

Efficient Removal of Retained Intracardiac Air Utilizing Buoyancy



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Retained intracardiac air has been an important issue in cardiac surgery. Although echo visualization has allowed detection of air and guided deairing procedures, adequate air removal is not always attained. Actually it has been attempted in each surgeon's manner without solid standard or evidence. Basically buoyancy is responsible for air retention as well as difficult deairing.

This paper is aimed to present the author's current measures of deairing, which turn this property of air into efficient removal, as test bed for discussion on this long-standing but pending issue.

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Retained intracardiac air potentially causes cardiac or cerebral dysfunction and effective deairing measures had been sought by means of M-mode transesophageal echocardiography (TEE) to detect bubbles in the 1980s [1, 2]. In 1990s, my colleagues and I reported 2-dimensional TEE findings of pooled air (Fig 1A) besides bubble form (Fig 1B) along with its common retention sites (Figs 1C, 1D), behavior, clinical implications, and quantitative analysis [3–5]. Since then, however, this issue has been pending and deairing is still attempted in each surgeon's manner without solid standard or evidence. This paper is aimed to present my current measures and criteria for air removal as test bed for discussion or further investigation.

Technique

The objective is to eradicate pooled air in cardiac chambers while minimizing the amount of air ejected into systemic circulation as a bolus or dense bubbles. Although buoyancy is responsible for difficult deairing, it may be reversely utilized to help remove the air in various ways suited at each stage of weaning from cardiopulmonary bypass (CPB).

Just After Aortic Declamping

Pooled air at the atrial orifice of right upper pulmonary vein (RUPV) and in the left atrium (LA) is noted. When there is a strong echo with swaying motion and RUPV is masked by acoustic shadow, air fills RUPV up to the atrial orifice, potentially amounting to several milliliters (Figs 1B, 2A). It should be removed before it migrates toward the left ventricle (LV). By loosening the tourniquet around the vent cannula with some water in pericardial space, air exits into the water by buoyancy (Fig 2B),

facilitated by right downward position and lung inflation. The proximal portion of RUPV becomes visible (Fig 2C).

Air is often found at the small recess formed between the superior vena cava (SVC) and ascending aorta, named "R spot" (Fig 2D). In a left downward position, the air migrates toward the vent entry site due to buoyancy. However, air in the R spot tends to stay because of a ridge formed by the SVC. Digital compression of R spot (between the SVC and aortic root) deforms the recess (Fig 2E), and the air moves toward the vent entry site. TEE shows the R spot inverted into the LA (Fig 2F) and disappearance of air.

During Weaning From CPB

As blood is returned to the body, numerous bubbles appear from the RUPV similar to popcorn (popcorn sign [3]), and form an echogenic line along the LA wall with reverberations behind it (Fig 3A). Be careful for side lobe artifact, which mimics a LA mass [6]. Air should be removed before it moves into the LV. The tourniquet of vent cannula is loosened to let the air exit (Fig 3B), while air in TEE image disappears. A slight elevation of cannula facilitates air exit. Lung inflation squeezes the air in the RUPV toward the LA as well as accelerates blood flow.

Air may appear again after the vent cannula is removed or air at R spot often stays despite vigorous agitation by the surgeon. The tourniquet is left unligated when the vent cannula is removed, and the SVC is elevated by a curved or rectangular forceps inserted through it. Air exits by buoyancy (Fig 3C) although one should be careful not to let the air return to the RUPV.

Air in the LV may amount to 5 to 6 mL and should be removed before it is ejected to the aorta. If the apex can be elevated, needle aspiration efficiently removes a large amount of air (Fig 3D). TEE shows a decreased amount of air following aspiration. Needle aspiration is not efficient for a small amount of air in the trabeculae but heart is agitated to stir up the air into bubbles.

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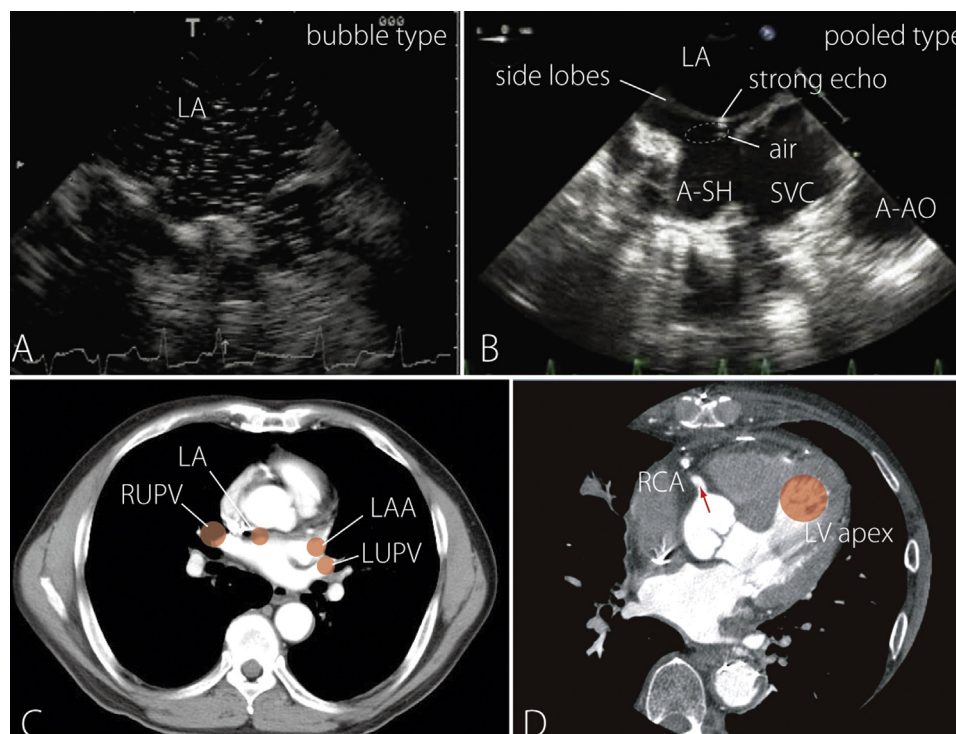


