Atrial fibrillation after surgical revascularization: is there any difference between on-pump and off-pump?

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Abstract

Objective: Postoperative atrial fibrillation (AF) is still frequent complication after cardiac surgery in spite of the improvements in the surgical procedures. There is still controversy whether or not, the absence of cardiopulmonary bypass results in a lower incidence of AF.

Methods: Six hundred and seventy patients that underwent revascularization by using in situ LIMA for single vessel disease were included in this retrospective study and the patients were divided in two groups. Group I included 328 patients who underwent complete revascularization with cardiopulmonary bypass and group II consisted of 342 patients who underwent complete revascularization without cardiopulmonary bypass. Then, the incidence and predictive perioperative factors of AF in two groups were determined and compared with each other. Results: There were no significant differences between two groups with respect to the preoperative demographic characteristics of the patients. The incidence of postoperative AF was determined as 16.1% after on-pump and 14.6% after off-pump revascularization. Avoiding cardiopulmonary bypass did not decrease the incidence of postoperative AF. Sex, age over 65 years, prophylactic β-blocker usage and left ventricular dysfunction were independent predictive factors in group I ($r^2=0.51; P<0.001$). However, only age over 65 years and prophylactic β-blocker usage were independent predictive factors in group II ($r^2=0.59; P<0.01$). The rates of AF in both groups were decreased by using prophylactic β-blocker usage ($P=0.05$ in group I, $P<0.001$ in group II). Conclusions: There is no reduction of AF rate in myocardial revascularization without cardiopulmonary bypass. However, prophylactic β-blocker usage decreases the incidence of AF after both on-pump and off-pump myocardial revascularization.

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Keywords: Atrial fibrillation; Myocardial revascularization; On-pump; Off-pump

1. Introduction

Postoperative arrhythmias are still frequent complications after cardiac surgery inspite of the improvements in the surgical procedures. The reported incidence of postoperative atrial fibrillation (AF) varies between 10 and 40% during the first postoperative week [1]. These variations in the incidence of AF depend on the patient populations studied, type of cardiac surgery, the definition of the arrhythmia and the duration of observation period [2].

In recent years, off-pump coronary artery bypass grafting (OPCAB) has emerged as an alternative method for conventional coronary artery bypass grafting (CCABG) and the advent of OPCAB brought with it the hope and the expectation that there would be a strikingly lower incidence of postoperative AF, because many of the hypothesized causes of AF could be eliminated. The early results reported an incidence of AF to be as low as 5% [3], which is contradictory to other off-pump studies with the same incidence (30%) of AF as previously shown for CCABG [4]. Moreover, more recent studies demonstrated that postoperative AF occurred with similar frequencies irrespective of the method of revascularization used, after adjusting for differences in baseline, and perioperative variables. Nowadays, AF is still the most frequent complication after open heart surgery despite the refinements in the surgical technique [5]. The probability of postoperative AF have strong influence on both outcomes and cost of the surgery.
The aim of this study is to determine whether the absence of CPB results in a lower incidence of postoperative AF and to determine the associations of other predictive factors with AF in both off and on-pump myocardial revascularization after adjusting for differences in baseline and perioperative variables.

2. Patients and methods

After the first use of the OPCAB with a modern stabilizer in 1997, 7517 patients underwent CABG surgery until September 2003 in our center. Among them, 698 (9.2%) patients underwent OPCAB surgery. At the beginning, OPCAB procedure was performed only in selected patients especially only for isolated left anterior descending coronary artery (LAD) lesions. But, with growing surgical experience, indication for OPCAB has been changing over the last few years and patients with multi-vessel grafts can now be a candidate for OPCAB. However, only the patients that underwent complete revascularization for single vessel disease with and without CPB were included in this retrospective study. After institutional ethic committee approval, the preoperative coronary angiographies of all patients that underwent revascularization for single vessel disease between January 1997 and September 2003 were examined retrospectively and among them, only the patients with isolated LAD lesion in which in situ left internal mammary artery (LIMA) was used for revascularization were determined. The patients with incomplete revascularization, with diminutive right coronary artery, with saphenous vein or free LIMA and with reoperation or preoperative AF were excluded from this study. Consequently, some of the hypothesized causes of AF could be eliminated and the patients were standardized.

