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Update: Cardiac Imaging (V)

Cardiovascular Imaging in the Electrophysiology Laboratory

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ABSTRACT

In recent years, rapid technological advances have allowed the development of new electrophysiological procedures that would not have been possible without the parallel development of imaging techniques used to plan and guide these procedures and monitor their outcomes. Ablation of atrial fibrillation is among the interventions with the greatest need for imaging support. Echocardiography allows the appropriate selection of patients and the detection of thrombi that would contraindicate the intervention; cardiac magnetic resonance imaging and computed tomography are also essential in planning this procedure, by allowing a detailed anatomical study of the pulmonary veins. In addition, in cardiac resynchronization therapy, echocardiography plays a central role in both patient selection and, later, in device adjustment and in assessing the effectiveness of the technique. More recently, ablation of ventricular tachycardias has been established as a treatment option; this would not be possible without planning using an imaging study such as cardiac magnetic resonance imaging of myocardial scarring.

Imagen cardiovascular en la sala de electrofisiología

Palabras clave:
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RESUMEN

La rápida evolución tecnológica producida en los últimos años ha permitido la aparición de nuevos procedimientos en electrofisiología que no habrían sido posibles sin el desarrollo en paralelo de las técnicas de imagen que sirven para planificar, guiar y monitorizar el resultado posterior de dichos procedimientos. Entre las intervenciones con mayor necesidad de apoyo con técnicas de imagen, se encuentra la ablación de la fibrilación auricular. La ecocardiografía permite seleccionar a los candidatos y detectar trombos que contraindicarían la intervención, y la resonancia cardiaca y la tomografía computarizada son también básicos para su planificación a través del estudio detallado de la anatomía de las venas pulmonares. Por otra parte, en la terapia de resincronización cardiaca la ecocardiografía tiene un papel central tanto para la selección de pacientes como posteriormente para el ajuste del dispositivo y evaluar la efectividad de la técnica. Más recientemente, la ablación de taquicardias ventriculares se ha consolidado como una alternativa de tratamiento que no habría sido posible sin planificarla mediante estudio con resonancia magnética cardiaca de las cicatrices en el miocardio.

INTRODUCTION

In recent years, the field of electrophysiology has expanded rapidly, with an increase in the complexity and number of techniques performed. This would not have been possible without the parallel development of noninvasive cardiovascular imaging techniques that allow the precise study of cardiac anatomy and complex cardiac function. Cardiac imaging techniques allow better patient selection and individualized planning of procedures, help guide the performance of procedures by detecting potential complications early, and lastly, assess the long-term treatment outcomes at follow-up. This review focuses on the usefulness of imaging techniques in some of the more complex procedures, such as ablation of atrial fibrillation (AF), cardiac resynchronization therapy (CRT), and ablation of ventricular tachycardias.

CARDIOVASCULAR IMAGING IN PATIENTS WITH ATRIAL FIBRILLATION TREATED WITH ABLATION

Atrial fibrillation is the most common arrhythmia in the general population, and its prevalence increases with age.[1] The pathogenesis of AF usually involves an ectopic focus in the pulmonary veins. There is also an anatomical substrate that favors the generation and persistence of the arrhythmia, which can be detected with imaging and essentially is identified by the presence of atrial dilatation[2] and dysfunction.[3] Transthoracic echocardiography is the first-line imaging technique used to identify this substrate and,

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Abbreviations

AF: atrial fibrillation
CMR: cardiac magnetic resonance
CRT: cardiac resynchronization therapy
CT: computed tomography
LA: left atrium
LV: left ventricle
VT: ventricular tachycardia

therefore, to select patients who are candidates for ablation treatment. This technique allows assessment of the presence of associated structural heart disease (such as valvular disease, left ventricular hypertrophy, and ventricular dysfunction). Transthoracic echocardiography also has therapeutic implications, as it indicates the risk of recurrence (according to atrial size and function[4]) and determines whether a combined therapeutic approach (for example, surgical ablation and mitral repair) would be appropriate, in cases of associated structural disease.

For estimation of the size of the left atrium (LA) 2-dimensional (2D) echocardiography is the most widely-used technique in clinical practice because of its availability; however, it underestimates LA volume compared with the 3-dimensional (3D) techniques of 3D echocardiography and cardiac magnetic resonance (CMR) imaging.[5] Left atrial size (diameter and volume) has been demonstrated to be a predictive factor for the occurrence of idiopathic AF[2] and its recurrence after cardioversion.[6] Regarding the success of AF ablation, although arterial hypertension and an anteroposterior LA diameter of > 45 mm have been demonstrated to be independent predictors of success,[7] mean atrial volume determined using 3D techniques (echocardiography[4] and computed tomography [CT])[8] has been demonstrated to predict AF recurrence after ablation better than LA measurements determined using conventional 2D echocardiography. Another recently introduced parameter is the sphericity index as measured on CMR[9]: spherical remodeling of the LA increases the risk of AF recurrence and is a better discriminator than atrial size.

