The Egyptian Journal of Hospital Medicine (July 2022) Vol. 88, Page 2619-2624

The Role of Posterior Pericardiotomy on The Incidence of Atrial Fibrillation and Pericardial Effusion after Coronary Revascularization

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ABSTRACT

Background: The most common type of arrhythmia following coronary artery bypass grafting (CABG) is atrial fibrillation (AF) with an incidence rate of 20-30%. Even though postoperative atrial fibrillation (POAF) can be self-limited, it may be complicated by lack of hemodynamic stability, increased hospital stay, home mortality, stroke, thrombotic complications, embolus, extra drug therapy, and consequently increased hospital expenses.

Objective: This prospective and retrospective study aims to demonstrate the effectiveness of posterior pericardiotomy in reducing the incidence of pericardial effusions and consequently reducing the related atrial fibrillation and development of delayed posterior cardiac effusions.

Patients and Methods: This prospective and retrospective randomized study was carried out on 100 patients undergoing coronary artery bypass grafting at Kasr El Ainy Hospital, Cairo University, and at Fayoum University Hospital, Department of Cardiothoracic Surgery between May 2017 and January 2018. One hundred patients were divided into two groups; each group included 50 patients. A 4-cm longitudinal incision was made parallel and posterior to the left phrenic nerve, extending from the left inferior pulmonary vein to the diaphragm in the posterior pericardiotomy group (group A). Posterior pericardiotomy was not performed in the conventional group (group B).

Results: Atrial fibrillation developed in five patients (10%) in group (A) and in 12 patients (24%) in group B (P =0.118). Early pericardial effusion developed in 6 patients (12%) in group A and 18 patients (36%) in group B (P =0.022), but no late pericardial effusion developed in group A despite six (12%) late pericardial effusions developing in group B (P=0.027).

Conclusion: Posterior pericardiotomy is a simple, safe, and effective technique for reducing not only the prevalence of early pericardial effusion but also delayed posterior pericardial effusion and tamponade without significant reduction in post-operative atrial fibrillation (POAF).

Keywords: Atrial fibrillation, Coronary artery bypass grafting, Posterior pericardiotomy, Pericardial effusion.

INTRODUCTION

The most common type of arrhythmia following coronary artery bypass grafting (CABG) is atrial fibrillation (AF) with an incidence rate of 20-30% [1]. Even though postoperative atrial fibrillation (POAF) can be self-limited, it may be complicated by lack of hemodynamic stability, increased hospital stay, home mortality, stroke, thrombotic complications, embolus, extra drug therapy, and consequently increased hospital expenses [2].

Various factors contribute to the development of AF. Yet, the exact cause remains unknown. Among the factors contributing to the occurrence of AF are increased sympathetic and parasympathetic tone, an enlarged atrium, transmission of electrolytes and intercellular fluids, pericardial inflammation, metabolic disturbances, and pericardial effusion [3]. Some studies have reported that posterior pericardiotomy (PP) can decrease the postoperative AF in patients undergoing on-pump CABG [1].

However, the mechanism by which PP causes a decrease in postoperative arrhythmia is unknown. Yet, it is possible that the pericardial effusion induces a mechanical pressure on the atrium leading to atrial irritation and finally to arrhythmia [3]. PP causes the drainage of blood and fluids from the pericardial space into the pleura leading to decreased pericardial effusion [4]. PP can produce complications such as obstruction of the bypassed grafts, as a result, of compression by the PP ridges and cardiac hernia [5]. Posterior pericardiotomy is technically easy to perform and is a safe and effective technique that reduces not only the prevalence of early pericardial effusion and related atrial fibrillation but also delayed posterior pericardial effusion and tamponade.

PATIENTS AND METHODS

This study is a non-randomized comparative prospective retrospective study aimed to evaluate the effectiveness of posterior pericardiotomy in reducing the incidence of early, late postoperative pericardial effusion and postoperative atrial fibrillation. The study was conducted at Kasr El Ainy Hospital, Cairo University, and Fayoum University Hospitals during the period between May 2017 and January 2018. The study included one hundred patients with ischemic heart disease undergoing CABG, forty patients were studied retrospectively from medical reports, and sixty patients were studied prospectively.

