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A Simple and Effective Technique for Left Ventricular Deairing

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ABSTRACT

Objective. Despite careful deairing procedures, residual air has been found in the left ventricle. For this reason, we created a simple and effective left ventricular deairing technique.

Design. Forty patients with pure mitral valve disease were randomly divided into 2 groups. In group 1, deairing was done by filling the left atrium actively by a line coming from the aortic cannula line, and by venting from the antegrade cardioplegia line. In group 2, the air was removed by ventilating the lungs, and venting from the antegrade cardioplegia line, but not active filling of the left atrium. The patients were evaluated with transesophageal echocardiograpy during the procedure.

Results. According to the preoperative data, the groups were similar. After 3 minutes of deairing, 5 patients in group 2 had transesophageal echocardiographical air bubbles. In these patients, after 2 minutes, the air was removed by an active filling technique. None of the patients in group 1 had air bubbles.

Discussion. The technique described in this study seems to solve remaining air problems in the cardiac chambers. It can be applied easily, and it is safe and effective.

INTRODUCTION

One of the most common and serious complications of heart valve operations is the residual air that increases when the heart begins to contract. Deairing of the left heart in valve operations is often unsatisfying, even when every precaution has been taken to prevent left heart deairing. Deairing maneuvers sometimes fail to remove residual air in the left heart [Tingleleff 1995]. In the present study, we described a simple and effective left ventricular deairing technique, and we designed a randomized prospective study to evaluate the effectiveness of the technique.

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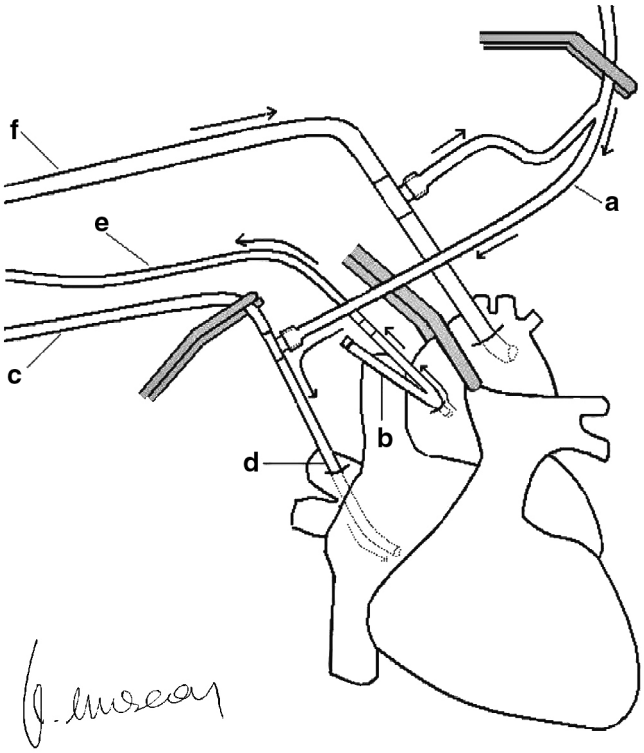
METHODS

The study was done at Gazi Hospital in Izmir, Turkey. After approval of the local ethics committee, the patients were randomly included in the study, including 40 patients who had an indication of mitral valve operation for pure mitral valve disease. Patients who had other cardiac comorbidities necessitating intervention were excluded from the study. The patients in the study were randomly divided into 2 groups; 20 of them were deaired with the technique described below (group 1), and the others by passive left atrial filling by ventilation of the lungs (group 2). Deairing was done for 3 minutes in both groups. During the procedure, the patients were prospectively evaluated with transesophageal echocardiography to find residual air in the cardiac chambers. All of the patients were instrumented as described below. The groups were evaluated for their perioperative and echocardiographic data.

Technique

Standard cardiopulmonary bypass techniques and standard operative techniques were used in our study. Our cardioplegia delivery system has been previously described [Yilik 2004]. For the preparation and delivery of blood cardioplegia, a Y-shaped line was connected to the aortic cannula (Figure part a). An antegrade cardioplegia cannula (Figure part b) was used for cardioplegia administration, and for aortic deairing; a routine right superior pulmonary vein vent cannula was connected (Figure part c). After completion of left atriotomy closure, we started pulmonary ventilation for left heart deairing. The antegrade cardioplegia line and left atrial vent line were clamped as shown in the figure. One leg of this line (Figure part a), which had been previously connected to the antegrade cardioplegia cannula for cardioplegia administration, was detached from the antegrade cardioplegia cannula (Figure part b), and was connected to the right superior pulmonary vein vent cannula (Figure part d) to fill the left atrium actively. In this way, blood coming from the aortic line (Figure part f) actively filled the left atrium with the same pressure of the arterial perfusion pressure. The open end of antegrade cardioplegia cannula was clamped, and the active venting started from the other end (Figure part e). The patient was placed in the Trendelenburg position for apical accumulation of air. Thereafter, the patient's position was changed from Trendelenburg to reverse Trendelenburg for



Schematic illustration of left ventricular deairing. Arrows indicate the active filling direction. Part a: Y-shaped cardioplegia delivery line; part b: aortic root cannula that is used for antegrade cardioplegia administration and aortic venting; part c: line for right superior pulmonary vein vent cannula; part d: left atrial vent cannula connected to the right superior pulmonary vein; part e: line for aortic root cannula; part f: ine for aortic cannula.

deairing the left ventricular apex. Active filling of the heart eliminated the trapped air in the left ventricle. One to 2 minutes was sufficient for these manuevers. Just before declamping the aorta, the patient's position was changed from reverse Trendelenburg back to Trendelenburg; the aorta was declamped under external compression of the carotid artery. The aortic root cannula actively vented during the reperfusion period, and aortic venting was continued after weaning from cardiopulmonary bypass; active aortic root venting was discontinued 1 minute after leaving the cardiopulmonary bypass.

