© Med Sci Monit, 2011; 17(1): CR48-55
PMID: 21169910

Received: 2010.04.18
Accepted: 2010.07.29
Published: 2011.01.01

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

Predictors of atrial fibrillation following coronary artery bypass surgery

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Source of support: Departmental sources

Summary

Background: New-onset atrial fibrillation is the most common form of rhythm disturbance following coronary artery bypass grafting surgery (CABG). It is still unclear which factors have a significant impact on its occurrence after this procedure. The aim of this study was to evaluate clinical predictors of post-operative atrial fibrillation (POAF) after myocardial revascularization.

Material/Methods: We performed a retrospective analysis of 322 patients who underwent the first CABG operation without baseline atrial fibrillation. All subjects underwent laboratory blood tests, echocardiography and selective coronarography with ventriculography. Patients were continuously electrocardiographically monitored during the first 48-72h after the operation for the occurrence of POAF.

Results: POAF was diagnosed in 72 (22.4%) of the patients. Multivariate logistic regression analysis was used to identify the following independent clinical predictors of POAF: age ⩾65 years (OR 1.78; 95%CI: 1.06–2.76; p=0.043), hypertension (OR 1.97; 95%CI: 1.15–3.21; p=0.018), diabetes mellitus (OR 2.09; 95% CI: 1.31–5.33; p=0.010), obesity (OR 1.51; 95%CI: 1.03–3.87; p=0.031), hypercholesterolemia (OR 2.17, 95%CI: 1.05–4.25; p=0.027), leukocytosis (OR 2.32, 95%CI: 1.45–5.24; p=0.037), and left ventricular segmental kinetic disturbances (OR 3.01; 95%CI: 1.65–4.61, p<0.001).

Conclusions: This study demonstrates that advanced age, hypertension, diabetes, obesity, hypercholesterolemia, leukocytosis, and segmental kinetic disturbances of the left ventricle are powerful risk factors for the occurrence of POAF.

key words: **atrial fibrillation • cardiac surgery • risk factors**

Full-text PDF: http://www.medscimonit.com/fulltxt.php?ICID=881329
Word count: 3218
Tables: 4
Figures: –
References: 36

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Background

New-onset atrial fibrillation is the most common form of rhythm disturbance following heart surgery. The incidence of postoperative atrial fibrillation (POAF) in patients after coronary artery bypass grafting surgery (CABG) varies from 20% to 35% [1,2]. POAF most commonly occurs between the second and the fourth postoperative day, and it can induce hemodynamic compromise, thromboembolic complications, increased total postoperative morbidity and mortality and prolonged hospital stay [3,4]. Postoperative atrial fibrillation not only increases postoperative mortality [5], but also reduces 10-year survival after surgical myocardial revascularization by 29% [6]. Therefore a large number of studies have been recently carried out to discover the risk factors responsible for its occurrence. The effects of many factors were estimated: age, sex, hypertension, diabetes, obesity, metabolic syndrome, renal failure, chronic obstructive pulmonary disease, left atrium size, left ventricular hypertrophy, markers of inflammation (leukocytosis, CRP, IL-6) and heart failure (BNP and pro-BNP), duration of the operation, number of grafts, or presence of significant left main stenosis. However, there is no agreement in the results of these investigations [7–9].

The aim of our study was to determine which risk factors in our population were responsible for the occurrence of atrial fibrillation after coronary artery bypass grafting surgery.

Material and Methods

This study included 367 consecutive patients >18 years old without preoperative episodes of atrial fibrillation who underwent a first isolated CABG operation at one of the cardiology departments of the Clinic for Cardiology, Clinical Center of Serbia, during the period from January 1, 2006 to June 30, 2008. The patients with earlier history of atrial fibrillation (14), artificial valves (2), moderate or severe valvular heart disease (4), recent myocardial infarction (<1 month) (1), renal failure requiring hemodialysis (1), thyroid dysfunction (2), previous carotid endarterectomy (7), repeated myocardial revascularization (5), or simultaneous operation of heart valves (9), were excluded from the study.

Preoperative, perioperative and postoperative data were retrospectively collected for each patient and entered into a computerized database.

