

# Effect of T1 and flip angle errors on hepatic arterial fraction calculation

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## Introduction

The measurement of the the proportion of blood flowing to the liver via the hepatic artery (hepatic arterial fraction, HAF) can be measured using dynamic contrast enhanced MRI techniques. One method for calculating this involves running a T1W 3D spoiled gradient echo sequence repeatedly over the abdomen, converting the signal intensities to tracer concentrations and fitting the data to an appropriate model. The conversion of signal intensities to tracer concentration can be performed if the pre contrast T1 of the liver, aorta and portal vein are known or assumed and if the parameters (e.g. flip angle) prescribed for the DCE-MRI sequence are accurately delivered. The aim of this study was to assess the impact of errors in pre contrast T1 and flip angle on the calculated hepatic arterial fraction.

## Method.

Aortic and portal venous concentration time curves obtained from a patient were used to generate liver concentration time curves assuming a dual input single compartment model (Equation 1, Materne et al) and an hepatic arterial fraction of 25%.

$$C_L(t) = \int_0^t [k_{1a}C_a(t') + k_{1p}C_p(t')] \cdot e^{-k_2(t-t')} dt'$$

where  $k_{1a}$  and  $k_{1p}$  represent the aortic and portal venous inflow rate constants respectively,  $k_2$  is the outflow rate constant and  $C_L$ ,  $C_a$  and  $C_p$  are the tracer concentrations in the liver, aorta and portal vein respectively. It is assumed that there is no delay between the vessels and the liver in these simulations.

The liver and vessel concentration time curves were converted into signal intensity curves using the spoiled gradient echo signal intensity equation using realistic values of TR. Signal intensity curves were produced assuming actual delivered flip angles of +/-10 % and +/-20 % of the nominal flip angle to simulate transmit flip angle errors. The T1 of blood and liver was assumed to be 1600 ms and 600 ms respectively. Three different nominal flip angles (10, 20 and 30°) were assessed. The resultant signal intensity data was then converted into concentration time curve data using the nominal flip angle and assumed T1. To assess the effect of errors in assuming a pre contrast T1 value of 1600 ms and 600 ms for the aorta and liver the T1 used to generate the signal intensity curves was varied between 1400 and 1800 ms for blood and 500 – 700 ms for the liver. This was performed for flip angles of 10° and 30°. The assumed T1 for converting signal intensity curves back into tracer concentration curves was fixed at 1600 ms and 600 ms. All resultant tracer concentration curves were then fitted to a standard dual input single compartment model as described by Materne et al. and the error this produced in the hepatic arterial fraction was calculated.

## Results.

Table 1 shows the results of the actual flip angle not being equal to the nominal flip angle for a hepatic arterial fraction of 25%. The error in HAF due to flip angle errors decreased as the nominal flip angle was increased from 10° to 30°. Table 2 shows the results of errors in T1. The errors in HAF due to pre contrast T1 errors in blood and the liver were smaller for a flip angle of 30° as compared to 10°.

Nominal Flip (°)	Actual Flip (°)	HAF
10	8	0.37
10	9	0.31
10	10	0.25
10	11	0.19
10	12	0.12
20	16	0.29
20	18	0.27
20	20	0.25
20	22	0.23
20	24	0.22
30	24	0.27
30	27	0.26
30	30	0.25
30	33	0.24
30	36	0.24

Table 1. The hepatic arterial fraction allowing for flip angle errors of +/-10% and +/- 20% for an actual HAF of 25%.

T1 aorta/pv (ms)	T1 liver (ms)	10°	30°	T1 aorta/pv (ms)	T1 liver (ms)	10°	30°
1400	600	0.277	0.254	1600	500	0.260	0.251
1500	600	0.265	0.252	1600	600	0.250	0.250
1600	600	0.250	0.250	1600	700	0.240	0.249
1700	600	0.233	0.248				
1800	600	0.214	0.246				

Table 2. Hepatic arterial fractions calculated allowing for pre contrast T1 errors of +/- 200 ms for blood and +/- 100 ms for the liver. The actual HAF is 25%.

## Conclusion.

The higher the flip angle in this study the smaller the error due to errors in the prescribed flip angle and the smaller the effect of errors in pre contrast T1 measurements of both blood and liver. A flip angle of 10° is very sensitive to errors in both flip angle and pre contrast T1 measurement. If a 30° flip angle is used then it may be possible to assume a value for the T1 of the liver and blood without this causing large errors in the calculation of HAF.

## References.

Materne, R., Smith, A. H., Peeters, F., Dehoux, J. P., Keyeux, A., Horsmans, Y., & Van Beers, B. E. 2002, "Assessment of hepatic perfusion parameters with dynamic MRI", *Magnetic Resonance in Medicine*, vol. 47, no. 1, pp. 135-142.