Prevention of atrial fibrillation after cardiac valvular surgery by epicardial, biatrial synchronous pacing

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Received 15 July 2003; received in revised form 19 September 2003; accepted 21 September 2003

Abstract

Objective: Postoperative atrial fibrillation (AF) after cardiac surgery is a frequent complication after valvular surgery (30–60%). The purpose of this prospective, randomized study was to determine if biatrial synchronous pacing reduces postoperative AF after cardiac valvular surgery as compared to conventional therapy. Methods: Eighty patients subjected to valvular surgery (52 men, age 66 ± 10 years) were randomized to one of two groups: one group was treated with biatrial, synchronous pacing (BAP) for 72 h postoperatively (n = 40) the other group received no atrial pacing (controls; n = 40). All patients had one pair of epicardial wires attached to the right atrium. An additional electrode was placed to the left atrium in the BAP group. These patients were continuously paced at a rate of 10 beats per minute higher than the intrinsic rate starting immediately after surgery. All patients were monitored with full disclosure telemetry or Holter monitors to identify onset of AF. Results: Eighteen of the 40 patients in the control group (45%) developed AF within the first 3 days postoperatively as compared to eight patients (20%) in the BAP group (P = 0.02). No complications occurred associated with the placement, maintenance and removal of the atrial pacing electrodes. Conclusions: Temporary, biatrial synchronous pacing during the first 3 postoperative days is safe and has a significant rhythm-stabilizing effect in patients undergoing valvular cardiac surgery.

Keywords: Arrhythmia; Atrial fibrillation; Pacing; Cardiac surgery; Heart valve replacement

1. Introduction

Atrial fibrillation (AF) is the most common arrhythmia observed after cardiac operations with an incidence of 30–60% [1–4]. Although postoperative mortality seems not to be affected by this complication, AF can lead to hemodynamic compromise, bears the risk for thromboembolic events and frequently necessitates the use of antiarrhythmic drugs [1,5,6]. Duration of ICU-stay and of overall hospitalization may be prolonged by this complication, which contributes substantially to increased costs [1–3]. The incidence of AF after cardiac surgery is influenced by various factors such as type of cardiac surgery, age of the patient and perioperative treatment or withholding of betablockers [1,3,4,7–10]. A recent review article on AF after cardiac surgery exemplified the extent of this problem [4]. Age has been repeatedly shown to be the major risk factor for atrial fibrillation after cardiac surgery [1,3,7]. The persistently high incidence of this complication over the past decades despite progress in surgical techniques and anesthesia can be explained by the increasing age of patients. Among the different types of cardiac operations, the combination of coronary artery bypass grafting (CABG) and valve procedures has the highest incidence reaching 62% [4].

Trials of prophylactic treatment with antiarrhythmic agents to prevent AF after cardiac surgery showed variable efficacy [11–13]. Substances with proven benefit such as amiodarone, sotalol and procainamide also have a substantial potential for adverse effects limiting their use for prevention of arrhythmias [8,11–16]. Because of the many drawbacks involved in pharmacological prophylactics, the development of other non-pharmacological strategies to prevent postoperative AF are of great interest.

Chronic biatrial or dual site atrial pacing has been shown to stabilize sinus rhythm in some patients with paroxysmal AF who are refractory to drug therapy [17].
Prophylactic biatrial pacing has been studied in several trials as a non-pharmacological intervention to prevent postoperative AF after CABG [18–22]. The results of different studies are conflicting, ranging from a significant benefit to proarrhythmic effect [18–22]. The aim of our prospective, randomized controlled study was to investigate the role of biatrial synchronous pacing via temporary epicardial electrodes during the first 3 days after valvular surgery on the incidence of postoperative AF as compared to conventional therapy.

2. Material and methods

2.1. Patient population

Eighty consecutive patients in sinus rhythm undergoing valvular surgery (e.g. aortic valve replacement, mitral valve replacement, mitral valve repair, and tricuspid valve repair) with or without CABG were enrolled in the study. Exclusion criteria were a history of atrial fibrillation in the past or prior antiarrhythmic treatment with amiodarone, sotalol, propafenon, quinidine or diltiazem. Also excluded from evaluation were patients with permanent pacemakers, patients undergoing reoperation as well as those with significant electrolyte disorders upon admission or with known hyperthyroidism. Potassium levels were held above 4.0 mmol/l in all patients during the entire postoperative period. After obtaining written informed consent eligible patients were randomized between biatrial synchronous stimulation and conventional management. Detailed clinical data were obtained from all patients. The study protocol was approved by the institutional ethics committee.