Patients are eligible for enrollment in this study if they have been referred for on-pump CABG. Patients were excluded from this study if they had a history of atrial fibrillation before surgery, known history of thyrotoxicosis, redo cardiac surgery, severe chronic obstructive pulmonary disease (COPD), poor left ventricular function ejection (LVEF) <30%, left atrial

Received: 03/01/2022
Accepted: 01/03/2022

dilatation (LA diameter) >50 mm, pericardial adhesions, any active inflammatory disease at the time of surgery (including active infective endocarditis), associated valvular surgery.

Patients were divided into two groups: Group (A) (Posterior pericardiotomy group (PP) Group): 50 patients in which posterior pericardiotomy techniques were performed, and Group (B) (Control Group): 50 patients with no posterior pericardiotomy technique in their operations.

Clinical study endpoints:

The endpoints of this study were to evaluate the efficacy of posterior pericardiotomy in reducing the incidence of early, late postoperative pericardial effusion and postoperative atrial fibrillation. Moreover, the effect of posterior pericardiotomy on the incidence of reopening for bleeding, cardiac tamponade, length of ICU, and hospital stay.

Study procedures:

Transthoracic echocardiography (TTE), M mode, two-dimension, and Doppler echocardiography was performed at baseline and 3months after surgery for all patients in both study groups to detect different dimensions of the cardiac chambers as well as the ejection fraction (EF), regional wall motion abnormalities (RWMA), evaluation of cardiac valves. Coronary angiography was done preoperatively for each patient to detect the number of diseased vessels, site of lesions, and site of diseased vessels. Randomization was performed after the completion of baseline investigations in patients who met the eligibility criteria according to surgeons' preferences.

Surgical technique:

All surgical procedures were performed through a longitudinal median sternotomy during normothermic cardiopulmonary bypass (CPB) with intermittent antegrade warm blood cardioplegia. All patients underwent conventional multivessel CABG with the use of the left internal mammary artery (LIMA) grafted to the left anterior descending (LAD) coronary artery and the great saphenous vein (GSV) used to revascularize any other coronary artery in all the patients in the two studied groups. In patients randomized to posterior pericardiotomy (GroupA), under cardiopulmonary bypass after proximal anastomoses were established a longitudinal incision, 4cm long and 2cm in width, was made parallel and posterior to the left phrenic nerve, extending from the left inferior pulmonary vein to the diaphragm. In other patients (Group B), no posterior pericardiotomy was done. Postoperative intensive care unit management was standardized for all patients.

Clinical and echocardiographic follow-up:

All patients were followed up through ICU stay, one week and 3 months postoperative by clinical examination, electrocardiogram (ECG) to detect arrhythmias, and echocardiography to detect early and late effusions and tamponade. Clinical, ECG, and TTE controls were performed. Preoperative and postoperative clinical status was determined according to the criteria of NYHA functional class and the Canadian Cardiovascular Society (CCS) for heart failure and angina. In both groups, ECG was routinely done, immediately upon arrival of the patient to the ICU and subsequently, continuous monitoring was reinstituted whenever an arrhythmia was suspected, if there were any changes in the heart rate or when the patient complained of palpitation. The patient was considered to have POAF when an episode of AF persisted longer than 30 min even after correction of hypoxia and electrolyte imbalance. Postoperative anti-arrhythmic drugs were not given routinely.

Potassium and magnesium supplements were given as necessary to maintain electrolyte balance within the normal range (serum potassium level was corrected if less than 4 mmol/l). Two-dimensional echocardiography was done also in both groups, one week and 3 months postoperative to assess the presence of any pericardial effusion. If echo-free space in the diastole has no effusion related to any wall, the patient is considered free. Pericardial effusion <1 cm was considered small, 1 to 2cm was considered moderate, and >2 cm was considered severe. Cardiac tamponade was diagnosed by clinical signs and symptoms in addition to echocardiographic criteria of cardiac compression. Any effusion > 1 cm is considered significant in our study. In both groups, follow-up data were obtained in 100 patients 3 months after surgery. Follow-up ended in January 2018. The mean follow-up was 3 months.

Ethical consent:

Approval of the study was obtained from Cairo University and Fayoum University Academic and Ethical Committee. Every patient signed informed written consent for the acceptance of participation in the study. This work has been carried out following The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

Data were coded and entered using the statistical package SPSS (Statistical Package for the Social Sciences) version 25. Data were summarized using mean, standard deviation, median, minimum and maximum in quantitative data and using frequency (count) and relative frequency (percentage) for categorical data. Comparisons between quantitative variables were done using the non-parametric Mann-Whitney test. For comparing categorical data, Chi-square (X^2) test was performed. The exact test was used instead when the expected frequency is less than 5. P-values less than 0.05 were considered statistically significant.

