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Relationships between cardiac magnetic resonance imaging abnormalities in the inter-ventricular septum and Selvester QRS scoring criteria for anterior–septal myocardial infarction in patients with right ventricular volume overload

Adeel M. Siddiqui, MD,[a] Zainab Samad, MD,[a,b] Anna Lisa C. Crowley, MD,[a] Nina Hakacova, MD, PhD,[c] J. Kevin Harrison, MD,[a] Galen S. Wagner, MD[a,b,*]

[a]*Division of Cardiology, Department of Medicine, Duke University Hospital, Durham, NC, USA*
[b]*Duke Clinical Research Institute, Durham, NC, USA*
[c]*Department of Pediatric Cardiology, Children's Heart Centre, Skåne University Hospital, Lund, Sweden*

Abstract

Background: Patients with ostium secundum atrial septal defects (ASDs) were studied to determine the prevalence of Selvester anteroseptal myocardial infarction QRS points, and to test the hypothesis that there is a relationship between these criteria and thinning and/or scarring of the inter-ventricular septum (IVS).

Methods: Demographic, electrocardiographic (ECG), and cardiac magnetic resonance imaging (CMR) data were acquired on 46 patients with a secundum ASD closed percutaneously. Selvester QRS scoring on patient ECGs was performed for areas representing the anteroseptal region of the left ventricle (LV). The IVS to LV free wall thickness ratio was used to assess thinning of the IVS while late gadolinium enhancement (LGE) of the IVS was used for scarring; both using CMR.

Results: Twenty-four (52%) patients scored Selvester QRS points in the anteroseptal region with a mean score of 2.6±1.8. The mean IVS/LV free wall thickness ratio at the basal level and mid-ventricular level was 1.1±0.3 and 1.3±0.3, respectively. There was no association of Selvester QRS points with IVS/LV free wall ratio at the basal ($p=0.59$) or mid-ventricular ($p=0.13$) levels. The one patient with LGE in the IVS had 4 Selvester anteroseptal QRS points.

Conclusion: The results of our study demonstrate that in our patient population there is a 52% prevalence of Selvester anteroseptal QRS points which are due to thinning and/or scarring of the IVS in only one patient.

Keywords: Atrial septal defect; Anterior infarct criteria; RV volume overload; Electrocardiogram; Magnetic resonance imaging

Introduction

The Selvester QRS scoring system was developed to estimate the size of myocardial infarction (MI) using the standard 12-lead electrocardiogram (ECG).[1] Localization of the left ventricular LV wall infarcted is determined using specific Selvester criteria based on morphology of the QRS waveforms: septal, anterior, lateral, and inferior.[2] Use of this method has also been documented in the presence of non-ischemic cardiomyopathies, probably because of scarring.[3–5]

Other conditions that cause changes in morphology of the QRS complex influence the Selvester scoring criteria. Left ventricular hypertrophy (LVH) tends to shift the QRS forces posteriorly, similar to changes of anterior and septal myocardial infarction (ASMI),[6] and right ventricular hypertrophy (RVH) tends to shift the QRS forces anteriorly, similar to the changes of lateral (formerly termed posterior) myocardial infarction (LMI).[7,8]

Since the cardiac ventricles tend to hypertrophy to compensate for pressure overload, but dilate to compensate for volume overload,[9] it was necessary to determine if these conditions have similar effects on QRS morphology, and therefore on the Selvester QRS scoring criteria. A recent study of a population with RV volume overload due to isolated ostium secundum atrial septal defects (OS-ASD) by

* Corresponding author. Duke University Medical Center, 2400 Pratt St., Durham, NC 27705, USA.
E-mail address: galen.wagner@duke.edu

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Siddiqui et al.[10] documented low sensitivity of criteria for RV hypertrophy, based on the increased anterior and rightward QRS forces of RV pressure overload.

It was, therefore, necessary to perform a further study in this population, to determine if other aspects of RV volume overload cause changes in QRS morphology that are reflected by Selvester criteria for infarction in other LV regions. One effected wall could be the interventricular septum, that could be thinned and or scarred by RV volume overload, causing QRS changes similar to those of anteroseptal infarction (ASMI). Cardiac magnetic resonance imaging (CMR) with delayed enhancement has the capability to detect myocardial scarring from various conditions,[11–15] and this test had been performed in many of the patients in the study of Siddiqui et al.[10]

This study was performed to determine (1) the incidence of Selvester QRS Scoring criteria for ASMI in patients with OS-ASD, and (2) if the presence of these criteria is associated with thinning and/or scarring of the inter-ventricular septum.