There were 1176 patients that underwent single vessel revascularization between January 1997 and September 2003. Six hundred and seven patients underwent revascularization with CPB and 569 patients underwent revascularization without CPB. After examination of preoperative angiographies and reports of the operations, 670 patients that underwent complete revascularization with in situ LIMA for single vessel disease were determined. Therefore, 328 patients revascularized with CPB (group I) and 342 patients revascularized without CPB (group II) were included in this study. Five hundred and six patients were excluded from study due to reasons mentioned previously. Then, the associations of per-operative predictive factors with postoperative AF, such as age, sex, hypertension, left ventricular dysfunction, preoperative β-blocker usage and type of cardioplegia (when CPB used for myocardial revascularization) were analyzed in each group.

Both OPCAB and CCABG procedures were performed through a median sternotomy approach with standard LIMA preparation. The type of stabilization device used in OPCAB procedures was determined by the preference of the individual surgeon. Revascularization in CCABG procedures was performed during a period of moderate systemic hypothermia (30–32 °C) and cardiac arrest. After aortic cross-clamping, cardiopleic arrest was achieved and maintained with individual surgeon preferences including antegrade cardioplegic techniques, either crystalloid or blood cardioplegia. One hundred and forty-two patients received blood cardioplegia (11 Blood, 20 meqiv. K⁺, 16 meqiv. HCO₃⁻, 3, 7.364 mg/l citrate, 16 mmol/l Mg²⁺ and 1 g/l glucose) and 186 patients received crystalloid cardioplegia (Plegisol; Abbot Laboratories, USA). The mean cross-clamp and CPB times were 14.6 ± 2.5 and 24.3 ± 4.4 min, respectively, in on-pump patients.

All patients were continuously monitored postoperatively during the duration of ICU stay. In the ward, routine clinical observation was performed every hour and 12 lead ECG was accomplished once a day. Continuous monitoring restarted in the case of any arrhythmia. Postoperatively all patients were kept within the normal range for plasma magnesium and potassium levels, which were replaced as needed and when the patients had been receiving pre-operative β-blocker, the regimen was restarted immediately after the patients were extubated. For the purpose of this study, AF was defined as sustained AF requiring pharmacological intervention or electrical cardioversion, or both.

Statistical analysis were performed using the Statistical Package for the Social Sciences, Version 10.1 (SPSS Inc, Chicago, IL). Age data are presented as mean (±SD) and compared between groups by using the Mann–Whitney U test. The associations of all predictive factors with postoperative AF and differences in incidences between the groups were analysed using piercing chi-square test with introducing Yate’s correction. Multivariate linear regression analysis was used to determine the level of relationship between the independent (predictive factors) and dependent variable (postoperative AF). All P values less than 0.05 were considered significant.

3. Results

The demographic characteristics of the patients were summarized in Table 1. There were no significant differences between groups with respect to age, sex, hypertension, left ventricular dysfunction, preoperative β-blocker usage and LVEF < 40%.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group I with CPB (n = 328)</th>
<th>Group II without CPB (n = 342)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>60.58 ± 8.48</td>
<td>61.09 ± 8.81</td>
<td>NS</td>
</tr>
<tr>
<td>Male</td>
<td>72% (235)</td>
<td>71% (243)</td>
<td>NS</td>
</tr>
<tr>
<td>Age over 65</td>
<td>38% (127)</td>
<td>39% (135)</td>
<td>NS</td>
</tr>
<tr>
<td>Hypertension</td>
<td>75% (246)</td>
<td>79% (271)</td>
<td>NS</td>
</tr>
<tr>
<td>LVEF &lt; 40%</td>
<td>7% (24)</td>
<td>9% (30)</td>
<td>NS</td>
</tr>
<tr>
<td>β-Blocker usage</td>
<td>74% (242)</td>
<td>78% (268)</td>
<td>NS</td>
</tr>
<tr>
<td>AF rates</td>
<td>16.1% (53)</td>
<td>14.6% (50)</td>
<td>NS</td>
</tr>
</tbody>
</table>

NS, not significant.
and non-hypertensive patients in both groups. Moreover, we determined that the rate of AF was significantly higher in patients with moderate to severe left ventricular dysfunction only in group I \((P < 0.04)\). But, the presence of moderate to severe left ventricular dysfunction did not significantly affect the occurrence rate of AF in off-pump myocardial revascularization.