Patient histories were used to obtain data on previous myocardial infarction, stroke, preoperative New York Heart Association (NYHA) class, chronic obstructive pulmonary disease, chronic renal failure, smoking, cardiovascular diseases in family members, medications taken, and anthropometric measures including height and weight. Body mass index (BMI) was calculated by dividing body weight in kilograms by height in meters. Arterial pressure values were obtained by measuring average value of 2 consecutive measurements obtained by conventional sphygmomanometer. Laboratory parameters used for this purpose were levels of glucose, triglycerides, total cholesterol, HDL cholesterol, and glomerular filtration rate calculated by the modification of diet in Renal Disease formula (eGFR). White blood cells (WBC) counts were assessed within 48 hours before cardiac surgery and at least once daily thereafter for the first 4 postoperative days. Peak WBC count was defined as the highest value during the first 5 postoperative days. The upper limit of normal for WBC count was 10×10^9/l.

The diagnosis of diabetes was based on the criteria of the World Health Organization published in 2006 [10], and arterial hypertension according to recommendations of the European Association for Hypertension in 2007 [11]. The blood levels of triglycerides ≥1.7mmol/L and total cholesterol ≥5.2mmol/L were considered increased. Obesity was defined as BMI ≥30kg/m^2.

Before the operation, patients used their regular therapy, as previously prescribed. Systemic prophylactic measures that could prevent the development of POAF were not used. The protocol was approved by the Research Ethics Committee of the Faculty of Medicine, University of Belgrade. Informed consent was obtained from all participants.

The analyzed parameters obtained by preoperative echocardiographic examination were: end-diastolic (EDD) and end-systolic diameters (ESD); the left atrial diameter; and parameters of the global systolic function (ejection fraction, EF and fractional shortening, FS, which were calculated using Teicholz formula). Left ventricular segmental kinetic disturbances, if any, were also registered.

In patients who underwent CABG with cardiopulmonary bypass (CPB), cannulation of the ascending aorta was performed with a single cannula in the right atrium, which was used for the venous return. Patient systemic temperature was reduced to between 28°C and 33°C (moderate hypothermia). Myocardial protection was provided via antegrade or retrograde cold blood cardioplegy with high levels of potassium. CABG without CPB (off-pump surgery) was performed in 15 cases.

In all operated patients, a continuous ECG monitoring was performed during the first 48–72 hours after surgery in the intensive care unit. Thereafter, a standard 12-lead ECG was recorded once a day, and after any clinical deterioration (palpitations, dyspnea, precordial oppression, or confusion). POAF was defined as an episode of atrial fibrillation lasting more than 15 minutes, or in the case of necessary medical treatment. Patients with sustained AF unresponsive to pharmacological therapy, or hemodynamically unstable patients, had an electrical cardioversion. In spite of performing cardioversion, the patients were monitored with continuous ambulatory ECG until 48 hours after resolution of the arrhythmia.

Based on the new onset atrial fibrillation, patients were divided into 2 groups: 72 patients with POAF and the remaining 250 patients who did not have registered POAF.

Continuous variables were presented as mean ±standard deviation (SD) and were compared by using a t-test for 2 independent samples, as they showed a regular distribution. Differences in proportion were compared by using the χ^2 test or Fisher's exact test, where necessary. The correlation between POAF occurrence and different factors was determined by univariate logistic regression (OR and 95% CI). Male sex and all the factors where $p<0.15$ were included in the multivariate logistic regression analysis in

order to identify independent predictors for POAF occurrence. Probability values less than 0.05 were considered statistically significant.

Results

Out of 322 patients who underwent CABG, 72 patients (22.4%) developed atrial fibrillation. All parameters of the 2 groups of patients are shown in Table 1.

The mean age of patients was 60±9 years of age. Patients with POAF were significantly older than those without AF (Table 1). Males were more prevalent, with 231 subjects (71%). Out of 322 patients who were included in the study, 207 had hypertension (64%) and 86 had diabetes (26.7%). Hypertriglyceridemia was found in 175 (54%) patients, hypercholesterolemia in 133 (41%) patients, and obesity in 115 patients (35.7%), while the mean BMI was 26.2±3.1 kg/m^2. All of these factors were significantly more frequent in the POAF group (Table 1).

There were no statistically important differences between the observed groups for average NYHA heart failure class, prevalence of NYHA III-IV and congestive heart failure (Table 1).

