Myocardial Rupture in Acute Myocardial Infarction: Mechanistic Explanation Based on the Ventricular Myocardial Band Hypothesis

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ABSTRACT

Background: Torrent-Guasp explains the structure of the ventricular myocardium by means of a helical muscular band. Our primary purpose was to demonstrate the utility of echocardiography in human and porcine hearts in identifying the segments of the myocardial band. The second purpose was to evaluate the relation of the topographic distribution of the myocardial band with some post-myocardial infarction ruptures. Methods: Five porcine and one human heart without cardiopathy were dissected and the ventricular myocardial segments were color-coded for illustration and reconstruction purposes. These segments were then correlated to the conventional echocardiographic images. Afterwards in three cases with post-myocardial infarction rupture, a correlation of the topographic location of the rupture with the distribution of the ventricular band was made. Results: The human ventricular band does not show any differences from the porcine band, which confirms the similarities of the four segments; these segments could be identified by echocardiography. In three cases with myocardial rupture, a correlation of the intra-myocardial dissection with the distribution of the ventricular band was observed. Conclusions: Echocardiography is helpful in identifying the myocardial band segments as well as the correlation with the topographic distribution of some myocardial post-infarction ruptures. (REV INVES CLIN. 2015;67:318-22)

Key words: Cardiac rupture. Acute myocardial infarction. Myocardial band.

INTRODUCCIÓN

The ventricular myocardial band (VMB) described by Torrent-Guasp is an anatomical description of the ventricular myocardium1,2. The myocardial band hypothesis describes the human right and left ventricles originated from a single myocardial band that extends from the root of the pulmonary artery, wrapping around in 180 degrees, constructing the right and left ventricles in an ascending and descending
fashion, and ending at the aortic root. Once unwrapped, one can appreciate the helical fiber orientation and four distinct myocardial segments: right, left, descending, and ascending.

New cardiovascular imaging techniques such as diffusion magnetic resonance tractography have allowed a computational validation of the muscular structure of the heart as well as the topographic distribution of the VMB\textsuperscript{3,4}. In the same way, echocardiography has allowed identifying VMB segments as well as the development of post-infarction myocardial dissecting hematomas\textsuperscript{5-8}.

The purpose of this paper is to assess the utility of echocardiography in identifying the segments of the VMB in human and porcine hearts, as well as to evaluate the relation of the VMB with some post-infarction ventricular ruptures that are associated to dissecting hematomas.

MATERIAL AND METHODS

It is well known that the human heart is similar to the porcine heart\textsuperscript{9}. Accordingly, six hearts (five porcine and one human without cardiopathy) were harvested and dissected according to the VMB technique\textsuperscript{1,2}. The myocardial segments were color-coded for illustration and reconstruction purposes as indicated in figure 1, according to the Ballester technique\textsuperscript{10}. The right and left ventricular segments are illustrated in blue and red, whereas the descending and ascending are yellow and green, respectively. The reconstructed color-coded segments were then correlated to the parasternal and apical echocardiographic images.

Three patients with a diagnosis of post-infarction myocardial rupture were included. Their echocardiograms showed complex myocardial ruptures with evidence of intra-myocardial dissecting hematoma.

RESULTS

Anatomical-echocardiographic correlation

The first observation was that the unfolded human muscular band does not show any differences with the porcine band (Fig. 1), which confirms the similarities of the four segments. Figure 2 shows the anatomical plane that corresponds to the long-axis parasternal echocardiogram. The right band segment (blue color) constitutes the free wall of the right ventricle (RV) in 100%. The left segment (red color) covers a small area of the posterobasal portion of the left ventricular free wall coating portions of the descending and ascending segments (yellow and green colors). At the level of the middle portion of the interventricular septum (IVS), the ascending and descending segments form the septum in its entire thickness. The left ventricular posterior wall is formed by the left descending and ascending segments in its basal portion and by descending and ascending segments in its medial and apical portions.

The anatomical plane that corresponds to a short axis parasternal echocardiogram confirms the participation of the right segment in the formation of the right ventricular free wall. Furthermore, the ascending segment wraps the descending segment as a part of the left ventricular wall (Fig. 3).

In the anatomical plane that corresponds to an apical four-chamber echocardiogram, the descending segment occupies the most internal surface of the left ventricle and is surrounded by the ascending segment. The extension of the ascending segment is wide when forming the lateral left ventricular wall,
especially in the middle and apical portions. The thickness of the IVS is formed by ascending and descending segments (Fig. 4).

**Correlation between the pathways of the intra-myocardial dissection and the distribution of the ventricular myocardial band**

In all three cases, the ventricular rupture was correlated with the distribution of the segments of the VMB. In case 1 (60-year-old female) with anterior myocardial infarction and complex rupture of the IVS, the transesophageal echocardiogram (TEE) showed a separation of the descending and ascending segments of the myocardial band due to a septal hemorrhagic dissection. Figure 5 shows the correlation of the TEE with the segments of the VMB marked in a porcine specimen.

In case 2 (72-year-old male) with inferior myocardial infarction who died of a cardiogenic shock, the echocardiographic study demonstrated rupture of the ventricular septum with hemorrhagic dissection extending to the posterior wall of the right ventricle (RV) (Fig. 6). Postmortem study confirmed the septal rupture and a dissecting hematoma of the postero-basal portion of the RV (Fig. 6). It is precisely nearby the posterior wall of the RV where the four segments of the VMB get close.

In case 3 (52-year-old male) with anterior myocardial infarction, a first TEE showed a small apical rupture of the IVS; two days later another TEE evidenced septal hemorrhagic dissection with a pathway that separated the descending and ascending segments of the VMB (Fig. 7). The patient died of a cardiogenic shock prior to an attempt of corrective surgery of the septal dissection.
DISCUSSION

New cardiovascular imaging techniques such as diffusion magnetic resonance tractography have allowed a computational validation of the muscular structure of the heart as well as the topographic distribution of the VMB described by Torrent Guasp. In the same way, echocardiography has allowed us to identify in the IVS the margin that separates the ascending and descending segments of the helical band.

This is the first work illustrating color-coded myocardial segmentation according to the helical myocardial band architecture correlated with echocardiographic images. The echocardiography also allowed us to identify the development of post-infarction myocardial dissecting hematomas. In the three cases with cardiac rupture we correlated the myocardial dissection recorded with echocardiography and the topographic distribution of the components of the VMB. We believe that the findings are evidence of the utility of echocardiography in identifying the...
diverse segments of the VMB, which allows a better understanding of some post-infarction myocardial ruptures.

In conclusion, echocardiography is helpful in identifying the myocardial band segments, as well as its correlation with the topographic distribution of some complex post-infarction myocardial ruptures.

REFERENCES