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EDITORIAL COMMENT

Annular Velocities in Constrictive Pericarditis

Annulus and Beyond*

Allan L. Klein, MD, Arun Dahiya, MD

Cleveland, Ohio

An increasing incidence of constrictive pericarditis (CP) after open heart surgery and the availability of highly effective CP treatments continue to pique investigator interest in CP. Differentiating between CP and restrictive cardiomyopathy (RCM) remains clinically challenging and has been actively researched for decades. Many M-mode, 2-dimensional, and Doppler echocardiographic variables have been used to distinguish between these 2 conditions that have similar hemodynamic profiles (1–3). Respiratory variation of Doppler flows across the mitral valve, pulmonary vein, tricuspid valve, hepatic vein, and superior vena cava has been used to assess the dissociation of intrathoracic and intracardiac pressures and interventricular dependence noted in patients with CP (3). To differentiate patients with RCM from normal controls and patients with CP, Garcia et al. (4) used an additional tool in the form of tissue Doppler imaging (TDI) of the early peak diastolic annular velocity (E′), a marker of active left ventricular (LV) wall relaxation that represents the intrinsic mechanical elastic properties. They showed that E′ was lower at the lateral mitral annulus in RCM, a primarily myocardial disease, than in CP, a disease of the myocardium externally constrained by thickened pericardium but with preserved intrinsic myocardial function. In a follow-up study, patients with CP showed an increased TDI lateral annulus E′ velocity of >8 cm/s with a sensitivity and specificity of 89% and 100%, respectively, as well as color M-mode slope of >100 cm/s (also a measure of LV relaxation) with a sensitivity of 74% and 91%, respectively (5). The theory explored was that hearts encased with the constrictive process have normal or enhanced relaxation (thus increased E′ velocity and color M-mode slope) and could fill mainly in a longitudinal fashion but had difficulty filling in a lateral or circumferential fashion. In contrast, hearts with restrictive disease showed marked impairment of relaxation because of the myopathic process and had decreased annular E′ velocities and decreased color M-mode slope. Subsequently, other investigators (6,7) made the important observation that the constrictive process can actually involve the lateral annulus causing decreased motion (reduced E′) and recommended using the medial mitral annulus to better separate constriction from restriction. Ha et al. (8) proposed that there could be “annulus paradoxus,” or negative correlation, when they related elevated LV filling pressures to a decreased mitral E/annular medial E′ velocity ratio compared with a usual positive correlation noted in patients with chronic systolic heart failure, such as dilated cardiomyopathy. Recently an altered relationship of the lateral and medial mitral annulus “annulus reversus” was observed in patients with CP and demonstrated that E′ at the lateral mitral annulus was lower than E′ at the medial mitral annulus; this alteration was attributed to the tethering of the LV lateral free wall to the pericardium (9).

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In this issue of *iJACC*, Choi et al. (10) have shed new light on this field and extended the concept of “annulus reversus and paradoxus.” They postulated that there could be pericardial tethering associated with blunting of both the lateral mitral annular (LE′) as well as the lateral tricuspid annulus (RE′)

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From the Department of Cardiovascular Medicine, Heart and Vascular Institute, Cleveland Clinic, Cleveland, Ohio. All authors have reported that they have no relationships to disclose.

TDI velocity with an exaggerated compensatory rate of relaxation of the medial mitral annulus (SE′). Their findings showed that RE′/SE′ and LE′/SE′ ratios are reduced in patients with CP and thus can be used to discriminate CP (mean LE′/SE′ 0.94 ± 0.17 and RE′/SE′ 0.81 ± 0.26) from both RCM (mean LE′/SE′ 1.35 ± 0.31 and RE′/SE′ 1.96 ± 0.71) and normal (mean LE′/SE′ 1.36 ± 0.24 and RE′/SE′ 1.30 ± 0.32). The reduced ratios in patients with CP were convincingly shown in young individuals (who normally have an increased SE′) as well as in patients with previous cardiac surgery who have pericardial tethering from adhesions post-operatively. To support their hypothesis that constricting pericardial tethering is responsible for the reduction in RE′ and LE′, the researchers showed an inverse correlation of E′ with respective pericardial wall thickness as measured by computed tomography (CT). Thus, they provided a new and simple TDI measurement index that can be used clinically in daily practice to assess patients with CP or restriction.