Statistical Analysis

Statistical analysis was done with SPSS 10.0 statistical software program (SPSS Inc., Chicago, IL, USA). Randomization was also done with this program. Patients who met the study inclusion criteria were randomized prospectively. The patients were included in the group that the program assigned according to the consequence of the operation.

The difference between the groups according to gender was analyzed by chi-square test. Continuous variables were expressed as the mean ± 1 standard deviation (SD). Continuous variables were compared by the Mann-Whitney *U* test. The value $P < .05$ was considered to be statistically significant.

RESULTS

There were 10 male patients in group 1 and 8 in group 2 ($P = .751$). The mean ages of the groups were 49.9 ± 10.5 years and 50.7 ± 8.5 years, consequently in groups 1 and 2 ($P = .616$). The 2 groups were similar with respect to sex and age. The demographics of the groups were similar without any statistical significance (Table). Nine patients in group 1 had severe mitral stenosis, 8 had mitral insufficiency, and 3 had both mitral stenosis and insufficiency. In group 1, 10 patients had severe mitral stenosis, 7 had mitral insufficiency, and 3 had both mitral stenosis and insufficiency in group 2 ($P = .942$).

There were no deaths after the operation in either of the groups, and none of the patients had neurologic or systemic complications because of the procedures. After 3 minutes of deairing, 5 patients in group 2 had air bubbles detected by echocardiography. Two patients had air bubbles in the left atrium, and 3 patients had air bubbles in the left ventricle. Presence of air in the cardiac chambers was statistically significant ($P = .047$). After the echocardiographic evaluation, air bubbles were deaired with the above mentioned technique, and after 2 minutes, the air was removed by active filling. None of the patients in group 1 had air bubbles.

DISCUSSION

Deairing of the heart in open heart surgery is a must. Despite careful deairing procedures, large amount of air emboli has been found during filling of the empty beating heart. Therefore cerebral emboli in open heart procedures has been found to occur most likely during the redistribution of blood from the heart-lung machine to the patient when the heart is beginning to eject actively, despite careful standard deairing procedures [van der Linden 1991].

In a study by Rescigno et al, it has been shown that when Doppler signs of air in the left ventricle disappeared, transesophageal echocardiography revealed a small amount of remaining air in the left heart [Rescigno 1995]. Accordingly, most authors insisted that embolization was not prevented by

Perioperative Data of groups 1 and 2

	Group 1 (n = 20)	Group 2 (n = 20)	*P*
Sex, n (men: women)	10:10	8:12	.751
Age, y*	49.9 ± 10.5	50.7 ± 8.5	.616
Diabetes, n	4	3	1.000
Hypertension	4	2	.661
Smoker, n	4	2	.661
Left atrium diameter, mm*	55.5 ± 7.7	54.6 ± 5.0	.828
Left ventricular end systolic diameter, mm*	35.9 ± 6.5	37.9 ± 4.1	.254
Left ventricular end diastolic diameter, mm*	54.3 ± 7.8	55.9 ± 6.9	.480
Left ventricular ejection fraction*	54.7 ± 7.9	54.1 ± 5.9	.559
Mortality	0	0	1.000

*Data presented as mean ± standard deviation.

conventional left heart deairing methods [van der Linden 1991; Rescigno 1995; Bugge 1997; Milsom 1998]. Therefore, there have always been new attempts for a safer left heart deairing technique [Bugge 1997; Milsom 1998; Svenarud 2004]. One example is insufflation of CO_2 into the thoracic wound, which markedly decreased the incidence of microemboli [Svenarud 2004]. However, none of these new attempts seem to be the ideal method for deairing the left heart. Our study also demonstrated retained air bubbles in the cardiac chamber, despite the conventional air removal maneuvers that were done. However, active filling of the left atrium removed these bubbles successfully.

Conventional deairing techniques also bring about some complications. Left ventricular apical deairing after heart valve implantation, may severely injure the left ventricular wall. In our clinical experience, we have quited this technique after 2 posterior wall ruptures because of lifting of the ventricular apex for deairing. Pulmonary venous return during pulmonary ventilation is sometimes insufficient for left heart deairing especially when the pulmonary artery is clamped on aortic cross-clamping. We also believe that left atrial, apical, and aortic puncturing or venting during cardiac filling and pulmonary compression are insufficient.

This technique has been routinely used in our clinic for valvular operations since 2002. Over-pressuring the left atrium is not an issue due to decompression from the aortic root. Air embolization of the coronary arteries may be a complication with this technique, but it can also be encountered in any other technique. Additionally, if blood fills the left atrium, left vetricle, and the aortic root, the heart may start to contract, but this does not bring about any complications, because the aorta will be declamped afterwards. We have not encountered any complications with the mentioned technique; it seems to solve the mentioned problems, and it is safe, effective, and easy to apply.

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