Special Article
The Year in Perioperative Echocardiography:
Selected Highlights from 2017

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Abstract
This article is the second of an annual series reviewing the research highlights of the year pertaining to the subspecialty of perioperative echocardiography for the Journal of Cardiothoracic and Vascular Anesthesia. The authors thank the editor-in-chief, Dr. Kaplan, and the editorial board for the opportunity to start this series. In most cases, these will be research articles that are targeted at the perioperative echocardiography diagnosis and treatment of patients after cardiothoracic surgery; however, in some cases, these articles will target the use of perioperative echocardiography in general.

Key Words: perioperative echocardiography; atrial fibrillation; Lariat procedure; WATCHMAN device; stroke; strain imaging; speckle tracking; layer-specific strain imaging; echocardiographic guidelines; congenital heart disease; three-dimensional echocardiography; stress echocardiography; aortic valve stenosis, native valvular regurgitation; cardiac magnetic resonance

THIS SPECIAL ARTICLE is the second in an annual series for the Journal of Cardiothoracic and Vascular Anesthesia. The authors thank the editor-in-chief, Dr. Kaplan, and the editorial board for the opportunity to continue this series, namely the research highlights of the year that pertain to perioperative echocardiography in relation to cardiothoracic and vascular anesthesia. The major themes selected for 2017 are outlined in this introduction, and each highlight is reviewed in detail in the main body of the article. The literature highlights in the specialty for 2017 begin with the role of echocardiography in atrial fibrillation management with a particular focus on transesophageal echocardiography (TEE)-guided percutaneous left atrial appendage (LAA) occlusion or exclusion. Although electrophysiologists often use intracardiac echocardiography, these procedures continue to be guided predominantly with TEE. The second major theme in perioperative echocardiography in 2017 was the continued development of echocardiographic speckle-based strain imaging. A burgeoning new area of strain imaging is layer-specific strain imaging (LSSI), which attempts to recognize the different contributions to contraction from subendocardial versus midendocardial and epicardial myocardial layers. The third major theme for the subspecialty in 2017 was publication of numerous echocardiographic-based guidelines and expert consensus statements. These documents provide a significant review and update on 3-dimensional echocardiography in congenital heart disease, stress echocardiography, aortic stenosis (AS), and native valvular regurgitation. A review of each of the documents is included. The themes selected for this special article are only a sample of the advances in perioperative echocardiography during 2017. These highlights likely will further improve important perioperative outcomes for patients with cardiovascular disease.

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Echocardiography for Atrial Fibrillation

Atrial fibrillation is recognized as an independent risk factor for stroke and contributes to more than 20% of strokes in the United States. The 5-fold increase in risk conferred by atrial fibrillation combined with the yearly incidence (795,000) and impact (fourth leading cause of death) of stroke in the United States makes stroke prevention (eg, anticoagulation, WATCHMAN) or atrial fibrillation treatment (eg, medical management, pulmonary vein isolation) a rapidly expanding focus of interest. Given that the LAA is a frequent source of thrombus (91% of left heart thrombi in nonrheumatic atrial fibrillation and 57% of thrombi in rheumatic atrial fibrillation), many new devices, techniques, and research focus on the occlusion/exclusion as well as electrical isolation of the left atrial appendage.

The architects of the percutaneous alternative to the Maze procedure for the treatment of persistent or longstanding persistent atrial fibrillation (aMAZE trial) recognized the potential importance of the left atrial appendage in atrial fibrillation. The goal of this prospective, multicenter, randomized study is to determine the safety and efficacy of isolation and ligation of the left atrial appendage by the LARIAT system (SentreHEART, Redwood City, CA) as an adjunctive therapy to pulmonary vein isolation. If this ongoing study confirms the safety and efficacy of the LARIAT system in the treatment of atrial fibrillation, one can surmise that the number of LARIAT procedures performed annually will increase.

