REVISTA DE INVESTIGACIÓN CLÍNICA

Contents available at **PubMed**
www.clinicalandtranslationalinvestigation.com

PERMANYER

Rev Inves Clin. 2015;67:318-22

ORIGINAL ARTICLE

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

Jesús Vargas-Barron[1]*, Omar-Yassef Antunez-Montes[2], Francisco-Javier Roldán[1], Alberto Aranda-Frausto[1], Hector González-Pacheco[1], Ángel Romero-Cardenas[1] and Miguel Zabalgoitia[3]

[1]Instituto Nacional de Cardiologia Ignacio Chavez, México, D.F., México; [2]Escuela Superior de Medicina, Instituto Politecnico Nacional, México, D.F., México; [3]Valley Regional Medical Center, Brownsville, Texas, USA

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 myocardium[1,2]. 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

Corresponding author:
*Jesus Vargas-Barron
Instituto Nacional de Cardiología
Juan Badiano, 1
Del. Tlalpan, C.P. 14080, México, D.F., México
E-mail: eco_vargas@terra.com.mx

Received for publication: 25-08-2015
Accepted for publication: 21-10-2015

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[3,4]. In the same way, echocardiography has allowed identifying VMB segments as well as the development of post-infarction myocardial dissecting hematomas[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[9]. Accordingly, six hearts (five porcine and one human without cardiopathy) were harvested and dissected according to the VMB technique[1,2]. The myocardial segments were color-coded for illustration and reconstruction purposes as indicated in figure 1, according to the Ballester technique[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.

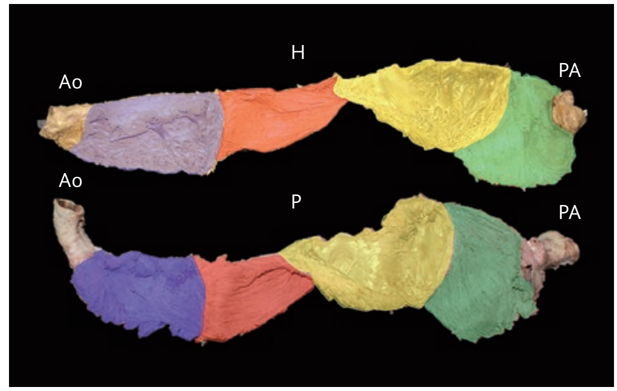
Three patients with a diagnosis of post-infarction myocardial rupture were included. Their echocardiograms showed complex myocardial ruptures with evidence of intra-myocardial dissecting hematoma.

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.

Figure 1. Unfolded ventricular muscular bands, human (H) and porcine (P). The right and left segments of the basal loop are in blue and red, respectively. The descending and ascending segments of the apical loop are in yellow and green, respectively.
PA: pulmonary artery; Ao: aortic root.



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,

Figure 2. **A:** corresponds to a long axis transthoracic echocardiogram where diverse segments of the ventricular myocardial band are observed. These segments in the porcine specimen **(B)** are identified with the assigned colors in figure 1.
RV: right ventricle. LV: left ventricle. LA: left atrium.