RESULTS

The preoperative demographics, medical history, clinical, ECG, echocardiographic, and coronary angiographic characteristics of the two surgical groups {Posterior pericardiotomy group (Group A) and control group (Group B)} are shown in **Table (1).** No statistically significant difference was found between the 2 groups according to preoperative demographics, medical history, clinical, echocardiographic, and coronary angiographic characteristics.

Table (1): Preoperative patient's characteristics

Variables	Group A (n=50)	Group B (n=50)	P-value
Age (years)			
Range	42 – 75	40 – 70	0.24
Mean±SD	58.34 ± 8.73	53.80 ± 8.56	
Sex:			
Females	17(34%)	10 (20%)	0.115 0.113
Males	33(66%)	40(80%)	
DM (yes)	25 (50%)	18 (36%)	0.157
HTN (yes)	30 (60%)	21 (42%)	0.072
Smoking (yes)	17 (34%)	22 (44%)	0.305
Myocardial infarction (infarcted)	16 (32%)	16 (32%)	---
Clinical examination (normal)	42 (84%)	48 (96%)	0.5
ECG (ischemic changes)	30 (60%)	36 (72%)	0.205
Left ventricular ejection fraction	5.6±0.44	5.62±0.49	0.88
Left ventricular end-systole	3.88±0.54	3.74±0.43	0.32
Ejection Fraction	58.84±9.60	58.32±10.59	0.89
Left main coronary artery	23 (46%)	16 (32%)	0.151
Left anterior descending artery	50 (100%)	50 (100%)	---
Right coronary artery	40 (80%)	43 (86%)	0.424
Left circumflex artery	37 (74%)	33 (66%)	NS

Data are expressed as mean ± SD or number (%) P> 0.05 = not significant.

Operative data:

Patients were admitted to CABG operation with posterior pericardiotomy in group (A) and CABG without posterior pericardiotomy in group (B). All the patients in both groups were operated upon using the cardiopulmonary bypass. Operative reports for both groups were assessed and the data recorded.

Table (2): Comparison of operative variables among the two studied groups

Variables	Group A (n=50)	Group B (n=50)	P-value
Graft number:			
1	2 (4%)	3 (6%)	
2	10 (20%)	6 (12%)	
3	28 (56%)	24 (48%)	0.505
4	7 (14%)	12 (24%)	
5	3 (6%)	5 (20%)	
Ischemia time (minutes)	20.5 ± 54.5	16.5 ± 59.2	0.076
Bypass time (minutes):	28.6 ± 88.6	22.9 ± 86.9	0.643
Weaning:			
Hot shot only	41 (82%)	43 (86%)	0.585
Direct current (DC) shock	9 (18%)	7 (14%)	0.585
Inotropes	8 (16%)	9 (18%)	0.834
Intra-aortic balloon pump (IABP)	1 (2%)	0	1

Data are expressed as mean± SD or number, P>0.05 = not significant

Table (2) illustrates that there is no statistically significant difference with a p-value >0.05 between study groups as regards the number of grafts, bypass time, cross-clamp time, and weaning from bypass. One patient in group (A) needed IABP support to wean from cardiopulmonary bypass due to a history of recent myocardial infarction and poor contractility. There were no significant differences in both groups (P=NS).

Postoperative Data:

All patients were discharged to the cardiothoracic ICU mechanically ventilated. Patients were discharged from ICU when hemodynamically stable without inotropic support, with no drains, and with satisfactory postoperative laboratory results and ECG.

During the ICU stay, the following data were collected from all patients in both groups and evaluated. Six (12%) patients in group (A) developed AF and became sinus after (medical or electrical) cardioversion in comparison to 12 (24%) patients in group (B) and were confirmed by ECG. Although the number of patients who developed AF in group (B) is more than those in group (A), it is still statistically non-significant.

Also, intercostal tube drainage was monitored and recorded in both groups till their removal. Two patients developed postoperative cardiac tamponade and reopened in group (B), while no evidence of tamponade in group (A) was detected, and only one patient was reopened for high drainage.

Table (3) illustrates that there is no statistically significant difference between both groups regarding to ICU and hospitalization variables.

