Posterior Pericardiotomy Reduces the Incidence of Atrial Fibrillation, Pericardial Effusion, and Length of Stay in Hospital after Coronary Artery Bypasses Surgery

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Artrial fibrillation is the most common arrhythmia that occurs after coronary bypass grafting operation with the rate of 30%. Atrial fibrillation is associated with hemodynamic instability, strokes, and prolonged hospital stay. Pericardial effusion is a risk factor for atrial fibrillation after cardiac surgery, and it occurs commonly in the posterior area during the post-operative period. The aim of this prospective study was to demonstrate the effectiveness of posterior pericardiotomy in reducing the incidence of atrial fibrillation. This prospective randomized study was carried out on 425 patients undergoing a coronary artery bypass grafting in our clinic between August 2009 and February 2011. There were 276 male patients and 149 female patients. These patients were randomly divided into two groups; posterior pericardial incision was performed in 213 patients (pericardiotomy group), while any pericardial incision was not performed in 212 patients (control group). Atrial fibrillation occurred more frequently in control group (62 patients, 14.6%), compared to the pericardiotomy group (14 patients, 3.1%; \( p < 0.0001 \)). The incidences of early pericardial effusion, late pericardial effusion, and tamponade were also significantly higher in control group. Moreover, posterior pericardiotomy was associated with the decreases in the duration of stay in hospital and intensive care unit. In fact, the total hospital costs were lower in the pericardiotomy group. In conclusion, posterior pericardiotomy is an effective and safe technique that reduces early pericardial effusion, atrial fibrillation, length of stay in hospital, and hospital costs after the coronary artery bypasses grafting.

Keywords: atrial fibrillation; coronary artery bypass surgery; hospital cost; pericardial effusion; posterior pericardiotomy

After a coronary bypass grafting operation (CABG), the most common arrhythmia is atrial fibrillation (AF), at the rate of 20-30% (Pires et al. 1995; Evrard et al. 2000). It is associated with hemodynamic instability, prolonged hospital stay, strokes, and increased costs (Arbatli et al. 2003; Lahtinen et al. 2004; Burgess et al. 2006). The pathogenesis of AF after cardiac surgery is multi-factorial, and the mechanisms are still largely unknown. An increase in circulating catecholamines, heightened sympathetic and parasympathetic tone, atrial stretch, trans-cellular fluid and electrolyte shifts, metabolic abnormalities, inflammation, and pericarditis are believed to be the important factors contributing to AF after cardiac surgery (Arbatli et al. 2003; Rho et al. 2009).

Pericardial effusion, especially in the posterior area, occurs commonly in the post-operative period. It is often small in amount and benign, but can be circumferential and quite large which may impede cardiac filling, reduce cardiac output, and lead to tamponade. It can also be regional and located in a strategic area, incrming the development of AF after CABG (Angelini et al. 1987). Previous reports have dealt with the clinical features and management of this problem and have emphasized the high mortality rates associated with delayed treatment (Borkon et al. 1981; Sahni et al. 1991; Chuttani et al. 1994).

Posterior pericardiotomy is considered a method that reduces the risk of AF, inasmuch as it allows the drainage of pericardial blood/effusion into the left pleural space, reducing the incidences of pericardial effusion, which may trigger AF (Mulay et al. 1995; Arbatli et al. 2003; Biancari and Mahar 2010).

The aim of this prospective, randomized trial was to test the hypothesis that posterior pericardiotomy reduces the postoperative incidences of arrhythmia by improving pericardial drainage. In addition, we examined the effect of posterior pericardiotomy in terms of pericardial effusion,
length of hospital stay, and hospital costs after CABG.

