BIATRIAL PACING AS A COST-EFFECTIVE STRATEGY FOR PREVENTION OF ATRIAL FIBRILLATION AFTER CORONARY ARTERY BYPASS SURGERY

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Background: Atrial fibrillation (AF) after coronary artery bypass graft surgery (CABG) constitutes the most commonly sustained arrhythmia and results in prolonged hospitalization. The purpose of this study was to assess simultaneous right and left atrial pacing as prophylaxis for postoperative atrial fibrillation.

Method: One-hundred and twenty patients, without structural heart disease, who underwent CABG were classified into one of the following 3 groups: biatrial pacing (BAP), left atrial pacing (LAP), and no pacing (control). Atrial pacing was performed for 4 days. Post-CABG AF was significantly reduced in BAP group compared to single-site and control groups (BAP, 17.5%; LAP, 30%; control, 45%; \( P < 0.01 \)).

Results: The mean length of hospital stay was significantly reduced in BAP group. Hospital charges were less in the BAP group compared to the other two groups. P-wave duration was significantly reduced by biatrial pacing and LAP compared to control group (before pacing, BAP: 69.2 ms; LAP: 73 ms, and after pacing, BAP: 58 ms; LAP: 64.2 ms respectively, \( P < 0.01 \)). However, only those patients who remained in sinus rhythm had a significant reduction in mean P-wave duration after pacing therapy.

Conclusion: Simultaneous right and left atrial pacing is well tolerated and is more effective in preventing post-CABG AF than single-site pacing and results in a shortened hospital stay. Identifying patients at risk for developing postoperative AF and using this prophylactic method may be the optimal cost-effective strategy.

Keywords: Arrhythmia • coronary bypass • fibrillation • pacing

Introduction

Atrial fibrillation (AF) after coronary artery bypass graft surgery (CABG) constitutes the most commonly sustained arrhythmia.\(^1\) Postoperative atrial fibrillation occurs in 10% to 40% of patients undergoing open-heart surgery.\(^2\) Postoperative AF is associated with stroke and a prolonged hospital stay.\(^3\) Although AF rarely causes serious problems, it can cause considerable discomfort for the patient.\(^2\) It is sometimes responsible for longer hospital stays and may interfere with recovery after discharge. There are controversial methods of preventing postoperative AF. Beta-adrenergic receptors and class 3 agents such as amiodarone confer some benefits in preventing post-CABG AF, but its incidence is still as high as 30% with these therapies.\(^4\) Preoperative and postoperative digoxin was recommended as an effective preventive method by some\(^5\) but is rejected by others;\(^6\) in one trial, only the combination of beta-blocker and digoxin was found to be effective.\(^7\) The pathogenesis of postoperative AF remains unclear and is presumably multifactorial. Fuller’s study showed the close association with the
Biatrial pacing has been shown to be effective in preventing AF among patients with AF and advanced interatrial block through atrial resynchronization. The purpose of this prospective study was to evaluate the efficacy of biatrial pacing as a prophylactic measure against AF after CABG when compared with no (control) or single-site atrial pacing in the left atrium.

**Patients and Methods**

From July 2001 to May 2002, 120 patients were screened for participation in this study within 3 days before they underwent open-heart surgery at Cardiovascular Surgery Department, Imam Khomeini Hospital, Tehran University of Medical Sciences. Inclusion criteria consisted of informed consent, age > 55 years, elective heart surgery requiring cardiopulmonary bypass, and normal sinus rhythm. Exclusion criteria included participation in another investigational protocol, presence of a permanent pacemaker, or the use of antiarrhythmic therapy other than beta-blockers, history of supraventricular (including atrial flutter or AF) or ventricular tachyarrhythmias, reoperation, patients with valvular heart surgery, and cardiogenic shock. All medications, including beta-blockers, were continued until surgery. Postoperatively, these medications were used according to clinical indications. Coronary artery bypass surgery was performed in all patients. Patients underwent CABG on standard cardiopulmonary bypass. Clinical data, lead parameter, and Holter data were collected and recorded in the database. Patients were randomly assigned to one of the following three groups: biatrial pacing (BAP), left atrial pacing (LAP), and no pacing (control group). On arrival in the Surgical Intensive Care Unit, the sensing and pacing thresholds of the pacing wires were measured. The configuration of atrial pacing for BAP was as follows: the LA pacing wire was connected to the negative pole of the pulse generator (Medtronic 5375, Medtronic), and the RA pacing wire was connected to the positive pole. For single-site atrial pacing, left or right atrial pacing wires were connected to the negative pole, and the pacing wire connected to skin (ground) was connected to the positive pole of the pulse generator. After completion of the surgical procedure, two temporary unipolar epicardial leads were attached to the right atrial appendage of the right atrium, and a second pair of epicardial leads was attached to the posteroinferior aspect of the left atrium between the coronary sinus and the right inferior pulmonary vein. Overdrive atrial inhibited pacing was initiated, with output programmed at 3 times the capture thresholds. Sensitivity was set at 1 mV. The lowest rate was 90 beats per minute or 10 beats above the intrinsic heart rate if it was > 90 beats per minute. The maximum pacing rate allowed was 120 beats per minute. Overdrive pacing was continued for 4 days, with continuous telemetry monitoring. The pacing and sensing thresholds were checked daily, and the output was adjusted accordingly. The 12-lead ECG was performed daily for 4 days at baseline and during pacing. The pacing wires were removed by simple transcutaneous retraction by the sixth day in the absence of a clinical end point. The ardiac surgery team directed the management of atrial fibrillation. Patients were reevaluated in the Cardiac Surgery Outpatient Clinic 4 weeks after surgery. In the immediate postoperative period, ECGs were obtained with 12 leads during normal sinus rhythm and atrial pacing.
respectively. Another variable that was calculated, was the P-wave duration (mean value of P-wave duration in each lead).