Risk factors for the development of cardiovascular diseases such as higher systolic and diastolic blood pressure, BMI, blood levels of glucose, total cholesterol, and triglycerides were significantly higher in the group of patients with POAF, while HDL level was significantly lower in the same group (Table 1). Glomerular filtration rate (eGFR) was significantly lower in the POAF group. There was no difference in preoperative WBC count between groups. Smoking was more prevalent in the POAF group, whereas mild valvular disease, family history of coronary artery disease, chronic obstructive pulmonary disease and chronic kidney failure, as well as eGFR ⩽30mL/min/1.73 m^2, were equally distributed in both groups (Table 1). Patients who developed POAF used beta-blockers and statins preoperatively significantly less frequently. Furthermore, there were no statistical differences in the use of other preoperative medications between the groups (Table 1).

There were no significant differences in echocardiographically estimated left ventricular dimensions (EDD and ESD), nor in the global systolic function of the left ventricle (EF), although patients with POAF had significantly larger left atrium size and higher frequency of left ventricular segmental kinetic disturbances (Table 1). Ejection fraction ⩽35%, 3-vessel coronary artery disease, previous myocardial infarction and stroke did not cause POAF.

Postoperative data confirmed that the number of grafts and off-pump surgical treatment did not differ between the 2 observed groups. Postoperative peak of WBC count was significantly higher and leucocytosis >20×10^9/l was more frequent in the POAF group. Hospital stay duration was significantly prolonged in the POAF group. Mortality in the first 30 days was higher in patients with atrial fibrillation, with borderline statistical significance (Table 2).

Univariate logistic analysis found that the patient age over 65 years, hypertension, obesity, diabetes, hypercholesterolemia, postoperative WBC >20×10^9/l, smoking and the left ventricular segmental kinetic disturbances were risk factors for the occurrence of POAF, while NYHA heart failure III–IV, congestive heart failure, family history of cardiovascular diseases, the left atrium size, and 3-vessel coronary artery disease were not (Table 3).

It was also found that there was a significant difference in preoperative therapy and the development of POAF (Table 3). Thus, the preoperative use of beta blockers reduced the risk of POAF by 45%, and the use of statins decreased that risk by 43%. Use of other drugs before operation (ACE inhibitors, calcium channel antagonists, amiodarone, diuretics, and aspirin) did not decrease the occurrence of POAF.

Multivariate logistic regression identified age (over 65 years), hypertension, diabetes mellitus, obesity, hypercholesterolemia, the left ventricular segmental kinetic disturbances and postoperative WBC count >20×10^9/l as independent risk factors for POAF occurrence (Table 4). Smoking, family history of cardiovascular diseases and left atrial size >4 cm were not independent predictors of AF. Moreover, beta-blockers and statins were not identified as independent predictors in the prevention of postoperative atrial fibrillation.

Discussion

Data on the occurrence of POAF are inconsistent. In most studies, POAF incidence ranges between 20% and 35% [5–9]. In our study, 22.4% of subjects developed atrial fibrillation after myocardial surgical revascularization.

The underlying mechanisms involved in development of postoperative atrial fibrillation are multifactorial and mostly unresolved. Some possible mechanisms are: pericardial inflammation, autonomic imbalance during the postoperative period with excessive production of catecholamines, systemic inflammatory response, and interstitial mobilization of fluid with resultant changes in volume and electrolyte imbalance.

These can result in a change of intravascular volume, pressure, neurohumoral environment, and susceptibility of the myocardium to atrial fibrillation. The same mechanisms might change the atrial refractoriness and slow atrial conduction. It seems that the multiple re-entry wavelets resulting from the dispersion of atrial refractoriness are the main electrophysiological mechanism of POAF [12].

Despite numerous investigations [1–9], the most important factors that contribute to POAF development have not yet been determined. Older age is the only concurrent risk factor of all conducted studies [1,2,7–9,13,14]. Advanced age is associated with degenerative changes such as fibrosis and dilatation, which affect the atrial electrophysiological characteristics (shortness of effective refractory period, dispersion of refractoriness and conduction, abnormal automaticity), and represent a precondition for the development of POAF. Our study also showed that being 65 years of age and older is an independent predictor of postoperative AF.

Males were significantly more likely to require surgical myocardial revascularization; however, the role of sex in the etiology of atrial fibrillation is not proven. Some studies found that male sex is an independent predictor of POAF

Table 1. Clinical preoperative data of patients undergoing CABG with and without postoperative atrial fibrillation.