Materials and Methods

Patient Population

Between August 2009 and February 2011, 500 coronary artery bypass operations were performed at the Erzurum Regional Training and Research Hospital Cardiovascular Surgery Department. This study was carried out meticulously, and reporting was done on the randomization and blinding methods employed. The 425 patients (276 male, 149 female: average age 58.8 ± 11.3 in male, 59.0 ± 11.3 in female) were studied in this prospective randomized study. Ethical permission was given by the Erzurum Region Training and Research Hospital ethics committee, and informed written consent was obtained from all participants and/or parents or guardians. The Hospital Ethical Committee Permission was obtained prior to commencement of the study. Furthermore, all procedures were carried out in accordance with the Declaration of Helsinki.

A 4-cm circular incision was made parallel and posterior to the left phrenic nerve, extending from the left inferior pulmonary vein to the diaphragm in posterior pericardiectomy group (PP group; 213 patients) as described by Mulay and colleagues (Mulay et al. 1995) (Fig. 1). The pericardiectomy was not performed in conventional treatment group (control group; 212 patients). Two chest tubes (left pleural cavity and anterior mediastinum) were inserted into the pericardium. No drains were placed behind the heart in either group, thereby avoiding tube-induced arrhythmias.

The patients who had AF and ventricular rhythm problems before the operation and renal failure, left ventricular aneurysm, chronic obstructive pulmonary disease, severe left ventricular dysfunction, hyperthyroidism, valvular heart disease, and bleeding disorders were not included in the study. In addition, the patients with rhythm problems and valvular pathologies using orally anti-coagulant and with more than two drainage tubes installed, and those who required surgery, except for isolated CABG surgery, were also not included in the study.

Operative Procedure

All operations were performed with the use of an intermittent global ischemia with the systemic temperature allowed between 32-34°C. Anesthetic medication and surgical techniques were applied to both groups using the same procedure. The cardiopulmonary bypass was initiated with a roller pump, (Maquet, Jostra HL-20, Solna, Sweden) a non-pulsatile flow between 2.0 and 2.4 lt/m² per min, and a membrane oxygenator (Dideco, Sorin Group, Mirandola, Italy). The activated clotting time was more than 480 seconds. The arterial pressure was maintained at 50-70 mmHg. A single cross-clamp, antegrade and retrograde blood cardioplegia was used, which was repeated every 20 min with a hot shot before the removal of the cross-clamp. Heparin was reversed by protamine at the end of the cardiopulmonary bypass. The left pleural cavity was opened down to the phrenic nerve in all the patients in order to ensure better drainage of the pericardium into the pleura, but patients with dense adhesion of the left lung were excluded. The left internal thoracic artery was the graft of choice for the left anterior descending coronary artery in all the patients, and the saphenous vein grafts for the other anastomosis. After the removal of the cross clamping, the posterior pericardiectomy was performed on the PP group patients. The demographical features of the patients were shown in Table 1 before the operation.

In all patients, two drainage tubes were inserted into the space of a 32 F drainage left thorax and a 30 F drainage anterior mediastinum. The blood loss was recorded until the drain removal the following day. The average 20 mm Hg continuous absorbing pressure was applied for drainage. Chest tubes were removed the following day when the drainage was less than 20 ml/h for a consecutive 4 h. The presence of pericardial effusion was assessed by a two-dimensional echocardiography, which was performed in postoperative days 1 and 5, before discharge (early pericardial effusion and tamponade) and 1 month after discharge (late pericardial effusion). Any effusion image greater than 1 cm in echocardiogram was considered as significant between the epicardial and pericardial surfaces. Perioperative data are depicted in Table 2.

Charges Data

Hospital charges are obtained through the hospital billing department as reported to our hospital authorities. These represent all hospital charges for the index admission only and include charges incurred during the operation. The charges data is divided into the following categories: routine charges, operating room facility use, operating room supply use, pharmaceutical charges, laboratory charges, radiology charges, physical therapy charges, etc. Disposable supply costs are based on actual acquisition costs. The labor costs for nurses, technicians, fellows, residents, secretaries, orderlies, and other personnel are derived directly from actual salaries and include benefits. All costs were calculated per patient and presented in U.S. dollars.

