IOP Publishing Physics in Medicine and Biology

Phys. Med. Biol. **52** (2007) 7281–7294 doi:10.1088/0031-9155/52/24/006

Noninvasive assessment of the rheological behavior of human organs using multifrequency MR elastography: a study of brain and liver viscoelasticity

Dieter Klatt[1], **Uwe Hamhaber**[2], **Patrick Asbach**[1], **Jürgen Braun**[2] **and Ingolf Sack**[1]

[1] Department of Radiology, Charité–Universitätsmedizin Berlin, Campus Charité Mitte, Charitéplatz 1, 10117 Berlin, Germany
[2] Institute of Medical Informatics, Charité–Universitätsmedizin Berlin, Campus Benjamin Franklin, Hindenburgdamm 30, 12200 Berlin, Germany

E-mail: ingolf.sack@charite.de

Received 8 June 2007, in final form 19 September 2007
Published 23 November 2007
Online at stacks.iop.org/PMB/52/7281

Abstract

MR elastography (MRE) enables the noninvasive determination of the viscoelastic behavior of human internal organs based on their response to oscillatory shear stress. An experiment was developed that combines multifrequency shear wave actuation with broad-band motion sensitization to extend the dynamic range of a single MRE examination. With this strategy, multiple wave images corresponding to different driving frequencies are simultaneously received and can be analyzed by evaluating the dispersion of the complex modulus over frequency. The technique was applied on the brain and liver of five healthy volunteers. Its repeatability was tested by four follow-up studies in each volunteer. Five standard rheological models (Maxwell, Voigt, Zener, Jeffreys and fractional Zener model) were assessed for their ability to reproduce the observed dispersion curves. The three-parameter Zener model was found to yield the most consistent results with two shear moduli $\mu_1 = 0.84 \pm 0.22$ (1.36 ± 0.31) kPa, $\mu_2 = 2.03 \pm 0.19$ (1.86 ± 0.34) kPa and one shear viscosity of $\eta = 6.7 \pm 1.3$ (5.5 ± 1.6) Pa s (interindividual mean $\pm$ SD) in brain (liver) experiments. Significant differences between the rheological parameters of brain and liver were found for μ_1 and η ($P < 0.05$), indicating that human brain is softer and possesses a higher viscosity than liver.

(Some figures in this article are in colour only in the electronic version)

Introduction

Palpation is a standard clinical practice for assessing tissue's health near the surface of the body. This method relies on the stress–strain response of soft biological tissue subjected