**Statistical analysis**

Continuous variables were expressed as mean ± SD. The means of the continuous variables were compared by two-tailed Student’s *t*-tests and discrete variables were compared using the χ² test. For univariate predictors associated with *P* < 0.1, stepwise logistic regression analysis was performed; the odds ratio and 95% confidence interval were calculated to ascertain significant predictors of AF. Linear regression models for length of hospital stay were performed to identify important independent predictors. *P* < 0.05 was considered statistically significant.

**Results**

There were 40 patients in each of the three study groups. The mean age was 61.79 ± 7.1 years, and 59.1% of patients were males. The mean ejection fraction was 45.9 ± 9.2. All clinical characteristics in each group were similar and well matched (Table 1). Beta-blockers administration before and after operation and mean maximum sinus rate per day were not statistically different. The prevalence of postoperative atrial fibrillation was significantly less in the patients randomized to BAP group when compared with the other two remaining groups (Figure 1). An episode of atrial fibrillation occurred in 7 (17.5%) of 40 patients in the BAP group compared with 12 (30%) of 40 patients in the LAP group (*P* = 0.02), and 18 (45%) of 40 patients in control group (*P* < 0.01). The first postoperative episode of atrial fibrillation occurred 2.5 ± 1.3 days after surgery in LAP group, 2.4 ± 1.6 days after surgery in control group, and 2.8 ± 0.7 days after surgery in BAP group (*P* = 0.5). The mean duration of atrial fibrillation was 6.9 ± 4.2 hours. There was no significant difference between the duration of atrial fibrillation between 3 groups (*P* = 0.3).

If AF was not converted spontaneously to sinus rate (SR), either pharmacological means or electrical cardioversion were used to restore SR before discharge. The mean hospital stay was 9.2 ± 4.0 days. The length of stay was most significantly reduced in BAP group (6.1 ± 1.2 versus 9.0 ± 4.1 days in the control groups; *P* = 0.002, and 8.7 ± 1.3 days in LAP groups; *P* = 0.01). The mean length of stay in the intensive care unit was also significantly reduced in the BAP group (2.8 ± 0.7 versus 4.6 ± 4.5 days in control group; *P* = 0.04, and 4.2 ± 3.2 days in LAP group; *P* = 0.01). Cerebral events (including stroke or transient ischemic attacks) occurred in 7 patients (5.8%). These events were significantly higher in those patients who developed AF (1.1% in SR group and 10.1% in AF group; *P* < 0.001). A good correlation was seen between AF and intensive care unit stay and

![Figure 1. Incidence of post-CABG AF in biatrial pacing (BAP), left atrial pacing (LAP), and control groups, *P* < 0.01.](image-url)
nursing ward stay. The mean costs of hospital stays in the BAP group was significantly reduced compared with the mean costs in the control group ($p < 0.05$). In our study the mean P-wave duration was significantly reduced with atrial pacing compared to control group (before pacing, BAP: 69.2 ms; LAP: 73 ms, and after pacing, BAP: 58 ms; LAP: 64.2 ms, respectively; $P < 0.01$) (Figure 2). At baseline, no significant difference was found in the mean P duration between patients who developed AF and those who remained in sinus rate for BAP and LAP group. However, only those patients who remained in SR had a significant reduction in mean P duration after pacing therapy (Figure 3). Postoperative complications in each group are presented in Table 2.