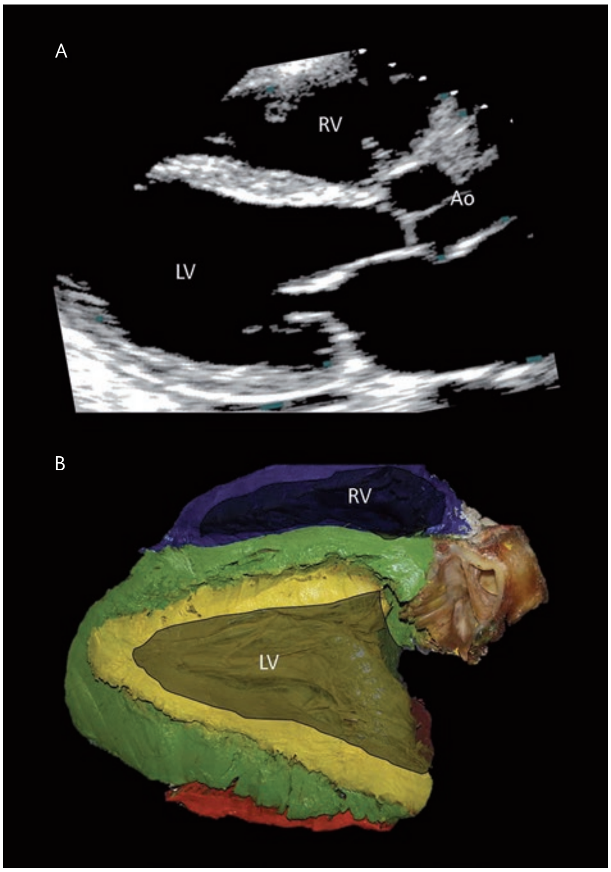


Figure 3. **A:** a short-axis transthoracic echocardiogram is shown. In the porcine specimen **(B)** the diverse segments of the muscular band are identified according to their color.

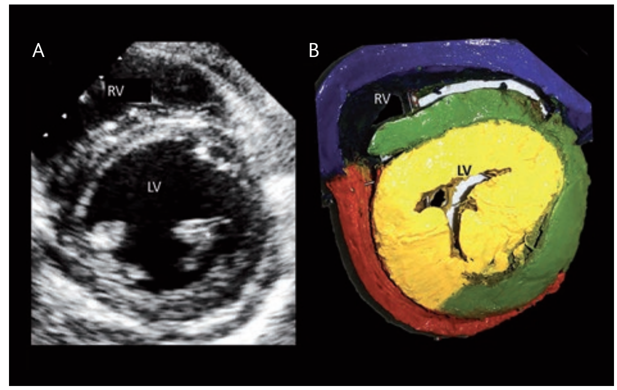
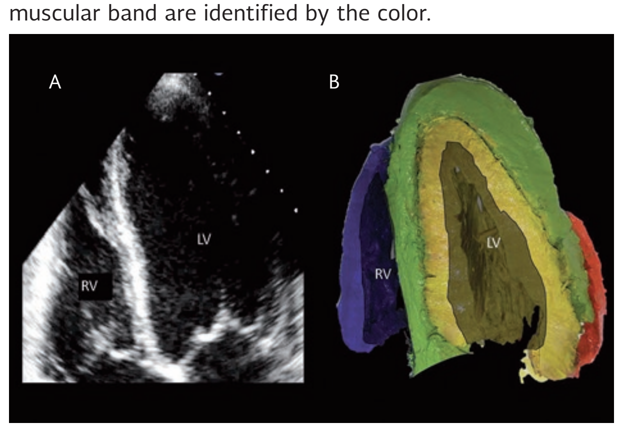


Figure 4. **A:** corresponds to a four-chamber apical echocardiogram. In the porcine specimen **(B)** the segments of the muscular band are identified by the color.



especially in the middle and apical portions. The thickness of the IVS is formed by ascending and descending segments (Fig. 4).

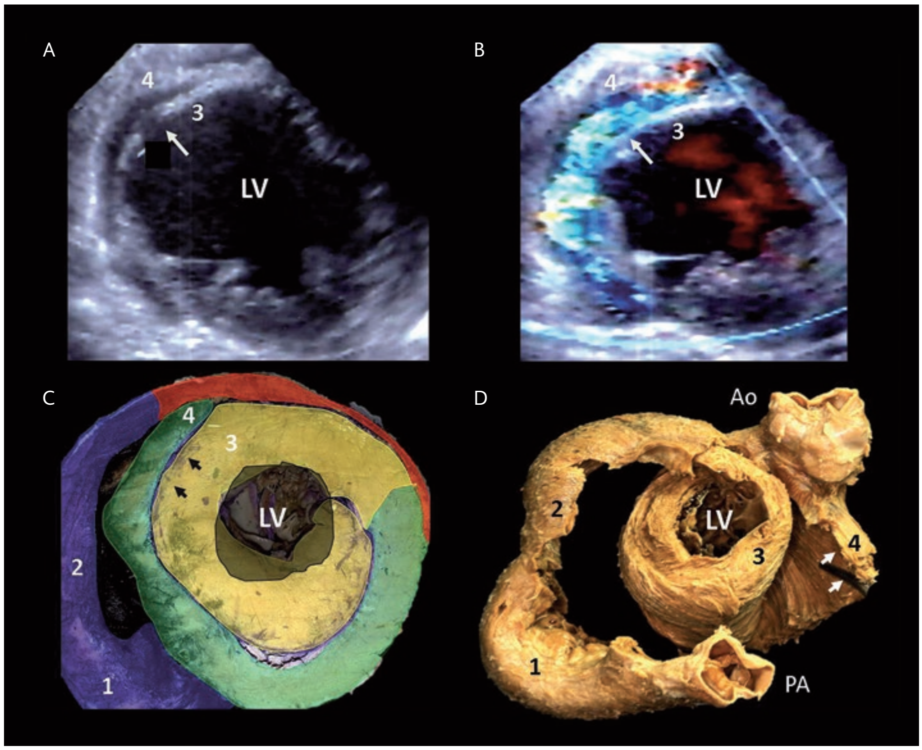
Correlation between the pathways of the intra-myocardial dissection and the distribution of the ventricular myocardial band

