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EDITORIAL COMMENT

The Role of Multimodality Imaging and 3D Printing in Ventricular Cone Constriction*

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In the report by Pumacayo-Cardenas et al[1] in this issue of *JACC: Case Reports*, the authors describe circumferential constriction of the heart at the level of the ventricular cone combined. The authors suggest that this may be the result of an abnormal remodeling of the trabecular layer and incomplete formation of the papillary muscles.

This report describes a unique case of equatorial myocardial constriction and speculates about its origin because of abnormal remodeling of the trabecular layer. This is beautifully illustrated with multimodality imaging and 3D printed models.

The abnormality in the papillary muscle might be explained by a deviation of the normal trajectory from development that tends to occur between weeks 8 and 10 of gestation.[2] Papillary muscles originate from the trabecular layer of the ventricular wall during a process known as delamination of the ventricular myocardium.[2,3] This ventricular development explains different valve anomalies. An abnormal position or number of papillary muscles may lead to different cardiac malformations, such as left ventricular tract obstruction or mitral valve anomalies. In these cases, the papillary muscle morphologic character can be explained by an incomplete delamination of the trabecular ridge from the left ventricular wall, disturbed loosening of the cushion tissue, and underdevelopment of the chordae.[3]

As illustrated by the authors in this outstanding case report, multimodality imaging is the key to evaluate papillary muscles. Cardiovascular magnetic resonance (CMR) is a valuable imaging modality for the evaluation of papillary muscles and provides both morphologic and functional information.[4,5] The morphology of the papillary muscles varies broadly, as do abnormalities regarding position, number, and functionality.[5] A few articles have reported the importance of the position of the papillary muscles and the mitral valve competency valve based on CMR. Velasco Forte et al[6] describe the differences in papillary muscle anatomy between normal, borderline, and hypoplastic left ventricles.

Sung et al[7] described the case of an 83-year-old woman who was admitted with dynamic, high resting left ventricular midwall gradient without obvious septal hypertrophy or systolic anterior motion. In particular, they combined 3D echocardiography and CMR to identify this specific type of hypertrophic cardiomyopathy that arose secondary to solitary papillary muscle hypertrophy.

When the papillary muscles are attached in an abnormal fashion, they are located in an atypical position within the LV, which may result in dynamic midcavity obstruction.[5] The case described by Pumacayo-Cárdenas et al[1] showed an equatorial constriction of the ventricular cone with biventricular deformation but without signs of obstruction or dysfunction.[1] To date, this is the first known report to describe this scenario.

In addition, this case illustrates the role of novel imaging modalities such as 3D printing in the diagnosis of this equatorial constriction and

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provides insight into future management.[1,8,9] Three-dimensional printing is an emerging technology that is able to reproduce complex cardiac anatomy. By using 3D printed models, cardiologists and surgeons can comprehend the complex 3D cardiac structure as well as the spatial positional relationship before performing cardiac surgery, thus improving decision making.[10]

This report enhances the awareness of the papillary muscles' development and consequences in the context of an abnormal display. In addition, it shows the important role of implementing multimodality imaging, including 3D printing, as part of the diagnostic process. Further studies are needed to refine the usefulness of 3D printing models in individuals with unique and unusual anatomic variants.

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