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The Use of Arterial Grafts of the Left Internal Mammary Artery is Not a Predictor for the Incidence of Pericardial Effusion

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Abstract

BACKGROUND: The left internal mammary artery (LIMA) is used very often for coronary artery bypass grafting (CABG). During the cardiac surgery, surgical preparation of LIMA graft could be the reason for mediastinal bleeding and pericardial effusion (PE).

AIM: This current study was, therefore, undertaken to show the prediction of PE occurrence comparing the usage of LIMA and venous graft.

METHODOLOGY: The study population comprised 1929 patients (1.562 men mean age 57.1 years) who underwent CABG due to coronary disease. Patients were separated into two groups: Patients with venous and patients with arterial grafts on left anterior descending (LAD) artery. The first group included 1468 patients with arterial graft (LIMA) who underwent surgery from October 2008 to January 2014 and the second group included 461 patients with venous graft on LAD that were treated before 2008. Both groups were compared with respect to occurrences, size, and location of PE, which was determined on the 5th day after surgery by echocardiography.

RESULTS: PE was identified in 1219 (63.1%) patients. There was no difference between compared groups in the proportional occurrence or absence of effusion: In the first group 931 (63.4%) and in the second 288 (62.4%) patients had PE ($p > 0.05$). There were significant differences ($p < 0.001$) in localization of effusion; circular effusion was found in 797 (41.3%) patients while localized effusion in 422 (21.8%) patients.

CONCLUSION: Surgical experience can lead to a reduced risk of occurrence of PE when using arterial graft with no differences compared to using a venous graft. The use of arterial LIMA graft is not a predictor for the incidence of PE.

Introduction

Pericardial effusion (PE) is a common finding in patients after surgical operations on the heart and aorta [1], [2, [3], [4]. The most common reasons are due to traumatic factors during surgery and/or inflammatory and immunological ones in the immediate post-operative period [2], [5], [6]. This condition is an important predictor of the post-operative patient status, prolonged hospital stay, and further medical observation as well as additional therapeutic approaches [7]. Although PE in majority of the patients is reversible process, in a minority of cases it leads to a severe hemodynamic disorder including cardiac tamponade [8]. The arterial graft was first introduced in coronary surgery in 1960 (Goetz) [9], with significant expansion in the recent decades due to good patency compared to venous grafts [10]. Ten years after coronary artery bypass grafting (CABG), half of all venous grafts become impassable contrary to arterial graft with good patency in 90% of cases [11]. The most often used arterial graft is the left internal mammary artery (LIMA) but the preparation may later be (a) the source of bleeding and incidence of PE is higher [3], [12]. The distal anastomosis of this arterial graft is usually placed on the left anterior descending (LAD) branch of the left coronary artery, less frequently on a diagonal branch, and quite exceptionally on the right coronary artery [13]. This current study was, therefore, undertaken to show the prediction of PE occurrence comparing the usage of LIMA and venous graft.

Patients and Methods

Patients

From October 2008 to January 2014, 1468 patients underwent CABG with arterial graft (LIMA) due to coronary disease at the University Cardiovascular Clinic. A control group of 461 patients who received venous graft was treated before 2008, was selected for comparison. Patients with aortic aneurysm, pseudoaneurysm, valvular repair only, aortic dissection, and congenital heart defect were excluded from the analysis. Pre-operative evaluation included all cardiac disease examination including transthoracic echocardiography and coronary angiography (Siemens, Erlangen, Germany) in all of the patients. Routine transthoracic echocardiography post-operative control was performed on the 5th post-operative day by two experienced cardiologist and the presence or absence of early post-operative PE was validated.

It is a general policy at our institute that on admission, patients must sign an informed consent that allows the use of their data for retrospective analysis. Furthermore, approval from the local Ethical Committee for the particular study was obtained.

PE is defined as the maximum layering of pericardial sheets in diastole. By size, PEs were classified as minimal (up to 5 mm), small (6–10 mm), medium-large (11–15 mm), and large (over 15 mm). By type, the effusions are defined as circular – around the left and right heart cavities – and localized (regional) – behind some of the walls of the left ventricle or in front of the right ventricle and right atrium [4].

Surgical treatment and administration of drugs

Surgery was performed under general anesthesia. After sternotomy, incision of the pericardium was made, but later stitching of both pericardium layers (in the process of reconstruction of the required layers of tissue) in front of the heart was not insisted upon. All patients received antibiotics prophylaxis. After surgery, from the 2nd post-operative day, acetylsalicylic acid (100 mg/d) and statins (20 mg/d) were administrated. Other cardiovascular medications were used when clinically indicated.

