OPTIMAL BREATHING PROTOCOL FOR DYNAMIC CONTRAST ENHANCED MRI OF SOLITARY PULMONARY NODULE AT 3T

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INTRODUCTION

MRI of the lung is difficult due to motion artifacts (cardiac and respiratory), strong susceptibility artifacts within the lung parenchyma and low MR signal due to low proton density in the lung. [1] Dynamic contrasted-enhanced MRI measurement of the signal-time curves is a useful technique for obtaining functional information on blood volume and blood flow, interstitial and cell volume and vascular permeability, probably reflecting tumor angiogenesis. Previous studies have shown that it may be possible to differentiate among solitary pulmonary nodules (SPN's) based on their contrast pharmacokinetic profiles. [2, 3] The purpose of this study was to evaluate optimal breathing strategies that minimize lung parenchyma movement. These will be important to evaluate small lung lesions such as SPN during dynamic contrasted-enhanced MRI scans.

MATERIAL AND METHODS

A healthy volunteer and a patient presenting with a SPN were scanned using a 3 Tesla (GE Medical Systems, MI) with torso phase-array coils. Both subjects signed an institutional review board-approved informed consent. The volunteer was scanned for two and half minutes for each of two respiratory maneuvers, positioned in the supine posture, using the 2D spoiled gradient-echo sequence. Two different breathing protocols were used. First, the subject was instructed to breath-hold as much as possible, and breathe in between breath-holds. Second, the volunteer was instructed to breathe freely and shallowly throughout the scan. On the images obtained with each, the distances between the highest point of the right diaphragm and the inferior border of the FOV were measured. For the measurements of displacement of lung parenchyma portions, the main vessels branches-located in the four different anatomic regions: apex-anterior; apex-posterior; base-anterior and base-posterior were obtained in two dimensions (cranial-caudal and anterior-posterior planes). Distances between the vessel branches and the closest border of the FOV were measured. A patient with a 20 mm SPN was scanned using dynamic contrast-enhanced MRI. In addition to the sequences performed in the volunteer, axial single-shot fast spin-echo images including the center of the nodule were obtained as anatomical maps. In total, 120 images including the center of the SPN were obtained over 4 minutes utilizing a 2D spoiled gradient-echo (SPGR) sequence (TR= 15.0 ms, TE = 1.5 ms, flip angle=70^{O}, slice thickness = 5 mm, FOV = 40 cm, bandwidth=31.25 kHz, frequency direction: superior-inferior, acquisition time = 2 secs/image). The scan started at the same time as the bolus injection of 0.1 mM/kg of body weight of Gd-DTPA. During the dynamic scan, the patient was instructed to breathe shallowly and freely. A generalized kinetic model developed by Tofts, et al. based on k-trans and extravascular volume fraction was applied to the signal intensity vs. time curve of the SPN during dynamic contrast-enhanced scan. [4]

RESULTS

Variations in the displacement of cranial caudal locations of diaphragm were smaller during the free breathing protocol than when breath-hold instructions were used (Figure 1). The standard deviation of the excursion of highest point of the right diaphragm was 0.25 cm during the free breathing protocol. The standard deviation of the excursion of highest point of right diaphragm was 1.03 cm during the breath-hold protocol. The motions of the lung parenchyma were also estimated using the pulmonary vessels as markers during two breathing protocols. Dynamic contrast-enhanced MRI was obtained targeting the center of the nodule (Figure 2) and respectively fitting curve was obtained. An example of the model-based parametric analysis fitting in the patient with the SPN (adenocarcinoma, histologically) is shown on Figure 3.

DISCUSSION

Our preliminary results indicate that less displacement of the lung parenchyma structures were observed during scans with shallow breathing protocol. In conclusion, dynamic contrasted-enhanced MRI of pulmonary nodule is feasible when the shallow breathing protocol is adopted. MR perfusion study of SPN using 3T MR system with high spatial and temporal resolution may provide a secondary characterizing method to distinguish benign from malignant nodules with minimal associated risks, thereby avoiding unnecessary intervention for benign lung nodules and associated mortality /morbidity.

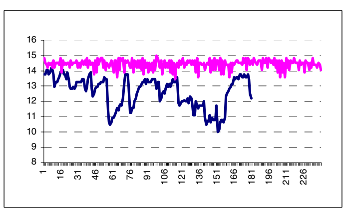

Fig.1: Graphs showing the positions of the highest points of the right hemi diaphragm of the volunteer during the two breathing protocols. The blue line indicates the position of the right hemi diaphragm during the breath-hold protocol, the pink line indicates the position of the of the right hemi diaphragm during the shallow-breathing protocol. The standard deviation of the position of the right hemi diaphragm with the breath-hold protocol was 1.03 and 0.25 during the shallow-breathing protocol.

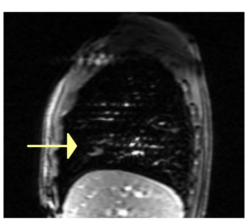

Fig.2: Dynamic sagital SPGR images demonstrates intense enhancement of the nodule

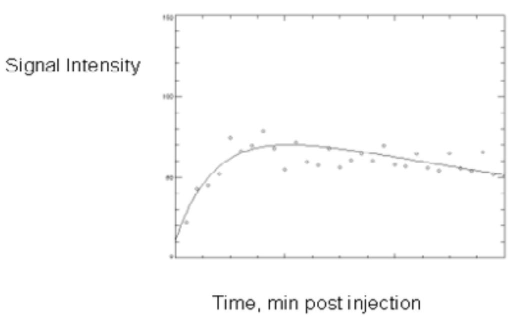

Fig.3 is an example of model- based full parametric analysis fitting of signal intensity vs. time curve of 2 cm nodule following bolus injection of Gd-DTPA. The fitted curve is similar to the curve classified as Type A in the report by Schaefer et al [3]. The signal intensity measurement if the SPN as well as the subsequent model-based parametric analysis was successfully performed.

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