Statistical Analysis

Statistical analysis was performed with SPSS software version 17.0 (SPSS Inc., Chicago, IL). Clinical data are shown as the mean ± s.d. Student “t”-test, χ² test, and the Fisher’s exact test were used as indicated. The differences were considered to be significant for p value < 0.05.

Results

The groups were corresponded in terms of age, sex,
beta-blockers use, LV function, risk factors, and unstable angina pectoris. There was no statistically significant difference in terms of preoperative features (Table 1). Smoking was the highest as a risk factor among patients (31.8%). Unstable angina pectoris (25.6% and 24.5%) and pre-operative myocardial infarction (26.3% and 25.2%) occurred in both groups at almost equal rates. The groups were similar with respect to the number of grafts (including the use of internal thoracic), ischemic time, total perfusion time, usage of retrograde cardioplegia (a solution which is used to stop and to protect the heart), the number of endarterectomy (the cleaning the plaque in coronary artery), and internal thoracic artery usage (Table 2).

There was no statistically significant difference in the amounts of bleeding, blood products use and drainage, the duration of extubation, reoperation for bleeding control, per-operative myocardial infarction, sternal dehiscence, exitus, low cardiac output syndrome, and intra-aortic balloon pump usage in the groups (Table 3). Most of the reoperations were undergone due to bleeding from a side branch of the internal thoracic artery. The groups were similar with regard to the duration of mechanical ventilation. There were three and four hospital deaths in PP and control groups, respectively, because of low cardiac output. The intra-aortic balloon pump was generally inserted into the patients with preoperative myocardial infarction. One patient with the intra-aortic balloon pump in both groups died; others recovered and were discharged from hospital.

AF attacks disrupting the hemodynamic and requiring medical treatment developed in 62 patients (14.6%) in control group, and in 14 patients (3.1%) in PP group. All AFs were seen in the first two days after the operation, mostly on the second (48 patients) and first (14 patients) postoperative days. When the two groups were compared with respect to AF, there was statistically significant difference as \( p < 0.0001 \) (Table 3). Arrhythmias were also significantly more commonly associated with the presence of pericardial effusion. There was no re-occurrence of AF with anti-arrhythmic therapy, and none of the patients needed electrical cardioversion. The pleural effusion requiring intervention was higher in PP group (59 patients, 13.8%) than control group (32 patients, 7.5%) (Table 3). There was a statistically significant difference in pleural effusion between the groups \( (p = 0.002) \). Early pericardial effusion detected by the echocardiography was significantly higher in control group (46 patients; 10.8%) \( (p < 0.001) \). Late pericardial (more than 30 days after operation) effusion was also common in control group (32 patients; 7.5%). We did not encounter tamponade in PP group, whereas cardiac tamponade occurred in seven patients (1.6%) of control group \( (p = 0.007) \).

The duration in the intensive care unit (> three days)
and in hospital (> seven days) was longer in control group compared to PP group ($p < 0.001$ for each, Table 3). Because pericardial effusion, AF, period in intensive care and hospital stay were less in number in PP group than control group, the hospital costs were significantly lower for PP group than control group ($>$ $5,000$ costs for 28 patients in control group) ($p = 0.012$).

### Discussion

Although CABG surgery is now relatively common, there are still a number of well-known potential complications such as arrhythmia, pericardial effusion and tamponade. After cardiac surgery, the pericardial effusions can accumulate in the space around the heart; sometimes more than others. Pericardial effusions have been determined at a rate of 85% after open-heart surgery. The advanced progressive pericardial effusion is associated with high rates of morbidity and mortality (Kuvin et al. 2002; Arbatli et al. 2003). The surrounding cardiac pericardial effusions may be responsible for supra-ventricular arrhythmias, such as AF, and tamponade after cardiac surgery.