The LARIAT procedure, which involves establishing a magnetic link between a trans-septally positioned catheter and an epicardial catheter followed by epicardial suture ligation of the left atrial appendage, possesses the unique advantage of not only eliminating a potential source of thrombus but also electrically isolating the LAA. Furthermore, the procedure does not result in any foreign material in the left atrium. Therefore, the LARIAT procedure can be performed in patients who cannot tolerate even brief periods of anticoagulation post-procedure. Although the LASSO device (Aegis Medical Innovations, Vancouver, BC, Canada) also can ligate the left atrial appendage, it is not currently Food and Drug Administration (FDA) approved. Interestingly, the LARIAT device is not approved specifically for percutaneous exclusion of the LAA by the FDA but has received class II clearance under the 501(k) protocol.

Despite the unique features of the procedure and LARIAT device, reliance upon periprocedure TEE persists. The recent review article by Vainrib et al. in the Journal of the American Society of Echocardiography extensively described LAA exclusion/occlusion procedures as well as the nuances of procedural TEE. Given that pericardial access is required, contraindications unique to the LARIAT procedure include a history of cardiac surgery or pericarditis. In addition, a large LAA body (eg, > 45 mm) and a superiorly oriented LAA preclude percutaneous pericardial suture ligation. As with any of the occlusion/exclusion procedures described, intraprocedure TEE also is invaluable for catheter guidance, the rapid identification of pericardial effusions, and the determination of procedural success. However, TEE also is used during to confirm that the right ventricle has not been punctured while obtaining pericardial access in the LARIAT procedure.

Although there are multiple endocardial closure devices available worldwide, the WATCHMAN device (Boston Scientific, Minneapolis, MN) is currently the only FDA-approved device (Fig 1). The Amulet device (St. Jude Medical, Minneapols, MN), a second-generation LAA occluder, currently is under investigation in the United States. The reviews by Vainrib et al. and Mitrev et al. highlighted the importance of echocardiography in the successful deployment of a WATCHMAN device. Not only does the echocardiographer determine the morphology of the appendage (eg, cactus, chicken wing, windsock, cauliflower, or broccoli), ostium size, and depth of the main lobe, guide the septal puncture, and confirm the adequacy of occlusion (eg, peridevice leaks < 5 mm are acceptable, device diameter compression), but also is relied upon to identify any additional contraindications to device implantation (eg, atrial septal defect, patent foramen ovale, prior interatrial occlusion device, aneurysmal interatrial septum, intracardiac thrombus, significant mitral valve pathology) and procedural complications (eg, pericardial effusion, mechanical compression of pulmonary vein flow). Although intracardiac echocardiography of the LAA has been described, the procedure presently relies upon TEE guidance. Given that Reddy et al. recently reported that LAA occlusion with the WATCHMAN provided comparable stroke prevention to warfarin in nonvalvular atrial fibrillation, the number of WATCHMAN devices deployed with TEE guidance may increase steadily.

The role of the anesthesiologist during pulmonary vein catheter ablations also is expanding beyond the provision of general anesthesia. The case report by Khamooshian et al. and subsequent editorial by Amir et al. highlighted the importance of 2-dimensional (2D) as well as 3-dimensional (3D) echocardiography in the diagnosis and management of pulmonary vein stenosis, a complication of atrial fibrillation procedures that occurs in 0.4% to 1.0% of cases. Given the number of pulmonary catheter ablations completed in the United States...
per year (40,000 to > 150,000 cases/year has been reported in the literature), the reliance upon anesthesiologists with TEE knowledge may continue to increase in the future. Therefore, anesthesiologists with echocardiographic privileges should be familiar with the presenting symptoms, echocardiographic characteristics (e.g., a reduction in pulmonary vein diameter > 3.25 mm, pulmonary vein velocity > 1.1 m/s, and turbulent flow on color flow Doppler), and management (e.g., balloon angioplasty, stenting, surgery) of this potential complication.

However, the utility of TEE in pulmonary vein isolation cases is not limited to rare complications such as pulmonary vein stenosis. Despite a shift in the literature toward uninterrupted periprocedural anticoagulation regimens, thromboembolic events associated with catheter ablations still do occur. In fact, reports state that intracardiac echocardiography have identified intracardiac thrombus in the left atrium in as many as 10.3% of catheter ablations. It is not surprising that the 2017 expert consensus statement on catheter and surgical ablation of atrial fibrillation found that 51% of the writing group employed intracardiac echocardiography during atrial fibrillation ablations, and 37% of those who use intracardiac echocardiography screened for left atrial thrombus prior to puncturing the interatrial septum.

