Is shear viscosity a sign for malignancy in liver tumours?

J. L. Daire[1], R. Sinkus[2], M. Wagner[1], N. Haddad[1], V. Vilgrain[1], and B. V. Beers[1]
[1]INSERM U773, CRB3 Centre de Recherches Biomédicales Bichat-Beaujon, Paris, France, [2]Institut Langevin, ESPCI, Paris, France

Introduction

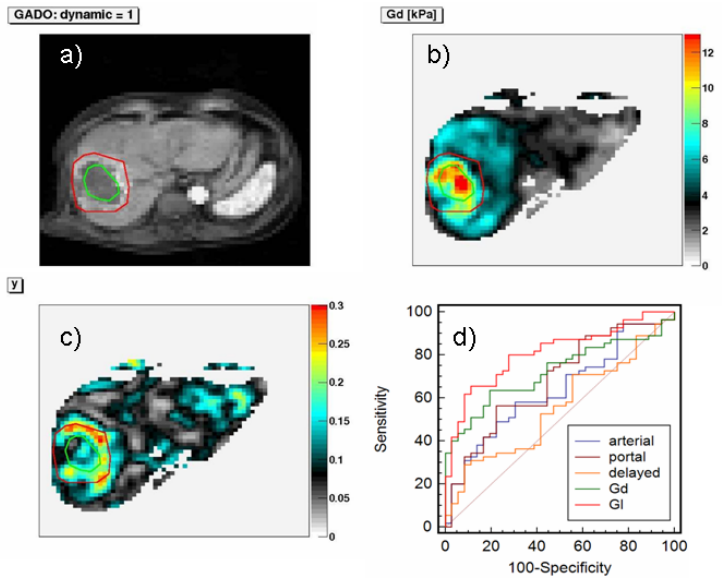
Liver tumours are very frequent. They include benign lesions and malignant primary or secondary tumours (metastases). About 1 million people die each year from liver cancer or liver failure caused by viral hepatitis. The liver is also a frequent site of metastases. Currently, there is no established non-invasive imaging Goldstandard available in order to characterize malignancy for liver tumours. Very often, the enhancement characteristics of a bolus (Gadolinium) are used in order to differentiate benign from malignant tumours. Here, we intend to prospectively evaluate the complex shear modulus $G^* = Gd + iGl$ as measured via MR-elastography (MRE) in the assessment of malignancy or benignity of liver lesions and compare its performance to those of three enhancement characteristics of the bolus passage.

Material & Methods

The study was IRB approved and informed consent from patients was obtained. 100 liver tumours (40 benign, 60 malignant) in 63 patients were evaluated. 40 tumours where histologically proven. The other lesions were diagnosed by combination of clinical and imaging data. All benign lesions were stable over a year of follow-up, at least. All scans were obtained on a 1.5T fully body system (Philips Medical Systems, The Netherlands). 3D steady-state 2nd harmonic fat-suppressed SE-EPI (factor 15) MRE was used operating at 50Hz mechanical driving frequency and 100Hz motion sensitizing gradient frequency [1,2] (4x4x4 mm^3 resolution, 3 breath-holds of each 13secs, ~1min total acq time). The mechanical transducer was attached to the right side of the rib cage. MRE was used in combination with T2-weighted fat-suppressed anatomical TSE imaging (2x2x4 mm^3 resolution) and 3D dynamic contrast enhanced imaging using Gadolinium as CA with 4 dynamic scans (native, arterial phase, portal phase, delayed) providing a resolution of 1.5x1.5x2.3 mm^3. Reconstructed maps of the complex shear modulus G^* were geometrically mapped to anatomical and dynamic images. Mean elasticity (Gd) and viscosity (Gl) valued for the liver lesions were generated from manually specified regions of interest placed in the tumour. ROC analysis was performed to compare the ability to differentiate benign from malignant liver tumours.

Results

Figs.1a-c) show an example of a hepatocholangiocarcinoma in combination with a cirrhotic component (hence strongly elevated elasticity values in the parenchyma when compared to normal liver tissue [3]). The bolus image a) of the arterial phase shows well the presence of a lesion with ring-like enhancement pattern and lower central enhancement. The corresponding images of Gd (b) and ratio of Gl/Gd (c) show well a central stiff (fibrotic) area and a viscous outer periphery (strongly vascularised) of the tumour. Fig.1d shows the corresponding ROC curves for the various parameters, i.e. arterial relative enhancement (AUC=0.64±0.06), portal relative enhancement (AUC=0.68±0.06), delay relative enhancement (0.56±0.06), Gd (AUC=0.72±0.05) and Gl (AUC=0.81±0.04). It is obvious that the viscosity outperforms all other variables and the difference to the portal information is statistically significant (p=0.038).



Discussion & Conclusions

MRE is a clinically feasible technique capable of providing novel information for the characterization of liver tumours. Maps of elasticity and viscosity as obtained from MRE show rather complex internal structures within the liver tumours. Those structures can anatomically well be mapped to regions with different enhancement patterns (fibrotic, necrotic, and strongly vascularised). As a novel finding, this analysis suggests that the shear viscosity Gl appears as a pertinent parameter for the characterization of malignancy. It outperforms the different "classical" information provided by the bolus injection. We might speculate the reason for this interesting observation: malignancy is accompanied with neo-vascularization with anarchic and chaotic organization. These additional microscopic structures influence strongly the macroscopic measurements of G* leading finally to enhanced apparent viscosity [4]. Further detailed in-vitro and in-vivo tests are necessary to validate this hypothesis.

[1] Herzka DA, et. al. Magnetic resonance elastography in the liver at 3 Tesla using a second harmonic approach. Magn Reson Med. 2009 May 15
[2] Huwart L. et. al. MR elastography of liver fibrosis: preliminary results comparing spin-echo and echo-planar imaging. Eur Radiol. 2008 Nov;18(11):2535-41. Epub 2008 May 27.
[3] Huwart L et. al. Magnetic resonance elastography for the noninvasive staging of liver fibrosis. Gastroenterology. 2008 Jul;135(1):32-40. Epub 2008 Apr 4.
[4] Sinkus R., et. al. Anomalous shear wave propagation reveals micro-architectural properties - potential implications for diagnostic imaging -. Proceedings ISMRM 2009