

EDITORIAL COMMENT

Is Our Assessment of Ventricular Function Now Twisted?*



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Most commonly, an ejection fraction is used in clinical practice to describe ventricular function. However, this simplistic view fails to capture the beauty of myofibril motion. Given the spiral arrangement of its structure, the left ventricular chamber twists clockwise at the base and counterclockwise at the apex upon viewing the structure from the apex.^{1,2} In fact, the ventricle undergoes a radial inward, longitudinal downward, and circumferential rotation during systole which resembles the wringing of a towel, more complex than mere volumetric changes which relate to the ventricular fiber arrangement noted in pathological specimens.^{3,4}

Torsion represents the difference between apical and basilar twist in degrees which occur in opposite directions divided along the entire ventricular length, thereby correcting the relative twists over the size of the chamber. The measure is reported as degrees per cm of ventricular length. Thus, the ventricular chamber size is accounted for when assessing the degree of towel wringing.

In this issue of *JACC: Advances*, the work by Gearhart et al⁵ examines torsional mechanics after total cavopulmonary anastomosis, the Fontan procedure, for single ventricle physiology. The research group characterized ventricular mechanics by cardiac magnetic resonance imaging in the single ventricle patient compared to patients with normal circulation

and to determine if some ventricular characteristics correlated with adverse events such as heart transplantation or death. After evaluating a large sample of Fontan patients, the authors report diminished ejection fraction, decreased basal and apical rotation, and an abnormal torsion compared to subjects with biventricular circulation. Additionally, they found that the single right ventricle and higher end-diastolic ventricular volumes independently associated with poor outcomes. Single left ventricle subjects with negative torsion also fared poorly in this study.

Presumably maladaptive ventricular mechanics contribute to chamber enlargement, diminished ejection fraction, and abnormal torsion. The right ventricle compared to the left ventricle carries fibers arranged in the longitudinal direction and does not rely on inward motion when linked to systemic circulation as a single ventricle would require.^{3,4} Perhaps the histological difference in myocardial arrangements yield differences in torsion in the right ventricle compared to the left ventricle. Additionally, Gearhart et al report protective effects of a normal positive torsion in the left ventricle when part of a Fontan circulation.

Although not ideal, Fontan circulation offers survival to single ventricle patients; however, diminished ventricular function, atrioventricular valve regurgitation, protein losing enteropathy, pulmonary disease, and liver disease contribute significantly to morbidity and mortality.⁶⁻⁹ Ventricular function and atrioventricular valve regurgitation often coincide and represent a failure of the single ventricle's contractility. Ejection fraction for the single ventricle represents the volumetric changes in the chamber but fails to capture subtle dysfunction or may overestimate function in the setting of valve regurgitation. Myocardial deformation or strain by speckle tracking offers a glimpse into subtle dysfunction not noted by ejection fraction.¹⁰⁻¹³ Perhaps myocardial

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torsion also offers the same detection of subtle dysfunction in the Fontan patient.

Small published pediatric studies potentially support this assertion. Heart transplant recipients' left ventricles appear to have increased baseline echocardiography speckle tracking-derived torsion but depressed torsion with exertion compared to normal controls subjects.¹⁴ Pediatric pulmonary hypertension patients demonstrate diminished cardiac magnetic resonance imaging derived left ventricular systolic torsion rate compared to controls and this measure correlated with mean pulmonary artery pressure and vascular resistance.¹⁵ In children with hypertrophic cardiomyopathy, enhanced basal rotation is noted while patients with concentric hypertrophy demonstrated increased counterclockwise apical rotation compared to age and gender-matched controls.¹⁶

In a prior study, children with Fontan palliation had preserved longitudinal strain of the single left ventricle but depressed ejection fraction, basal circumferential strain, and rotation but with increased apical rotation and torsion.¹⁷ As we apply torsion and twist to other cardiac conditions in larger pediatric series, we gain knowledge about the maladaptive patterns of the ventricle in diseased states and potentially which patients will have ventricular performance issues earlier than overt dysfunction determined through conventional measures such as ejection fraction.

In general, once cardiac anatomy has been established in clinical practice, patients with congenital or acquired heart disease require routine assessment of

valve and ventricular function. The clinicians must be armed with multiple tools in their kit to get a better grasp of ventricular performance. Certainly, the qualitative assessment which often overrules the characterization of function is not enough, given our inherent biases. Reproducible, readily available, and objective measures of ventricular function are needed to ensure we take appropriate care of our single ventricle Fontan patients. Why not have multiple ways to assess ventricular function such as myocardial strain, ejection fraction, myocardial twist, and torsion? Thus, if collectively these more objective measures of function demonstrate an abnormality, we may be more likely to recognize it. Additionally, we must rely on ways to find subtle dysfunction to better counsel our patients and families. This work certainly addresses the paucity of torsion research on single ventricle, but more must be done to gain an understanding of ventricular mechanics. In the end, ventricular function is what affects Fontan patients the most and having a broader understanding of the cardiac condition will only help us identify problems and potentially prescribe targeted care.

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