The rates of AF were 13.6% in patients receiving prophylactic per-operative \(\beta\)-blocker and 23.2% in patients not receiving \(\beta\)-blocker in group I \((P = 0.05)\). However, the rates of AF were 10.4% in patients receiving prophylactic \(\beta\)-blocker and 29.7% in patients not receiving \(\beta\)-blocker in group II \((P < 0.001)\). The rate of AF was significantly higher in patients that did not receive prophylactic peroperative \(\beta\)-blocker without regarding the method of myocardial revascularization. But, this difference was statistically more significant in off-pump patients.

When type of cardioplegia was considered as a predisposing per-operative factor, we determined that the usage of blood or crystalloid cardioplegia did not significantly affect the occurrence of AF in on-pump myocardial revascularization.

Linear regression analysis showed that sex \((P < 0.02)\), age over 65 years \((P < 0.01)\), prophylactic \(\beta\)-blocker usage \((P = 0.05)\) and left ventricular dysfunction \((P < 0.03)\) affected the probability of occurrence of postoperative AF in group I and this was highly significant \(\chi^2 = 0.51; P < 0.001\). Sex \((P < 0.02)\), age over 65 years \((P < 0.01)\), prophylactic \(\beta\)-blocker usage \((P = 0.05)\) and left ventricular dysfunction \((P < 0.03)\) were independent predictive factors when CPB was used in myocardial revascularization. However, only prophylactic \(\beta\)-blocker usage \((P < 0.001)\) and age over 65 years \((P < 0.03)\) were independent predictive factors when off-pump myocardial revascularization was preferred. \(\chi^2 = 0.59; P < 0.01\).

### 4. Discussion

Atrial fibrillation frequently occurs after cardiac surgery. Postoperative AF increases the risk of hemodynamic instability, thromboembolic events, ICU and hospital stay and increases the cost of surgery [6–8]. Management of AF in this setting is often frustrating. The advent of OPCAB brought with it the hope and the expectation that there would be a strikingly lower incidence of postoperative AF. But present study showed that there is no reduction of AF rate in myocardial revascularization without cardiopulmonary bypass after adjusting for differences in baseline and perioperative variables.

The pathophysiological mechanisms of postoperative AF have been the subject of speculations for decades despite extensive investigations focusing on the identification of risk factors for the initiation of AF. There are several per-operative conditions that per se could predispose to the development of AF. Older age is one of the most
important preoperative risk factor and has consistently predicted a higher incidence of AF after CCABG [9–13]. The incidence of AF is increased by at least 50% per decade of older age [12]. This higher incidence is possibly due to increased atrial fibrosis and dilatation by aging [14]. In this present study, the probability of AF occurrence after myocardial revascularization also increased significantly as the patient age increased over 65 years of age without regarding the method of myocardial revascularization.

Sex is the second important preoperative predictive factor and male gender are more prone to develop post-CABG AF due to sex differences in ion-channel expression and hormonal effects on autonomic tone [6,9,10,13]. The rate of AF was significantly higher in men after on-pump myocardial revascularization in this study ($P<0.04$). But there was no such significant difference between male and female in off-pump patients.

Hypertension was reported as another important preoperative predictive factor for AF as in general population [6,10,14]. Since it causes fibrosis and dispersion of atrial refractoriness. However, we determined that hypertension rates did not significantly affect the occurrence rates of AF in both on-pump and off-pump revascularization.

It was also stated in the literature that previous AF and previous congestive heart failure were predictive factors for post-CCABG AF [7,11]. In this study, the rate of AF was also significantly higher in patients with moderate to severe left ventricular dysfunction in on-pump revascularization. However, there was no such significant difference in off-pump patients when regarding left ventricular dysfunction as a predisposing factor. As the patients with previous AF were excluded from this present study, we could not analyze the affect of previous AF on postoperative AF rates in both groups.

The usage of peroperative β-blocking agent is a way for preventing postoperative AF. Moreover, usage of prophylactic β-blocking agent is the only preoperative factor that can be managed by the physician. As β-blocking agent are frequently used in treatment of coronary artery disease, many patients continue their ordinary medication until the operation. Reinstitution of β-blocking agent decreases the incidence of postoperative supraventricular tachycardia (SVT) [9,12]. The hypersensitivity in the atria that was induced by the adrenergic stimulation after β-blocker withdrawal may induce postoperative SVT [15]. This rebound effect is more pronounced after 24–60 h, when postoperative AF is most likely to occur [2]. Although β-blocker may cause a reduced incidence of postoperative SVT, there is no defined subset of patients who would benefit from such prophylactic therapy [16]. Numerous randomized, controlled trials have been demonstrated the benefit of prophylactic use of β-blocking agent in patients undergoing cardiac surgery [17–19]. The meta-analysis demonstrated that therapy with a β-blocking agent decreased the incidence of post-CABG AF by 77% [18].