2.2. Study protocol

One day before surgery, left atrial size was assessed by two-dimensional echocardiography and the electrocardiographic P wave length was determined. During surgery all patients had two temporary epicardial pacing leads (Medtronic Inc., Minneapolis, MN) placed at the lateral wall of the right atrium (standard technique). In patients randomized into the treatment group one additional pacing lead was attached to the left atrium, between the insertion of the pulmonary veins. This lead functioned as the cathode for left atrial stimulation. After surgery, pacing and sensing thresholds were determined for the left and right atrium separately. Biatrial synchronous pacing was achieved in the AAI mode with an external pulse generator (Biotronik EDP 30/A, Biotronik GmbH and Co, Berlin, Germany) by insertion of both cathodes together in the negative pole of the pulse generator. Output was programmed at three times the upper pacing threshold, sensing at the lowest possible value (0.1 mV). The presence of biatrial capture was confirmed by P wave morphology in the surface ECG. The pacing rate was set at 10 beats/min above the underlying rhythm and was repeatedly corrected up to a maximum pacing rate of 110/min. BAP was maintained for the first 72 h after surgery. Immediately postoperatively all patients were monitored in the intensive care unit for at least 24 h. During this time all arrhythmias were recorded on rhythm strip and documented in the bedside chart. When transferred to the floor, rhythm monitoring continued either by telemetry or Holter ECG up until 72 h postoperatively. Right atrial pacing was allowed in the control group for hemodynamic reasons in patients with a heart rate <80/min or in hypotensive patients requiring catecholamines. All epicardial leads were removed by standard technique (transcutaneously) before discharge.

2.3. Outcome measures

The main outcome measure was the occurrence of AF during the first 72 h after surgery. AF had to be sustained for at least 2 min to qualify as an endpoint. The documented episodes of AF were confirmed by two independent physicians. The time interval between surgery and the occurrence of AF and the need for therapeutic interventions were recorded. Secondary endpoints were presence or absence of sinus rhythm and the use of antiarrhythmic therapy upon discharge.

2.4. Statistical analysis

All analysis were done on an intention to treat basis. Student’s unpaired, two-tailed t-test was used to compare continuous variables. The distribution of categorical variables was compared with the chi-square test. P values <0.05 were considered significant. Kaplan–Meier analysis was used to compare the probability of remaining in sinus rhythm in the biatrial pacing group compared with the control group.

3. Results

3.1. Patient characteristics

Between February 2000 and July 2002 a total of 83 patients were included in the study. Three patients had to be excluded due to total loss of capture and therefore inability of biatrial pacing immediately postoperatively (possibly due to dislodgement of electrode). Fifty-two of the remaining 80 patients were men (65%) and the mean age was 66 ± 10 years. There was no significant difference observed in the patient characteristics of the two groups (Table 1). In particular, there was no difference in regard to patient age, preoperative p-wave length, left atrial size and treatment with betablockers (Table 1).

Among all surgical procedures the largest fraction underwent aortic valve replacement (AVR) alone (N = 35, 44%) followed by 27 AVR combined with...
In the group treated with BAP the incidence of AF within the first 3 postoperative days was significantly lower with eight of 40 (20%) as compared to 18 of 40 (45%) among controls \((P = 0.02)\).

The highest incidence of AF occurred on the second postoperative day. This applied for patients in the BAP group as well as for controls. The first occurrence of AF was 24–48 h postoperatively in 11 of 18 (61%) patients in the control group and in five of eight (63%) patients in the BAP group (Fig. 1). In patients pretreated with betablockers BAP was particularly effective in preventing AF: in the pacing group (six on sotalol, one on amiodarone, \(P = 0.015\)). One patient in the BAP group had successful DC-cardioversion and remained in sinus rhythm without antiarrhythmic treatment. No complications occurred associated with the placement, maintenance and removal of the atrial pacing electrodes. There was no mortality in both groups.

### 4. Discussion

Our study showed that prophylactic, biatrial synchronous pacing significantly reduces the incidence of postoperative AF in patients after valve surgery by half without any adverse effects. Consequently the potentially negative
hemodynamic effects of this arrhythmia were avoided in a significant proportion of patients in the BAP group. Upon discharge, fewer patients of the group treated prophylactically with biatrial pacing were still on an antiarrhythmic drug than controls. During the first 24 h postoperatively no difference is observed between paced patients and controls. In both groups more than 60% of all episodes of AF occurred between 24 and 48 h postoperatively (Fig. 1). Biatrial pacing during the first 24 h is of uncertain benefit. However, our data support an extension of biatrial pacing to the full length of 72 h postoperatively. No complications occurred with the temporary epicardial leads and the synchronous biatrial pacing was well tolerated. The total time of surgery was not affected by attaching the left atrial lead.

