Tips and Pitfalls on the Role of Echocardiography in Percutaneous Intervention for Hypertrophic Cardiomyopathy

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Hypertrophic cardiomyopathy (HCM) is the most prevalent genetic heart disease, affecting approximately 1 in 500 individuals in the general population,[1-3] with asymmetric septal hypertrophy as the most common phenotype. In obstructive HCM (oHCM), clinical relevance is greater due to its association with atrial fibrillation, heart failure, thromboembolic events, arrhythmias, and sudden cardiac death.[2,3] For patients who remain symptomatic despite optimized medical therapy, septal reduction has become an established strategy, with surgical septal myectomy as the gold standard.[4] Alcohol septal ablation is an alternative when surgical risk is prohibitive, there are contraindications to surgery, advanced age, or favorable coronary anatomy; it should be performed in experienced centers.[5-8] Other percutaneous approaches — such as radiofrequency septal ablation,[1] the use of coils, or liquid embolic agents — have also been described.

Echocardiography plays a central role throughout the management of oHCM undergoing percutaneous intervention. Beyond diagnosis, it is essential for periprocedural guidance and for postoperative assessment. Understanding its capabilities and recognizing potential pitfalls are critical to success. This editorial offers practical tips for echocardiographers and highlights key points that, if overlooked, may compromise outcomes.

The first challenge occurs before the procedure. In addition to measuring left-ventricular size and systolic/diastolic function, it is essential to confirm the location, distribution, and maximal wall thickness of hypertrophy; verify whether there is significant dynamic obstruction at the left ventricular outflow tract (LVOT) or at the mid-ventricular level; identify systolic anterior motion (SAM) of the mitral valve; and grade mitral regurgitation. Underestimation of the gradient is frequent when provocative maneuvers — such as the Valsalva maneuver or exercise — are not used.[2,3] In symptomatic patients whose peak LVOT gradient remains < 50 mm Hg after Valsalva, exercise stress echocardiography — preferably on a cycle ergometer — should be performed, as it allows continuous monitoring of obstruction progression and gradient rise.[2,3]

Overestimation is another common error, typically caused by inadvertently measuring the velocity of the mitral regurgitation jet instead of the LVOT jet. On apical continuous-wave Doppler, these envelopes often overlap, particularly when lateralization of the transducer is insufficient and the LVOT alignment passes near the origin of the regurgitant jet, causing contamination (Figure 1B). Careful interrogation of the continuous-wave Doppler — considering the onset, contour, and timing of the peak — is required to distinguish them.[2,3] Gradient magnitude also varies across the respiratory cycle, influenced by preload and afterload, which can further complicate interpretation. If uncertainty persists, a practical approach is to obtain the best mitral-regurgitation envelope on continuous-wave Doppler, measure the peak transmitral systolic gradient, and add the estimated left-atrial pressure (typically 10-15 mm Hg) to infer left-ventricular peak systolic pressure; the estimated dynamic gradient corresponds to the difference between ventricular and aortic systolic pressures (Figure 2). Finally, contractility, preload, and afterload should always be verified, as they determine the magnitude of the Venturi effect; abrupt volume depletion, for example, increases the gradient in any obstructive phenotype (Figure 1).

Once the diagnostic stage is complete, periprocedural planning becomes paramount. Echocardiographic guidance substantially increases procedural safety and efficacy and should be incorporated as a routine component of the protocol. Selection of the target septal branch for ablation depends on integrating coronary angiography with echocardiographic findings. Direct injection of radiographic contrast or, preferably, an ultrasound contrast agent (USCA) into the candidate septal branch is a mandatory step,[6,9] because it confirms perfusion of the region of interest and reveals inadvertent perfusion of off-target areas due to collateral flow between the septal artery and adjacent coronaries. It is essential to document perfusion of myocardial segments distant from the intended target — such as the anterolateral left-ventricular wall, the right-ventricular free wall, and the papillary muscles. In these situations, alcohol or other intravascular occlusive agents are contraindicated, and radiofrequency ablation is a viable alternative.[1] Use of USCA is associated with higher success rates, shorter procedure time, lower alcohol volumes, reduced risk of heart block, and smaller septal infarcts.[4,5,9] Transthoracic echocardiography is sufficient in most cases, but a transesophageal approach becomes

