Liver Function Test using SVD-based Deconvolutional Analysis in Gd-EOB-DTPA-Enhanced MRI

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Introduction

The diversity of functions of the liver and complexity of cellular processes involved, challenges the creation of a comprehensive liver function test (LFT). The ultimate LFT is probably a dynamic test. Using imaging, in stead of blood sampling in a dynamic test is advantageous. The principle has been demonstrated using SPECT as sampling method and ^{99m}Tc-HIDA as test substance [1]. Gadolinium ethoxybenzyl diethylenetriaminepentaacetic acid (Gd-EOB-DTPA) displays kinetic properties similar to HIDA, making it suitable as substrate for a dynamic test [2]. Most previous reports of scintigraphy-based liver function testing used semi-quantitative analysis of simple time-activity curves, not accounting or correcting for effects of test substance reperfusion on measurements. Calculating hepatic extraction applying deconvolutional analysis (DA), will remove the effect of contrast recirculation. DA can be done by a division in the Fourier domain[3], or by matrix inversion using singular value decomposition (SVD) [4]. Using DA, one thus estimates a hepatic extraction/time curve as if a single bolus contrast passage was used. In this pilot study we describe dynamic Gd-EOB-DTPA MRI as a segmental LFT.

Methods

Gd-EOB-DTPA-enhanced MRI was performed on 4 healthy volunteers (2 women and 2 men). Data was collected using a Philips Intera 1.5T scanner (Best, Holland), with a Philips 4-channel SENSE body coil. A T1-weigthed 3-D gradient-echo pulse sequence (TR/TE/FA 4.1ms/2.0ms/10deg, FOV=415mm, matrix 256x192, 40 slices, thickness 10mm and SENSE factor R=2) was used. A total of 41 dynamic phases (12 seconds acquisition time) was made, 3 frames pre-contrast for baseline calculations, followed by 38 frames in a non-linear fashion (sample points are denoted in Figure 1). A dose of 0.1ml/kg Gd-EOB-DTPA (Primovist, Schering, Berlin, Germany), was injected, coinciding with the 4th acquisition. A region of interest (ROI) was placed in the aorta at the level of the celiac trunk, which defined the aortic input curve. In the liver, ROI´s were drawn in liver segments II to VIII, excluding visible blood vessels and bile ducts. The mean ROI size was 17.3 ± 8.7 (mean ± SD) voxels. DA applying SVD was performed using an in-house software, written in Matlab 7.0 (Mathworks, Michigan). From these curves hepatic extraction fraction (HEF) was calculated as proposed by Juni et al [3]. Time to peak (ttp), time from injection to a 10% decay from peak value (10% decay) and maximum peak value (peak) were all calculated from the relative enhancement curves.

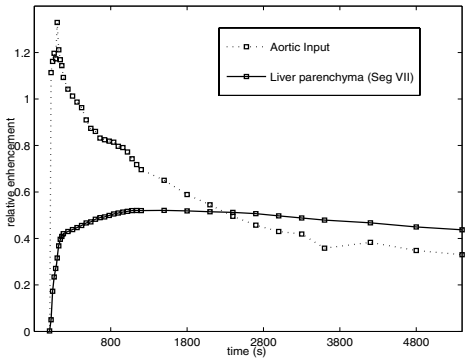

Figure 1: Relative enhancement curves for the aorta and a hepatic parenchyma segment (Seg VI).

Results

Figure 1 shows the relative enhancement/time curves for the aortic input and liver parenchyma. In Figure 2 a segmental deconvoluted hepatic extraction curve with a mono-exponential fitted curve, used to calculate HEF, is shown. HEF, ttp, 10% decay and peak for the different segments are summarized in Table 1. HEF was found to be relatively homogenous in the different hepatic segments (46.7% ± 8.9). Nor were any segmental differences seen in mean ttp and mean 10% decay. Right sided segments (V-VIII) had a higher peak enhancement, than the left sided segments (II-IVb). Figure 3 shows a parametric map of HEF for one transverse liver section. The parametric map is in conjunction with ROI measurements of HEF.

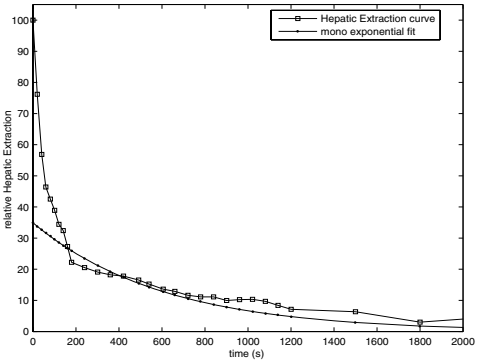

Figure 2: The deconvoluted hepatic extraction curve and mono exponential fitted curve used to calculate HEF.

Discussion

Measured hepatic contrast agent enhancement may be more dependent on the input than the actual hepatocellular function, making provision for input function imperative. The SVD approach to deconvolution is superior for hepatic extraction estimation, than the extrapolated Fourier approach. Fourier based deconvolution lacks robustness in dealing with noisy data. Furthermore, SVD DA does not need an extrapolated curve as is the case with Fourier based deconvolution. HEF was originally described using ^{99m}Tc-disofenin, known to have a hepatic uptake of 88% [3]. In normal livers HEF was shown to be 100%, declining with increasing liver dysfunction. The significant renal uptake of Gd-EOB-DTPA, probably accounts for the HEF of approximately 50% observed in this study.

Conclusion

We describe a novel approach for MRI based liver function testing using Gd-EOB-DTPA. The accuracy, reproducibility and value of the technique need to be investigated in larger numbers of subjects.

References

[1] Jonas E et al. Nucl Med Commun. Feb 2001;22(2):127-134.
[2] Schmitz SA et al. Invest Radiol. Mar 1996;31(3):154-160.
[3] Juni JE et al. Radiology. 1990;177(1):171-175.
[4] Ostergaard L et al. Magn Reson Med. Nov 1996;36(5):715-725

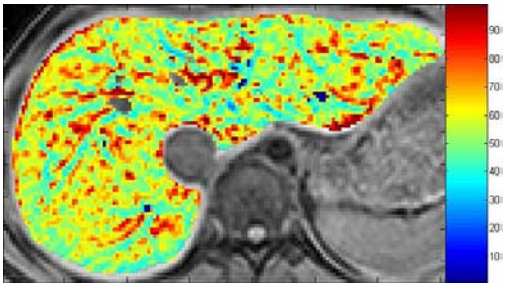

Figure 3: A parametric map of HEF (%).

Table 1: HEF and summary parameters

Seg	mean HEF (%)	±SD	mean ttp (s)	±SD	mean 10% decay (s)	±SD	mean peak (%)	±SD
II	48.7	9.4	2131	1791	4200	1096	82	4.1
III	43.2	15.4	1732	1679	2857	1384	81	9.3
IVa	46.7	7.0	1117	122	4275	1305	78	1.7
IVb	42.4	8.5	1326	606	2722	1918	84	2.1
V	50.2	7.6	1875	665	4125	1436	98	1.8
VI	46.2	9.9	1792	822	3826	1132	100	0.5
VII	45.0	9.6	1950	574	4575	1282	94	2.9
VIII	51.0	6.6	1860	539	3375	1328	93	5.6
mean	**46.7**		**1723**		**3744**			
SD	**8.9**		**336**		**687**			