In this present study, when the patients had been receiving preoperative β-blocker, the regimen was restarted immediately after the patients were extubated. The rates of AF in patients that used peroperative β-blocker were 13.6% in on-pump and 10.4% in off-pump revascularization. However, when the patients did not receive per-operative β-blocker the rates were 23.2% in on-pump and 29.7% in off-pump revascularization. The rates of AF in both groups were decreased by using peroperative β-blocker usage ($P=0.05$ in on-pump, $P<0.001$ in off-pump).

This study showed that sex ($P<0.02$), age over 65 years ($P<0.01$), prophylactic β-blocker usage ($P=0.05$) and left ventricular dysfunction ($P<0.03$) were independent predictive factors when CPB was used in myocardial revascularization ($r^2=0.51$; $P<0.001$). But, when off-pump myocardial revascularization was preferred, only prophylactic β-blocker usage ($P<0.001$) and age over 65 years ($P<0.03$) were independent predictive factors ($r^2=0.59; P<0.01$). Therefore, prophylactic β-blocking agent usage is still one of the effective strategy to reduce the rates of postoperative AF in both on and off-pump myocardial revascularization.

There were also several intraoperative factors for developing postoperative AF. Many of the intraoperative factors previously considered to be important in the initiation of AF have been related to CPB and myocardial preservation during the cross-clamp period. The use of CPB may induce a systemic inflammatory response syndrome which could be associated with increased risk for the development of postoperative AF [20,21]. The optimal myocardial preservation during cardioplegic arrest requires the maintenance of electromechanical arrest. Persistent atrial activity during cardioplegic arrest could be a marker of poor atrial protection and ischemia resulting in increased risk of AF. By monitoring bipolar atrial electrograms during aortic cross-clamp period a significantly longer duration of atrial activity, suggesting poor atrial preservation, was found in the group with postoperative supraventricular arrhythmia (SVA) compared to the group maintaining sinus rhythm without correlation to the aortic cross-clamp time [22]. Several intraoperative conditions such as type of cardioplegia used, the aortic cross-clamp time, the CPB time and ineffective cooling and preservation of the atria have been associated with postoperative SVA [23]. However, another extensive study found no relationship with postoperative AF and intraoperative variables [17]. Although the ischemic times in this present study may be considered to be quite short (CCT: 14.6±2.5 and CPB: 24.3±4.4 min), there were no significant differences between the patients that were protected with blood or crystalloid cardioplegia when considering the method of cardioplegia and the occurrence of postoperative AF.

After the introduction of OPCAB surgery, even the patients with multi-vessel disease can be completely revascularized without extracorporeal circulation. So, avoiding of CPB can be received as a chance to reduce the rates of postoperative AF. However, recent studies
demonstrated that postoperative AF occurred with similar frequencies irrespective of the method of revascularization used [5,24,25]. In this present study, the incidence of postoperative AF was determined as 16.1% after on-pump and 14.6% after off-pump revascularization.

The aim of this study was to determine the role of CPB in the initiation of AF in the patients with similar peroperative variables that were predictors of postoperative AF. Although this study is a retrospective study and the patients can be accepted as low risk patients to develop AF, the patients selections with similar peroperative variables allow us to assess correctly the effect of CPB on the occurrence of postoperative AF. But there was no statistically significant difference between two groups when considering the incidence of postoperative AF. Although, the data presented here do not suffice to exclude a possible advantage of OPCAB in patients with multi-vessel disease, the avoidance of cardiopulmonary bypass does not decrease the incidence of AF. However, prophylactic β-blocker usage decreases the incidence of AF after both on-pump and off-pump myocardial revascularization.

In summary, postoperative AF remains a challenging problem that has not been resolved or even consistently reduced by eliminating the pump. Unfortunately, it seems that the mere process of opening the pericardium predisposes many patients to AF. So much attention should still be focused on prevention of AF by the prophylactic drug regimens such as preoperative β-blocker prophylaxis, and/or prophylactic administration of other antiarrhythmic agents instead of avoidance of CPB.

References