Preoperative data	POAF (N=72)	No POAF (N=250)	p
Age (years)	63±7	59±9	0.001
Sex (% male)	53 (74)	178 (71)	0.767
NYHA class	1.7±0.4	1.6±0.5	0.120
NYHA class III-IV (%)	22 (31)	55 (22)	0.158
Congestive heart failure	8 (11)	12 (5)	0.091
Systolic arterial pressure (mmHg)	142±16	137±15	0.015
Diastolic arterial pressure (mmHg)	87±11	84±10	0.029
Fasting glycemia (mmol/l)	6.2±2.1	5.7±1.8	0.046
Tryglicerides (mmol/l)	1.89±0.92	1.68±0.81	0.061
Total cholesterol (mmol/l)	6.3±1.95	5.4±1.72	<0.001
HDL (mmol/l)	1.01±0.31	1.10±0.32	0.035
eGFR (mL/min/1.73m^2)	54±8	68±10	<0.001
eGFR ≤30 mL/min/1.73m^2	5 (7)	13 (5)	0.565
WBC count (baseline, ×10^9/l)	6.4±1.8	6.5±1.7	0.665
BMI (kg/m2)	28.1±3.4	25.6±2.9	<0.001
Hypertension (%)	57 (79)	150 (60)	0.003
Diabetes mellitus (%)	31 (43)	55 (22)	<0.001
Hypertrygliceridemia (%)	45 (63)	130 (52)	0.703
Hypercholesterolemia (%)	40 (56)	93 (37)	0.007
Obesity (%)	35 (49)	80 (32)	0.012
Smoking (%)	46 (66)	125 (50)	0.044
Family history of CV diseases (%)	58 (81)	175 (70)	0.099
Chronic renal failure (%)	2 (3)	5 (2)	0.655
COPD (%)	6 (8)	10 (4)	0.213
Mild valvular heart disease (%)	44 (61)	162 (65)	0.579
Beta blockers (%)	31 (43)	145 (58)	0.031
Amiodarone (%)	2 (3)	8 (3)	0.998
ACE inhibitors (%)	42 (58)	156 (62)	0.581
Nitrates (%)	55 (76)	200 (80)	0.513
Calcium channel antagonist (%)	6 (8)	18 (7)	0.799
Diuretics (%)	14 (20)	45 (18)	0.863
Aspirin/thienopyridine (%)	68 (95)	240 (96)	0.524
Statins (%)	25 (35)	121 (48)	0.044
EF (%)	52±10	54±11	0.167
EF≤35% (%)	4 (6)	13 (5)	0.994
LA (cm)	4.03±0.51	3.84±0.57	0.011
LVEDD (cm)	5.41±0.74	5.47±0.64	0.50
LVESD (cm)	3.97±0.84	3.93±0.77	0.704
LV segmental kinetic disturbances (%)	37 (51)	50 (20)	<0.001
Left main ≥50% coronary stenosis (%)	24 (33)	90 (36)	0.78
Three-vessel coronary artery disease (%)	60 (83)	185 (74)	0.118
Previous myocardial infarction (%)	37 (51)	126 (50)	0.894
Previous stroke (%)	2 (3)	5 (2)	0.655

POAF – postoperative atrial fibrillation; NYHA – New York Heart Association; eGFR – glomerular filtration rate calculated by the Modification of Diet in Renal Disease formula; CV – cardiovascular; COPD – chronic obstructive pulmonary disease; EF – ejection fraction; LA – left atrium; LVEDD – left ventricle end-diastolic dimension; LVESD – left ventricle end-systolic dimension.

Table 2. Clinical postoperative data of patients undergoing CABG with and without postoperative atrial fibrillation.

Postoperative data	POAF(N=72)	No POAF(N=250)	p
Number of coronary grafts	2.63±0.43	2.58±0.42	0.389
Off-pump (%)	3 (4)	12 (5)	0.99
WBC count (peak, $\times 10^9$/l)	16.1±2.6	14.2±1.9	<0.001
Postoperative WBC count >20$\times 10^9$/l (%)	6 (8)	5 (2)	0.018
Hospital stay duration (days)	12±3	9±2	<0.001
30-day mortality (%)	2 (3)	0	0.049

WBC – white blood cells.

Table 3. Univariate Logistic Regression Analysis of Potential Risk Factors of POAF.