Before full-scale adoption of this new index as a diagnostic tool, there are a number of study limitations that should be noted. These include patient selection, CP diagnostic criteria, and the small sample size with limited variability of etiologies in the respective groups. First, the study was performed on patients with an established diagnosis of RCM and CP rather than on a prospective cohort of patients presenting with new heart failure symptoms; therefore, the study design may predispose to selection bias. Second, although RCM was confirmed by biopsy in all 35 patients, only 13 patients from the CP group had a diagnosis confirmed by surgical inspection. Third, limited variability of etiologies in the sample studied may restrict the universal applicability of proposed annular tissue velocity ratio in distinguishing CP because post–cardiac surgery and radiation-induced CP account for a large number of patients with CP in the general population. In a series from the Mayo Clinic, post-cardiac surgery and radiation-induced CP were 2 of the top 3 identifiable causes of CP (11). Finally, the study sample only included patients with CP with increased pericardial thickening measured by CT. Although the authors showed an inverse correlation of pericardial thickening with respective annular tissue velocity, it has been previously shown that 18% of patients with CP have normal pericardial thickness (12), implying that pericardial thickness may not have a direct relationship with the severity of tethering.

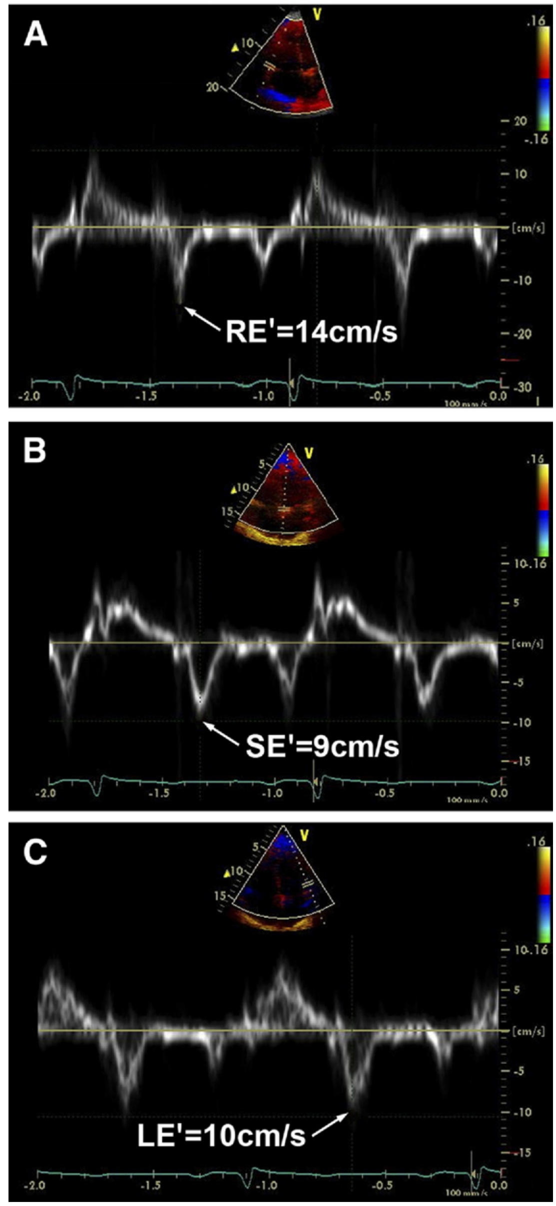

Figure 1. Annular velocities

Annual velocities at **(A)** right lateral (RE′), **(B)** septal (SE′), and **(C)** lateral annulus (LE′) in a patient with constrictive pericarditis that was subsequently confirmed on surgical inspection (LE′/SE′ 1.11 and RE′/SE′ 1.55).