### Discussion

In previous studies it has been demonstrated that the use of beta-blockers and sotalol have a beneficial effect in the prevention of postoperative AF. Daoud et al showed that preoperative amiodarone therapy was effective in the reduction of postoperative AF. Medical therapy as a prophylactic agent against post-CABG AF may be limited by other medical factors, such as asthma, thyroid dysfunction, or liver function derangement. Biatrial pacing has been shown to prevent AF recurrence in patients with paroxysmal AF, but single-site pacing has not been proposed as an effective intervention in patients with AF. There have been some preliminary reports on the effectiveness of atrial pacing in preventing post-CABG AF. Our study compared biatrial pacing with single-site atrial pacing. Previous clinical trials have investigated the effect of double-site atrial pacing. The recent study had a design comparable to our study and reported a similar reduction in AF occurrence after CABGs. Biatrial pacing prevents AF by two mechanisms: 1) The common cause of initiation of AF is premature atrial beat, especially during sinus bradycardia. Biatrial pacing at a relatively high rate may result in suppression of atrial ectopy. 2) Atrial conduction delay and dispersion of atrial refractoriness serve as a predictor for reentry and initiation of AF. In our study, a triggered pacing mode was chosen to assure early activation of the atrial myocardium near the coronary sinus.

### Table 2. Postoperative complications in patients with biatrial pacing (BAP), left atrial pacing (LAP), and control groups.

<table>
<thead>
<tr>
<th>Complications</th>
<th>BAP ($n = 40$)</th>
<th>LAP ($n = 40$)</th>
<th>Control ($n = 40$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bleeding</td>
<td>2 (5)</td>
<td>1 (2.5)</td>
<td>2 (5)</td>
</tr>
<tr>
<td>Respiratory failure</td>
<td>1 (2.5)</td>
<td>1 (2.5)</td>
<td>1 (2.5)</td>
</tr>
<tr>
<td>Wound infection</td>
<td>1 (2.5)</td>
<td>Zero</td>
<td>1 (2.5)</td>
</tr>
<tr>
<td>Renal failure</td>
<td>1 (2.5)</td>
<td>1 (2.5)</td>
<td>1 (2.5)</td>
</tr>
<tr>
<td>Stroke/TIA</td>
<td>2 (5)</td>
<td>2 (5)</td>
<td>3 (7.5)</td>
</tr>
<tr>
<td>Perioperative MI</td>
<td>2 (5)</td>
<td>2 (5)</td>
<td>1 (2.5)</td>
</tr>
<tr>
<td>Pericardial effusion</td>
<td>1 (2.5)</td>
<td>1 (2.5)</td>
<td>1 (2.5)</td>
</tr>
</tbody>
</table>

* TIA = transient ischemic attack, MI = myocardial infarction.
Premature atrial conduction ceased in either the right or left atria and hence reduced atrial dispersion. Daoud’s study showed that biatrial pacing reduced the conduction delay and width of the right posterior interatrial septum caused by early premature atrial depolarization.  

The increased costs associated with the development of postoperative AF mainly due to prolongation of hospital stay. The study by Taylor et al showed that the most expensive post-CABG complications were respiratory failure and sternal wound infection, but these complications occurred in only 3% and 0.4% of patients, respectively. However, AF was the least expensive but the most common complication, occurring in 20% of patients. In our study, hospital stay and hospital costs were significantly reduced by biatrial pacing, compared to single site or no pacing groups. The technique of biatrial pacing was not associated with side effects. Identifying patients at risk for developing post-CABG AF and using biatrial pacing may be the optimal cost-effective strategy. Unfortunately, at the present time it is not possible to accurately predict post-CABG AF, so we recommend prophylactic biatrial pacing in all of the CABG cases with sinus rhythm. 

AF is commonly encountered post-CABG and results in an increase in both the length of hospital stay and the financial cost of this stay. An ideal prophylactic approach is one that is effective in a diverse patient population and is associated with minimal expense and risk. Biatrial pacing may be such a technique, and is more effective in preventing post-CABG AF than single-site atrial pacing and it results in a shortened length of hospitalization. This technique is not associated with a risk of ventricular arrhythmia, bradycardia, or hypotension, unlike antiarrhythmic agents. Identifying patients at risk for developing post-CABG AF and using biatrial pacing may be the optimal cost-effective strategy.

**References**

18. Fan K, Lee KL, Chiu CS. Biatrial pacing is more effective in preventing postoperative atrial fibrillation.