	OR	95% CI	p
Age (≥65 years)	2.06	1.01–3.21	0.027
Male sex	1.14	0.51–2.71	0.71
NYHA III-IV class	1.56	0.87–2.79	0.156
Congestive heart failure	2.48	0.97–6.62	0.095
Hypertension	2.53	1.35–5.45	0.004
Diabetes	2.68	1.65–5.67	0.001
Hypercholesterolemia	2.18	1.12–3.59	0.013
Obesity	2.01	1.25–4.45	0.015
Smoking	1.77	1.09–3.87	0.044
Beta blockers	0.55	0.47–0.63	0.031
ACE inhibitors	0.84	0.75–1.93	0.196
Statins	0.57	0.47–0.67	0.045
LA >4cm	1.87	1.07–3.62	0.033
LV segmental kinetic disturbances	4.23	2.01–9.53	<0.001
Three-vessel coronary artery disease	1.76	0.97–2.62	0.124
Postoperative WBC count >20×109/l (%)	4.45	1.32–15.05	0.017

LA – left atrium; LV – left ventricle; WBC – white blood cells.

development [9], but it seems that there are many more authors who do not agree with that [3,7,8,14]. In our study male sex was not found to be an independent variable in the occurrence of atrial fibrillation.

Numerous studies have shown that hypertension increased the risk of POAF [1,4,12,15], but there are authors who disagree [7,16]. The results of our study showed that hypertension was an independent predictor, one of the most important, for the development of POAF in our population. Basically, arterial hypertension causes POAF due to mechanical and electrical remodeling of the left atrium, primarily because of diastolic dysfunction and left ventricular hypertrophy [17].

It is known that diabetes mellitus type 2, commonly found in patients who require surgical revascularization of the myocardium, is characterized by insulin resistance, increased oxidative stress, elevated levels of free fatty acids and chronic inflammation. All of these metabolic disorders can lead to left ventricular hypertrophy, impairment of its function and ischemic disease, which can cause structural and electrophysiological changes in the left atrium, and new onset of atrial fibrillation [18]. Results from the literature are controversial, as some authors have shown that diabetes increases the risk of POAF [19,20], while others disagree [8]. In our group of patients, presence of diabetes contributed to POAF even more than did hypertension.

Obesity may induce atrial fibrillation in many ways. Combination of insulin resistance and increased preload lead to left ventricular diastolic dysfunction, hypertrophy and the left atrial remodeling, including left atrial dilatation, which

Table 4. Multivariate Logistic Regression Analysis of Risk Factors of POAF.

	OR	95% CI	p
Age (≥65 years)	1.78	1.06–2.76	0.043
Male sex	1.17	0.51–2.38	0.673
Hypertension	1.97	1.15–3.21	0.018
Diabetes	2.09	1.31–5.33	0.010
Hypercholesterolemia	2.17	1.05–4.25	0.027
Obesity	1.52	1.03–3.87	0.031
Smoking	1.36	0.81–2.01	0.134
Beta-blockers	0.69	0.47–1.28	0.068
Statins	0.84	0.61–1.14	0.091
LA >4cm	1.49	0.92–2.86	0.072
LV segmental kinetic disturbances	3.01	1.65–4.61	<0.001
Three-vessel coronary artery disease	1.32	0.89–4.02	0.231
Postoperative WBC count $>20\times10^9$/l (%)	2.32	1.45–5.27	0.037

LA – left atrium; LV – left ventricle; WBC – white blood cells.

was shown in the Framingham Study [21]. Postoperative volume overload additionally increases heart pressure, induces left atrial enlargement and finally leads to POAF, which has been confirmed in a number of recent studies [22,23]. Our results showed that obesity was very common (about 36%) among the patients who were related to surgical myocardial revascularization. Multivariate logistic regression analysis confirmed that obesity increased the risk of POAF.

Analysis of our investigation's results showed that hypercholesterolemia and smoking were associated with POAF. Hypercholesterolemia was even an independent predictor of atrial fibrillation, which might occur due to oxidative stress and proinflammatory properties.

There was no difference in left ventricular dimensions and function between these 2 groups of patients. Univariate analysis showed that left atrium size and presence of left ventricular segmental kinetic disturbances were predictors for POAF. However, multivariate analysis revealed that only segmental kinetic disturbances represented an independent predictor. This could be explained by increased arithmogenic potential in atherosclerotic coronary artery disease, which is certainly present in patients who underwent coronary artery bypass grafting surgery. On the other hand, the POAF group did not have higher prevalence of 3-vessel coronary artery disease, as we expected, due to the increased percentage of segmental kinetic disturbances in this group. The localization of the affected left ventricular segments is not known, but it is quite possible that the location most involved was the left ventricular inferior wall, which is derived from the right coronary artery (RCA), and it is known that atherosclerotic disease of RCA is associated with increased risk of POAF [20,24].