A survey of the aforementioned writing group identified that 51% of members also performed a TEE in all patients presenting for atrial fibrillation ablation regardless of the presenting rhythm or anticoagulation status. In patients undergoing atrial fibrillation ablations who have received systemic anticoagulation, the incidence of sludge or thrombus in the LAA on TEE is between 1.5% and 2.1%. Therefore, it is not surprising that approximately 72% of centers in the United States require a TEE prior to an atrial fibrillation ablation procedure. Furthermore, many authors advocate for a screening TEE, which is the gold standard for LAA screening and possesses a high sensitivity (> 95%) and specificity (> 95%), in high-risk patients. Alternative studies suggest that a screening TEE may not be necessary in patients without a history of atrial fibrillation with rapid ventricular response that resulted in hypopharyngeal and esophageal injuries, which ultimately resulted in a total esophagectomy and tracheostomy. Therefore, despite the low quoted incidence of esophageal and gastric perforations (0.01%-0.03%), “minor and major” complications (0.2%-0.5%), and mortality (< 0.01%), the placement of a TEE probe should not be taken lightly.

Peeling the Onion: Measurement of Layer-Specific Strain Using Speckle Tracking Echocardiography

It is hard to imagine modern-day management of cardiac disease without any estimation of global left ventricular (LV) function to guide it. Echocardiography traditionally has been the mainstay in measuring LV function using ejection fraction (EF), mostly due to its availability and simplicity. However, geometric assumptions, foreshortening, load dependence, and inter-observer variability have limited the accuracy of 2D echocardiography when compared with cardiac MRI. Strain imaging (SI) derived from speckle tracking echocardiography has been used to evaluate the LV and validated as a sensitive and specific tool to detect subclinical myocardial dysfunction (Fig. 2). Speckle tracking uses discrete bright dots or, “speckles,” and tracks them throughout the cardiac cycle to analyze various aspects of systolic and diastolic function. Strain measurement is derived from spatial relationships of these speckles and employs the shortening of the distance between these speckles as a measure of ventricular function. Its utility has been shown to exceed EF in predicting various cardiovascular outcomes. Speckle tracking is now the principal technique for analyzing strain, having superseded the Doppler-based approach, which is how SI began in the first place.

The analysis of the LV as a single layer is a little simplistic, though. The LV wall long has been recognized as a complex structure with circumferential fibers in the mid-myocardial layer and longitudinal fibers in the outer epicardial (EPI) and inner subendocardial (SEN) layers. This differentiation has profound clinical implications because myocardial dysfunction is known to appear first in the SEN layer owing to its susceptibility to ischemia. It presumably could be a substrate where treatment modalities can be observed to have an earlier and more robust benefit. Evidence supporting this hypothesis was provided by a report on patients undergoing aortic valve

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replacement either via transcatheter route (28 patients) or conventional surgical means (33 patients). The authors reported improvement in strain generation in all the myocardial layers following valve replacement, which was maintained at 1 year post-valve replacement. However, it was SEN strain, which was also the earliest to change, that showed the maximum improvement. MRI-based analysis has revealed a gradient between the 3 layers as well, with maximum strain being generated in the SEN layer (perhaps another reason for it being prone to ischemia), with an outward decrease. However, SI from MRI data is relatively time-consuming and not as readily available in dynamic clinical environments such as the operating room. Interest in the analysis of layer-specific function (using echocardiography) started in the early part of the decade, but reports of its widespread application only recently have gathered momentum.

