
INTRACARDIAC AIR: DETECTION BY INTRAOPERATIVE TRANSESOPHAGEAL ECHOCARDIOGRAPHY (TEE)* (Detection of retained air)

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Intraoperative transesophageal echocardiography (TEE) was used in 26 patients to detect the presence of air bubbles after cardiopulmonary bypass. After standard deairing procedures, retained intracardiac air was detected in 69.2% of the patients. Right upper pulmonary vein (RUPV) and the left ventricular (LV) apex were the most common locations of air bubbles.

The RUPV and LV apex should be routinely observed before determining the completeness of deairing procedures.

Key words: Intracardiac air, transesophageal echocardiography, cardiopulmonary bypass.

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In spite of major refinements in the apparatus and techniques associated with cardiopulmonary bypass (CBP), air embolism still remains as a serious threat during open heart surgery. With all forms of cardioplegic arrest and open cardiac repair, air embolism to the coronary, cerebral and peripheral arterial system is a major concern. Since the brain is clearly the most vulnerable organ, the complications resulting from the introduction of air into the systemic circulation are primarily manifest by neurologic injury, which is a particularly devastating complication physically, emotionally and economically.

Echocardiography is a very sensitive method to detect air bubbles even of microscopic size. Furuya et al. successfully detected the air emboli by transesophageal echocardiography (TEE) in both the right and left sides of the heart¹.

In this study, two-dimensional TEE was used to localize the retained intracardiac air and found to be a very safe method to monitor the completeness of air evacuation after CBP.

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Material and Methods

Intraoperative TEE was performed in 26 patients undergoing open heart surgery (22 males, 4 females, ranging from 15 to 64 years old). Of these, 15 underwent mitral, aortic or combined valve operations, six of them coronary artery bypass grafting and left ventricular aneurysm resection, four of them ventricular septal defect closure, and one atrial septal defect closure. CPB was instituted with a membrane oxygenator. Mild to moderate hypothermia, cold crystalloid potassium cardioplegia and topical myocardial cooling were employed for myocardial protection. Standard anesthesia and CBP techniques were used for all patients.

A 5.0 MHz single plane TEE probe and HP Sonos 1000 echocardiography apparatus were used in all examinations. The TEE transducer was introduced into the esophagus after induction of anesthesia. It was initially advanced into the esophagus approximately 25 to 30 cm from the incisors to obtain a basal short-axis scan,

Table I: Locations of intracardiac air detected by TEE

	n	%
RUPV	5	27
LA	2	11
LV APEX	4	22
RUPV+LV APEX	7	38

RUPV: Right upper pulmonary vein,
LA: Left atrium,
LV: Left ventricle

and the pulmonary veins were visualized. With further advancement of the probe into the esophagus, or retroflexion of the probe (or both) long-axis view of the heart (the left atrium, left ventricle and left ventricle outflow tract) was visualized. The echocardiogram was intermittently visualized before, and continuously 30 minutes after the termination of CBP. During the weaning process from the CBP, the long and short axis scans were visualized se-

