Comparison of single to dual bolus MR myocardial perfusion imaging for detection of coronary artery disease

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Introduction

Absolute myocardial perfusion can be determined using first pass MR myocardial perfusion imaging with a Fermi-model constrained deconvolution [1]. In the analysis, a linear relationship between contrast concentration and signal intensity is mostly assumed. However, at high contrast concentration saturation effects cause a non linear effect. As low contrast concentrations limits the contrast to noise ratio, a dual bolus technique has recently been introduced to compensate for the saturation effect in the blood pool where the arterial input function is derived [2]. The dual bolus approach has shown to provide absolute perfusion values comparable to values determined by microspheres in animals [3] and positron emission tomography (PET) in healthy volunteers [4].

In clinical practice, MR perfusion imaging is used as a diagnostic tool in patients with suspected coronary artery disease (CAD). The main objective of this study was to investigate the incremental diagnostic value for detection of significant CAD of the dual bolus over the single contrast bolus technique. Secondly, this study compared dual bolus absolute perfusion values to values obtained from the single contrast bolus technique in patients with no or only mild CAD, as a reproduction of earlier studies.

Method

Patients (n=49) with suspected CAD underwent first pass adenosine stress and rest magnetic resonance myocardial perfusion imaging at a 1.5 Tesla scanner (Sonata or Avanto, Siemens, Erlangen, Germany). Invasive coronary angiography (CA) was used as standard of reference. For MR a single shot saturation recovery gradient-echo planar pulse sequence was applied, accelerated 2 times by TSENSE. Typical scan parameters were: TR/TE = 5.6/1.1 ms, saturation time 110 ms, flip angle 18^o, echo-planar factor 4, matrix-size 160 x 144 and voxel size 2.5 x 2.5 x 10 mm^3. Gd-DTPA was injected with a pre-bolus (1 ml) and a large bolus (0.1 mmol/kg), each followed by a 15 ml saline chaser at a rate of 3 ml/s. Three short axis slices were obtained each heart beat during 50 beats.

For the single bolus technique, the arterial input function (AIF) was obtained from the large contrast bolus. For the dual bolus technique, the AIF was reconstructed from the pre-bolus by convolution of the pre-bolus up to the volume of the main bolus [4]. Absolute myocardial perfusion was calculated by Fermi-model constrained deconvolution for 18 myocardial segments [1]. These segments were allocated to 3 coronary artery territories according to the AHA model [5]. Significant CAD was defined as >50% diameter stenosis in two orthogonal directions on quantitative coronary analysis. Receiver operating characteristic (ROC) analysis was used to investigate diagnostic accuracy of MR myocardial perfusion imaging for detection of significant CAD at vessel based analysis. The minimal segment value within a vessel territory was used.

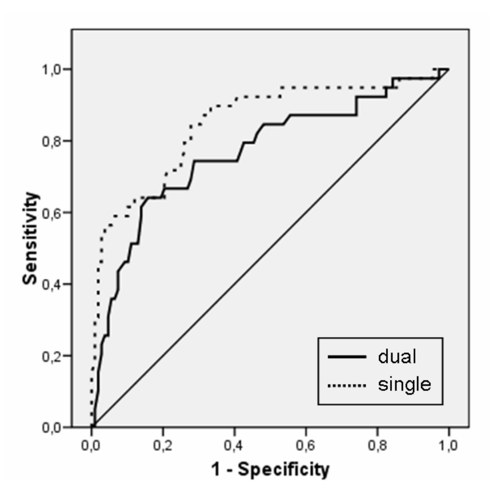

Figure 1: ROC curves of single and dual bolus minimal stress perfusion value for detection of significant CAD at vessel based analysis.

Results

Less saturation was observed in the AIF using the pre-bolus signal. The degree of saturation, defined by the area under the curve of the dual bolus AIF divided by this area for the single bolus AIF, was 3.4 ± 1.8 and 2.2 ± 1.7 at rest and during stress, respectively. Mean rest perfusion in patients with no or only mild CAD on CA (n=15) were 2.2 ± 0.9 ml/g/min and 0.5 ± 0.2 ml/g/min for single and dual contrast bolus technique, respectively ($p<0.001$).

Significant CAD was observed on CA in 39 out of 147 vessels. The single bolus showed a higher diagnostic value of the minimal stress perfusion value for the detection of significant CAD. The ROC analysis (figure 1) showed an area under the curve (AUC) of 0.85 ± 0.04 (95% CI: 0.77-0.93) and 0.77 ± 0.05 (95% CI: 0.67-0.86) for the single and dual bolus technique, respectively. For the myocardial perfusion reserve the AUC was not significant different between the two techniques (p=0.05), 0.71 ± 0.05 (95% CI: 0.62-0.81) and 0.63± 0.05 (95% CI: 0.53-0.73) for the single and dual bolus technique, respectively.

Discussion

This study showed lower mean perfusion values for the dual bolus technique, as reported in earlier [4], and outcomes closer to PET mentioned in other reports. However, the relative low values suggest still a too high concentration of the main bolus within the myocardium. Secondly, in this study the dual bolus technique had no incremental diagnostic value over the single bolus technique for detection of significant CAD. The addition of noise by the extra measurement (the pre-bolus measurement) might be the cause for this.

References: *[1] Jerosch-Herold M et al, Med.Phys. 1998;25:73. [2] Kostler H et al, J.Magn Reson.Imaging 2008;28:382. [3] Christian TF et al, Radiology 2004;232:677. [4] Kostler H et al, J.Magn Reson.Imaging 2008;28:382. [5] Cerqueira MD et al, Circulation 2002;105:539.*