Number of distal anastomoses	3.4 ± 0.7	2.5 ± 0.8	0.001
Creatine kinase isoenzyme MB [ng/mL]	57.2 ± 13.0	7.6 ± 1.3	0.003
Drainage on 1 st day [mL]	551.5 ± 305.6	668.6 ± 303.3	0.3
Time in intensive care unit [h]	26.8 ± 14.2	27.3 ± 17.3	0.9

Data are expressed as mean ± standard deviation or number (percentage). The EuroSCORE data are expressed as median and minimum and maximum; CABG — coronary artery bypass grafting; OPCAB — off-pump coronary artery bypass

a history of arterial hypertension (68.9% vs. 58.9%, p = 0.00003) and peripheral arterial disease (14.2% vs. 8.2%, p = 0.00004). Patients in the CABG group were characterized by a higher number of distal anastomoses performed (3.4 ± 0.7 vs. 2.5 ± 0.8, p = 0.001) and higher postoperative levels of creatine kinase isoenzyme MB (57.2 ± 13 vs. 7.6 ± 1.3, p = 0.003) than patients in the OPCAB group. All these data are summarized in Table 1.

The mean aortic cross-clamp time in the CABG group was 44.1 ± 13.9 min, and the mean CPB time was 86.6 ± 51.1 min.

The length of postoperative stay in the ICU did not differ between the two groups (Table 1).

Postoperatively, AF was observed in 344 (18.7%) patients. The AF incidence was 18.3% in the CABG group and 19.3% in the OPCAB group (OR 0.88, 95% confidence interval [CI] 0.69–1.12, p = 0.3).

The peak incidence of AF was observed on the second and third postoperative days similarly in both CABG and OPCAB patients (Fig. 1).

Patients who developed postoperative AF were significantly older, more often hypertensive,

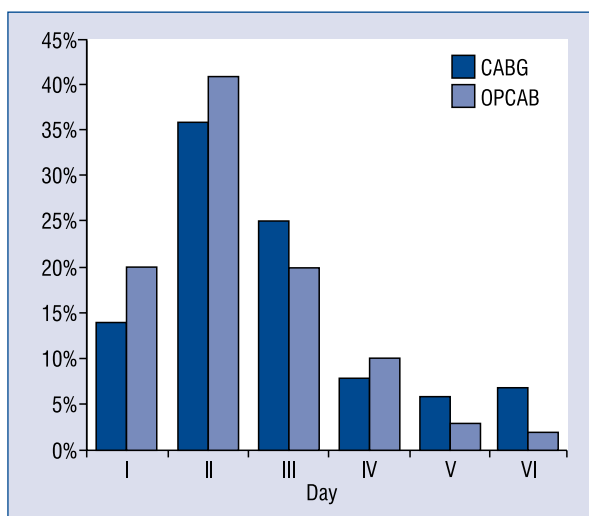


Figure 1. Daily distribution of atrial fibrillation incidence in 344 patients operated with or without cardiopulmonary bypass; CABG — coronary artery bypass grafting; OPCAB — off-pump coronary artery bypass.

and had higher EuroSCORE values than those who remained in SR (Table 2). Hypertension and age

Table 2. Clinical data of 1836 patients with or without postoperative atrial fibrillation (AF).

	AF (n = 344)	SR (n = 1492)	P
Age [years]	63.7 ± 8.5	60.5 ± 9.4	0.0002
Body mass index [kg/m ²]	27.3 ± 4.1	27.4 ± 3.6	0.9
Gender:			0.1
Male	249 (72.4%)	1138 (76.3%)	
Female	94 (27.3%)	353 (23.6%)	
Previous myocardial infarction	204 (59.3%)	810 (54.3%)	0.07
Hypertension	238 (69.2%)	924 (61.9%)	0.008
Diabetes	91 (26.4%)	317 (21.2%)	0.3
Chronic obstructive pulmonary disease	14 (4.1%)	38 (2.5%)	0.08
Peripheral arterial disease	32 (9.3%)	167 (11.2%)	0.3
Beta-blocker	281 (81.6%)	1253 (83.9%)	0.7
Angiotensin converting enzyme inhibitor	208 (60.5%)	1018 (68.2%)	0.1
Statin	250 (72.6%)	1137 (76.2%)	0.7
Left ventricular ejection fraction [%]	52.5 ± 13.4	53.8 ± 12.4	0.3
EuroSCORE	3.4 ± 2.5	2.91 ± 2.2	0.02