Table (3): Comparison of ICU and hospitalization variables among different study groups

Variables	Group A (n=50)	Group B(n=50)	P-value
Intercostal tube drainage	547.0±277.64	478.99±229.05	0.183
ECG (AF)	6 (12%)	12 (24%)	0.118
Inotropes (yes)	17 (34%)	18 (36%)	0.834
Cardiac temponade	0 (0%)	2 (4%)	0.495
Re-opening	1 (2%)	2 (4%)	1
ICU Stay (hours)	2.26±0.44	2.28±0.54	0.912
Hospital stay (days)	6.1±1.25	6.3±1.83	0.525

Data are expressed as mean ±SD, p>0.05= not significant.

Follow up Data: (1-week duration)

Follow-up was completed in 100% of the patients in both groups after 1 week of follow-up (chest x-ray to detect any pleural collection, ECG, and Echocardiography data).

Table (4): Comparison between 1 week follow up variables among different study groups:

Variable	Group A (n=50)	Group B (n=50)	P-value
ECG (AF)	0	0	--
Chest X-ray (CXR) (pleural collection)			
- No	35 (70%)	40 (80%)	
- Mild	12 (24%)	8 (16%)	0.569
- Moderate	3 (6%)	2 (4%)	
- Severe	0	0	
Echocardiography (pericardial effusion)			
- No	44 (88%)	32 (64%)	
- Mild	6 (12%)	18 (36%)	0.005 *
- Moderate	0	0	
- Severe	0	0	

Data are expressed as number (%) P>0.05=not significant *= significant p-value

Table (4) illustrates that there is no statistically significant difference between both groups regarding 1 week postoperative AF and pleural collection, but there is a statistically significant difference between both groups regarding early postoperative pericardial collection with P-value < 0.05 (P value=0.005).

Follow up Data: (3 months duration)

Follow-up was completed in 100% of the patients in both groups. All patients were called after 3 months for follow-up of their chest x-ray, ECG, and Echocardiography data.

Table (5): Comparison between 3 months follow up variables among different study groups

Variables	Group A (n=50)	Group B (n=50)	P-value
ECG (AF)	0	0	--
CXR (pleural collection)			
- No	45 (90%)	36 (72%)	
- Mild	5 (10%)	14 (28%)	0.022 *
- Moderate	0	0	
- Severe	0	0	
Echo (pericardial effusion)			
- No	50	44 (88%)	
- Mild	0	6 (12%)	0.027 *
- Moderate	0	0	
- Severe	0	0	

Data are expressed as number (%) P>0.05=not significant *=significant p-value .

Table (5) illustrates that there is no statistically significant difference between both groups regarding 3 months of postoperative AF, but there is a statistically significant difference between both groups regarding the late postoperative pericardial collection and pleural collection with P-value < 0.05 (P value=0.022, 0.027 respectively).

DISCUSSION

Although CABG surgery is now relatively common, there are still some well-known potential complications such as arrhythmias, pericardial effusion, and tamponade. Pericardial effusion and the associated complications are common after all kinds of cardiac surgery due to postoperative bleeding or post-cardiotomy syndrome. Pericardial effusions have been determined at a rate of 85% after open-heart surgery. However, clinically significant pericardial effusion occurs rarely and can be a crucial risk factor for supraventricular arrhythmias, such as AF, and cardiac tamponade. The advanced progressive pericardial effusion is associated with high rates of morbidity and mortality [6,10]. Atrial fibrillation is the most common postoperative form of arrhythmia and occurs in up to 20-30% of cases, in different studies, with major occurrences generally two days after surgery [7]. Its etiology is not entirely understood. Multifactorial triggering mechanisms are likely responsible for its development such as age, atrial dilatation, perioperative ischemia, electrolyte imbalance, volume overload, right coronary artery involvement, hyperthyroidism, left ventricular aneurysm/aneurysmectomy, additional valve surgical procedures, low cardiac output, renal failure, respiratory complications and pericardial effusion [7].

The potential to decrease POAF and its associated complications will improve our clinical knowledge and surgical practice while decreasing patient morbidity and mortality [8].

After a CABG operation, the space anterior to the heart can be easily drained by placing a chest drain underneath the sternum, whereas the posterior space is a closed space behind the heart that cannot be easily drained with a chest drain placed underneath the heart that can cause mechanical irritation and injury in addition to its proximity to the grafts. Therefore, a small amount of pericardial effusion accumulated in the posterior pericardium may compromise the left atrium and ventricle and lead to localized tamponade and AF. To prevent arrhythmias and tamponade, which may develop as a result of the pericardial effusion, the idea of opening this dead space posterior to the heart into the left pleural space was proved by many studies to drain freely into the pleural space reducing the prevalence of pericardial effusion and AF [9,10,11].Similar to any surgical procedure, posterior pericardiotomy is associated with potential complications. Aside from the complications associated with any cardiac procedure, it is associated with a risk of phrenic nerve injury, cardiac herniation, and extended drainage time of left-sided pleural effusions. Proper operative identification of the phrenic nerve should be emphasized and special attention should be given not to extend the posterior pericardiotomy incision beyond 4 cm to avoid the risk of cardiac herniation [8].

