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Review Article

Aortic Leaflet Billowing as a Risk Factor for Repair Failure After Aortic Valve Repair



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OVER THE PAST 20 years, key advances in surgical techniques of aortic valve (AV) repair and annular stabilization have transformed the field to challenge alternative AV replacement strategies as the optimal treatment in patients with pure aortic regurgitation (AR).^{1–18} Advantages of AV repair are a lower incidence of subsequent thromboembolic events, the avoidance of long-term anticoagulation, and reduced risks of endocarditis.¹³ As midterm and long-term data for recurrent AR and survival after AV-sparing procedures accrue,^{8,19–21} data on risk factors predisposing a patient to repair failure (greater-than-moderate AR) in the intraoperative setting after AV repair are becoming available.^{3,22,23} Such information is critical for optimal decision-making from the surgical side during the initial surgery because risk factors predisposing a patient to early recurrent AR may facilitate the surgical team to make the right decision regarding re-repair of a valve versus consideration of valve replacement.

After a discussion of the definition and clinical relevance of aortic leaf billowing in AV repair, the roles of echocardiography in this setting are explored.

Defining Leaflet Billowing

Billowing occurs when the nadir, or lowest portion, of the body of the aortic leaflet lies on the ventricular side of the

ventriculoarterial junction (VAJ), where the left ventricular outflow tract meets the aortic root, but the leaflet tip remains above it (Figs 1 and 2). Billowing reflects a predisposition for loss of leaflet structural support when the repaired valve is resuspended low in the aortic root complex. Billowing after cardiopulmonary bypass can occur in a symmetric or asymmetric fashion. Fig 1A shows the desired result after AV replacement, in which the nadirs of the leaflets are above the VAJ and the leaflet tips reach the midpoint of the sinus of Valsalva (SOV). Fig 1B depicts billowing of both cusps, and Fig 1C depicts asymmetrical billowing, in which the nadir of 1 or 2 of the leaflets lies below the VAJ but at least 1 leaflet nadir lies above the VAJ. With symmetric billowing, the nadirs of all the leaflets lie at the same distance below the VAJ.

Prolapse is another form of valvular incompetence. AV prolapse is defined as downward displacement of 1 or more leaflet tips below a line joining the points of attachment of the AV leaflets. With prolapse (Fig 1D), the leaflet tip of the right coronary cusp falls below the VAJ during diastole.

Clinical Relevance of Billowing for AV Repair

The concept of leaflet billowing gained attention as a marker for poor durability of AV repair in 2 surgical series and may be a risk factor for redo surgery.^{22,26} The first study, by le Polain de Waroux et al,²² was a retrospective review of the echocardiograms of 186 consecutive patients undergoing AV

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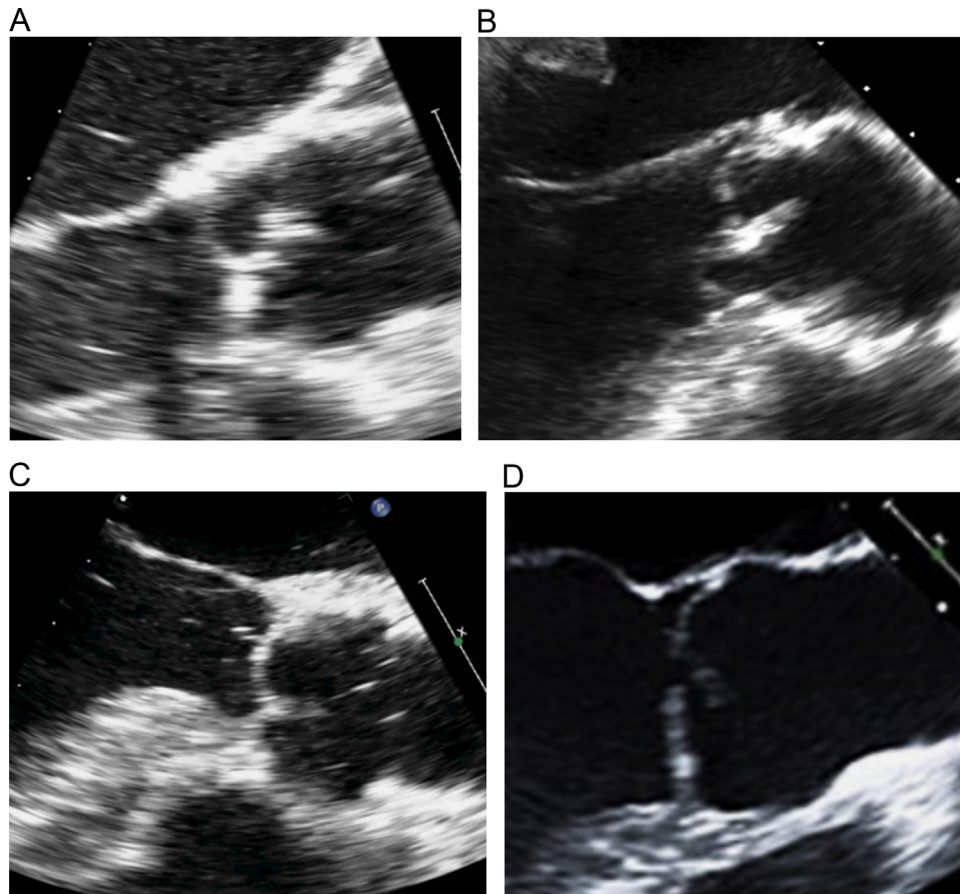