Left atrial function can be divided into 3 phases (reservoir, conduit, and booster pump) that can be studied using echocardiography with either volumetric measurements (2D or 3D) or myocardial deformation imaging (strain and strain rate)[10] (Figure 1). A reduction in either the reservoir function[4,11] or the contractile, or booster pump, function[12] of the LA has been associated with AF occurrence and with successful ablation. Study of LA function can identify those patients whose arrhythmia will be stopped by ablation, both in patients with AF treated with a first ablation and in those treated with a second procedure.[13]

Delayed-enhancement CMR is attracting increasing interest for the detection of atrial fibrosis, which is considered an indicator of the arrhythmogenic substrate of AF. A prospective multicenter study (the DECAAF study)[14] showed an association between the degree of fibrosis and AF recurrence after ablation. Patients were classified according to the degree of fibrosis (Utah stage), and recurrence was significantly associated with the initial degree of fibrosis (stage I, 15.3%; stage II, 32.6%; stage III, 45.9%; stage IV, 51.1%). Fibrosis detection using CMR could be useful for stratifying the risk of AF occurrence or AF recurrence after ablation.[15] However, there are some technical limitations in terms of standardization: CMR has a limited spatial resolution, and the atrial wall is very thin; in addition, good atrial wall segmentation is needed, and currently there are various algorithms that use different thresholds of signal intensity to define fibrosis.[16]

Imaging also allows the detection of potential complications that would contraindicate the technique. The detection of a thrombus in the left atrial appendage using transesophageal echocardiography is one of the most well-known contraindications

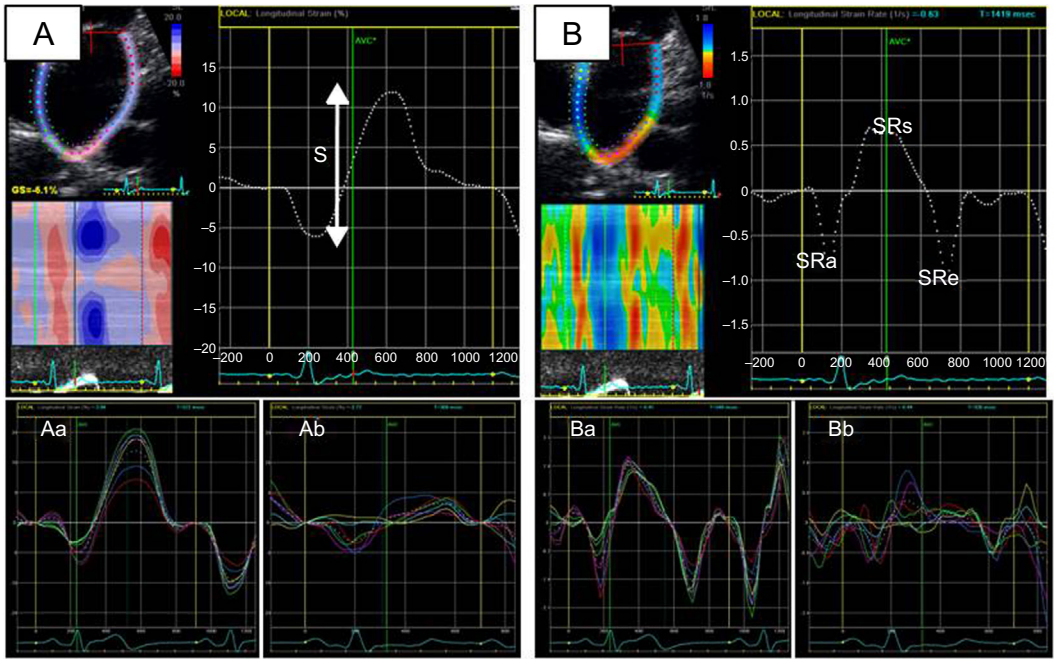

Figure 1. Study of left atrial function using myocardial deformation derived from 2-dimensional echocardiography (speckle-tracking strain). A: left atrial strlain (a, patient with normal left atrial strain; b, patient with decreased left atrial strain). B: left atrial strain rate (a, patient with normal left atrial strain rate; b, patient with decreased left atrial strain rate). S, global left atrial strain; SRa, strain rate during atrial contraction (contractile function); SRe, strain rate during the early ventricular filling phase (conduction function); SRs, strain rate during ventricular systole (reservoir function).