The age of the studied groups of patients ranged from 42 to 75 years in group A and from 40 to 70 in group B, with a mean of 58.34(± 9.6) years in group A and 53.8(±8.56) years which is nearly similar to **Fawzy *et al.*** [12], who reported that the average age of his studied group was 55.9(±9.5) years and **Kaygin *et al.*** [1] reported that the average age of his group was 59±11.3. Also, previous reports demonstrated that increased patient age was one of the dominant factors promoting the development of AF postoperatively [13]. **Farsak and colleagues** [9] reported that the increased age played an important role in promoting postoperative atrial fibrillation (AF) where in their two groups the combined incidence of AF was 7 of 64 patients (10.9%) younger than 60 years old and 24 of 86 patients (27.9%) older than 60 years ($P \leq 0.014$). Also, our results demonstrate that age was a major significant factor in the development of POAF as 13 of 38 (34.2%) of our patients with POAF were older than 60 years and 5 of 62 patients (8 %) were younger than 60 years with (P=0.001). In contrast, **Fawzy and colleagues** [12] demonstrated that age was not a significant factor in the development of POAF as 41.9% of their patients with POAF were younger than 60 years and 58.1% were older than 60 years with no significant difference.

In our study, the incidence of AF was not statistically different in the two groups; namely, AF

occurred in 5 patients (10%) in the PP group and 12 patients (24%) in the control group (p=0.118). Thus, AF prevalence is not significantly lower in the PP group. However, our study shows that early and late pericardial effusion is significantly less frequent in the PP group (6, 0 patients) compared to (18, 6 patients) in the control group (p=0.005, 0.027) respectively, whereas 2 patients (4%) developed tamponade in the conventional group and needed reopening, no patient in the PP group developed tamponade, but only one reopening for high drainage, which is nearly the same in **Fawzy *et al.*** [12] (0 vs.3%) and **Kaygin *et al.*** [1] (0 vs. 1.5). So, the antiarrhythmic effect of PP is associated with a significant reduction in early and late pericardial effusion with posterior pericardiotomy.

Previous results show a correlation between the presence of pericardial effusion and the higher incidence of AF that is proved by **Angelini *et al.*** [14] who solved the problem of postoperative supraventricular arrhythmias by evacuation of pericardial effusion and a subsequent sinus rhythm. Regarding pleural drainage, **Asimakopoulos *et al.*** [15] **and Fawzi *et al.*** [12] pointed out that the pericardiotomy group had a significantly higher incidence of pleural drainage, while **Farsak *et al.*** [9] **Arbatly *et al.*** [10] **and Kuralay *et al.*** [16] did not find significantly increased chest drainage in their fenestration group. In our study, we did not find a significant total blood loss difference between the two groups; however, the pleural drainage was higher in the posterior pericardiotomy group as expected. Although our study shows no significant difference in the early pleural collection in the PP (15 patients) group compared to the control group (10 patients), (p= 0.569), it shows a statistically significant difference in the late pleural collection in the PP group (14 patients) compared to (5 patients) in the control group (p=0.022), which implies that this results in more effective pericardial drainage into the pleural cavity. Thus, this method provides an effective pathway of drainage of pericardial blood/effusion to the pleural cavity, which otherwise would have been collected in the pericardium and compressed the heart, which reduces the incidences of AF.It is unlikely that increased drainage was the result of bleeding from the pericardial incision because the edges were cauterized and specifically checked for bleeding. Although there was increased pleural effusion in the PP group, pulmonary complications and prolonged extubation were not significantly more frequent in the pericardiotomy group. Finally, we did not face any postoperative complications because of the posterior pericardiotomy incision.

CONCLUSION

Posterior pericardiotomy is technically easy to perform and represents a safe and effective technique that significantly reduces not only the prevalence of early pericardial effusion but also delayed posterior pericardial effusion and tamponade without significant reduction in postoperative AF.

Financial support and sponsorship: Nil.
Conflict of interest: Nil.

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