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The Dipolar ElectroCARdioTOpographic (DECARTO)–like method for graphic presentation of location and extent of area at risk estimated from ST-segment deviations in patients with acute myocardial infarction

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Abstract A graphic method was developed for presentation of the location and extent of the myocardium at risk in patients with acute myocardial infarction (AMI). This method is based on a mathematical processing of ST-segment deviations of standard 12-lead electrocardiogram following the concept of Titomir and Ruttkay-Nedecky in their dipolar electrocardiotopographic method. The center of the location of the area at risk is given by the spatial orientation of the resultant spatial ST vector, and the extent of the area at risk is derived from the Aldrich score. The areas at risk are projected on a spherical image surface, on which a texture of the anatomical quadrants of the ventricular surface and its coronary artery supply are projected. The method was tested in 10 patients with AMI with single-vessel disease, including 6 patients with an occlusion in the proximal left anterior descending coronary artery (LAD), 3 patients with an occlusion in the right coronary artery, and one patient with occlusion in the left circumflex coronary artery. The estimated areas at risk were compared with myocardial perfusion single photon emission computed tomography. Eight (80%) patients of 10 were correctly localized according to the Aldrich decision rules for the location of AMI. The areas at risk in patients with LAD occlusion correctly localized by the Aldrich score were situated in the anteroseptal and anterosuperior quadrants. In the inferior AMI group, the area at risk was localized in the posterolateral and inferior quadrants. The visual comparison with myocardial perfusion single photon emission computed tomography (SPECT) showed best agreement in patients with LAD involvement. The initial testing showed that this method allows a graphic presentation of estimated area at risk using clinically defined diagnostic rules. The area at risk can be displayed in images that are familiar for clinicians and can be compared with or superimposed on results of other imaging methods used in cardiology.

Keywords: ECG; Myocardial infarction; ST deviation; Area at risk; SPECT

Introduction

ST-segment deviations in patients with acute myocardial infarction (AMI) have been associated with the location and extent of myocardium at risk, with severity of acute transmural ischemia as well as with clinical outcomes.[1-4] In addition, early resolution of ST-segment elevation correlates with myocardial salvage and better prognosis in patients with AMI treated with reperfusion therapy.[5-8] The evaluation of ST deviation is therefore of utmost importance for early diagnosis, rapid selection of appropriate reperfusion therapy, and evaluation of its prognostic effect.

In practical electrocardiogram (ECG) diagnostics, the location of the area of myocardium at risk is estimated from the presence of ST-segment elevations and/or depressions in particular leads of the 12-lead electrocardiogram.[9] For estimation of the extent of the area at risk, Aldrich et al[1] developed formulas that predicted the final myocardial infarction size in the absence of acute reperfusion therapy, in which the extent of the area at risk is expressed as a percentage of the left ventricular myocardium.

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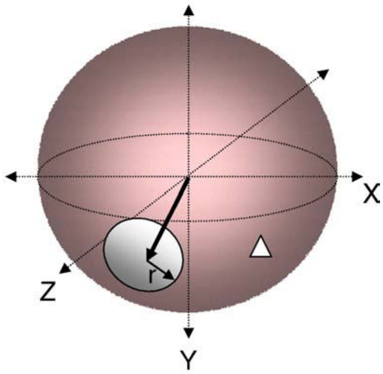

Fig. 1. The basic principle of the method. The ventricular surface is represented by a spherical surface, the so-called image surface. The location of the area at risk is indicated by the orientation of the spatial ST vector, which is calculated from X, Y, Z components, obtained from ST deviations of 12-lead ECG using the inverse Dower's transformation matrix.[13] The origin of the ST vector is located in the center of the image sphere, and the intersection of the spatial ST vector with the image surface indicates the center of the area at risk. The radius of the area at risk r is derived from the Aldrich score using the formula for the corresponding location. The triangle indicates the position of the apex of the heart.