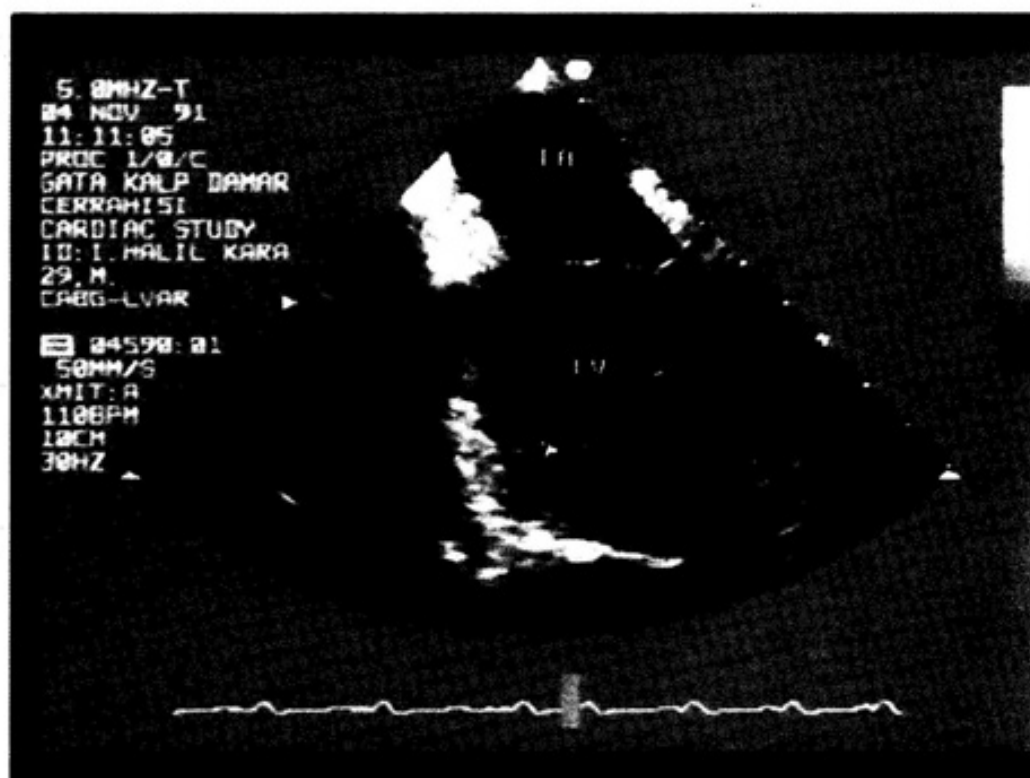


Figure 1. Long -axis scan showing air bubbles (Arrow) in the left ventricle after modified Jatene left ventricle aneurysm repair. Note intracardiac patch at the bottom. LA: Left atrium, LV: Left ventricle.

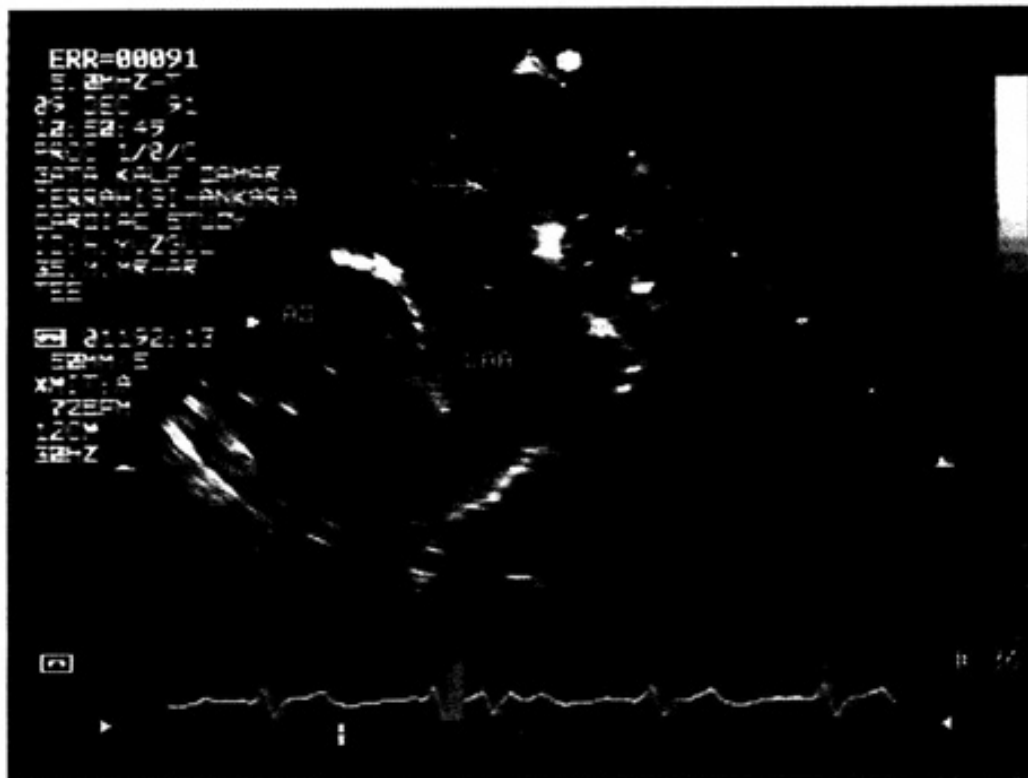


Figure 2. Basal short-axis scan. Air bubbles (Arrows): the right arrow points to the air bubbles in the left upper pulmonary vein(LUPV). LAA: Left atrial appendix, Ao: Aorta.

quentially. The presence of air was confirmed by strong echogenicity and buoyancy in the heart.

