Suppression of Atrial Fibrillation after Coronary Artery Bypass Surgery through Temporary Atrial Epicardial Pacing

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Abstract

Background: Atrial fibrillation (AF) after coronary artery bypass graft surgery (CABG) constitutes the most common arrhythmia and results in morbidity and prolonged hospitalization secondary to hemodynamic decompensation. Although pharmacologic therapy has been used to help prevent postoperative atrial fibrillation, it suffers from limited efficacy and adverse effects. In the non-operative setting, novel pacing strategies have been shown to reduce recurrences of atrial fibrillation and prolong arrhythmia-free periods in patients with paroxysmal atrial arrhythmias.

Aim of the Study: Was to assess the role of different modalities of temporary epicardial pacing for postoperative AF prophylaxis.

Methods and Results: From November 2004 to March 2006, in Cairo University Hospitals (old and new hospital) 75 patients without structural heart disease and who underwent CABG were randomly classified into one of the following 3 groups:

- Biatrial pacing (BAP).
- Right atrial pacing (RAP) and no pacing (control).

Pacing was performed for 5 days immediately post-CABG. Atrial fibrillation was significantly reduced in the BAP group compared to RAP and control group (BAP, 16%; RAP, 28%; control, 44%; \( p \leq 0.04 \) and \( p \leq 0.02 \) respectively).

The mean length of stay in the intensive care unit (LOS ICU) and in the hospital (LOS HOS) were also significantly reduced in the BAP pacing group (2.8 ± 0.7 versus 4.6 ± 4.5 days in control group; \( p = 0.04 \), and 4.2 ± 3.2 days in RAP pacing group; \( p = 0.01 \)) and (6.1 ± 1.2 versus 9.0 ± 4.1 days in the control groups; \( p = 0.002 \) and 8.7 ± 1.3 days in RAP pacing groups; \( p = 0.01 \)) respectively.

Conclusions: 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 effective strategy.

Key Words: Atrial fibrillation (AF) – Pacing – Arrhythmia – Coronary bypass – Biatrial pacing (BAP) – Right atrial pacing (RAP).

Introduction

The pathogenesis of postoperative AF remains unclear and is presumably multifactorial. Fuller’s study showed the close association with the patient’s age and male gender [1]. Multivariate analysis showed no relationship with the aortic cross-clamp time, the volume of cardioplegia, the number of grafts, the presence of postoperative infarct, or the postoperative CK-MB level [2], although two studies have found a relationship between postoperative AF and the length of the operation [3]. Previous studies demonstrated that arrhythmia was caused by operative damage to the atrial myocardium, so one would expect AF to occur immediately after the operation. By contrast, AF develops most frequently on the second or third postoperative day. These observations suggest a different mechanism, such as inflammatory response with atrial edema, pericarditis, or reperfusion injury, rather than a direct ischemic insult [4,5]. The transient nature of this problem when seen after cardiac surgery suggests a reversible trigger; abnormal automaticity and atrial conduction delay are possible substrates. These would result in the occurrence of atrial ectopy and prolonged atrial activation, with lengthening of the P wave recorded by the ECG [6].

Supraventricular tachyarrhythmia such as atrial fibrillation (AF) or atrial flutter have been reported to occur in 20%-50% of patients after coronary artery bypass grafting (CABG) [7,8].

This results in significant morbidity including cerebrovascular accidents, thromboembolic complication and hemodynamic instability, with consequent increases in length of hospital stay and overall medical costs [17,18]. Although drugs such as beta blockers & Class III antiarrhythmic such as amiodarone have been proven to reduce the incidence of AF after CABG, they are not without
side effects that require withdrawal or holding of treatment due to early postoperative concerns [9,10]. Thus, there is progressive interest in nonpharmacological strategies to prevent AF after open heart surgery.

Continuous overdrive pacing was considered to be effective in promoting sinus rhythm in patients with paroxysmal AF refractory to drug therapy or whom patients that pharmacological treatment not legible [11,12]. Several studies have demonstrated that overdrive pacing can reduce the incidence of AF after open heart surgery [3,14].

This study was undertaken to assess the effects of biatrial overdrive pacing on AF after CABG.

**Patients and Methods**

From November 2004 to March 2006, Cairo University Hospitals (old and new hospital), 75 patients who underwent CABG were recruited for the overdrive pacing study. Patients were randomly assigned in a double-blind fashion immediately after surgery to 1 of 3 pacing modes:

- Biatrial pacing (BAP), Right atrial pacing (RAP) and No pacing (Control).

Exclusion criteria were concomitant valve or aortic surgery, presence of a permanent pacemaker or preoperative paroxysmal or chronic AF, emergency operation and post-CABG low cardiac output syndrome.