Fig 1. Transesophageal echocardiograms of intracardiac air and retention sites. (A) Bubble type in the left atrium (LA). (B) Pooled type in the right upper pulmonary vein (RUPV), which is masked by acoustic shadow (A-SH). (C, D) Common retention sites include RUPV, LA, left atrial appendage (LAA), left upper pulmonary vein (LUPV), and left ventricular (LV) apex. (A-AO = ascending aorta; RCA = right coronary artery; SVC = superior vena cava.)

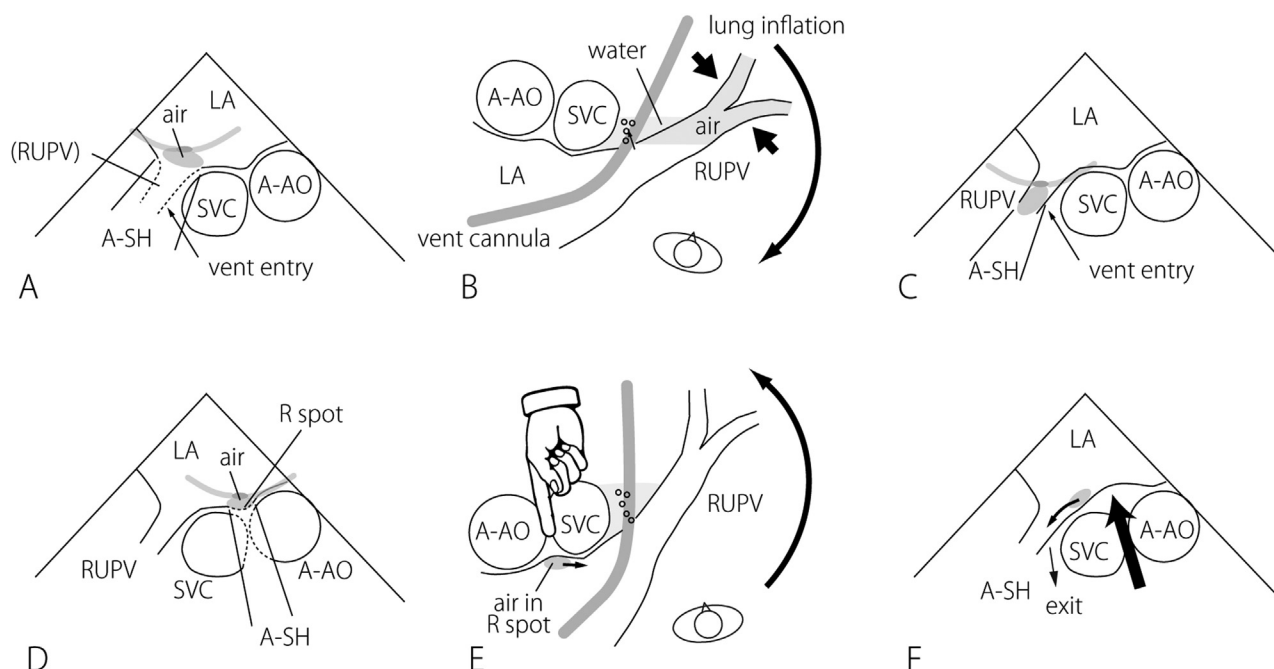


Fig 2. Air removal at the early stage of weaning from cardiopulmonary bypass. (A) Pooled air in the right upper pulmonary vein (RUPV) up to the left atrium (LA). (B) Tourniquet for fixing the vent cannula is loosened in the right down position. (C) Atrial orifice of RUPV appears as the air is reduced. (D) R spot: the recess between superior vena cava (SVC) and ascending aorta (A-AO). (E) Digital compression of R spot. (F) Corresponding echogram of R spot compression. (A-SH = acoustic shadow.)

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