Strain encoding MRI (SENC) for the quantification of regional ventricular function in pulmonary arterial hypertension

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Introduction:

Right ventricular function evaluation and monitoring are considered important prognostic factors in many cardiac and/or pulmonary disorders. Pulmonary arterial hypertension (PAH) is considered a group of disease causing increased vascular resistance that eventually leads to right ventricular (RV) dysfunction and failure with consequent left ventricular (LV) involvement due to ventricular interdependence especially noted at interventricular septum. As a three dimensional multiplanar non invasive tomographic tool, cardiovascular MRI (CMR) has been successfully implemented for accurate measurement of global ventricular function. For regional function evaluation, modulation of magnetization using tissue tagging introduced by Zerhouni et al [1] has been implemented for the LV. However, in the RV, this technique has been limited by thin myocardium. Strain encoding MRI is a novel technique proposed by Osman et al [2] that allows instantaneous real time strain quantification by applying tagging parallel to the imaging plane. This technique provides higher spatial resolution compared to conventional tagging as a result of reduced tag spacing, thus constituting a better tool for RV function assessment especially in the longitudinal direction (E_{LL}) which is the main contributor to RV contractile function. Fast strain encoded MRI (fSENC) further allows for single heartbeat, non breath hold acquisitions; providing an alternative to patients experiencing difficulty in breath holding.

Objective:

Analyzing the effect of PAH on regional longitudinal myocardial strain in the RV using SENC MRI.

Methods:

Using 3T MRI, SENC technique was performed for 6 healthy volunteers using a breath hold acquisition of 13 seconds (TR= 22msec, TE= 0.8msec, flip angle= 40º, FOV= 350x350mm at a spatial resolution of 3x3mm). On the other hand, non breath hold, single heartbeat, fast SENC imaging (TR=32msec, TE=0.8msec, flip angle=40º, FOV=150x150mm and spatial resolution of 4x4mm) was used to scan 5 patients with catheter established diagnosis of PAH (mean ± SD pulmonary artery pressure (PAP) =35.4 ± 9.5 mmHg). Three short-axis slices were prescribed from a four chamber horizontal long-axis view at the basal, mid and apical ventricular levels starting 1 cm distal to the mitral valve plane . Analysis was performed using custom software. In each slice, regional E_{LL} was computed from three equidistant RV segments starting at the anterior septal insertion and ending at its posterior insertion. E_{LL} measurement was also performed at the interventricular septum as a main contributor to ventricular interdependence. In each segment, two measurements were acquired and averaged to calculate peak systolic E_{LL}. One poor image quality apical slice and two right ventricular anterior segments intersecting the RV out flow tract were excluded during image analysis. Unpaired Student-t test was used to compare regional E_{LL} in PAH patients with the corresponding regions in control group.

Results:

In 5 catheter proven PAH patients, significantly low RV strain values were observed at basal, mid and apical anterior RV free wall (mean ± SD = -14.8 ± 3.1 vs. -21.3 ± 1.04, -13.5 ± 2.2 vs. -20.3 ± 1.4, -17.6 ± 1.4 vs. -20.6 ± 1.6, respectively, $p<0.05$) with no significant difference noted in the remaining examined RV regions (Figure 1A). In addition, interventricular septum at basal and mid ventricular levels demonstrated less E_{LL} strain in patients compared to controls (mean ± SD= -13.1± 4.03 vs. 19.8 ± 2.1 and 13.6 ± 2.8 vs. 20.1 ± 2 respectively, $p<0.05$) (Figure 1B).

Conclusion:

Strain encoded MRI imaging shows significant reduction of longitudinal strain at the anterior RV free wall at basal, mid and apical ventricular levels. Decreased E_{LL} was also noted at the interventricular septum at basal and mid levels (Figure 2). SENC imaging provides a novel technique for rapid right ventricular regional strain analysis in PAH patients thus enabling non invasive ventricular function monitoring.

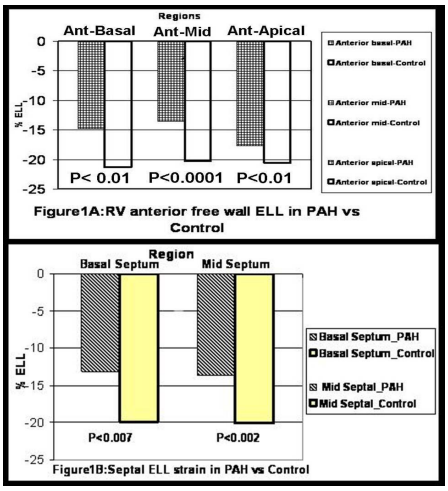

Figure1A:RV anterior free wall ELL in PAH vs Control

Figure1B:Septal ELL strain in PAH vs Control

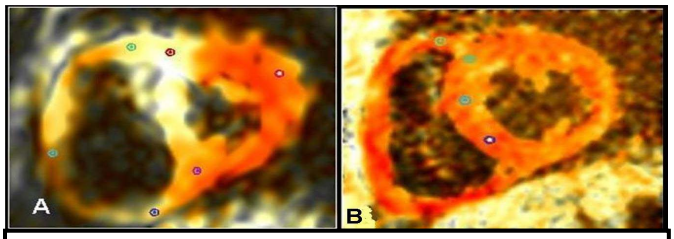

Figure2: A) F-SENC short axis basal slice showing decreased strain at anterior RV and antero-septal LV walls. B) SENC short axis basal slice in normal subject

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2. Osman, N.F., et al., Magn Reson Med, 2001. **46**(2): p. 324-34.