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Meeting abstract

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2133 Effect of the bolus size on the quantification of myocardial perfusion using MRI

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Introduction

A limitation of MRI for cardiac perfusion on routine clinical MR scanners is the trade-off between the temporal resolution and spatial coverage. Assuming that a higher contrast media dose and a slower injection rate allow lower sampling rate without a significant loss of precision in an one compartmental model, we performed a simulation study to compare two contrast injection strategies (wide and narrow bolus). The validity of the protocol was then demonstrated in patients with a history of myocardial infarction, using 201-Tl SPECT imaging as reference.

Methods

The myocardial perfusion is quantified using the one compartment model described by: dCmyo(t)/dt = K1Cart(t) – K2Cmyo(t) where Cart(t) and Cmyo(t) are the arterial and myocardial signal intensity time curves respectively, K1 the perfusion index related to the first order transfer constant from the LV blood to the myocardium and the ratio K1/K2 the fractional distribution volume of the contrast media.

Simulation study

to evaluate the effect of the bolus shape on the model, two arterial input functions (AIF), narrow (0.035 mmol/kg at 5 cc/sec) and wide (0.08 mmol/kg at 0.5 cc/sec) were derived from real data and used as input stimuli. Using a constant value for K1 and K2, Cmyo curves have been simulated by the discrete transfer function of the one compartment model derived from the Laplace transform. The output error (OE) method was used as a system identification method to estimate K1 and K2. Finally, estimated values of K1 and K2 are described for different noise indices (the standard deviation of a zero mean Gaussian process varies from 0 to 10%) and different under-sampling strategies. Bias and standard deviation of fitted K1 and K2 values were described in each case as well as the Bode diagram. (Figure 1 and 2).

Clinical study

The validity of the protocol was then demonstrated in 12 patients with a history of myocardial infarction, using 201-Tl SPECT imaging as reference. The MR perfusion sequence was a T1 weighted FGRE sequence with eight slices (4 short-axis, and 4 long-axis) acquired during three to six cardiac cycles, depending on patient's heart rate. the average inter-image delay was 4 seconds (± 0.5). A bolus of 0.08 mmol/kg Gd-DTPA was injected in a brachial vein at 0.5 ml/s injection rate. Standard one compartment model analysis was then applied.

Results

Simulation study

the Bode diagram showed a similar behaviour of the narrow and wide AIF around the cut-off frequency and indicating that both bolus shapes are adapted to this one compartment model. No significant difference in bias and standard deviation were observed with the identification process between the two shapes. Under-sampled curves introduce an increase of standard deviation of K1 and K2