Generally, the cause of postoperative AF is not entirely clear, and the development of atrial fibrillation is not dependent on one single cause. AF is a common complication following CABG and has occurred in up to 20-30% of cases, in different studies, with major occurrences generally two days after surgery (Fuller et al. 1989; Curzen and Poole-Wilson 1994; Pires et al. 1995; Evrard et al. 2000; Biancari and Mahar 2010). Many etiologic factors have been emphasized as age, the correct coronary artery involvement, atrial dilatation, hyperthyroidism, left ventricular aneurysm/aneurysmectomy, additional valve surgical procedures, peri-operative myocardial infarction, low cardiac output, renal failure, respiratory complications and lately pericardial effusion in the development of AF (Mendes et al. 1995; Savelia and Camm 2001; Zarse et al. 2002). In order to prevent arrhythmias and tamponade, which may develop as a result of the pericardial effusion, the idea of pericardiotomy has been suggested in some studies over the last decade (Mulay et al. 1995; Kuralay et al. 1999; Ekim et al. 2006). These studies have demonstrated a dramatic reduction in the incidences of pericardial effusion and AF with a posterior pericardial incision. Asimakopoulos et al. (1997) have shown that pericardiectomy was more effective for pericardial drainage, but have also shown that AF prevalence were not significantly reduced (20%) in comparison with conventional techniques (26%). In our study, the incidence of AF was statistically different in the two groups; namely, AF occurred in 14 patients (3.1%) in the PP group and in 62 patients (14.6%) in the control group. Thus, AF prevalence is significantly lower in the PP group.

The anti-arrhythmic effect of posterior pericardiotomy was associated with a significant reduction in the incidence

### Table 3. Postoperative data between groups.

<table>
<thead>
<tr>
<th></th>
<th>PP group</th>
<th>Control group</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>First 24 hours amount of drainage &lt; 500 cc</td>
<td>193</td>
<td>194</td>
<td>0.877</td>
</tr>
<tr>
<td>First 24 hours amount of blood transfusion &lt; 400 cc</td>
<td>180</td>
<td>180</td>
<td>1.000</td>
</tr>
<tr>
<td>Early pericardial effusion</td>
<td>10</td>
<td>46</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Late pericardial effusion LV posterior &gt; 1 cm fluid image</td>
<td>2</td>
<td>32</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Tamponade</td>
<td>0</td>
<td>7</td>
<td>0.007</td>
</tr>
<tr>
<td>Pleural effusion requiring intervention (&gt; 1,000 cc)</td>
<td>59</td>
<td>32</td>
<td>0.002</td>
</tr>
<tr>
<td>Revision for bleeding</td>
<td>13</td>
<td>15</td>
<td>1.000</td>
</tr>
<tr>
<td>Perioperative MI</td>
<td>5</td>
<td>4</td>
<td>0.503</td>
</tr>
<tr>
<td>Low cardiac output</td>
<td>12</td>
<td>12</td>
<td>0.995</td>
</tr>
<tr>
<td>IABP usage</td>
<td>24</td>
<td>25</td>
<td>0.986</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>14</td>
<td>62</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Duration of stay in ICU &gt; 3 days</td>
<td>25</td>
<td>51</td>
<td>0.001</td>
</tr>
<tr>
<td>Hospitalization time &gt; 7 days</td>
<td>28</td>
<td>71</td>
<td>0.012</td>
</tr>
<tr>
<td>Charge (as dollar) &gt; 5,000 $</td>
<td>12</td>
<td>28</td>
<td>1.000</td>
</tr>
<tr>
<td>Prolonged extubation</td>
<td>25</td>
<td>24</td>
<td>0.865</td>
</tr>
<tr>
<td>Pulmonary complications</td>
<td>41</td>
<td>38</td>
<td>0.910</td>
</tr>
<tr>
<td>Sternal dehiscence</td>
<td>11</td>
<td>9</td>
<td>0.724</td>
</tr>
<tr>
<td>Exitus</td>
<td>3</td>
<td>4</td>
<td>0.071</td>
</tr>
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</table>

