Right Ventricular 3-Dimensional Strain in Pulmonary Hypertension

The Quest to See the Future*

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According to legend penned by Sir Thomas Malory (1), King Arthur’s knights searched far and long for the Holy Grail. Modern cardiologists are a far cry from the knights-errant of antiquity, but we, too, pursue our holy grails. What quest or goal does an echocardiographer long to see today? How about an accurate, foolproof echo technique to quantify mitral regurgitation? Perhaps, at last, could we find a reliable method to quantify myocardial ischemia with contrast echocardiography? We also long for a more complete evaluation of right ventricular (RV) anatomy and function. The RV has begged for 3-dimensional (3D) assessment for years. Recent studies have suggested that 3D echo imaging of the RV is indeed feasible, and its results compare reasonably well with magnetic resonance imaging (MRI) (2).

In this issue of the Journal, Smith et al. (3) extend analysis of RV function to 3D measurement of strain. Although originally designed for evaluating the left ventricle, software programs for 2D strain analysis by speckle tracking have been applied effectively to the RV (4). For example, 2D strain imaging of the RV has been shown to help predict outcomes in patients with left ventricular systolic failure referred for heart transplantation (5). Also, improvement in 2D RV strain with medical treatment has correlated with better survival in patients with pulmonary hypertension (6). Recently, Fine et al. (7) examined a large population with pulmonary hypertension and found that 2D RV strain analysis could discriminate between patients who had a relatively good versus a poor prognosis.

In the past few years, left ventricular strain analysis has moved forward to 3D imaging, but as described by Reichek (8), RV strain imaging has lagged behind in this regard. The RV is an extremely asymmetric structure with a thin free wall, making tissue tracking more difficult and less reliable. In addition, the proprietary software packages for 3D strain analysis are all designed for the left ventricle. The authors of the current paper went to great lengths to “tweak” their system and capture RV images, but 21% of patient and 36% of control images were inadequate for evaluation. This problem will likely not change without significant improvements in both programming and echo hardware.

Smith et al. (3) evaluated 3D RV free wall strain and RV ejection fraction in 97 patients with pulmonary hypertension and in 60 controls. The RV was divided into 7 segments (3 basal, 3 mid, and 1 apical). Mean RV systolic strain was measured longitudinally, circumferentially, and radially. Strain of the entire free wall area was assessed as well. All of these values are negative except radial strain: the free wall becomes thicker during systole, but its circumference, long axis (from tricuspid annulus to apex), and total area all decrease. The systolic dyssynchrony index also was calculated (essentially, the standard deviation of the mean time to peak systolic strain for the 7 RV segments—the wider the dispersion, the greater the dyssynchrony index) (9).

As one would expect, the authors found that the magnitudes of all RV strain parameters were diminished in patients versus controls. Of note, area strain correlated particularly well with RV ejection fraction. The systolic dyssynchrony index was significantly
greater in the patient population than in controls and correlated inversely with RV ejection fraction. This suggests that—similar to the left ventricle—the extent of RV dyssynchrony is related to the extent of RV systolic dysfunction.

The authors constructed receiver-operating characteristic curves (ROC) and assessed the various strain vector cutoff points for both impaired RV ejection fraction and (more importantly) overall mortality. Figure 6 of Smith et al. (3) demonstrates the capability of the strain parameters to discriminate between survivors and nonsurvivors with pulmonary hypertension. Interestingly, RV ejection fraction and tricuspid annular plane systolic excursion (TAPSE) were less discriminating than strain. Also, RV pressure did not correlate with RV strain values reliably. In a multivariate analysis, RV area strain emerged as the only independent echocardiographic variable associated with mortality. Because this parameter cannot be assessed with 2D strain analysis, these results suggest an incremental benefit of 3D imaging in pulmonary hypertension.

Smith et al. (3) discuss the limitations of their study, including the inability to obtain adequate images in all subjects and the lack of validation for echo-derived RV strain with methods such as MRI or sonomicrometry. Ultimately, though, these difficulties do not negate their results.

Where do we go from here? First, a study validating echo-derived 3D RV strain with MRI would be reassuring. Second, software modifications designed specifically for 3D RV strain are needed for more complete and reliable data acquisition: inadequate RV strain imaging in ~30% of patients is clinically unacceptable and must be improved for the technique to be useful in day-to-day practice. Most importantly, a prospective trial to test the cutoff points in the current study could potentially confirm the prognostic utility of RV strain.

In summary, the work by Smith et al. (3) is intriguing because it is the first to show that 3D RV strain imaging may have independent prognostic value in patients with pulmonary hypertension. The word “may” in the previous sentence cannot be overemphasized. The authors have discovered an association between 3D strain parameters and clinical outcomes in pulmonary hypertension. This cannot be translated to say that 3D strain predicts outcome (and the authors are careful not to claim this). A prospective, long-term follow-up study will be necessary to prove or disprove this possibility. If such a study does demonstrate predictive value, strain could both inform and potentially improve clinical care. If this occurs, 3D RV strain evaluation could eventually become a standard part of the RV echo exam, much like TAPSE and tricuspid annular velocity are today.

So, have we found the holy grail of RV 3D imaging? No, clearly not yet, but the current study is provocative. If a prospective trial confirms the predictive and prognostic value of RV strain in pulmonary hypertension, we will at least—like Galahad—be on the road to Castle Corbenic.

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