Fig 1. (A) Ideal result after valve-sparing aortic valve repair. The body of the leaflets remain above the VAJ. The leaflet tips reach to the midpoint of the sinus of Valsalva. (B) Symmetric leaflet billowing. Note that the nadirs of the body of both leaflets shown reach the same level below the VAJ while the leaflet tips remain above it. (C) Symmetric billowing, with the body of the right coronary leaflet extending farther below the VAJ than the other leaflet. (D) Aortic leaflet prolapse, in which the leaflet tip extends below the VAJ. (D) From Hall et al.²⁴

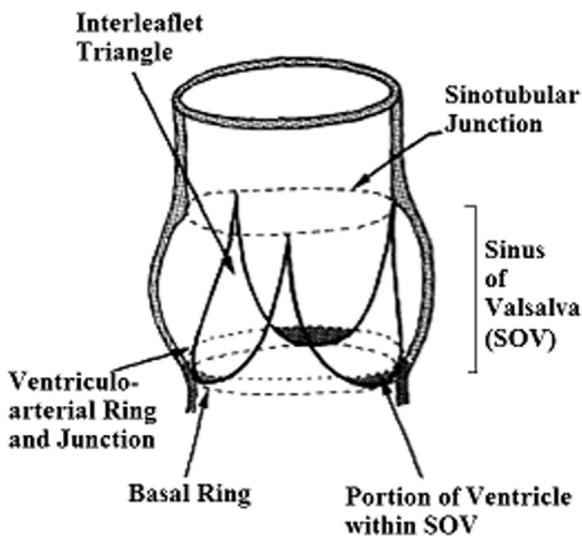


Fig 2. Diagram of the aortic root. The sinotubular junction and the ventriculoaortic junction compose the borders of the aortic root. The sinus of Valsalva is composed of expanded portions of the aortic root that lies between the STJ and VAJ. The basal attachment of the aortic cusps forms the basal ring, also often described as the "aortic annulus." Adapted from Sutton et al.²⁵

repair. Moderate or greater AR on follow-up was associated on univariate analysis with decreased coaptation length, coaptation level below the VAJ, the presence and degree of residual AR immediately after bypass, and the presence of leaflet billowing after AV repair. The second was a retrospective series of 86 patients by Miyahara et al,²⁶ in which leaflet billowing significantly correlated with greater-than-mild AR on follow-up 4 years after valve-sparing aortic root replacement with or without primary leaflet repair. Recurrent more-than-mild AR was associated with a lower effective height (EH) (7.47 ± 3.3 mm in the greater-than-mild AR group *v* 8.81 ± 2.1 mm in the less-than-mild AR group, $p = 0.049$); an eccentric AR jet postoperatively; and leaflet billowing. EH is the distance from the VAJ to the leaflet tip. Leaflet billowing was seen on echocardiography in 78.6% of patients with more-than-mild AR versus 20.8% of patients with less-than-mild AR. The presence of leaflet billowing increased the likelihood of recurrent AR (hazard ratio 10.96, 95% confidence interval 3.24-50.9; $p < 0.0001$). Risk factors for redo surgery on univariate analysis were an enlarged preoperative sinotubular junction (STJ), aortic dissection, postoperative eccentric jet, and leaflet billowing after repair.

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