Comparison of myocardial perfusion by MRI and SPECT in one-stage infusion of ATP (hybrid stress test)

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Purpose

Single-photon emission computed tomography (SPECT) is widely used for assessment of myocardial perfusion in clinical practice. However, one of the main disadvantages of the use of SPECT is that with some patients with three-vessel coronary artery disease (CAD), violations of the perfusion in pools of blood supply by coronary arteries are not always detected, moreover, sometimes these values may be normal due to global reduction of blood flow.

MRI is the method of functional diagnostics of myocardial ischemia with high spatial resolution without typical SPECT artifacts and ionizing radiation.

Thus, the aim of this study is to evaluate the diagnostic value of stress perfusion MRI and SPECT for the detection of myocardial ischemia in patients with angiographically proven three-vessel coronary artery disease (CAD) with a single-stage introduction perfusion indicators.

Comparison of #MR myocardial perfusion and SPECT with the single-stage introduction of a stress agent (ATP) was carried out on the following criteria:

1. number of segments having stress perfusion defects (including the number of defects subendocardial<25% of the thickness of the myocardium);

2. valuing the MR cardiac perfusion in comparison to SPECT #f the heart (the number of segments with clots, the number of segments with a scar).

Methods and Materials

We enrolled 19 men (323 cardiac segments; average age of patient 61.6 years) with angiographically proven three-vessel coronary artery disease who underwent single-stage stress-perfusion MRI (Achieva 1.5 T, Philips Medical Systems) and SPECT (Infinia Hawkeye-4, GE Medical Systems). The excluding criteria were: Asthma, Chronic obstructive lung disease, Acute coronary failure, Hypotension (BP <90mmHg), Chronic heart failure (IV FC by NYHA), AV-Block II-III, Permanent atrial fibrillation.

The patients had to refrain from coffee, tea, chocolate or other caffeinated beverages and food for at least 24h before exams.

Cardiac magnetic resonance imaging (CMR):

All CMR examinations were performed on a 1.5 T scanner (Achieva). Standard SSFP axial, short axis, 3- and 4-chamber view orientations were acquired for volumetric and
functional imaging (the echo time 1.5ms, the repetition time 3.0ms with a flip angle 60°, slice thickness 8mm). Stress perfusion of the left ventricle was acquired on the three levels by short axis using a B-TFE sequence (the repetition time 2.5ms, the echo time 1.2ms with a flip angle or 50°, slice thickness 8mm) with a single-stage introduction perfusion indicators: 99mTc-Technetri (550 MBq) and mniscan (Gadodiamid, GE HealthCare) were injected sequentially. The stress test was applied infusion of ATP with the speed of introduction of 140 mg/kg*min for 3 minutes. During infusion we were monitoring ECG in the 2nd standard lead and blood pressure. For infusion vasodilator (ATP) and bolus perfusion indicators we used separate venous lines (catheters type «Venflon» established in ulnar vein). A rest perfusion imaging was made 5-10 minutes after the stress imaging at the same locations and at the same dose of mniscan. Delayed enhancement (DE) images were acquired for visualising myocardial scar 10-15 minutes after application of 0.2 mmol per kg bodyweight mniscan two-dimensional delayed enhancement imaging was performed using a #1_FFE SPIR sequence (the repetition time 2.7ms, the echo time 0.9ms with a flip angle or 15°, slice thickness 10mm) and a two-dimensional T1-weighted PSIR turbo gradient echo sequence with a standard inversion time of 350 ms and a slice thickness of 10 mm (the repetition time 4.8ms, the echo time 2.3ms with a flip angle or 15°. Typical in plane resolution 1.88x2.02mm).

Single-photon emission computed tomography (SPECT):

We used a two-day study Protocol. Registration data scintigraphy of myocardium was performed in ECG - compare mode using 2-detector gamma camera (Infinia Hawkeye-4), equipped with high-performance parallel collimators for low energies (LEHR). Myocardium scanning was initiated 60-75 min after intravenous injection of 99mTc-Technetri (550 MBq). Scintigraphic imaging record was performed in 64 projections, in 64x64 pixels matrix, with rotation - 1800, synchronization of R-wave ECG, segmentation of RR interval per 8 images, starting angle - RAO -135°, angular spacing - 2.8°, image exposure time - 30-40 seconds, up to 30 cardiac cycles per a projection, 150-200 thousand pulses for the entire field of view, the total time of the investigation - 25-30 minutes.

CMR and SPECT image analysis:

Image analysis was independently performed offline by three fully independent observers respectively, using a Philips MR Extended workSpace (Version 2.6.3.4) and workstation GE Xeleris (Version 2.1753).

According to MRI myocardial perfusion was estimated at three levels, from the ring of the mitral valve to the top of the left ventricle. For assessing the results of a drug test we conditionally defined three severities of violations of myocardial perfusion. The division was based on a subjective assessment of the degree of violation of myocardial perfusion, persistence and intensity of perfusion defect.
According to the received data SPECT we evaluated regularity, intensity and extent of the deviation from normal distribution of the indicator in the myocardium of the left ventricle using a standard 4-point scale (0 - absence of defect accumulation, 1 point - small reduction, 2 points - moderate decrease, 3 points - pronounced reduction, 4 points - the absence of perfusion of the indicator in the myocardium). As a result of the analysis of data on perfusion at rest and during stress test we obtained SRS (a summary measure alone), SSS (the total figure in the stress test) and SDS (severity of the stress perfusion defect).

Images for this section:

Fig. 1: B-FFE short axis orientation showing the stress perfusion defects in 3,4,9,10,15 segments of left ventricle. #-stress perfusion, B-rest perfusion. "Bull's eye" scheme of left ventricular segmentation (American Heart Association [AHA]) with corresponding coronary artery territories (C) and stress defects
Fig. 2: SPECT perfusion images at rest and during stress test. Stress defect in 3,4 (1 points), 9,10 (2 points), 15,17 (3 points) segments
Results

As a result of the analysis the three independent operators revealed the following results:

1. 48 segments of the stress perfusion defects were detected by MRI; 35 segments of stress defects were detected by SPECT (5 of them in segment 17), $\#<0,01$;

2. Subendocardial (< 25%) stress defects were identified in 22 segments according to MR myocardial perfusion;

3. MRI revealed clots in 11 segments (3.4%);

4. Myocardial scars of different depths were found in 62 segments by MR myocardial perfusion and in 51 segments by SPECT, $\#<0,01$.

Conclusion

1. MR perfusion with ATP is more sensitive and specific method compared to SPECT, but it does not allow analyzing the apex of the left ventricle (segment 17) routinely.

2. Hybrid stress test has advantages over MRI with stress-test and SPECT separately.

References


Personal Information