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Original article

Quantification of Myocardial Area at Risk: Validation of Coronary Angiographic Scores With Cardiovascular Magnetic Resonance Methods

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ABSTRACT

Introduction and objectives: Quantification of myocardial area-at-risk after acute myocardial infarction has major clinical implications and can be determined by cardiovascular magnetic resonance. The Bypass Angioplasty Revascularization Investigation Myocardial Jeopardy Index (BARI) and Alberta Provincial Project for Outcome Assessment in Coronary Heart Disease (APPROACH) angiographic scores have been widely used for rapid myocardial area-at-risk estimation but have not been directly validated. Our objective was to compare the myocardial area-at-risk estimated by BARI and APPROACH angiographic scores with those determined by cardiovascular magnetic resonance.

Methods: In a prospective study, cardiovascular magnetic resonance was performed in 70 patients with a first successfully-reperfused ST-segment elevation acute myocardial infarction in the first week after percutaneous coronary intervention. Myocardial area-at-risk was obtained both by analysis of T2-short tau inversion recovery sequences and calculation of infarct endocardial surface area with late enhancement sequences. These results were compared with those of BARI and APPROACH scores.

Results: BARI and APPROACH showed a statistically significant correlation with T2-short tau inversion recovery for myocardial area-at-risk estimation (BARI, intraclass correlation coefficient=0.72; $P<.001$; APPROACH, intraclass correlation coefficient=0.69; $P<.001$). Better correlations were observed for anterior acute myocardial infarction than for other locations (BARI, intraclass correlation coefficient=0.73 vs 0.63; APPROACH, intraclass correlation coefficient=0.68 vs 0.50). Infarct endocardial surface area showed a good correlation with both angiographic scores (BARI, intraclass correlation coefficient=0.72; $P<.001$; with APPROACH, intraclass correlation coefficient=0.70; $P<.001$).

Conclusions: BARI and APPROACH angiographic scores allow reliable estimation of myocardial area-at-risk in current clinical practice, particularly in anterior infarctions.

Cuantificación del área miocárdica en riesgo: validación de puntuaciones angiográficas coronarias con métodos de resonancia magnética cardiovascular

Palabras clave:
Área de miocardio en riesgo
Puntuaciones angiográficas
Resonancia magnética cardiovascular

RESUMEN

Introducción y objetivos: La cuantificación del área miocárdica en riesgo tras el infarto agudo de miocardio tiene repercusiones clínicas importantes y puede determinarse mediante resonancia magnética cardiovascular. Las puntuaciones angiográficas *Bypass Angioplasty Revascularization Investigation Myocardial Jeopardy Index* (BARI) y *Alberta Provincial Project for Outcome Assessment in Coronary Heart Disease* (APPROACH) se han utilizado ampliamente para la estimación rápida del área miocárdica en riesgo, pero no han sido validadas de manera directa. Nuestro objetivo es comparar el área miocárdica en riesgo estimada mediante las puntuaciones angiográficas BARI y APPROACH con la determinada mediante resonancia magnética cardiovascular.

Métodos: En un estudio prospectivo, en la primera semana siguiente a la intervención coronaria percutánea, se realizaron exploraciones de resonancia magnética cardiovascular a 70 pacientes con un primer infarto agudo de miocardio con elevación del segmento ST reperfundido con éxito. El área miocárdica en riesgo se determinó mediante el análisis de secuencias T2-*short tau inversion recovery* y el cálculo del área endocárdica con infarto utilizando secuencias de contraste tardío. Estos resultados se compararon con los de las puntuaciones BARI y APPROACH.

Resultados: Las puntuaciones BARI y APPROACH mostraron una correlación estadísticamente significativa con el T2-*short tau inversion recovery* para la estimación del área miocárdica en riesgo (BARI, coeficiente de correlación intraclase = 0,72; $p < 0,001$; APPROACH, coeficiente de correlación intraclase = 0,69; $p < 0,001$). Se observaron correlaciones mejores para el infarto agudo de miocardio de cara anterior que para otras localizaciones (BARI, coeficiente de correlación intraclase, 0,73 frente a 0,63;

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APPROACH, coeficiente de correlación intraclase, 0,68 frente a 0,50). El área de superficie endocárdica con infarto mostró buena correlación con ambas puntuaciones angiográficas (con BARI, coeficiente de correlación intraclase = 0,72; $p < 0,001$; con APPROACH, coeficiente de correlación intraclase = 0,70; $p < 0,001$).

Conclusiones: Las puntuaciones angiográficas BARI y APPROACH permiten obtener una estimación fiable del área miocárdica en riesgo en la práctica clínica actual, sobre todo en los infartos de cara anterior.