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 posterobasal 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.

Figure 5. **A:** a transesophageal echocardiogram shows a rupture of the ventricular septum (arrow). The color Doppler study **(B)** evidences hemorrhagic dissection that separates the descending (3) and ascending (4) segments of the myocardial band. In the porcine specimens **(C and D)** the arrows point out the separating edge of the descending (yellow) and ascending (green) segments of the septal myocardium.
1: right segment; 2: left segment.



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[4]. 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[5].

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[6,7]. 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

Figure 6. **A:** a transgastric echocardiogram shows a post-infarction complex septal rupture with hemorrhagic dissection (*), which extends to the posterior wall of the right ventricle (arrow). Postmortem study **(B)** confirmed the septal rupture and a dissecting hematoma in the right ventricular posterobasal wall (arrow). **C:** corresponds to a porcine specimen showing the site of convergence of the four segments of the muscular band. IVS: interventricular septum.

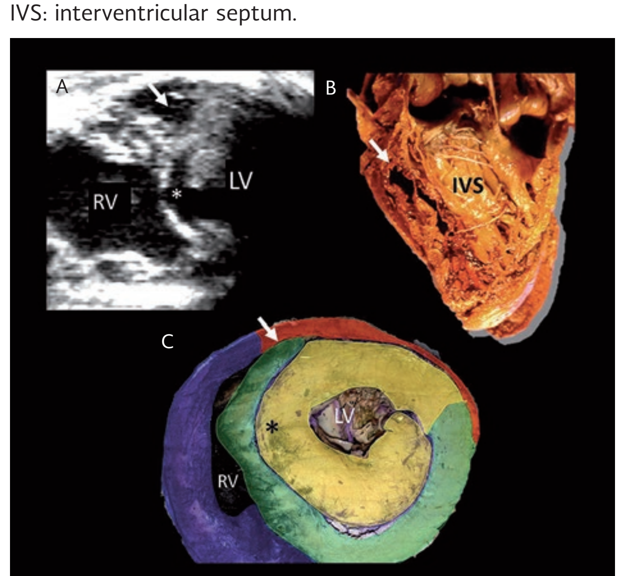
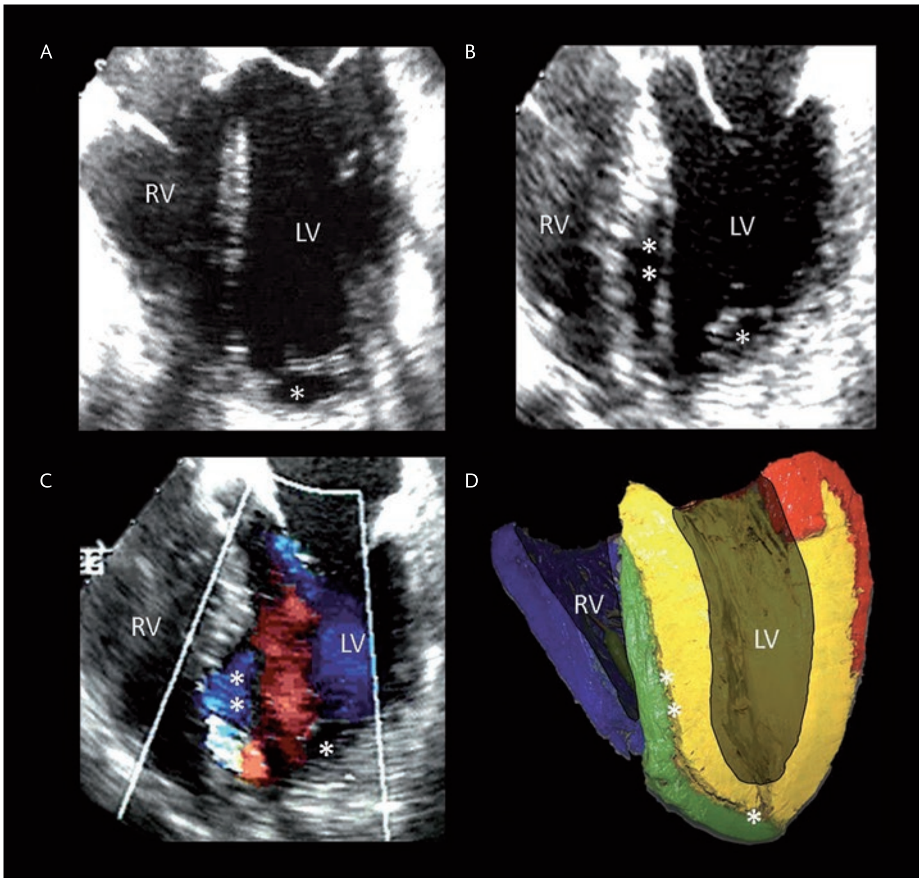