However, the coordinate system of the standard 12-lead ECG is a complicated hexaxial system consisting of 6 well-defined axes of limb leads for the frontal plane and 6 not well-defined axes of chest leads for the quasi-horizontal plane. Therefore, the location of the involved myocardial area requires a good sense of spatial orientation in the hexaxial coordinate system in relation to the cardiac anatomical structures and the position of the heart in the chest, as well as of the coronary artery anatomy. Thus, the final "mental image" of the area at risk requires linking the spatial orientation of the ST vector in a hexaxial coordinate system of the 12-lead electrocardiogram, its relation to the anatomy of the heart, its position in the chest, the corresponding coronary artery supply, and the relative size of the area at risk. Furthermore, the routine graphic presentation of the electrocardiogram—the scalar recording—is not comparable with the images of the heart acquired with imaging methods used in cardiology.

To facilitate the understanding of this mental image, as well as to provide a format for presentation of the electrocardiogram comparable with other imaging methods used in cardiology, we developed a method for graphic presentation of the location and extent of area at risk in patients with AMI. The center of the location is provided by the spatial orientation of the resultant ST vector, and the extent is derived from the Aldrich score.[1] The areas at risk are visualized on a spherical surface approximating the surface of the heart that is textured with the image of the corresponding coronary artery supply and the anatomical segments of the ventricular surface.

Materials and methods

Description of the method

In this dipolar electrocardiotopographic (DECARTO)–like graphic method, the areas at risk are constructed from the ST-segment deviation values of the 12-lead electrocardiogram. The basic principles of the method are (Fig. 1) as follows:

- The ventricular surface (the image surface) is represented by a spherical surface.
- The location of the area at risk is indicated by the orientation of the spatial ST-segment vector.
- The extent of the area at risk is represented by a spherical cap on the image surface. The proportion of the cap area with respect to the total spherical surface is derived from the Aldrich score.

The image surface

The ventricular surface is represented by a spherical surface. On this surface, the texture of the anatomical segments of the heart is projected, as well as the coronary artery supply. For the anatomical segment of the ventricular

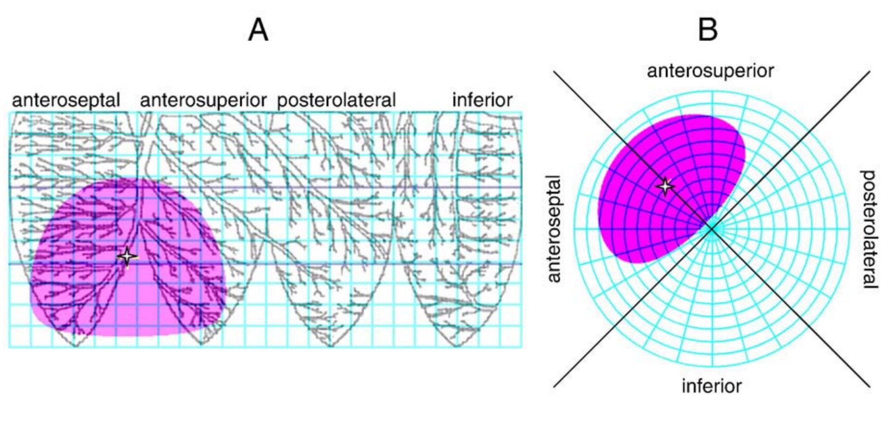

Fig. 2. Polar and Mercator projections. Presentations of an anteriorly located area at risk in Mercator (A) and polar projection (B). A, The Mercator projection of the area at risk. The bottom of the rectangle represents the apex, and the top represents the base, of the ventricles. The texture of a schematic coronary artery supply is projected on the image surface. The area at risk is projected on the apical and middle parts of the anteroseptal and anterosuperior quadrants, which are supplied by the LAD. B, The polar projection of the area at risk. The center of the polar projection represents the apex, and the outer circle represents the base of the ventricles. The area at risk is projected on the apical and middle parts of the anteroseptal and anterosuperior quadrants. The star symbol indicates the center of the area at risk.