4.1. Mechanisms explaining antiarrhythmic effect of biatrial pacing

Some electrophysiologic effects unrelated to pacing site may contribute to the rate stabilization of postoperative atrial pacing. The prevention of bradycardia has an antiarrhythmic potential by several mechanisms. Overdrive suppression of atrial premature beats arising from automatic foci is used to prevent AF in permanent pacing [23]. The negative consequences of compensatory pauses are avoided by the same mechanism [24]. The occurrence of so-called 'long–short cycles' or 'short–long–short cycles', which frequently act as a trigger for AF can be eliminated. Simultaneous biatrial pacing helps in addition to correct temporal dispersion of left and right atrial action potentials and refractory periods and promotes inter-atrial synchrony [17].

4.2. Technical considerations

The successful maintenance of biatrial pacing depends on various factors. Careful surgical technique while placing the epicardial leads is of utmost importance to achieve good pacing thresholds and avoid complications. In some patients diaphragmatic stimulation and loss of capture may occur. This is most likely due to anatomical reasons. Pacing the left atrium generally is more difficult than right atrial pacing. The external pacemaker used must have excellent atrial sensing capabilities to avoid any proarrhythmogenic effect due to sensing failure [22]. Deterioration of pacing threshold may occur with temporary epicardial leads early in the postoperative period. Daily assessment of pacing threshold of both right and left atrial electrode separately is advisable. Otherwise loss of capture, particularly of the left atrium, may go unnoticed on the continuously monitored surface ECG.

4.3. Previous studies

Several randomized controlled trials over the last years showed ambiguous results with BAP in patients after CABG [18–22]. The outcome in patients treated postoperatively with BAP ranged from a higher incidence of AF to significant reduction of this arrhythmia. Kurz et al. outlined several possible technical problems associated with biatrial pacing [22]. Loss of atrial detection or left atrial lead displacement may seriously hamper the success of biatrial pacing or even lead to a serious proarrhythmic effect. Close monitoring, particularly of the left atrial lead, is essential to ensure the efficacy of BAP. Two studies by Gerstenfeld et al. and Greenberg et al. did not demonstrate a benefit of biatrial pacing in patients after CABG [18,20]. In Gerstenfeld’s study neither right atrial pacing nor biatrial pacing showed a benefit over the control group (no atrial pacing). However, the author noted that frequency of AF episodes in a subgroup of patients treated with betablockers was significantly lower in the paced groups than in the control groups. Greenberg et al. reported right atrial pacing in the first 4 days after CABG to be superior over left atrial pacing, biatrial pacing and no atrial pacing. Levy et al. demonstrated a significant reduction of AF due to postoperative biatrial pacing when compared to controls and Fan et al. found in a similar patient group BAP to be superior compared to left atrial pacing, right atrial pacing and controls [19,21]. All of these trials focused on patients after CABG. Patients subjected to valvular surgery have not been investigated in any of these studies. As mentioned earlier the preventive effect of atrial pacing may be enhanced by drug therapy [18]. The DAPPAF study provided an important insight that concomitant class I or III antiarrhythmic treatment improved the suppression of AF in patients on dual-site right atrial pacing [25]. For methodological reasons we excluded patients on these antiarrhythmic drugs. In daily postoperative care, based on these study results, it seems reasonable to use a combined preventive approach to suppress AF in patients at highest risk.

4.4. Study limitations

For practical purposes a blinding of our study was not possible. However, all arrhythmias were documented by continuous ECG Holter recording and reviewed by two independent physicians. We excluded patients with history of paroxysmal or recurrent AF, patients requiring redo-operations and patients undergoing MIDCAB (minimally invasive direct coronary artery bypass) or off-pump operations. Therefore, our study-results cannot be extrapolated to these particular patient groups. Whether an additive effect could be achieved by combining BAP with prophylactic antiarrhythmic treatment, e.g. with amiodarone would have to be tested. Our results were obtained in patients with frequent (30%) pretreatment with betablockers. It was also not an aim of our study to assess the influence of BAP on length of ICU- and total hospital stay, as well as possible reduction of costs. This must be addressed in a larger, specially designed study.
5. Conclusions

Biatrial, synchronous pacing for 3 days significantly reduced the incidence of AF after cardiac valvular surgery without adverse events. This non-pharmacological measure helps to decrease the incidence of this common arrhythmia and therefore to reduce the need for antiarrhythmic drugs.

Acknowledgements

We would like to acknowledge the efforts of the entire team of the Department of Cardiovascular Surgery and Cardiology. The study would not have been possible without the dedicated efforts of ICU-staff and the anesthesiologists of the Triemli Hospital.

References