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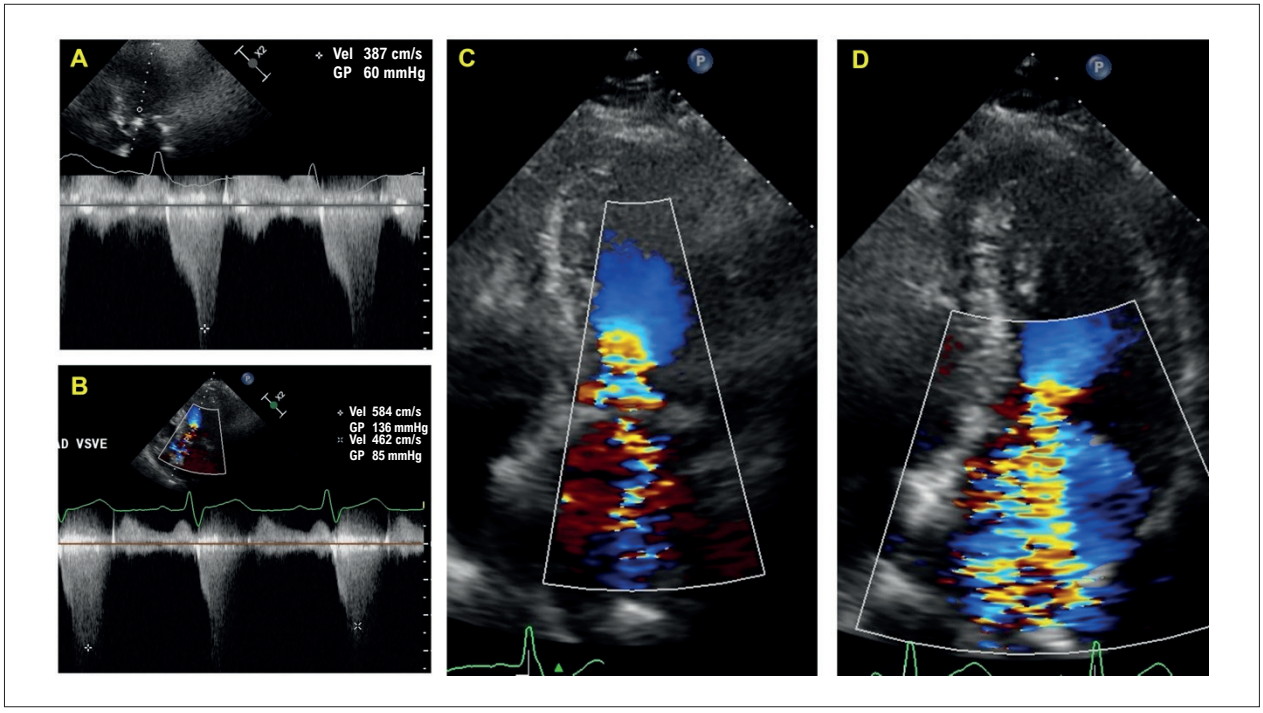

Figure 1 – *Increase in LVOT gradient from 60 mm Hg (A) to 136 mm Hg (B) and worsening mitral regurgitation (MR) from moderate (C) to severe (D) after dialysis with ultrafiltration. These findings indicate intensification of obstruction (greater Venturi effect) due to reduced preload. The post-ultrafiltration gradient curve suggests possible overlap of the mitral regurgitation signal. IM: mitral regurgitation; LVOT: left ventricular outflow tract; PG: pressure gradient; Vel: velocity.*