Standardization (to find out the population averages) is one of the first things to occur with a new modality of investigation, and this particular one is no different. Early in 2017, Nagata et al. endeavored to establish the reference values of layer-specific strain (both circumferential and longitudinal) with its measurement in 254 healthy subjects. They also attempted to subcategorize the data into normal ranges based on age and sex. Normal values for longitudinal strain were obtained and fell between −17% and −23% based on layers (remembering that strain, normally, is a negative number). The corresponding values for circumferential strain were between −15% and −25%, showing a greater variation. SEN strain was on average higher than EPI, which was consistent with MRI findings reported previously, and female patients manifested higher strain in all layers and across all segments. Interestingly, the whole group showed a decrease in longitudinal strain in the base and mid segments after the fifth decade of life. Another study corroborated these findings and found reduced SEN strain generation in patients suffering from diabetes. Fibrotic remodeling of the LV and increased LV mass is likely to have contributed to the reduction in strain seen in the basal and mid segments with age, but the significance of these findings is not entirely clear at the moment. As understanding of function in the different layers of the LV improves, LSSI may prove to be a window into understanding the development of subtle myocardial dysfunction with age and then studying efficacious preventive measures.

When it comes to stress echocardiography and its use for detecting underlying ischemia, conventional echocardiography suffers from operator-dependent variability in image acquisition and interpretation of regional wall motion abnormalities. SI has shown promise in detecting ischemia-related myocardial dysfunction at an early stage; given the variability of ischemia across myocardial layers, it is logical to investigate patients with coronary artery disease (CAD) for variations in layer-specific strain. This was done in a study published in *Echocardiography*, where the authors analyzed data from 80 patients who were worked up for angina and had 2D data available for LSSI. These patients underwent myocardial perfusion imaging, and the half (n = 40) that were positive for ischemia then were assessed with coronary angiography for true CAD. The authors report significantly lower longitudinal strain in patients with angiographic disease across all layers (eg, endocardial strain: −18% v −21.4%; p < 0.001). Further analysis revealed an association between stenosis location (in the supplying vessel) and regional strain reduction in the lateral and inferior walls, but not in other areas of the ventricle. They also could not prove an independent association between CAD and endocardial strain. This was in stark contrast to epicardial strain, for which there was an association. This surprising finding needs further investigation, since the
authors offered no clear hypothesis or explanation for it. The same group recently published the results of their longer-running trial in which only EPI and whole-wall strain (but not SEN stain) could independently predict major adverse cardiovascular events. This could be an area for further work given these discrepant observations. Further along the spectrum, attempts have been made to extend the utility of LSSI to the assessment of the myocardium that is known to suffer from chronic ischemia. The ability to discriminate transmural scar versus scar that is restricted to the endocardial layer is important, since it helps identify the parts of the ventricle that are viable, and thus will benefit from revascularization. A group from Switzerland recently published data looking at 49 patients with chronic ischemic cardiomyopathy versus 21 healthy controls. Cardiac MRI and LSSI using echocardiography was used to examine the LV, and the results of the 2 were compared. They found that although LSSI could discriminate between scar tissue and normal myocardium, it could not differentiate between transmural and SEN scar. It is conceivable that tethering to the adjacent viable myocardium and subsequent movement impaired the accuracy of SEN measurements, or that imaging from transthoracic windows produced interference with analysis. Indeed, the authors reported poor imaging in 12% to 13% of the segments, particularly in the apical views. Since SEN fibers mostly are longitudinal, their conclusions cannot be considered robust, but it does represent an interesting avenue to pursue.

Impaired longitudinal strain, as indeed EF, has been associated with worse outcome and increase in the risk of all-cause mortality. But this association is much stronger in patients with cardiac dysfunction. The challenge is to detect LV dysfunction early, while still reversible to a greater extent. Since SEN stain) could independently predict major adverse cardiovascular events. This expert consensus statement fills in a gap from previous statements and guidelines that provide recommendations on TTE, TEE, and 3DE in the adult population, noting 3DE’s usefulness in procedural planning prior to surgical correction, guidance of catheter-based interventions as well as functional assessments, particularly ventricular volume and function. This consensus statement includes a primer on the basics of 3DE techniques, data set acquisition modes and principles, as well as recommended standard orientation approaches to image display. The recommendation is to orient anatomy either in the same orientation as a person standing in an upright position (superior structures placed at the top of the screen) or as a “surgical orientation” (placing the structure in a similar fashion to what is visualized intraoperatively by the surgeon). Examples are provided for certain structures such as atrial and ventricular septums, atrioventricular valves, and outflow valves. The authors clearly note that 3DE is a complementary technique to 2D echocardiography as opposed to a replacement technique.

