JACC: CARDIOVASCULAR IMAGING
VOL. 10, NO. 2, 2017

ISSN 1936-878X/$36.00
PUBLISHED BY ELSEVIER
http://dx.doi.org/10.1016/j.jcmg.2016.03.021

EDITORIAL COMMENT

Myocardial Strain in the Identification of Tachycardia-Induced Cardiomyopathy

Unscrambling the Egg*

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The relationship between cardiac dysfunction and cardiac arrhythmia has been recognized for almost as long as the diagnosis of cardiomyopathy itself (1). The much greater frequency of both supraventricular and ventricular arrhythmia in patients diagnosed with cardiomyopathy has been attributed to many factors, including neurohormonal activation (2), changes in atrial and ventricular structure and function (3), and varying degrees of regional and interstitial fibrosis (4). Conversely, disordered cardiac rhythm may lead to adverse cardiac remodeling, which may exacerbate existing cardiomyopathy or be primarily responsible for the development of cardiomyopathy (5). Given the close relationship between these 2 clinical entities, a major focus for researchers and clinicians alike has been determining when cardiac arrhythmia is simply a consequence of an existing cardiomyopathy and when it is the root cause, akin to the allegorical question of which came first, the chicken or the egg? As the efficacy of arrhythmia management improves, primarily through advances in mapping and ablation, the accurate identification of patients most likely to benefit from these procedures has become increasingly important.

Although the identification of cardiac arrhythmia as either a consequence or a cause of cardiomyopathy remains problematic, 1 exemplar of the latter is tachycardia-induced cardiomyopathy (TIC). This condition is most strictly defined by the presence of impaired cardiac function in the presence of near incessant tachycardia, with normalization of cardiac function following successful ablation (6). However, this is by definition a retrospective diagnosis and offers little help to clinicians when the diagnosis of TIC is unclear. A range of arrhythmias may be responsible for arrhythmia-mediated cardiomyopathy, including supraventricular tachycardia (SVT), atrial arrhythmias, and ventricular ectopic beats, with a burden of at least 10% to 20% required to be potentially responsible (7). The presence of an arrhythmia and unexplained cardiomyopathy remains a vexed question for clinicians working in this field. In this context, the findings of Kusunose et al. (8) in this issue of *iJACC* offer important new insights.

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In this prospective study, 71 patients with presumptive TIC and 30 age- and sex-matched control subjects underwent assessment of myocardial strain with transthoracic echocardiography prior to management of the arrhythmia in the TIC group.

ARRHYTHMIA-MEDIATED CARDIOMYOPATHY

In the present study, presumptive TIC was defined by the presence of left ventricular (LV) dysfunction (left ventricular ejection fraction [LVEF] <50%) in the absence of other known cardiovascular disease, with a concurrent history of either SVT or ventricular tachycardia. The mean of the tachycardia burden was 14% to 17%, with a breakdown according to arrhythmia of importance given that SVT was responsible for 20% of cases. SVT is an unusual cause of cardiomyopathy aside from near incessant atrial tachycardia (6), as re-entrant SVT is rarely of sufficient burden to be cardiomyopathic. The majority of arrhythmias were atrial fibrillation (61%), which may be either a consequence of or responsible for

*Editorials published in *JACC: Cardiovascular Imaging* reflect the views of the authors and do not necessarily represent the views of *JACC: Cardiovascular Imaging* or the American College of Cardiology.

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JACC: CARDIOVASCULAR IMAGING, VOL. 10, NO. 2, 2017
FEBRUARY 2017:127–9

cardiomyopathy. Effective treatment was achieved in 75%, which included catheter ablation in 23 patients and antiarrhythmic drugs in 30 patients. However, a significant proportion of patients were treated with bisoprolol (n = 16) and carvedilol (n = 10), which may have been responsible for improvements in LV function through cardiac remodeling rather than arrhythmia suppression. Holter monitoring was completed in 83%, and tachycardia suppression was not necessarily absolute.