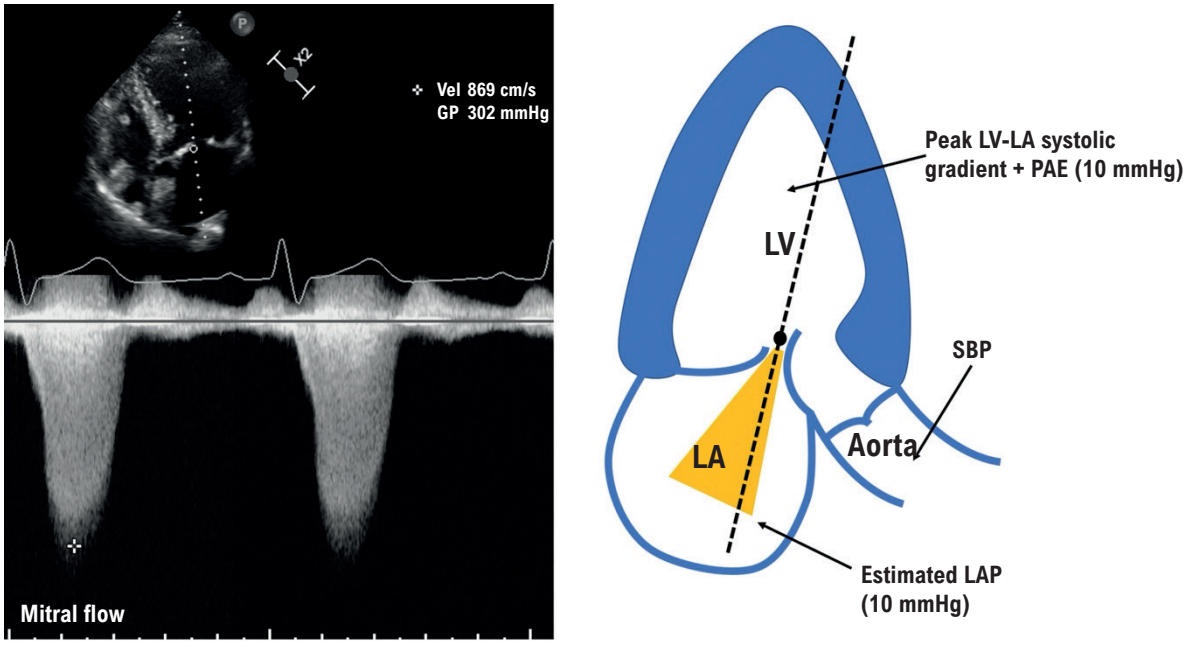

Figure 2 – *Cross-check of the post-ultrafiltration LVOT gradient by estimating left-ventricular systolic pressure from the peak systolic LV-LA transmitral gradient of the mitral-regurgitation jet. The difference between the estimated LV systolic pressure and brachial SBP matches the LVOT gradient estimated in Figure 1. LA: left atrium; LAP: left atrial pressure; LV: left ventricle; LVOT: left ventricular outflow tract; PG: pressure gradient; SBP: systolic blood pressure; Vel: velocity.*

mandatory when the transthoracic window is inadequate or when more detailed assessment of the interventricular septum and adjacent structures is required.

During the procedure, the echocardiographer's role becomes even more critical. An immediate gradient reduction indicates success — regardless of technique — and should be > 50% from baseline or leave a residual resting gradient < 30 mm Hg.[5,7] Interpretation, however, requires caution: transient changes driven by inflammatory mediators and acute hemodynamic fluctuations after the septal infarct can mask the final effect. At this stage, only akinesia of the alcoholized segment is observed; septal thinning from fibrotic scarring — and the resulting enlargement of the LVOT — develop later. Accordingly, additional parameters must be monitored with equal rigor, including reduction or resolution of SAM and the degree of mitral regurgitation, while ensuring proper Doppler alignment at every step.[2,3]

The most feared immediate complication is reflux of alcohol into the left anterior descending (LAD) artery, usually due to incomplete balloon occlusion of the septal branch, balloon rupture, or retrograde flow through collaterals. This risk can be prevented or mitigated by slow, judicious infusion of absolute alcohol by the interventionalist with vigilant, continuous echocardiographic monitoring.[6,9] When present, reflux almost invariably leads to distal LAD occlusion and an acute infarction of the anterior left-ventricular wall; therefore, global and regional systolic function of both ventricles should be continuously assessed and documented. Another rare complication that requires echocardiographic surveillance — from the acute phase through scar consolidation — is a ventricular septal defect.

In post-procedure follow-up, echocardiography remains indispensable. During the first weeks, the gradient may paradoxically increase because of edema in the infarcted septum, before fibrosis develops and consolidates durable remodeling.[8] Recognizing this temporal pattern is crucial to avoid a premature diagnosis of technical failure. Success should be documented with serial studies demonstrating a progressive decline in the gradient accompanied by clinical improvement.

Another essential point is the need for highly specialized training. There is a learning curve for echocardiographers in HCM, and misinterpretation can lead to inappropriate management. Consensus supports restricting these procedures to specialized centers where interventional cardiologists and echocardiographers work collaboratively with standardized protocols.[2,3]

In summary, echocardiography is indispensable at every stage of percutaneous intervention for oHCM: rigorous candidate selection, intraoperative strategy, procedural monitoring, and long-term follow-up. The chief pitfalls include under- or overestimation of the dynamic gradient, errors in selecting the target septal branch, and premature judgments of procedural success. These realities underscore the importance of operator experience, continuous training, and standardized protocols. In an era when percutaneous therapies are established as an effective alternative to surgery, the vigilant, judicious oversight of an experienced echocardiographer enhances both the safety and the efficacy of the procedure.

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