A general caveat using annular velocities with TDI is that surgical annular rings, prosthetic mitral valves, and mitral annular calcification are all known to reduce E′ velocity and may limit the utility of annular tissue velocity ratio as a diagnostic tool. Furthermore, patients with CP frequently have

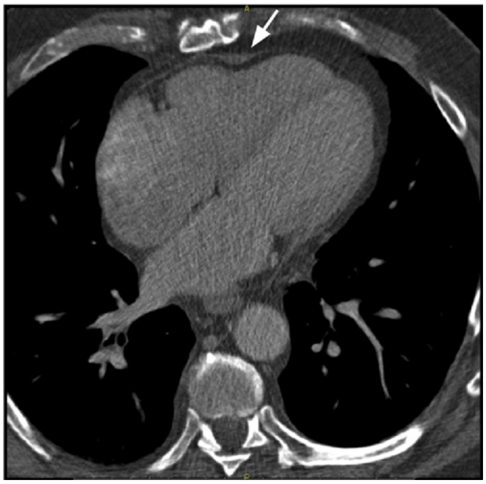

Figure 2. Computed Tomography

Computed tomography of the same patient (Fig. 1) depicting pericardial thickening adjacent to mid RV free wall **(arrow)** with sparing of annulus.

localized CP or intrinsic left- and right-sided myocardial disease, such as coronary artery disease and radiation heart disease, which can reduce annular velocities regardless of the severity of tethering. In our experience, the heterogeneous location of pericardial involvement is another important consideration in CP. Figure 1 shows almost preserved annular tissue velocity ratio in a post-cardiac surgery patient who had hemodynamics consistent with CP, subsequently confirmed on surgical inspection. In this particular patient, an increase in pericardial thickness was adjacent to the mid segment of the right ventricular free wall with sparing of the annulus (Fig. 2). Hence, the concept of using a tissue velocity ratio in the diagnosis of CP may have to be individualized based on the distribution of the pericardial involvement. It would have been interesting if a spin-off of the study had examined the impact of the treatment on the annular tissue velocity ratio in patients with CP. An important take home message from this significant study (10) is that the reduction in RE′ and LE′ in patients with CP may not always represent intrinsic myocardial elastic properties because it can be influenced by pericardial tethering.

Future studies could be directed toward noninvasive techniques that focus on ventricular interdependence, which is considered the hemodynamic hallmark of CP. The modern era clinician is fortunate to not only have access to the latest echocardiographic techniques, such as 2-dimensional speckle tracking, but also to have a cardiac magnetic resonance (CMR) imaging option (13). CMR imaging can elegantly show ventricular interdependence with free breath images and also show the presence of pericardial inflammation by gadolinium enhancement (14). However, CMR imaging is expensive and not universally available. Applicability of annular tissue velocity measured by pulsed wave TDI may be limited to patients with advanced constriction with predominant tethering or thickening around the annulus, but the use of regional strain can enhance our ability to assess the impact of tethering on the entire free wall on a segment-by-segment basis. Sengupta et al. (15) described a disparate pattern of myocardial mechanics in patients with CP and RCM using 2-dimensional speckle tracking; however, the possibility of regional strain variation similar to the regional E′ variation as reported by Choi et al. (10) remains to be investigated.

In 2011, what does the clinician do to separate constriction from restriction? He/she is left with using his/her clinical skills and multimodality imaging, including a comprehensive "diastology" study with variables, such as respiratory variation of Doppler flows and the new and simple annular velocity ratio index, to improve patient outcomes.

Reprint requests and correspondence: Dr. Allan L. Klein, Cleveland Clinic, Heart and Vascular Institute, 9500 Euclid Avenue, Desk J1-5, Cleveland, Ohio 44195. *E-mail: kleina@ccf.org.*

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Key Words: annulus paradoxus ■ constrictive pericarditis ■ tissue Doppler.