CARDIAC IMAGING AND TIC

Longitudinal strain (LS) of the myocardium was assessed with speckle tracking, and variations in regional LS strain were evaluated. The relative apical longitudinal strain ratio (RALSR), defined as the ratio of average apical LS divided by the sum of average basal and mid LS strain, was calculated as an index of regional strain distribution. The key findings were that in those patients with presumptive TIC, global LS strain was reduced compared with control subjects, but more important, a higher RALSR was associated with an absence of recovery following treatment of arrhythmia in patients with TIC. Furthermore, the investigators provide a threshold of 0.61 for RALSR for the prediction of functional recovery, with sensitivity and specificity of 71% and 90%, respectively.

These findings provide an important progression in the determination of how newer cardiac imaging techniques may be incorporated into the management algorithm of patients with suspected TIC; however, there are important caveats to consider. First, this was a small study, with a fairly broad definition of presumptive TIC and arrhythmia suppression. Second, as a consequence of the small sample size, the investigators did not validate the suggested RALSR cutoff of 0.61 for the prediction of functional recovery in a prospective cohort of patients. Finally, although reduced apical strain, as indicated by a reduction in RALSR, was associated with a high rate of reversible cardiac dysfunction suggestive of TIC, the reduction in apical strain was not significantly different in absolute terms between patients with and those without improvement in LVEF at follow-up. In fact, the main driver of the difference in RALSR between the 2 groups was the denominator of this ratio, with both mid and basal strain being significantly increased in those patients who subsequently demonstrated recovery of LVEF compared with those who did not, although neither remained predictive of recovery in multivariate analysis. The combination of regional strain assessments to form a relative strain ratio (such as RALSR) would appear justifiable in conditions with known regional variations in their distribution through the myocardium, but it may also lead to erroneous conclusions because of the effects of error propagation. In this regard, a proposed mechanism by which the observed variations in regional strain might be linked to the pathophysiology of TIC is critical.

The assessment of LV strain is more sensitive than conventional measures such as LVEF in the identification of subtle cardiac dysfunction (9). Furthermore, global and regional disturbances of cardiac strain may identify specific cardiomyopathy phenotypes, such as hypertrophic cardiomyopathy (10) or amyloid cardiomyopathy (11). However, in both hypertrophic cardiomyopathy and amyloid cardiomyopathy there is a regional variation of myocardial hypertrophy and infiltration that is consistent with the observed regional variation in myocardial strain. In the present study, the investigators suggest that experimental models of TIC exhibit relative reductions in apical strain; however, this may simply be a reflection of regional myocardial remodeling due to pacing of the right ventricular apex typically used to induce TIC in animal models. To our knowledge, there are no data in humans demonstrating similar changes in cardiac ultrastructure in TIC. In a prior study using cardiac magnetic resonance T1 mapping, patients with TIC and confirmed recovery of LV function demonstrated significantly shortened post-contrast T1 times compared with control subjects, consistent with interstitial fibrosis despite years of normal LV function following successful ablation of atrial tachycardia (12). The absence of ventricular delayed enhancement may also be a useful tool in predicting recovery of LV function in patients with atrial fibrillation and unexplained cardiomyopathy (13). Additional pathophysiological data linking TIC and regional cardiac remodeling would provide essential support to the investigators' assertion that regional variations in myocardial strain may in future be an important predictor of future functional recovery.

CONCLUSIONS

Cardiomyopathy and cardiac arrhythmia separately represent 2 of the most common causes of cardiac mortality and morbidity in the developed world. However, in clinical practice these 2 entities are often observed together, with many common pathophysiological linkages. The continued emergence of more effective rhythm control therapies, principally by

catheter ablation, brings additional hope to those afflicted; however, there is a commensurate need to identify those in whom such therapies are most likely to benefit in order to limit unnecessary treatment-related morbidity and optimally utilize health care resources. The path forward for heart failure physicians and electrophysiologists relies on the unscrambling of what is cause and what is effect, to enable the most effective therapy to be offered to our patients. In this regard the findings of Kusunose et al. (8) represent an important first step.

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KEY WORDS functional recovery, strain imaging, tachycardia-induced cardiomyopathy