Abstract

The study of biological tissues movement is currently, one of the major thematics in the medical imaging field. The challenge is to provide additional clinical information and allow for diagnostic assistance. The recently introduced elastographic techniques, provide ample opportunities for biomechanical tissues characterization, particularly of cerebral tissues. An innovative passive-elastographic methodology for assessing mechanical properties of brain tissue is proposed. The eventual aim is to allow for the diagnosis of neurodegenerative diseases.

In research reported in this thesis, a new technique called "*Fast Cerebral Pulsatility Imaging*" (FCPI) was implemented, in order to obtain *in vivo* displacement and strain fields of brain tissue that arise from internal movements related to natural blood flow, called cerebral pulsatility. Of particular innovation was the development of a new low-frequency transducer, adapted specifically to trans-cranial propagation of ultrasound across the skull. This was connected to an ultrafast ultrasound imaging system which, was coupled to an MRI neuro-navigation system for precise real time anatomical localisation.

This thesis describes a series of experiments, focusing on the ultrasonic validation of movement estimation algorithms. We experimentally implemented these techniques to the assessment of phantom elasticity *in vitro* and the characterization of carotid pulsatility, both *ex vivo* and *in vivo*. A total of 50 healthy individuals were recruited and clinical studied under project ANR-COSTUM. This cross-cutting study, allowed us to evaluate FCPI methodology for age-dependent evolution. We observed a significant age-dependent decrease in cerebral tissue pulsatility. Moreover, in pathological studies, ultrasound measurement of brain pulsatility has shown great potential for the study of orthostatic hypotension (HTO) and Alzheimer's disease. A significant negative correlation was found between the maximum tissue displacement, as measured by ultrasound, and the volume of white matter lesions, as measured by MRI (ρ = - 0.86, p$<$0.01). In addition, brain tissue pulsatility was less regular in Alzheimer's patients. In a test of an elongated to a standing position in the HTO subjects, cerebral pulsatility and blood pressure were lower in the group of patients with positive HTO as compared to the control group with a negative HTO.

Accordingly, our results provide doctors with new clues for evaluating treatment responses involving pathologies. The brain pulsatility is potentially a noninvasive biomarker of brain function including vascular and biomechanical components.

Keywords : Cerebral pulsatility, Movement estimation, Ultrasound, Passive elastography, Brain aging, Alzheimer, Orthostatic hypotension.