Improved spatial display and awareness with 3DE provides the basis for live guidance of interventional procedures. Three-dimensional echocardiography is particularly helpful in complex lesions such as multiple or asymmetric shaped defects such as in atrial septal defects with an emphasis of multiplanar reformatting for accurate measurements of septal rims for percutaneous repair. Live 3D imaging is recommended during catheter-based interventions again due to improved spatial display of catheters and device location.

**Guidelines, Guidelines, and More Guidelines**

The American Society of Echocardiography (ASE) Committee on Guidelines and Standards was exceptionally productive in 2017 with the publication of 4 documents inclusive of guidelines, clinical recommendations, and consensus statements. Three of the documents are coauthored with the European Association of Cardiovascular Imaging (EACVI) and include an expert consensus document on three-dimensional echocardiography (3DE) in congenital heart disease (CHD), as well as clinical recommendations regarding the use of stress echocardiography (SE) in non-ischemic heart disease and a focused update on the echocardiographic evaluation of aortic valve stenosis (AS). The last document is coproduced with the Society for Cardiovascular Magnetic Resonance and focuses on recommendations for evaluation of native valvular regurgitation. This set of guidelines is comprehensive in nature and includes recommendations regarding cardiac magnetic resonance (CMR) evaluation of regurgitation and how to integrate both echocardiography and CMR into practice. Although each of the guidelines is extensive in nature, they provide a comprehensive review and update to the echocardiographic evaluation in their clinical arena. Highlights of the guidelines as related to perioperative echocardiography are provided below; however, the full content provided in the documents is certainly worth reading. One caveat worth mentioning is that the guidelines generally focus on transthoracic echocardiography (TEE) imaging and occasionally reference TEE, so appropriate extrapolation of recommendations is warranted.

**Three-dimensional Echocardiography in Congenital Heart Disease**

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In regard to ventricular volume assessment, the guidelines note that there are several techniques for assessing volumes, including summation method of discs and semi-automated border detection, which often have a systematic bias toward underestimation when compared to CMR and therefore are not interchangeable with CMR values. Additionally, the guidelines report that normal data is lacking and that “normal” 3D volume software should not be utilized for congenitally abnormal ventricles until appropriately validated. However, in regard to valvular disease, 3DE has demonstrated significant utility. As a complementary modality to 2D echocardiography, the improved spatial display allows for better visualization of anatomy, particularly for atrophicventricular valves, thereby assisting in surgical planning. Additionally, use of multiplanar reformatting of arterial valves allows accurate measurements of annular and root dimensions. Although 3DE demonstrates its benefit for anatomy assessments, utilization of 3DE for quantification of valvular regurgitation has not been validated in children or many congenital heart pathologies. The guidelines conclude with training recommendations for the congenital echocardiographer, noting the continued developing utility of 3DE and its existing learning curve.

Stress Echocardiography for Non-ischemic Heart Disease

The most common utilization of stress echocardiography (SE) is for the assessment of ischemic heart disease via identification of regional wall motion abnormalities under stress conditions, either physically or pharmacologically induced. The modality now is utilized for a variety of conditions including valvular disease, nonischemic cardiomyopathy, diastolic heart failure, hypertrophic cardiomyopathy, and pulmonary hypertension (PH), among others. The guidelines on SE begin with a review of stress-related methods, including physical exercise such as treadmill and semirecumbent bicycle protocols (noted for the bicycle’s ability to laterally tilt, allowing improved TTE imaging), as well as pharmacologic methods such as dobutamine or adenosine.