Figure 7. Four chamber transesophageal echocardiograms **(A, B and C)** in a patient with myocardial infarction. In (A), the integrity of the interventricular septum and a small apical dissecting hematoma (*) are observed. **B:** the descending and ascending components of the myocardial band are separated due to a formation of a septal dissecting hematoma (**). The color Doppler study **(C)** confirms the presence of flow between the descending and ascending components of the septal myocardium (**) which are respectively shown in yellow and green in the porcine specimen **(D)**.
IVS: interventricular septum.



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

1. Torrent-Guasp F. [Structure and function of the heart]. Rev Esp Cardiol. 1998;51:91-102.
2. Torrent-Guasp F, Kocica MJ, Corno AF, et al. Towards new understanding of the heart structure and function. Eur J Cardiothorac Surg. 2005;27:191-201.
3. Sosnovik DE, Wang R, Dai G, et al. Diffusion MR tractography of the heart. J Cardiovasc Magn Reson. 2009;11:47.
4. Carreras F, Ballester M, Pujadas S, et al. Morphological and functional evidences of the helical heart from non-invasive cardiac imaging. Eur J Cardiothorac Surg. 2006;295:S50-5 .
5. Hayabuchi Y, Sakata M, Kagami S. Assessment of the helical ventricular myocardial band using standard echocardiography. Echocardiography. 2015;32:310-18.
6. Vargas-Barron J, Roldan FJ, Romero-Cardenas A, et al. Two and three-dimensional transesophageal echocardiographic diagnosis of intramyocardial dissecting hematoma after myocardial infarction. J Am Soc Echocardiogr. 2001;14:637-40.
7. Vargas-Barron J, Roldan FJ, Romero-Cardenas A, et al. Dissecting intramyocardial hematoma: clinical presentation, pathophysiology, outcomes and delineation by echocardiography. Echocardiography. 2009;26:254-61.
8. Vargas-Barron J, Gonzalez-Pacheco H, Melendez-Ramirez G, et al. Intramyocardial hemorrhage in spontaneously reperfused myocardial infarction. Rev Inv Clin. 2014;66:107-12.
9. Douglas WR. Of pigs and men and research: a review of applications and analogies of the pig, *sus scrofa* in human medical research. Space Life Sc. 1972;3:226-234.
10. Ballester M, Ferreira A, Carreras F. The myocardial band. Heart Fail Clin. 2008;4:261-72.