MAGNETIC RESONANCE ELASTOGRAPHY (MRE) LUNG STIFFNESS: APPLICATION TO LONG COVID PATIENTS

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Background: Long COVID patients revealed more or less respiratory difficulties [1]. During the pandemic CT scan was the main medical test to evaluate the features of the COVID lung represented with ground class opacity [2-3]. However, CT uses X-rays, limiting the regular follow-up of patients. Thus, alternative imaging modalities (MRI, US) enable to subjectively characterize the structural properties of lung tissue.

Aims: The purpose of the present study was to quantify the functional behavior with personalized cartographies of lung stiffness for long COVID patients and to follow up the evolution of this quantitative mapping over time.

Methods: Seven healthy and seven long COVID participants referred for a lung CT test were recruited (#A01496-33) at the ACRIM department. All participants underwent CT and MRE tests. CT was performed with pixel size 0.73 mm, slice thickness 0.62 mm and 100-140 kV. A senior radiologist subjectively analyzed the structural properties (bronchial thickness,...). Moreover, the slice level where the intermediate trunk was clover-shaped in appearance was identified for future MRE assessment of the same lung region. CT density was calculated by converting the measured Hounsfield number into density units [4]. Less than one month later, a first MR lung density test followed by a first MRE test were performed. MR lung density obtained from a fast gradient-echo sequence was calibrated with a Gadolinium-doped water phantom placed on the sternum, and validated with the CT density values. MRE test was performed on a 1.5 T MRI, with a 22 s breath-hold, and a driver placed on the right lung inducing mechanical shear waves (50 Hz). A spin-echo echo-planar sequence, including a motion-encoding gradient, was applied with four offsets to obtain four axial phase images. The mechanical properties of the right lung were measured within a contour drawn by 2 operators. The true lung stiffness was then calculated from the phase images using multi-model direct inversion and a homemade post-processing (pixel-wise correction for density...). The monitoring (lung density, stiffness) was carried out after 4.7 to 11.2 months for each COVID patient.

Results: The density for COVID patients were significantly (P = 0.047) greater (170 kg.m^{-3}) compared to healthy (125 kg.m^{-3}) subjects. The evolution of the MR lung density over time, i.e from MR test N°1 to N°2, varies differently from one patient to another. In the first MRE test, the stiffness for the healthy subjects was always in the same range (about 1 kPa) while the COVID patients showed a larger range (from 1.39±0.04 kPa to 2.05±0.02 kPa). After a minimum delay of 4 months, the stiffness decreased (from 22% to 40%) for every COVID subject (Fig 1-2). Inter-operator correlation coefficient was excellent (0.78-0.97).

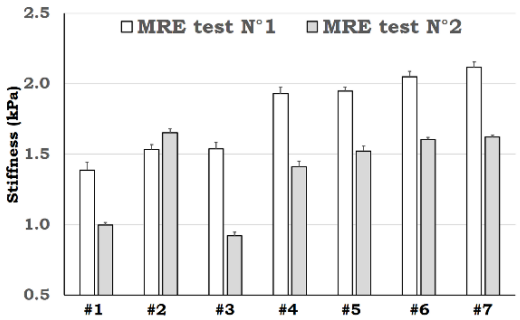

Fig 1. Evolution of the lung stiffness values in the MRE test N°1 and MRE test N°2 for the 7 long COVID patients.

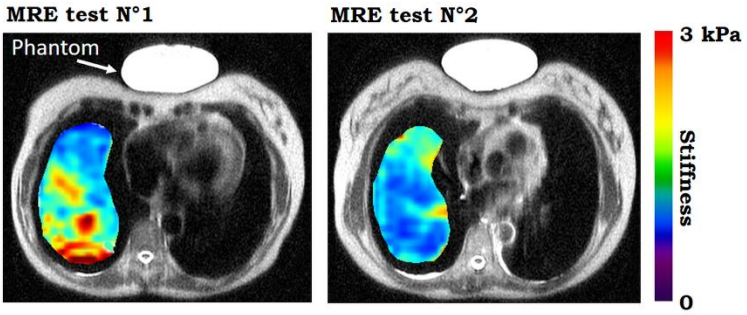

Fig 2. Evolution of the personalized lung stiffness for the patient #3 (cf. Fig 1).

Conclusions: MRE test is enough sensitive to monitor disease-induced change in lung stiffness. This non-invasive modality could yield complementary information as a new imaging biomarker to follow up long COVID patients.

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References: [1] Christopher et al PLOS Global Public Health 2024; [2] Hani et al Diagnostic and Interventional Imaging 2020; [3] Chakouch et al State of Art in Bioengineering 2022; [4] Schneider et al PMB 1996.