Abbreviations

AAR: area-at-risk
AMI: acute myocardial infarction
CMR: cardiovascular magnetic resonance
Infarct-ESA: infarct endocardial surface area
PCI: percutaneous coronary intervention
STIR: short tau inversion recovery

INTRODUCTION

Myocardial area-at-risk (AAR) is defined as the area of myocardial hypoperfusion during acute coronary occlusion in the absence of collateral circulation.[1–3] This parameter permits the extension of the salvaged myocardium to be calculated if the necrotic myocardium is subtracted. Both parameters are highly useful, not only regarding the effectiveness of reperfusion therapies but also as prognostic factors in patients with an acute myocardial infarction (AMI). Furthermore, they can play an important role in decision-making in myocardial revascularization since they are able to distinguish between necrosed and viable myocardium.[4,5]

T2-short tau inversion recovery (STIR) sequences, by cardiovascular magnetic resonance (CMR), have been validated with microsphere injection in animals, the reference technique for estimating AAR in experimental studies,[6] and have been widely used in routine common clinical practice to estimate the AAR in patients with an AMI. In cases of poor-quality images from T2-STIR sequences,[7–9] the infarct endocardial surface area (infarct-ESA), obtained by delayed enhancement sequences,[10,11] constitutes an alternative method.

The angiographic Bypass Angioplasty Revascularization Investigation Myocardial Jeopardy Index (BARI) and Alberta Provincial Project for Outcome Assessment in Coronary Heart Disease (APPROACH) scores have been proposed as alternative methods for early estimation of the AAR during coronary angiography, and are of particular interest when CMR is not available.[10,12–14] Moreover, it is unknown whether the AMI location plays a role in the accuracy of AAR measurements calculated through angiographic scores.[11]

The aim of this study was to validate estimation of the AAR obtained with angiographic BARI and APPROACH scores in order to establish their reproducibility and accuracy by comparing them with the measure provided by T2-STIR, considered the reference method, and infarct-ESA.

METHODS

Patients

Between October 2008 and June 2010, 75 consecutive patients with ST-segment elevation AMI successfully reperfused through primary percutaneous coronary intervention (PCI) and undergoing CMR within the first week after reperfusion were prospectively studied in a single center trial. The criteria to perform primary PCI were chest pain duration over 30 min, ST-segment elevation on the electrocardiogram $\geq$0.1 mV in 2 or more adjacent leads and performance of PCI within the first 24 h after symptom onset. Patients with hemodynamic instability, acute pulmonary edema or cardiogenic shock just prior to CMR, previous AMI or any other contraindication to the test, were not considered eligible to enter the study. Five (7%) patients were excluded since CMR could not be performed owing to claustrophobia, and none of them for other causes. Data from the remaining 70 patients were evaluated. The artery responsible for the AMI was identified from angiographic findings and clinical information (electrocardiographic data). Informed consent was obtained from all patients and the study was approved by the local ethics committee.

Cardiovascular Magnetic Resonance

All CMR studies were performed with 1.5 T equipment (Siemens Avanto). Images were obtained in synchronization with the electrocardiogram and in apnea. Short-axis cine views were performed to quantify the volumes and ejection fraction (SSFP sequences; slice thickness: 8 mm; space between slices 20%; matrix: 256×256: field of view: 300-370 mm; temporal resolution<50 ms). To evaluate the edema, STIR sequences were used in the same view as the cine sequences, all in mid-diastole (slice thickness: 8 mm; space between slices 20%; matrix: 256×256: FOV: 300-370 mm; temporal resolution<50 ms; repetition time: 2 R-R intervals; echo time: 100 ms; inversion time: 170 ms; flip angle: 160°; bandwidth, 781 Hz/pixel). Finally, late enhancement sequences were used to quantify the size of the AMI and were obtained 15 min after intravenous administration of 0.2 mmol/kg of dimeglumine gadopentetate–Magnevist® (slice thickness: 8 mm; space between slices 20%; matrix: 256×256: field of view: 300-370 mm; optimal inversion time to suppress the myocardium signal).

Image Analysis

All studies were analyzed on a workstation (QMASS MR 7.1, Medis Medical Imaging Systems, The Netherlands) by 2 cardiologists specialized in imaging and blinded to both the clinical and angiographic results. Endocardial and epicardial borders were delineated at end-systole and end-diastole with short-axis views to quantify volumes, functions and mass of the left ventricle (LV). The AAR was quantified in T2-STIR sequences delineating the areas of intensity, plus 2 standard deviations above average, obtained from the remote healthy myocardium, and normalized by the LV mass. Signal intensity was obtained in the edematous area, in the healthy myocardium contralateral to the edema (remote myocardium) and in the background noise area for calculation of the signal-to-noise and contrast-to-noise ratio.[5] Hypointense areas within hyperintense regions were interpreted as intramyocardial hemorrhage areas[15,16] and were thus included in the AAR territory.