The document subsequently follows with attention to a variety of conditions. In relation to diastolic SE, the modality allows the identification of diastolic reserve in patients with dyspnea and unclear diastolic indices. Noting a rise in LV filling pressures via E/e’ increases presence of peak tricuspid regurgitation (TR) velocity greater than 2.8 m/s or associated reductions in e’. Diastolic SE can be utilized independently or in association with ischemic SE. Similarly, peak TR velocity under stress as well as indices of RV function can be evaluated in patients with dyspnea and suspected PH. A more well-known use of SE is the evaluation of the patient with hypertrophic cardiomyopathy to evaluate for the presence of left ventricular outflow tract obstruction (LVOTO) in patients who fail to have an LVOT gradient > 50 mmHg with bedside maneuvers (eg, Valsalva maneuver). The guidelines note that in the outpatient arena, exercise is preferred over dobutamine as it is more physiologic; however, dobutamine can be utilized both pre- and post-CPB to guide surgical therapy.

A large portion of the SE for nonischemic heart disease guidelines focuses on the evaluation of native and prosthetic valve disease. This involves evaluating patients with severe valvular disease without symptoms to see if symptoms can be elicited, patients with nonsevere valvular disease to see if the patient has dynamically severe disease, and in the setting of valvular disease with low flow states to assess for a dynamic component. When evaluating primary mitral regurgitation (MR) with SE, noting worsening MR grades, dynamic PH (systolic pulmonary artery pressure ≥ 60 mmHg), absence of contractile reserve (< 5% increase in EF), and a limited RV contractile recruitment are all predictors of poor prognosis. Notably, the lack of a LV contractile reserve predicts post-bypass LV systolic dysfunction. In relation to secondary MR, SE is helpful in the patient with symptoms out of proportion to LV dysfunction or MR severity at rest. The document notes that SE cannot be used to grade aortic regurgitation (AR) as hemodynamics are significantly altered during stress; however, SE can play a role in eliciting symptoms in the patient with asymptomatic severe AR at rest. In regard to mitral stenosis (MS), SE plays a role in the evaluation of a symptomatic patient with non-severe MS. The identification of a mean gradient greater than 15 mmHg or elevation of systolic pulmonary artery pressure ≥ 60 mmHg with exercise are indicative of severe MS. In patients with asymptomatic severe AS, exercise stress echo may uncover symptoms as well as identify risk factors of poor prognosis such as increase in mean pressure gradient, lack of LV functional reserve, and development of PH. The increase in gradient of > 18-20 mmHg under stress may be an indication for AVR. In the setting of low-flow, low-gradient aortic stenosis, SE plays a significant role in identifying true severe AS, which benefits from AVR, versus pseudo-severe, where treatment focuses on improving LV function. In classical low-flow, low-gradient AS with reduced EF, the aortic valve area (AVA) is less than 1.0 cm²; however, the mean gradient is less than 40 mmHg. With low-dose dobutamine, true severe AS will manifest with an increase in flow and an increase in mean gradient > 40 mmHg. With pseudo-severe AS, low-dose dobutamine does not increase the mean gradient, yet the AVA increases > 1.0 cm². Lastly, SE can be utilized similarly in prosthetic valves to evaluate for prosthetic valve stenosis or patient-prosthesis mismatch. Low-dose dobutamine can help to differentiate between true dysfunction and pseudo-dysfunction. Identification of a change in mean gradient of > 20 mmHg across aortic prosthesis or > 10 mmHg across mitral prostheses indicates true dysfunction or patient-prosthesis mismatch.