After completion of CABG and with the heart in sinus rhythm, pacing wires were attached to each atrium in BAP group One wire was attached to the right atrial appendage and the other to the roof of the left atrium just behind the superior vena cava and the aorta. The right atrial wire was assigned as the anode and the left atrial wire as the cathode this is in addition to epicardial right ventricular wires.

In patients assigned to RAP group, proximally one wire was attached to the right atrial appendage (anode) and one wire attached to chest wall (cathode) and distally connected to an external pacemaker generator. After surgery, the pacing and sensing thresholds were tested Sensitivity of the pacing was set at 0.25mV.

The external temporary pacemaker (Medtronic dual-chamber temporary pacemaker) was then programmed to AAI mode. The rate was set at 90 pulses per minute or 10 pulses above resting rate, to a maximum of 140 pulses per minute. The pacing protocol started immediately after surgery when the patient was settled in the intensive care unit. Serum potassium levels were maintained between 4.5 and 5.0mmol/La and serum magnesium above 1.3mmol /L1. Continuous rhythm monitoring was performed until the day of discharge from the hospital. The pacing protocol extended for 5 days during which, pacing thresholds were checked 8 to 12 hourly. Patients who were taking beta blockers preoperatively resumed soon after surgery when hemodynamic conditions allowed.

Atrial fibrillation or flutter was recorded if it persisted for more than 60 minutes or if it caused hemodynamic instability requiring antiarrhythmic treatment. Once the patient developed AF, pacing was discontinued. Pacing wires were removed on the 7th postoperative day. The endpoint of the study was the occurrence of AF during hospital stay.

**Statistical analysis:**

Continuous variables were expressed as mean ± SD. Continuous variables were compared by means of ANOVA tests and discrete variables were compared using the χ² test. p<0.05 was considered statistically significant.

**Results**

The patients in this study comprised 25 patients in BAP group, 25 patients in RAP group and 25 patients in control group, respectively.

The mean age in each group were BAP, 64.2±8.2; RAP, 65.6±6.2 and control, 63±8.5; p=0.1.

15 patients (60%) in BAP, 14 patients (56%) in RAP and 15 patients (60%) in control group were males.

All clinical characteristics in each group were similar and well matched (Table 1).

<table>
<thead>
<tr>
<th>Variables</th>
<th>BAP (n=25)</th>
<th>RAP (n=25)</th>
<th>Control (n=25)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>64.2±8.2</td>
<td>65.6±6.2</td>
<td>63±8.5</td>
<td>NS</td>
</tr>
<tr>
<td>Sex (male %)</td>
<td>60%</td>
<td>56%</td>
<td>60%</td>
<td>NS</td>
</tr>
<tr>
<td>Hypertension%</td>
<td>60%</td>
<td>64%</td>
<td>60%</td>
<td>NS</td>
</tr>
<tr>
<td>Dyslipidemia %</td>
<td>64%</td>
<td>64%</td>
<td>68%</td>
<td>NS</td>
</tr>
<tr>
<td>DM %</td>
<td>32%</td>
<td>28%</td>
<td>28%</td>
<td>NS</td>
</tr>
<tr>
<td>No. of coronary</td>
<td>2.7±0.3</td>
<td>2.8±0.3</td>
<td>2.7±0.4</td>
<td>NS</td>
</tr>
<tr>
<td>EF %</td>
<td>54±12</td>
<td>59±15</td>
<td>61±14</td>
<td>NS</td>
</tr>
<tr>
<td>Beta blocker intake</td>
<td>64%</td>
<td>60%</td>
<td>64%</td>
<td>NS</td>
</tr>
<tr>
<td>Cross clamp time minutes</td>
<td>60±22</td>
<td>55±32</td>
<td>52±40</td>
<td>NS</td>
</tr>
<tr>
<td>Bypass time (perfusion time)</td>
<td>108±35</td>
<td>110±44</td>
<td>95±39</td>
<td>NS</td>
</tr>
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</table>
Beta-blocker administration before and after operation and mean maximum sinus rate per day was not statistically different.

The prevalence of postoperative atrial fibrillation was significantly less in patients randomized to BAP group when compared with the other two remaining groups (Figs. 1, 2 & Table 2).

![Graph](image1)

**Fig. (1):** Incidence of post CABG AF in BAP and RAP group, \( p=0.04 \).

![Graph](image2)

**Fig. (2):** Incidence of post CABG AF in BAP and control group, \( p=0.02 \).

**Table (2):** Incidence of post CABG AF in BAP, RAP and control groups, \( p=0.2 \).

<table>
<thead>
<tr>
<th>Studied group</th>
<th>AF (number &amp; %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAP (25 patients)</td>
<td>4 (16%)</td>
</tr>
<tr>
<td>RAP (25 patients)</td>
<td>7 (28%)</td>
</tr>
<tr>
<td>Control (25 patients)</td>
<td>11 (44%)</td>
</tr>
</tbody>
</table>

An episode of atrial fibrillation occurred in 4 (16%) of 25 patients in the BAP group.