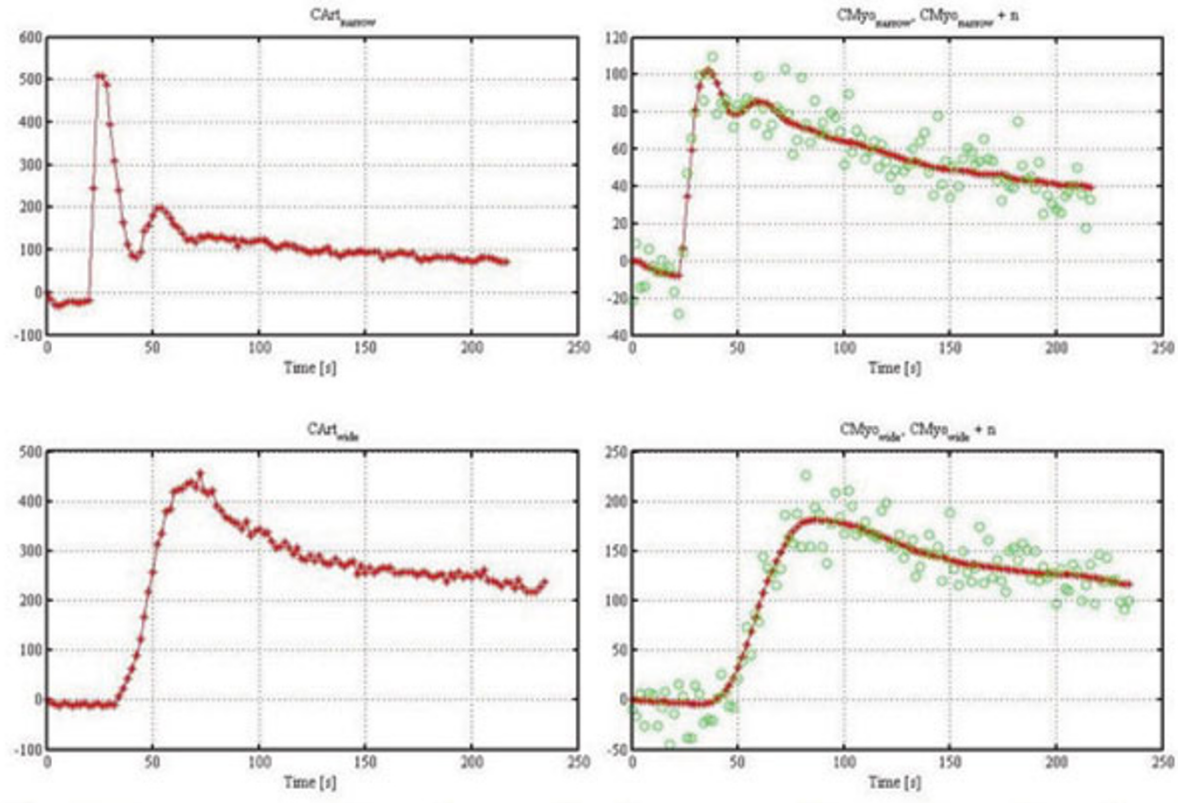

Figure 1
Narrow and wide arterial input function measured from renal data (left column) and the corresponding myocardial simulated responses with (circles in the right column) and without (diamonds in the right columns) added noise.

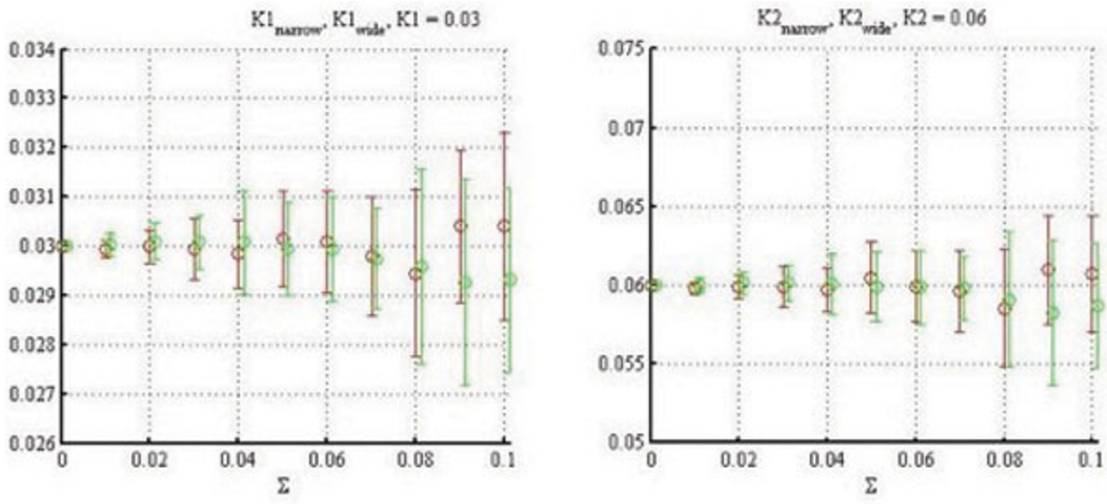

Figure 2
Fitted k1 and k2 values versus noise for the narrow and wide AIF. In this case, K1 was fixed to 0.03 and K2 = 0.06. Similar bias and deviation standard was observed for both AIF. Each point ± s.d is the result of 80 iterations.

but with a lower bias for the broad AIF. For typical noise encountered in patient data (around 1%), the standard deviation and biais remain within acceptable limits (< 5%). In the clinical study, the wide AIF protocol was able to differentiate between normal and abnormal thallium sectors. A decrease in the perfusion values measured by MRI in the infarcted regions was observed (k1 = 0.27 ± 0.21 ml/min/g compared to 0.4 ± 0.21 ml/min/g in normal, p 0.8).

Conclusion

The technique presented here overcomes the spatial limitation of cardiac MR perfusion assessment by allowing for reduced temporal acquisition rate without significant loss in accuracy for the perfusion quantification.

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