Measurement of Pulsatile Brain Motion in a Patient with a Meningioma

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Introduction

Palpation is a traditional method for detecting and differentiating pathologic changes in tissue. It is based on the examination of tissue stiffness. MR-Elastography (MRE) assesses elastic properties by applying external vibration to excite and measure a propagating shear wave [1].

The intracranial blood flow initiates pulsatile expansion of the brain tissue and represents an internal force [2]. Alterations of the elastic properties of brain tissue, often related to pathologic changes, influence the brain displacement fields. It is the objective of this work to show the feasibility of detecting stiff masses in the brain without the use of any external force but the intracranial pulsation driven by blood pulsation. For this purpose a patient with a meningioma in the central brain was examined with an optimized DENSE (Displacement Encoding Using Stimulated Echoes) [3] acquisition scheme to acquire 2D cine displacement images. Cauchy strain was calculated from the acquired data.

Methods

A patient with a meningioma was examined using a modified cine DENSE scheme [4] on a 3T Intera system (Philips Medical Systems, Best, The Netherlands). The sequence parameters were: spatial resolution: 2x2x4 mm^3, temporal resolution: 25 ms, heart phases: 45, displacement encoding frequency: 5 cycles/mm, EPI factor: 9, T_E/T_R 20/25 ms, NSA: 6. Two stacks were acquired with a relative rotation of 90° in-plane to map displacement values in two orthogonal directions. In post-processing the two data sets were combined by complex division thereby canceling unwanted phase terms. Cauchy strain was derived from the 2D displacement data with in-house software using 3-point- Lagrange interpolation

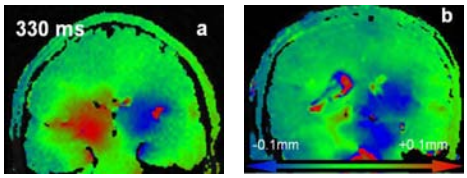

Figure 1: Comparison of RL displacements in a healthy volunteer (a) and the patient with the meningioma (b).

Results

The highly motion sensitive acquisition method yielded very detailed displacement maps, which typically show symmetric patterns in healthy volunteers. In contrast, the patient data reveal strong asymmetry (Figure 1). Phase wraps occurred due to the strong displacement encoding. The displacements in Figure 2 show very clearly the reduced displacement gradients in the tumor 200-400 ms after the R-wave, where the maximum displacement of the brain is reached. The effect is stronger in anterior posterior direction, which is then also reflected in the corresponding strain maps ε_{yy}. ε_{yy} at 230 and 330 ms. It is seen that strain drops at the boarder of the tumor and is constant low in inside, as expected for a stiff mass. The strain derived from RL displacements ε_{xx} did not show significant changes at the location of the tumor.

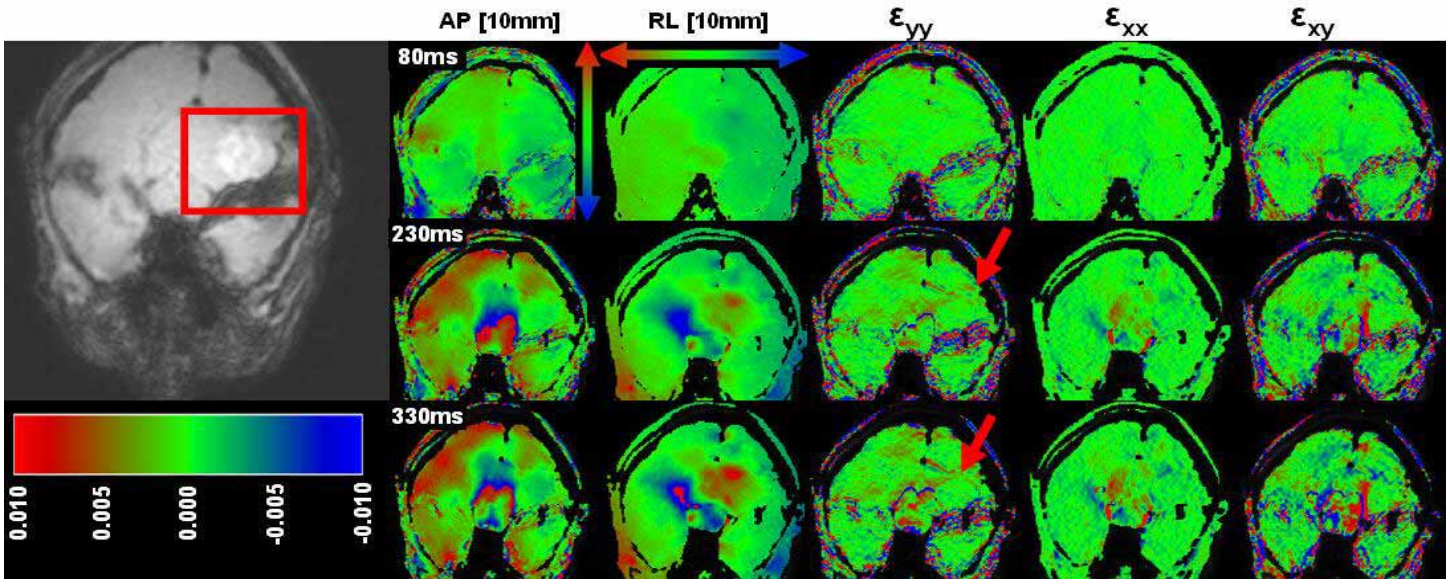

Figure 2: Displacement and strain maps of the tumor patient. The tumor is indicated with a red box on the magnitude image. The columns show displacement data in AP and RL direction, strain calculated from AP displacement (ε_{xx}), from RL displacement (ε_{yy}), and the cross term (ε_{xy}). 3 selected cardiac phases acquired at 80, 230 and 330 ms after the R-wave are displayed. The tumor is clearly visible in the displacement maps of the two later heart phases, but also in the ε_{yy} and ε_{xy} map a stiff mass is indicated at the tumor position.

Discussion

It could be shown that the detection of a stiff tumor with brain displacement measurements is possible. The preliminary results indicate potential for the assessment of relative elastic constants, especially if the temporal information gained is also considered for the analysis. It has to be stated that the brain motion has very low amplitude which is damped towards the skull of the brain. Thus the method is most likely restricted to the inner parts of the brain, and therefore complementary to MRE.

Literature

1. Muthupillai R et al, Science 1995; 269:1854-1857. **2.** Parker KJ et al, J. Acoust.Soc. Am 117:2705-2712. **3.** Aletras AH et al, J Magn Reson 1999;137(1):247-252. **4.** Soellinger M et al, Proc ISMRM 2005.