ASSESSMENT OF PULMONARY LESION USING FAST DYNAMIC CONTRAST ENHANCEMENT MR IMAGING

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Introduction

Non-invasive identification and characterization of tumor are crucial in diagnosis and treatment of lung cancer, the leading cause of cancer death in North American. [1] Dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) has been established as a primary technique of evaluating properties of the tumor microvasculature in various tumor entities [2] by detecting subtle changes in pharmacokinetic parameters, which are promising bio-markers for tumor characterization, including lung cancer [3]. In this study, we explored the feasibility of non-invasively assessing pulmonary lesions with DCE-MRI in human subjects.

Materials and Methods

DCE-MRI images were acquired from nine patients (5males and 4 females with an average age of 64±20 years) with known intrapulmonary lesions prior to therapeutic intervention, among which six had received follow up scans at every 8 week period of therapy. A 3D Fast Gradient Echo Sequence (TR: 6.46ms; TE: 2.12ms; FA: 16º ; FoV 500mm; matrix 256×256; in-plane resolution: 1.8 x 1.8 mm^2 ;slice thickness 7mm; acquisition time 10s; 50 time points) was used for DCE-MRI scan on a clinical 1.5T scanner (Twinspeed, GE, Milwaukee, WI). A gadolinium chelate contrast agent (Omniscan, GE Healthcare, 0.2 mmol/kg) was injected with a flow rate of 0.6 ml/sec after 5 time points by a power injector (Spectris®, MedRad, Indianola, PA).

Quantification of DCE-MRI data was carried out by region of interest (ROI) analysis with motion correction. ROIs were defined on tumors, neighboring arteries and muscles. Different established pharmacokinetic parameters, including amplitude (Amp [a.u.]), volume transfer constant (K^{trans} [min^{-1}]), exchange rate (k_{ep}^{B} [min^{-1}]) and elimination rate (k_{el} [min^{-1}]) from Brix's two-compartment model [4], and AIF-decomposed k_{ep} [min^{-1}] and k_{pe} [min^{-1}] from our model were evaluated. In addition, color-coded parametric maps (Fig 1) were created as a readily readable, intuitive way of displaying spatial distribution of pharmacokinetic parameters.

Results

Intrapulmonary lesions were detected in all cases with satisfactory image quality and were demonstrated to be assessable by pharmacokinetic analysis with motion correction. Pharmacokinetic mapping was achievable in all cases. Even while the current methodology produces moderate respiratory and cardiac artifacts. A moderate, rapid initial enhancement followed by a fast contrast agent washout was observed in the signal intensity curves from active intratumoral regions. All pharmacokinetic parameters within the tumor ROI were significantly higher than those from normal muscle (P<0.01). Substantial decreases in K^{trans} (10%-70%)and k_{ep}^{B} (32%-57%) values were observed in 4 of the 6 patients with follow up scans.

Kinetic Parameter	Lesions before therapy	Lesions after therapy	Muscle	Arteria
Amp [a.u.] ± S.D.	1.51 ± 0.46	1.45 ± 0.56	0.38 ± 0.10	4.12 ± 1.66
k_{ep}^{B}[min-1] ± S.D.	68.7 ± 23.9	32.2 ± 29.7	1.84 ± 0.58	74.6 ± 7.6
K_{el} [min-1] ± S.D.	0.06 ± 0.03	0.04 ± 0.02	0.01 ± 0.04	0.12 ± 0.02
K^{trans}[min-1] ± S.D.	1.4 ± 1	0.7 ± 0.6	0.2 ± 0.2	xx ± xx
AIF-decompose k_{pe} [min^{-1}]	64.8 ± 26.1	30.1 ± 26.8	1.0 ± 0.9	xx ± xx
AIF-decompose k_{ep} [min^{-1}]	3.6 ± 1.3	2.5 ± 1	0.5 ± 0.3	xx ± xx

Table 1: DCE-MRI pharmacokinetic parameters within muscle, arteria, pulmonary lesions without and with treatment.

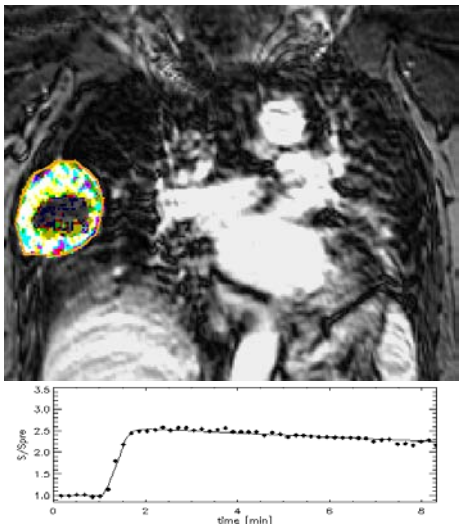

Fig 1: DCE-MRI parametric color-coded enhancement map overlaid on the morphologic image (upper) and time-intensity curve within the whole tumor ROI (lower).

Discussion and Conclusion

The unique characteristics of the pulmonary tissue make MR imaging of pulmonary lesion technically challenging because of the artifacts generated by physiological motions, and low signal to noise ratio due to low proton density. Previous efforts to overcome these difficulties include respiratory and cardiac gating, as well as using short echo times. [2] In our current study, we have demonstrated that satisfactory image quality can be obtained without using any gating and is fully compatible with DCE-MRI technique, which has a potential advantage over FDG-PET, which has very limited resolution so is not capable of detecting small lymph nodes. [3]

Pulmonary malignant lesions show distinct differences in contrast enhancement as compared to normal tissue in all pharmacokinetic parameters. This suggests Fast DCE-MRI might be a capable methodology to assess microcirculatory properties of intrapulmonary lesion on standard clinical MRI systems. Applying DCE-MRI technique to diagnosis and treatment of lung caner is promising for improving diagnostic characterization and response assessment of intrapulmonary lesions.

References

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