Despite many clinical trials dealing with the prevention of POAF and improvements in surgical techniques, questions about the optimal preventive medications for POAF still prevail. Because of its effects on the sympathetic nervous system, which is one of the main factors responsible for POAF, it is understandable that beta blockers are the most studied and used drugs. Based on a meta-analysis that included 4074 patients from 28 different studies, Crystal et al. concluded that the use of beta blockers reduced the incidence POAF by 65% [25]. Burgess et al. in another meta-analysis showed that the preoperative discontinuation of beta blockers was a stronger predictor of postoperative atrial fibrillations than when these drugs were not used [26]. Although it is recommended that before surgery all patients have beta blockers in therapy, if they are not contraindicated, it is quite different in practice. In our study, beta blockers were used by only slightly more than half of the patients (55%), and the univariate logistic regression revealed that they reduced the risk of POAF by 45%. However, in our study this group of drugs was not proven to be an independent predictor of postoperative atrial fibrillation protection.

There is no consensus about the use of statins before cardiosurgical intervention. Statins are believed to have anti-inflammatory and antisympathetic properties that contribute to a decrease in atrial fibrillation [27]. The results of the most recent studies are opposite. Liakopoulus et al., in a meta-analysis that included 17,643 postoperative patients, found that statins significantly reduced the risk of POAF [28], while Miceli et al. revealed that statins increased risk of postoperative atrial fibrillation in patients with surgical myocardial revascularization [29]. In our study statins were proven to be effective in the prevention of POAF, with a 43% risk reduction, although they were not an independent predictor in the prevention of atrial fibrillation. One of the possible reasons for this finding is the fact that the cholesterol level in patients with POAF was significantly higher than normal, which implied that statins were not sufficiently prescribed or were subdosed in patients with coronary artery disease.

The role of ACE inhibitors in POAF prevention is far more controversial than the use of beta blockers. The hypothesis of their preventive effect on atrial fibrillation onset is explained by afterload reduction, which prevents left atrial stretching and remodeling [30]. Due to frequent occurrence of hypertension in our study, a high percentage of patients (about 61%) used ACE inhibitors, but there was no significant correlation between the use of ACE inhibitors and the absence of POAF.

Postoperative data revealed that the number of grafts did not have an influence on POAF development. The off-pump surgical treatment in our study did not significantly change POAF prevalence. Some authors have obtained the same result [6], however there are also authors who disagreed [31,32]. Although use of the off-pump CABG technique has declined, the incidence of POAF remains controversial, despite the fact that it is a less invasive approach associated with a less marked perioperative inflammatory response [33].

Our study also revealed that high postoperative WBC count ($>20\times10^9$/l) was an independent predictor of POAF development. This strongly supports the association between the inflammatory response and postoperative AF [34]. The occurrence of AF alone and AF after cardiac surgery is closely followed by oxidative stress, the activation of the complement system (C3 and C4), release of acute-phase protein CRP, proinflammatory cytokines (interleukin 6) and inflammatory mediators, including tumor necrosis factor-α [35,36].

The mortality rate in the first 30 days was higher in patients with atrial fibrillation. POAF also significantly prolonged hospital stay duration. Similar results were obtained in other studies [16].

Our investigation has several limitations. Small sample size and lack of randomization are the main limitations. Atrial fibrillation was diagnosed by electrocardiographic monitoring only in the first 48–72 h after the operation. Furthermore, it is well-known that POAF can develop in the first 4 days, therefore it is possible that we underestimated the incidence of POAF, although our results agree with those from the literature.

Further studies with increased number of patients will provide the design of certain algorithms for detection of patients who are at risk of postoperative atrial fibrillation in our population. Based on results of these studies we could develop adequate guidelines for patients who required surgical myocardial revascularization and effective preventive therapy for POAF.