Data are expressed as mean ± standard deviation or number (percentage); SR — sinus rhythm

were independent risk factors for postoperative AF (OR 1.38, 95% CI 1.01–1.76, p = 0.008; and OR 1.38, 95% CI 1.01–1.76, p = 0.0002), With each decade over 40 years, a 10% increase in AF incidence was observed (Fig. 2).

The length of ICU stay was significantly longer in patients who developed postoperative AF than in those with SR (Table 3). This difference remained significant even after patients with complications other than AF were excluded from the analysis (47.8 ± 33.1 vs. 32.1 ± 19.3 h in patients with AF and SR, respectively).

Patients with AF had significantly higher rates of complications such as death, reoperation and the need to use an intra-aortic balloon pump (IABP) (Table 4).

Overall in-hospital mortality was 1.63% (30 of 1836 patients). In a multivariate regression model, postoperative AF was not associated with mortality. Independent risk factors for mortality were

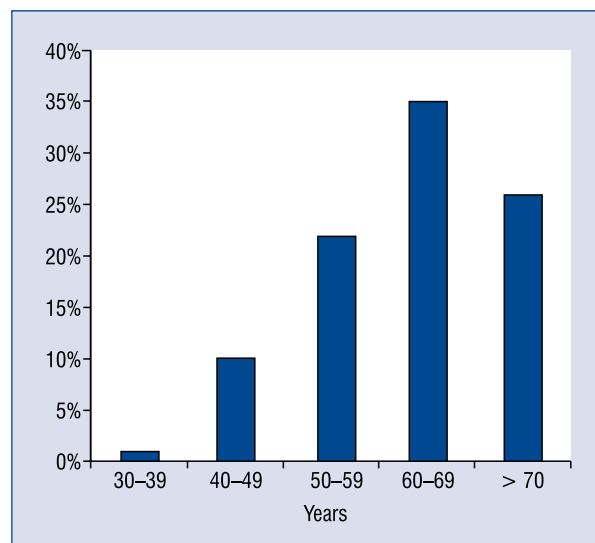


Figure 2. Atrial fibrillation incidence in relation to the age of operated patients.

Table 3. Perioperative data of 1836 patients with or without postoperative atrial fibrillation (AF).

	AF (n = 344)	SR (n = 1492)	P
Time in intensive care unit [h]	72.5 ± 78.8	34.6 ± 25.2	0.000001
Creatine kinase isoenzyme MB [ng/mL]	11.1 ± 5.7	41.9 ± 10.3	0.5
Drainage on 1 st day [mL]	611.6 ± 345.9	589.7 ± 283.5	0.8
Number of distal anastomoses	3.1 ± 0.9	3 ± 0.9	0.3

Data are expressed as mean ± standard deviation; SR — sinus rhythm

Table 4. Perioperative complications in 1836 patients with or without postoperative atrial fibrillation (AF).

	AF (n = 344)	SR (n = 1492)	P
Death	12 (3.1%)	18 (1.2%)	0.01
Reoperation	20 (5.2%)	41 (2.8%)	0.02
Intra-aortic balloon pump	26 (6.8%)	49 (3.4%)	0.002

Data are expressed as number (percentage); SR — sinus rhythm

Table 5. Predictors of postoperative atrial fibrillation in a logistic regression model.

	Odds ratio (CI)	P
IABP	2.1 (1.27–3.4)	0.003
Reoperation	1.9 (1.09–3.3)	0.02
Successful resuscitation	1.2 (0.5–1.5)	0.2
Respiratory distress	1.4 (0.3–2)	0.4
Psychosis	0.9 (0.6–1.3)	0.6
Pneumothorax	0.9 (0.1–1.2)	0.8
Acute renal failure	1.3 (0.08–1.5)	0.6
Need for epicardial pacing	0.8 (0.3–1.3)	0.8
Pleural effusion	1.2 (0.09–1.8)	0.7
Infection	1.4 (0.6–1.9)	0.4

CI — confidence interval; IABP — intra-aortic balloon pump

reoperation (p = 0.002), IABP use (p = 0.009), and peripheral arterial disease (p = 0.01).