Focused Update: Echocardiographic Assessment of Aortic Valve Stenosis

These recommendations provide an update to the guidelines on echocardiographic assessment of valvular stenosis published in 2009, with a focus on ASs and particular attention to the subgroup of low-gradient AS. The guidelines begin with review of the basic approach to severity assessment including peak velocity, mean gradients, and AVA, including...
caveats of gradient measurements and pitfalls of LVOT area assessments. The document shines in its new algorithm that classifies AS based upon gradient, flow, and left ventricular ejection fraction (LVEF). The focus of the algorithm is on the decision tree of a patient with low-gradient AS (mean gradient < 40 mmHg), dividing these patients into normal flow (stroke volume index [SVI] > 35 mL/m²; likely moderate AS) and low flow (SVI < 35 mL/m²). The low-flow group further is subdivided by LVEF, into those with low LVEF (classical low-flow, low-gradient AS) and normal LVEF (paradoxical low-flow, low-gradient AS), who are patients often with significant LVH, low LV chamber volumes, and subsequent low cardiac output. In the low-flow groups, the recommendations are to consider dobutamine stress echocardiography as described earlier. An increase in AVA to > 1.0 cm² indicates pseudo-severe AS and the patient is best treated with management of LV dysfunction, while an increase of mean gradient to greater than 30-40 mmHg indicates severe AS with aortic valve replacement most likely indicated. The guidelines note that like many clinical entities, management of AS involves an integrated approach combining echocardiographic variables with clinical information, noting that echocardiographic variables should not be used in isolation.

Noninvasive Evaluation of Native Valvular Regurgitation

This guideline31 is a comprehensive review of the evaluation of native valvular regurgitation and includes both a review of echocardiographic as well as CMR assessments, noting an integrative approach of both 2D and 3D TTE, specifically denoting when CMR or TEE are indicated in the evaluation. These guidelines additionally are reviewed in greater detail with a focus for the perioperative echocardiographer by Cherry et al.32 Although the guidelines cover regurgitation of all valves—mitral, aortic, tricuspid, and pulmonic—the bulk of coverage focuses on MR and AR. The discussion of MR focuses on etiology or mechanism of regurgitation with a review of the well-recognized Carpentier classification of mitral valve anatomy and leaflet motion,33 including particular discussion on primary versus secondary MR. The basics of echocardiographic evaluation focus on a progression of 2D, color flow Doppler (CFD), and then spectral evaluation, including pitfalls of each technique. Two-dimensional analysis should include assessment of anatomy and leaflet motion as described but also the influence of chronic MR on chamber sizes. CFD evaluates the appearance of chronic MR with a focus on all 3 areas: the flow convergence zone, vena contracta, and jet area, as eccentric jets are underappreciated by jet area alone. The guidelines specifically reference the utility of 3DE-derived vena contracta area (VCA), describing how the VCA in primary MR is often circular shaped while secondary MR has a more elliptical shape, thereby explaining potential pitfalls with the proximal isovelocity surface area measurements in secondary MR (Fig 3).

The guidelines provide tables for grading severity that nicely contain bolded items that are specific for their severity grade. For example, in regard to MR, small central, brief jets with small flow convergence zones and systolic dominance on pulmonary vein flow likely represent mild severity, while
anatomically abnormal leaflets with large flow convergence zones and systolic flow reversal on pulmonary venous Doppler represent severe lesions. An algorithm is provided such that if specific criteria are not met for mild or severe, then quantitative methods such as proximal isovelocity surface area or regurgitant fraction should be employed to ensure moderately graded regurgitation. When TTE quality is poor or indeterminate MR is identified, TEE or CMR should be employed.

A similar evaluation of AR is provided beginning with a focus on etiology or mechanism, noting the classification described by Boodhwani et al., again emphasizing that mechanism strongly influences surgical decision-making. The basics of echocardiographic AR evaluation are included, noting 2D, CFD, and spectral techniques and including caveats such as the cautioned use of jet height to LVOT ratio in eccentric jets or the influence of hemodynamic changes in pressure half-time measurements. A table with bolded specific findings for mild and severe range AR is provided. In the same fashion, an algorithm is provided emphasizing that if mild or severe criteria are not met, quantitative methods such as regurgitant fraction should be utilized. In settings of unclear severity, TEE or CMR should be employed. For TR and pulmonary insufficiency (PI), similar recommendations are provided, noting that in both techniques if specific criteria of mild or severe are not met, quantification methods are less robust. In TR, a focus on vena contracta is emphasized while in PI consider regurgitant fraction. For indeterminate cases, consider CMR or TEE while noting that TEE is not a preferred modality in PI.

Although the guidelines provide significant amounts of detail in the review and recommendations across several clinical areas, they provide a very nice background and comprehensive review to each of their areas of interest. Additionally, they factor in the most recent literature to bring all echocardiographers up to date.

References