Compared with 7 (28%) of 25 patients in the RAP group \( (p=0.04) \) and 11 (44%) of 25 patients in control group \( (p=0.02) \).

The first postoperative episode of atrial fibrillation occurred 2.5 ± 1.3 days after surgery in RAP 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 were 6.9±4.2 hours in BAP, 6.1±2.8 hours in RAP and 7.2±1.6 in control group, \( (p=0.3) \).

If AF was not converted spontaneously to sinus rate (SR) in 48 hours either pharmacological treatment or electrical cardioversion was used to restore SR before discharge.

The mean length of hospital stay was most significantly reduced in BAP group (6.1 ± 1.2 versus 9.0±4.1 days in the control groups; \( p=0.01 \) and 8.7±1.3 days in RAP groups; \( p=0.02 \)).

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 RAP group; \( p=0.01 \)).

No thromboembolic or cerebral events (including stroke or transient ischemic attacks) had been occurred among the three studied groups.

**Discussion**

Atrial fibrillation is the most common postoperative complication following cardiac surgery \[1\]. Although it usually does not result in long-term squeals, it does add significantly to morbidity, utilization of hospital resources and length of hospitalization \[16\]. Treatment strategies have, until recently, centered on the use of pharmacologic therapy. Beta-blockers and class III antiarrhythmic agents have been shown to be effective in reducing the incidence of postoperative AF \[17,18\].

The limited efficacy of conventional agents has led to searches for nonpharmacological modalities for the prevention of postoperative AF. Coumel and colleagues \[19,20\] were among the first to report the potential of pacing to prevent AF almost a decade ago. They described the use of single-site atrial overdrive pacing to prevent AF or flutter in a selected group of patients with vagally mediated AF or flutter, \[20\]. Further studies by Murgatroyd et al. \[7\] utilized a unique pacing algorithm for suppression of atrial premature depolarizations. This technique resulted in a significant reduction in episodes of AF. The mechanism by which atrial overdrive pacing reduces the occurrence of AF is unclear, although suppression of atrial premature
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depolarizations and a reduction in the dispersion of refractoriness have all been proposed [22,23].

In the majority of cases, the onset of post-CABG AF was within 72 hours postoperatively, which is consistent with other reports [24,25]. Therefore, the duration of atrial pacing in our study protocol would have adequately covered the potential onset of post-CABG AF. Placement of the pacing wire at the left atrial roof was well tolerated. We did not encounter the side effect of phrenic nerve stimulation which was reported when the wire was placed near the interatrial groove and the right pulmonary veins [26].

The use of BAP was shown by Daubert and associates [27] to be effective in the prevention of atrial arrhythmias in patients with interatrial conduction block. By simultaneous stimulation from the right atrial appendage and the coronary sinus, the use of BAP was believed to resynchronize the atrial electrical activity and reduce intraatrial and interatrial asynchrony.

Medical therapy as a prophylactic agent against post-CABG AF may be limited by other medical disease, such as asthma, thyroid dysfunction, or hepatic dysfunction [28,29]. Biatrail pacing has been shown to prevent of AF recurrence in patients with paroxysmal AF [28, 30-35]. Another study demonstrated that single-site pacing has not been effective in patients with AF [36].

Our study was designed to compare Biatrail pacing with single-site atrial pacing and no pacing. Biatrail pacing is proved to prevent AF by two mechanisms:

1- The common cause of initiation of AF is premature atrial beat, especially during sinus bradycardia. Biatrail pacing at a relatively high rate may result in suppression of atrial ectopy [37,38].

2- Atrial conduction delay and dispersion of atrial refractoriness serve as a predictor for reentry and initiation of AF [37,38].

In our study, a triggered pacing mode was chosen to assure early activation of the atrial myocardium near the coronary sinus in response to premature atrial conduction sensed in either the right or left atria and hence reduce atrial dispersion. Taylor et al., 1990 showed that the most expensive complications post-CABG were respiratory failure and sternal wound infection, but occurred in only 3% and 0.4% of patients, respectively. However, AF was least expensive but most common complication, occurred in 20% to 40% of patients [39].

In our study hospital stay was significantly reduced by Biatrail pacing, compared to single site or no pacing groups. Despite these benefits this technique was not associated with side effects. Identifying patients at risk for developing post-CABG AF and using biatrial pacing may be the optimal effective strategy.

Conclusion:

AF is commonly reported post-CABG and results in an increased length of hospital.

Stay and cost. An ideal prophylactic approach against AF should be effective in wide number of patients population and associated with minimal expense and side effects.

Biatrail pacing may be such a technique and is more effective in preventing of post-CABG AF than single-site atrial pacing and no pacing group 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 effective strategy.

References