In a logistic regression model, reoperation and the need for perioperative IABP were significant predictors of postoperative AF (Table 5).

None of the following complications: successful resuscitation, respiratory distress, psychosis, pneumothorax, acute renal failure, pleural effusion infection were indicated to have independent association with AF (Table 5).

In the study population, the predominant strategy of SR restoration was administration of amiodarone (77.6%). Electrical cardioversion was performed in only 7.8% of patients. Among 314 patients who developed AF and survived the surgery, SR was restored in 247 (78.6%), and the remaining 67 (21.3%) were discharged to step-down units with AF.

Discussion

The question of whether postoperative AF is less frequent after off-pump cardiac surgery is still unresolved. One recently published meta-analysis of 43 randomized clinical trials has shown no sig-

nificant difference between CABG and OPCAB in the incidence of stroke and perioperative myocardial infarction but the incidence of postoperative AF was significantly reduced in the OPCAB group [16]. Another large multicentre trial that compared the safety of CABG and OPCAB in octogenarians showed a reduced risk of AF in patients operated without CPB [17].

The incidence of postoperative AF in our study was similar in both CABG and OPCAB groups and the difference was not significant. This is consistent with our previously published findings based on a smaller number of patients [18]. Recently, Bohatch Junior et al. [19] demonstrated no significant difference in the incidence of postoperative AF between on-pump and off-pump patients.

Most AF episodes were noted on the second and third postoperative day. This trend was similar in CABG and OPCAB patients. The observed peak AF incidence corresponds to some literature data suggesting that in patients after CABG, the highest activation of the complement system also occurs between the second and third postoperative day [20]. The hypothesis that eliminating OPCAB leads to a reduced postoperative inflammatory response was not confirmed by Czerny et al. [21] which showed no significant difference in postoperative levels of interleukin (IL)-6 and IL-10 between patients operated with or without CPB. Another study showed a significant increase in IL-6, IL-8, and C-reactive protein levels in patients after OPCAB, although only IL-6 correlated significantly with postoperative AF [22]. In the present study it was duly noted that daily distribution of postoperative AF incidence did not differ between CABG and OPCAB patients.

In addition, a relation has been suggested between increased oxidative stress and postoperative AF [23]. More recently, Dehghani et al. [24] noted a role of oral vitamin C in the prevention of AF after CABG. These data support the inflammatory/oxidative stress pathophysiology of postoperative arrhythmia.

The present study found that a need for reoperation or perioperative IABP use were independ-

ent risk factors for the development of postoperative AF. This is consistent with the data reported by Mariscalco et al. [25] who found that preoperative IABP was an independent predictor of AF.

Although AF was not an independent risk factor for in-hospital mortality, it could be a marker of a complicated postoperative course.

Postoperative AF incidence was a significant risk factor of prolonged ICU stay, even after adjustment for the presence of other complications. A probable explanation may be the fact that tachycardia and loss of coordinated atrial function during AF may enhance hemodynamic instability and compromise patient's postoperative clinical condition when compared to those who remain in SR.

In this study, age was a strong risk factor for the development of postoperative AF. This corresponds to other data [1–3]. More recently, Viles-Gonzalez et al. [26] have duly noted an advanced age was the strongest risk factor for AF after mitral valve repair.

A possible limitation of our study was a higher number of patients with hypertension in the OPCAB group. As hypertension has been indicated as an independent risk factor for postoperative AF, it could have influenced the results.

Conclusions

Our study provides data from a large single-centre group of consecutive patients operated with or without CPB suggesting that postoperative AF is a frequent arrhythmia independent of the type of surgical procedure and it occurs more frequently in patients with an increased risk of serious perioperative complications.

Conflict of interest: None declared

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