The relationship between the quantitative pharmacokinetic parameters of DCE-MRI and the types of uterine fibroids based on T2WIs

Chenxia Li[1,2], Hao Fu[1], Rong Wang[1], Jiayin Tong[1], Supin Wang[2], and Jian Yang[1,2]

[1]Department of Radiology, The First Affiliated Hospital of Xi' an Jiaotong University, Xi'an, Shan Xi Province, China, [2]Department of Biomedical Engineering, School of Life Science and Technology of Xi' an Jiaotong University, Xi'an, Shan Xi Province, China

Introduction

Uterine fibroids are the most common benign tumors in women of reproductive age. Menorrhagia, dysmenorrhea, pelvic pain, and bulk-related symptoms are common symptoms [1]. Hysterectomy or myomectomy is standard treating approach of fibroids. Magnetic resonance-guided high-intensity focused ultrasound (MRg HIFU) ablation, along with uterine fibroid embolization(UAE), is currently major nonsurgical options in the treatment of uterine fibroids [2]. The safe and effective use of MRg HIFU is affected by fibroid type in T2-weghted images (T2WIs) which were the current clinical criterion to select patients for MRg HIFU ablation[3]. The K^{trans}, K_{ep} and V_e based on Tofts model [4] of dynamic contrast-enhanced MR images (DCE-MRI) represent the process of Gd-DTPA transfer across the capillary wall, which is a surrogate of capillary permeability [5]. The aim of this study is to investigate the relationship between the quantitative pharmacokinetic parameters of DCE-MRI and the fibroid type based on T2WIs ,with expectation to select suitable fibroids for MRg HIFU ablation.

Methods

This study was approved by the local institutional review board. Twenty-three fibroids in 23 females (37~53 years, mean age:43.96±4.38 years) underwent T1 weighted images(T1WIs), T2WIs and DCE-MRI. The fibroids were divided into three types based on signal intensity in T2WIs[6]: type 1, low signal compared to skeletal muscle, 11 cases; type 2, lower signal than the myometrium and higher than skeletal muscle,7cases; type 3, signal equal to or higher than that of myometrium, 5 cases. In this study, the turbo field echo (TSE) T1WIs，two-dimensional TSE T2WIs and three-dimensional T1-weighted DCE-MRI were performed in a 1.5T scanner (Achieva, Philips Medical System, the Netherland) with 16-channel XL torso coil. DCE-MRI was performed including a precontrast scan (with a flip angle of 5) and a dynamic scan (with a flip angle of 15) after a single dose injection of Gadopentetate dimeglumine (Magnevist) at a dose of 0.1 mmol/kg through a peripheral vein at a rate of 2 mL/s. Dynamic scan was performed by 60 dynamics, TR/TE=4.84/2.35ms, field of view = 200mm×200mm×96mm, matrix = 176×176, voxel size= $1.7×1.7×4mm^3$,NSA=2, scan duration is 330second.The analysis of DCE-MRI data was performed using IDL version 6.4 Software. The process mainly included: Load the data, define the AIF, map calculation, review results, export. The quantitative parameters of K^{trans}, K_{ep} and V_e were obtained in workstation. The differences of K^{trans}, K_{ep} and V_e among the three types were determined using One-Way ANOVA. All statistical analyses were considered to be significant with $P<0.05$.

Results

The quantitative pharmacokinetic parameters (K^{trans}, K_{ep} and V_e) of each type were shown in Table 1 as mean±standard deviation. P-value of ANOVA analysis among the three fibroid types were shown in Table 2. The K^{trans} of the three fibroid types is very close and there are no statistic differences among them. The K_{ep} of type 3 is higher than type 1 and type 2.The significant differences of K_{ep} were shown between type 1 and type 3, type 2 and type 3. Moreover, there were no significant differences of V_e among the three fibroid types , although average values of V_e seem to be large difference among them from Table 1. The three fibroid types were shown typically with T2WIs and color maps of K^{trans}, K_{ep} and V_e in Fig 1.

Table 1 K^{trans}, K_{ep} and V_e of three fibroid types

Group	K^{trans} (min^{-1})	K_{ep} (min^{-1})	V_e
Type1(n=11)	0.38±0.25	0.16±0.05	1.94±2.53
Type2(n=7)	0.47±0.30	0.14±0.05	2.27±2.55
Type3(n=5)	0.35±0.23	0.28±0.13	0.62±0.40

Table 2 Differences of K^{trans}, K_{ep} and V_e among 3 fibroid types

	K^{trans}	K_{ep}	V_e
Type1&2	0.673	0.294	0.762
Type1&3	0.892	0.023*	0.293
Type2&3	0.642	0.005*	0.233

*: $P<0.05$

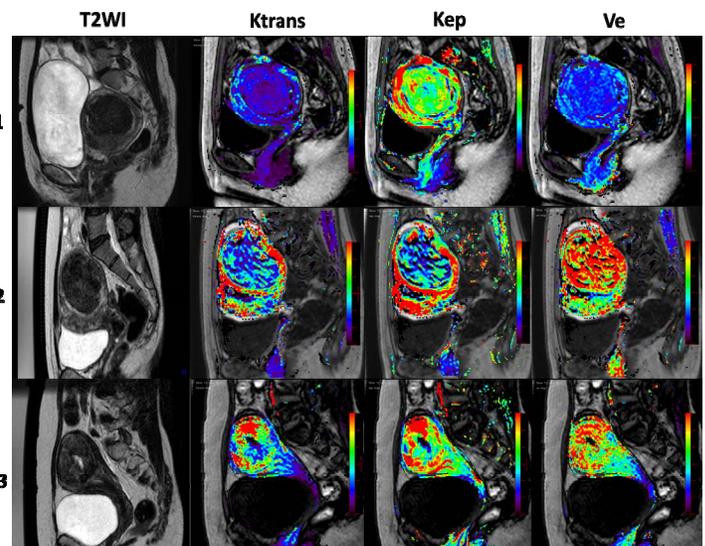Fig.1 T2WI and color maps of K^{trans}, K_{ep} and V_e in the 3 fibroid types

Discussion & Conclusions

To our knowledge, this is the first study to compare the DCE-MRI derived contrast agent kinetic characters among the three fibroid types by using K^{trans}, K_{ep} and V_e based on Tofts model. There were no statistic differences of K^{trans} among the three fibroid types, suggesting the similar volume transfer constant of Gd-DTPA between the capillary and extravascular extracellular space (EES). In current study, the V_e representing the volume of EES per unit volume of tissue were no significant differences among the 3 fibroids types , but the V_e of type 1 and type 2 were greater than 1. It indicated that the length of the dynamic scanning for this study may not be long enough to accurately estimate V_e in voxels. On the other hand, it demonstrated that type 3 fibroids have the haemodynamic characters of a fast wash-out. In addition, K_{ep} of type 3 was higher than type 1 and type 2. All of these demonstrated that the wash-out of type 3 is faster than other two types. It implied that the more heat energy may be taken away if carry out the HIFU ablation. Therefore, the patients with fibroids of type 3 may be not very suitable for MRg HIFU.

In sum, the K^{trans}, K_{ep} and V_e based on Tofts model, as an objective and sensitive method for DCE-MRI data analyzing, can reveal differences of capillary permeability and blood flow among the three fibroid types, and be proposed to guide patients selection for MRg HIFU ablation.

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