Conclusions

Atrial fibrillation is the most common rhythm disorder after surgical revascularization of the heart, which significantly complicates the postoperative course and increases morbidity and mortality. There is no agreement on particular risk factors for POAF occurrence. In our investigation, independent predictors of postoperative atrial fibrillation were patient age (65 years of age and older), hypertension, diabetes, obesity, hypercholesterolemia, left ventricular segmental kinetic disturbances and postoperative leukocytosis (WBC count $>20\times10^9$/l). Beta blockers, ACE inhibitors, calcium channel inhibitors, amiodarone, diuretics and statins were not proven to be independent factors in reducing POAF incidence or congestive heart failure. This study has shown that there are new risk factors of POAF that require our attention: preoperative hypercholesterolemia and the left ventricular segmental kinetic disturbances, as well as postoperative leukocytosis. These factors imply that metabolic, inflammatory and ischemic lesions of the heart have synergistic effects in POAF appearance. Intensive prophylactic measures, including pharmacologic strategies of reduction of glucose and cholesterol levels, decrease of postoperative WBC count and maintenance of normal body weight and blood pressure will result in reduction of the postoperative AF incidence. This research has shown that many risk factors of POAF could be modified, which would significantly decrease the incidence of POAF.

References:

1. Cagli K, Gol MK, Keles T et al: Risk factors associated with development of atrial fibrillation early after coronary artery bypass grafting. Am J Cardiol, 2000; 85: 1259–61
2. Kalman JM, Munawar M, Howes LG et al: Atrial fibrillation after coronary bypass grafting is associated with sympathetic activation. Ann Thorac Surg, 1995; 60: 1709–15
3. Amar D, Shi W, Hogue CW Jr et al: Clinical prediction rule for atrial fibrillation after coronary artery bypass grafting. J Am Coll Cardiol, 2004; 44: 1248–53
4. Mathew JP, Parks R, Savino JS et al: Atrial fibrillation following coronary artery bypass graft surgery: predictors, outcomes, and resource utilization. MultiCenter Study of Perioperative Ischemia Research Group. JAMA, 1996; 276: 300–6
5. Benussi S, Galanti A, Alfieri O: Restoring sinus rhythm in patients at a high risk for postoperative atrial fibrillation. Arch Med Sci, 2008; 4(2): 108–15
6. Filardo G, Hamilton C, Hebeler RF et al: New-onset postoperative atrial fibrillation after isolated coronary artery bypass graft surgery and long-term survival. Circ Cardiovasc Qual Outcomes, 2009; 2: 164–69
7. Arribas-Leal JM, Pascual-Figal DA, Tornel-Osorio PL et al: Epidemiology and new predictors of atrial fibrillation after coronary surgery. Rev Esp Cardiol, 2007; 60(8): 841–47
8. Magee MJ, Herbert MA, Dewey TM et al: Atrial fibrillation after coronary artery bypass grafting surgery: development of a predictive risk algorithm. Ann Thorac Surg, 2007; 83: 1707–12
9. Zaman AG, Archbold RA, Helft G et al: Atrial fibrillation after coronary artery bypass surgery a model for preoperative risk stratification. Circulation, 2000; 101: 1403–8
10. WHO Guideline Development Committee: Definition and diagnosis od dijabetes mellitus and intermediate hyperglicaemia. Report of a WHO/IDF Consultation, Geneve 2006
11. 2007 ESH-ESC Practice guidelines for the management of arterial hypertension: ESH-ESC task force on the management of arterial hypertension. J Hypertens, 2007; 25: 1105–87
12. Konings KT, Kirchhof CJ, Smeets JR et al: High-density mapping of electrically induced atrial fibrillation in humans. Circulation, 1994; 89: 1665–80
13. Auer J, Weber T, Berent R et al: Risk factors of postoperative atrial fibrillation after cardiac surgery. J Card Surg, 2005; 20: 425–31
14. Hosokawa K, Nakajima Y, Umenai T et al: Predictors of atrial fibrillation after off-pump coronary artery bypass graft surgery. Br J Anaesth, 2007; 98: 575–80
15. Sedrakyan A, Zhang H, Treasure T, Krumholz HM: Recursive partitioning – based preoperative risk stratification for atrial fibrillation after coronary artery bypass surgery. Am Heart J, 2006; 151: 720–25
16. Mathew JP, Fontes ML, Tudor IC et al: A multicenter risk index for atrial fibrillation after cardiac surgery. JAMA, 2004; 291(14): 1720–29
17. Healey JS, Connolly SJ: Atrial fibrillation: hypertension as a causative agent, risk factor of complications, and potential therapeutic target. Am J Cardiol, 2003; 91: 9G–14G
18. Nichols GA, Reinier K, Chugh SS: Independent contribution of diabetes to increased prevalence and incidence of atrial fibrillation. Diabetes Care, 2009; 32(10): 1851–56