Statistical analysis

Standard descriptive statistics were used. Cox univariate and multivariable analyzes were performed to assess predictors of PE. Individual differences were considered to be statistically significant for $p < 0.05$. SPSS version 17.0 (SPSS Inc, Chicago, Ill) was used for all statistical calculations.

Results

The first group included 1468 patients with arterial graft (LIMA), and the second group included 461 patients with venous graft on LAD. Transthoracic echocardiography post-operative control was performed on the 5th post-operative day in all the patients. PE was found in 1219 (63.1%) patients, circular effusion was found in 797 (41.3%), and localized effusion in 422 (21.8%) patients. Regarding the size of effusion, the minimal effusion was found in 701 (36.3%), small 241 (12.4%), medium to large in 152 (7.87%), and large in 125 (6.4%) patients. Localized PEs are marked as per the regional distribution around the chambers of the heart showed in Table 1.

Table 1: Localization of PE[1]

Localization of PE	n=422	%
Behind IPwLV	36	8.5
Behind LwLV	182	43.2
Front of the RV	23	5.4
Front of the RA	63	14.9
Front of the RA+RV	33	7.8
Behind LwLV+RV	23	5.4
Behind AwLV	12	2.8
Behind LwLV+RA	50	11.8

[1]IpwLV: Inferoposterior wall of the left ventricle, LwLV: Lateral wall of the left ventricle, RV: Right ventricle, RA: Right atria, AwLV: Anterior wall of the left ventricle.

The incidence of circular PE was found statistically significant ($p < 0.05$) in both LIMA and venous graft groups, and general group also (LIMA and venous graft groups all together). Observing only localized PE, there was a statistically significant incidence of PE behind lateral wall of the left ventricle ($p< 0.001$) in both LIMA and venous graft groups and general group (Tables 2 and 3).

Table 2: Localization of PE in patients with arterial graft[1]

Localization of PE	n=327	%
Behind IPwLV	29	8.8
Behind LwLV	150	45.8
Front of the RV	18	5.5
Front of the RA	38	11.6
Front of the RA+RV	25	7.6
Behind LwLV+RV	18	5.5
Behind AwLV	9	2.7
Behind LwLV+RA	40	12.2

[1]IpwLV: Inferoposterior wall of the left ventricle, LwLV: Lateral wall of the left ventricle, RV: Right ventricle, RA: Right atria, AwLV: Anterior wall of the left ventricle.

Comparing LIMA and venous graft group, there was no difference between these two groups because the percentage of both circular and localized PE was nearly the same. Therefore, there is no difference in the incidence of PE in patients with LIMA or venous graft. In conclusion, post-operative PE does not occur more often when using LIMA graft.

Table 3: Localization of PE in patients with venous graft[2]

Localization of PE	n=95	%
Behind IPwLV	10	10.5
Behind LwLV	48	50.5
Front of the RV	3	3.1
Front of the RA	10	9.5
Front of the RA+RV	6	6.3
Behind LwLV+RV	6	6.3
behind AwLV	3	3.1
behind LwLV+RA	9	9.5

[2]IpwLV: Inferoposterior wall of the left ventricle, LwLV: Lateral wall of the left ventricle, RV: Right ventricle, RA: Right atria, AwLV: Anterior wall of the left ventricle.

PE was found in 931 (63,4%) patients with arterial graft; circular effusion was found in 604 (41.1%) while localized effusion had 327 (22.2%) patients. PE was found in 288 (62,4%) patients with venous graft; circular effusion was found in 193 (41.8%) while localized effusion had 95 (20.6%) patients. Effusion size did not differ significantly with the use of LIMA graft with respect to the use of venous graft. The minimal effusion was found in 535 (36.4%), small 184 (12.5%), medium to large in 116 (7.9%), and large in 96 (6.5%) patients with arterial graft. The minimal effusion was found in 167 (36.2%), small 59 (12.7%), medium to large in 32 (6.9%), and large in 30 (6.5%) patients with venous graft.