Methods

Population

The study subjects were consecutive patients more than 18 years or age with an OS-ASD who received both ECG and CMR prior to transcatheter closure with an Amplatzer device[16] at Duke University Medical Center between March 2002 and December 2007. This population has been described in detail in a previous report.[10] The 46 patients with neither complete right or left bundle branch block on ECG, nor history of myocardial infarction, were included in this study.

Demographic data were extracted electronically from the Duke Information System for Cardiovascular Care (DISCC) database at Duke University Medical Center. CMR was performed with a 1.5-T scanner (Siemens Sonata, Siemens Medical Systems, Malvern PA; maximum gradient performance, 40-mT/m amplitude; slew rate, 200 $T \cdot m^{-1} \cdot s^{-1}$). After initial scouting, single-shot morphologic imaging was performed. Tomographic images of the chest were obtained in the axial, sagittal, and coronal planes to define cardiovascular anatomy. Typical parameters were as follows: slice thickness, 6 mm; gap, 2 mm; matrix, 256; and in-plane resolution, 1.7 × 1.4 mm. Cine imaging with multiple contiguous views was obtained for initial assessment of the ASD. Short-axis images covered the entire heart from the ventricular apex to the atrial base (slice thickness, 6 mm; gap, 4 mm). Additionally, long-axis, four-chamber views that covered the region of the fossa ovalis were obtained in all patients (slice thickness, 6 mm; no gap; minimum, 7 slices). Typical parameters were as follows: matrix, 256; in-plane resolution, 1.7 × 1.4 mm; and temporal resolution, 35 ms/phase.

CMR measurements

CMR images were analyzed using WebPax, and the late gadolinium enhancement (LGE) protocol used has been described in a previous study.[11] Short-axis views were obtained every 10 mm throughout the entire LV myocardium. Slice thickness was 6 mm; typical in-plane resolution was 1.9 × 1.4 mm. CMR imaging was performed before and at 10 and 30 min after gadolinium administration.

The IVS thickness was measured on each patient's CMR using the four-chamber long-axis view at the basal level, i.e. immediately inferior to the mitral valve, and midway between the base and the apex of the left ventricle at end-diastole. The lateral free wall thickness was measured directly opposite the IVS thickness measurement in the four-chamber view, i.e. to a point in the free wall on a line perpendicular to the ICS (Fig. 1).

LGE was defined by bright regions only visualized on post-contrast images. LGE data were collected in the short-axis view at the basal level, i.e. immediately inferior to the mitral valve, mid-ventricular level, apical level, and at the apex; and recorded as present or absent. Presence and quantification of scar were determined in each of the four LV quadrants, and at the anterior and posterior sites of insertion of the RV free wall into the septum using the method of Kim et al.[11]

ECG analysis

Standard 12-lead ECGs were printed from the Philips TraceMasterVue (2006) database at Duke University Medical Center and analyzed on each patient. Selvester QRS scoring was performed according to the method of Strauss and Selvester,[3] and each point was considered equivalent to scarring of 3% of the left ventricular myocardium. The Selvester criteria were considered according to the LV quadrant that they represent: anterior and septal (anteroseptal), decreased positive forces in V1 and V2 and all criteria in V3 to V6; lateral (formerly posterior), increased positive forces in V1 and V2 and all criteria in I and aVL; and inferior, all criteria in II and aVF.

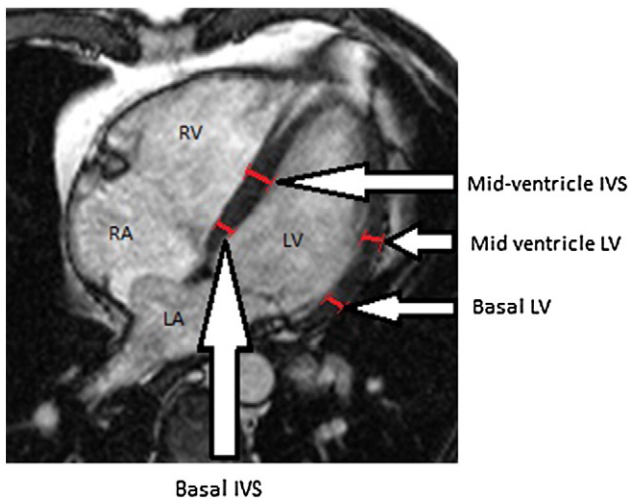

Fig. 1. Heart Imaging Technologies (LLC, Durham, NC) at Duke University Medical Center. RA, right atrium; RV, right ventricle; LA, left atrium; LV, left ventricular lateral free wall; IVS, inter-ventricular septum.