Routine deairing procedures were performed (Needle aspiration of the ascending aorta, left ventricular and left atrial aspiration after careful passive chamber filling, and vigorous chamber ballotement) in all patients. CPB were maintained until TEE showed no retained air.

Results

After standart deairing procedures, retained intracardiac air bubbles were detected in 18 patients (69.2%). Locations of air bubbles were in the right upper pulmonary vein (RUPV) in 5 patients (27%), in the left atrium in 2 patients (11%), in the left ventricular apex in 4 patients (22%), and in the RUPV and left ventricular apex in 7 patients (38%).(Table 1). The air in

the left ventricular apical region was seen as a linear echodensity on the endocardium in 5 patients, and was scattered after shaking the heart. Figures 1 and 2 show air bubbles in the left ventricle and left upper pulmonary vein respectively.

The air passed from RUPV into the left atrium after manual hyperinflation of the lungs, and initiation of positive pressure ventilation .

None of the patients had either postoperative neurologic disturbances or evidence of coronary air embolism.

Discussion

The importance of retained air as a cause of systemic and coronary air embolism after open-heart surgery has been known for years². Air embolism remains third as a cause of morbidity and mortality secondary to CPB³. Echocardiog-

raphy is the most sensitive method in the detection of intracardiac air bubbles⁴. The bolus injection of air of 0.0001 ml/kg into the left ventricle has been detected by echocardiography¹. Feinstein et al. reported that the smallest air bubble size detectable has varied between 2 to 125 micrometers⁵. Air bubbles have been identified within the cardiac chambers in 14% to 67% of patients having CPB⁶.

Although there has been no accurate correlation between the presence of air microbubbles and neurologic outcome, visible air bubbles may always signify a risk factor of air embolism and they must not be disregarded.

Long-axis and basal short-axis scans of the heart should be routinely obtained before determining the completeness of deairing procedures. Special attention should be paid to pulmonary veins because they frequently harbor unsuspected air.

Despite the routine deairing procedures, the incidence of air bubbles were found to be high at weaning from CPB. Air bubbles were most commonly found at the *RUPV* and *left ventricular apex*. Such retained air, if it is unnoticed, can cause sudden onset of circulatory and neurologic derangements in the postoperative period.

Reference

- 1- Furuya H, Suzuki T, Okumura F, Kishi Y, Uefuji T: Detection of air embolism by transesophageal echocardiography. *Anesthesiology* 1983; 58: 124-129.
- 2- Oka Y, Moriwaki KM, Hong Y, et al: Detection of air emboli in the left heart by M-mode transesophageal echocardiography following cardiopulmonary bypass. *Anesthesiology* 1985; 65: 109-113.
- 3- Stoney WS, Alford NC, Burns GR, et al: Air embolism and other accidents using pump oxygenators. *Ann Thorac Surg* 1980; 29: 336-340.
- 4- Oka Y, Inoue T, Hong Y, Sisto DA, Strom JA, Frater RWM: Retained intracardiac air: Transesophageal echocardiography for definition of incidence and monitoring removal by improved techniques. *J Thorac Cardiovasc Surg* 1986; 91: 329-338.
- 5- Feinstein SB, Shah PM, Bing RJ, et al: Microbubble dynamics visualized in the intact capillary circulation. *J Am Coll Cardiol* 1984; 4: 595-600.
- 6- Rodingas PC, Meyer FS, Hausler GB, Dubroff JM, Spotnitz HM: Intraoperative two-dimensional echocardiography: Ejection of microbubbles from the left ventricle after cardiac surgery. *Am J Cardiol* 1982; 50: 1130-1132.