Discussion

The main findings of the current study indicate that there is no difference between patients with arterial grafts and patients with venous grafts in the occurrence of PE. One of the accompanying complications in the early post-operative period in patients operated on open heart is PEs; however, the clinical condition of the patient is not compromised except in a small number of large effusions with pericardial tamponade [14]. Two-dimensional echocardiography and Doppler examination are powerful diagnostic tool for accessing the type, size and localization of post-operative PE and cardiac tamponade [1], [2], [3], [4], [14]. pericardial space (the heart sac) contains normally between 15 and 35 ml of liquid [15]. The normal unexpanded pericardial sac may contain an additional 80–200 ml of liquid while maintaining the curve of intrapericardial pressure – volume in initial flat part [16]. If the intrapericardial volume reaches up to 100 ml and 200 ml liquid with a sharply increase, it results in increased intrapericardial pressure [16]. Furthermore, intrapericardial pressure can significantly increase after the accumulation of small amounts of liquids if the pericardium is changed due to fibrosis. Early post-operative, PE is obviously caused by bleeding in the pericardial space and can be a cause of resternotomy despite adequate pericardial drainage [1], [5], [17]. In addition, PE may be the result of bleeding, residual undrained blood, or other accumulation of fluid (exudate, transudate, or lymph), increasing the incidence of PE in the 1st post-operative week [2]. Fortunately, the cardiac tamponade occurs in <1% [18], [19]. On the other hand, use of anticoagulant therapy is considered the biggest contributing risk factor for development of massive hemorrhage and pericardial tamponade [18], [20]. Postpericardiotomy syndrome is also considered major causal factor in the formation of PE one or more weeks after the surgery with incidence of PE ranged from 3% to 30% [6], [21], [22], [23], [24] and tamponade <1% [6], [18]. The pericardial fluid can be ultrafiltrate of myocardial and pericardial capillary plasma. This may be due to the accumulation of excessive intestinal fluid or it may be actively or passively created by serous pericardium cells. It is probably drained through the lymphatic system, possibly by different way from those involved in lymphatic drainage of the myocardium [25]. The issue of operative techniques, closing or non-closing the pericardium also has significance [26]. Some studies showed that the closure (suturing) of pericardial incision reduces the formation of PE and cardiac tamponade [27]. It is explained by the fact that within the closed pericardium (unlike the one open to the left), cardiac tamponade can be redistributed in that extrapericardial (mediastinal) bleeding and is eliminated as a causal factor. Extrapericardial bleeding usually includes bleeding from the mediastinal pleura, the sternum, the thymus, the pericardium, and from the drain position. Intrapericardial bleeding includes bleeding from the atrial incision, the right ventriculotomy, and aortic incision. Furthermore, a small percentage of bleeding may occur from an unspecified source [27]. It seems that the use of LIMA as a coronary graft increases PE, possibly because of greater mediastinal bleeding, although there are studies indicating that there were no major post-operative bleedings from pericardial drainage in these patients [3]. Contrary to our study, some papers have shown that in patients where LIMA grafts were used, PE was more prevalent [3] although there was no difference between the groups in post-operative bleeding in standard pericardial drainage [3], [28]. We found that localized effusion was most common at the lateral wall of the left ventricle (n = 182, 43.2%). Pepi *et al*. [4] reported that in patients with CABG PE with anterior localization of the left ventricle was statistically significantly more prevalent, which can be caused by higher incidence of bleeding into the internal thoracic wall during preparation of LIMA. Ashikhmina *et al*. [7], following the occurrence of mostly late and symptomatic PE (30 days), noted that the lowest incidence of PE occurred in the patients with CABG compared to valvular surgery and other operations, probably due to the open left pleural space. Hall *et al*. [29] report that re-exploration due to post-operative bleeding was performed in 3.6% of the patients and the most frequent cause was surgical bleeding, represented in 66% patients. The most common site of bleeding is side branches of bypass grafts and thorax, primarily of the internal mammary artery. In our paper, PE was reported in 63.1% patients with CABG and majority of these patients had circular effusion (41.3%). Regarding the size of the effusion, the most were common minimal and small findings given a total number of 942 (48.7%) patients. These results in our study partly coincide with the results of similarly designed studies [3], [4]. There was no difference in comparison between patients with only arterial grafts and those with only venous grafts in the occurrence of effusion. Our results indicate that there is no additional extrapericardial bleeding during the surgical preparation of LIMA graft.

Study limitations

The pericardial drainage through drainage tubes lasted from the end of the surgery and during the first 24 h, when the tubes were removed. Patients who underwent reoperation in the first 48 h due to suspected pericardial bleeding, occlusion of grafts or other reasons, are not included in the study. Some believe that the pericardial or mediastinal hemorrhage usually occurs early (0–48 h) after the surgery [5]. There is also a dilemma regarding the amount of drained content (if the quantity is larger, the PE appears more frequently) [1] or the opposite opinion that there is no difference in the occurrence of PE in relation to the amount of drained contents in the early post-operative period [3]. In our study, we have not evaluated the pericardial drainage, although it is likely that its effect on two comparable groups of patients is minimal. Finally, the use of venous grafts only for coronary revascularization is rarely used in the modern era.

Conclusion

Our results indicate that in spite of the potential risk of a higher incidence of PE in the preparation of the arterial graft (mediastinal bleeding and opening of the pleura), current surgical experience brings them to a minimum, so there is no difference in the occurrence of early post-operative PE depending on the type of graft.

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