Late echocardiographic findings after one years

<table>
<thead>
<tr>
<th></th>
<th>PP group</th>
<th>Control group</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EF&gt; 50</td>
<td>122</td>
<td>124</td>
<td>0.878</td>
</tr>
<tr>
<td>3˚ Mitral deficiency</td>
<td>15</td>
<td>16</td>
<td>0.511</td>
</tr>
<tr>
<td>Ventricular hypertrophy</td>
<td>64</td>
<td>70</td>
<td>0.910</td>
</tr>
</tbody>
</table>

ICU, Intensive care unit; LV, Left ventricle; MI, Myocardial infarction.
of early and late pericardial effusion. It is likely that the reduced risk of AF after posterior pericardiotomy is due to decreased pericardial effusion, which may trigger postoperative supra-ventricular arrhythmias. The mechanisms by which pericardial effusion may lead to these arrhythmias are not clear. We can only speculate that a certain amount of fluid/hematoma into the pericardium may represent a mechanical stimulus to the atria, whose function can be affected by external compression.

Our study demonstrated a significantly greater pleural drainage in the PP group (59 patients) compared to the control group (32 patients), which implies that this results in more effective pericardial drainage ($p = 0.002$). Thus, this method provides an effective pathway of drainage to the pleural cavity of pericardial blood/effusion, which otherwise would have been collected in the pericardium and compressed the heart, which reduces the incidences of AF. It is unlikely that an increase in drainage is the result of bleeding from the pericardial incision. Although there was increased pleural effusion in PP group, pulmonary complications and prolonged extubation were not significantly more frequent in the pericardiotomy group.

The efficacy in preventing AF after CABG surgery has been evaluated in the meta-analysis (Biancari and Mahar 2010). Their meta-analysis indicates that posterior pericardiotomy markedly reduces the incidences of AF and supra-ventricular arrhythmias after CABG (Biancari and Mahar 2010). They analyzed six prospective randomized studies and reported on postoperative AF in 763 patients after CABG. The cumulative incidences of AF were 10.8% in the posterior pericardiotomy group and 28.1% in the control group. Early pericardial effusion and late pericardial effusion were significantly less frequent in the posterior pericardiotomy group. The result of our study was consistent with Biancari’s study. Our study suggested that adding posterior pericardiotomy during CABG seems to reduce the incidence of postoperative AF. The marked reduction of postoperative pericardial effusion observed after posterior pericardiotomy suggests that the former is one of the main triggers of AF occurring after cardiac surgery. In addition, early and late pericardial effusions were less in the posterior pericardiotomy group in our study as in Biancari’s Meta analysis.

The increased chest drainage in the posterior pericardiotomy group and the results obtained from the echocardiographic follow-up confirmed that this maneuver results in a more effective pericardial drainage. Although Yorgancioglu et al. (2000) experienced the protrusion of a sequential graft from the posterior pericardiotomy side; posterior pericardiotomy is a technically easy, safe and effective technique that does not add any morbidity to the patient and any harm to the surgeon without complications. Also, the potential risk of cardiac herniation, and bypass grafts after CABG, can protrude through and be squeezed by the edges of the posterior pericardiotomy (Yorgancioglu et al. 2000). These complications are likely to be minimized by performing a limited posterior pericardiotomy at the end of the procedure at a significant distance from the bypass grafts.

After CABG operations, the posterior pericardiotomy significantly reduces hospital costs due to a reduction in the duration in the intensive care unit and hospital stay ($p = 0.012$) because these patients had less rhythm problems and pericardial effusion.

**Conclusion**

Posterior pericardiotomy reduces the incidence of postoperative atrial fibrillation and pericardial effusion. In addition, posterior pericardiotomy is associated with the decreases in length of stay in hospital, intensive care unit admissions, and total hospital costs after a CABG operation.

**Conflict of Interest**

The authors have no conflict of interest.

**References**