19. Kalus JS, White CM, Caron MF et al: Indicators of atrial fibrillation risk in cardiac surgery patients on prophylactic amiodarone. Ann Thorac Surg, 2004; 77(4): 1288–92
20. Mueller XM, Tevaearai HT, Ruchat P et al: Atrial fibrillation and minimally invasive coronary artery bypass grafting: risk factor analysis. World J Surg, 2002; 26(6): 639–42
21. Wang TJ, Parise H, Levy D et al: Obesity and the risk of new-onset atrial fibrillation. JAMA, 2004; 292: 2471–77
22. Filardo G, Hamilton C, Hamman B et al: Relation of obesity to atrial fibrillation after isolated coronary artery bypass grafting. Am J Cardiol, 2009; 103(5): 663–66
23. Açıl T, Çölkesen Y, Türköz R et al: Value of preoperative echocardiography in the prediction of postoperative atrial fibrillation following isolated coronary artery bypass grafting. Am J Cardiol, 2007; 100: 1383–86
24. Aytemir K, Aksoyek S, Ozer N et al: Atrial fibrillation after coronary artery bypass surgery: P wave signal averaged ECG, clinical and angiographic variables in risk assessment. Int J Cardiol, 1999; 69(1): 49–56
25. Crystal E, Garfinkle MS, Connolly SS et al: Interventions for preventing post-operative atrial fibrillation in patients undergoing heart surgery. Cochrane Database Syst Rev, 2004; CD003611
26. Burgess DC, Kilborn MJ, Keech AC: Oct 2. Interventions for prevention of post-operative atrial fibrillation and its complications after cardiac surgery: a meta-analysis. Eur Heart J, 2006; 27(23): 2846–57
27. Pliquett RU, Cornish KG, Peuler JD, Zucker IH: Simvastatin normalizes autonomic neural control in experimental heart failure. Circulation, 2003; 107: 2493–98
28. Liakopoulos OJ, Choi YH, Kuhn EW et al: Statins for prevention of atrial fibrillation after cardiac surgery: a systematic literature review. J Thorac Cardiovasc Surg, 2009; 138(3): 678–86
29. Miceli A, Fino C, Fiorani B et al: Effects of preoperative statin treatment on the incidence of postoperative atrial fibrillation in patients undergoing coronary artery bypass grafting. Ann Thorac Surg, 2009; 87(6): 1853–58
30. Miceli A, Capoun R, Fino C et al: Effects of angiotensin-converting enzyme inhibitor therapy on clinical outcome in patients undergoing coronary artery bypass grafting. J Am Coll Cardiol, 2009; 54: 1778–84
31. Banach M, Rysz J, Drozdz JA et al: Risk factors of atrial fibrillation following coronary artery bypass grafting: a preliminary report. Circ J, 2006; 70: 438–41
32. Siebert J, Lewicki Ł, Młodnicki M et al: Atrial fibrillation after conventional and off-pump coronary artery bypass grafting: two opposite trends in timing of atrial fibrillation occurrence? Med Sci Monit, 2003; 9(3): CR137–41
33. Athanasiou T, Aziz O, Mangoush O et al: Does off-pump coronary artery bypass reduce the incidence of post-operative atrial fibrillation? A question revisited. Eur J Cardiothorac Surg, 2004; 26: 701–10
34. Lamm G, Auer J, Weber T et al: Postoperative white blood cell count predicts atrial fibrillation after cardiac surgery. J Cardiothorac Vasc Anesth, 2006; 20(1): 51–56
35. Korantzopoulos P, Kolettis T, Siogas K, Goudevenos J: Atrial fibrillation and electrical remodeling: the potential role of inflammation and oxidative stress. Med Sci Monit, 2003; 9(9): RA225–29
36. Gaudino M, Andreotti F, Zamparelli R et al: The-174G/C interleukin-6 polymorphism influences postoperative interleukin-6 levels and postoperative atrial fibrillation: Is atrial fibrillation an inflammatory complication? Circulation, 2003 ; 108(Suppl II): II195–II199