Quantitative Measurements of Permeability and Blood Volume in Meningiomas using Dynamic Susceptibility Contrast-Enhanced Perfusion Imaging

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Introduction

Preoperative information about the histological grades and subtypes of meningiomas is very important as it aids the surgeon in planning the resection. Atypical and anaplastic meningiomas are associated with high morbidity, mortality and recurrence rate because of their aggressive behavior. Measurements of cerebral blood volume (CBV) have been widely used in brain tumors[1]. However its use in meningiomas remains limited due to lack of blood brain barrier of meningioma capillaries. Earlier study showed that atypical meningiomas have elevated permeability, as expressed by vascular transfer constant (K^{trans}) compared with typical meningiomas[2]. It has also been reported that rCBV or cerebral blood flow (CBF) values were the greatest for angiomatous meningiomas and lowest for fibroblastic meningiomas[3-4]. The purpose of this study is to determine whether permeability and rCBV measurements can help in determining the histologic grades and subtypes of meningiomas.

Materials and Methods

Thirty-one meningiomas from thirty patients with histopathologic diagnosis of atypical (n=8, Grade II, 6M/2F, age 47-80), anaplastic (n=3, Grade III, 3F, age 41-76) and typical (n=20, Grade I, 5M/15F, age 27-86) meningiomas were included in this study. Subtypes of typical meningiomas included 8 fibroblastic, 2 transitional, 9 meningothelial, 1 angiomatous. Atypical and anaplastic meningiomas were grouped together as atypical meningiomas. All patients underwent MR studies before surgery on a 3T Siemens Tim Trio scanner with a 12-channel phased-array head coil. Dynamic susceptibility contrast (DSC) T2* weighted gradient-echo echo planar images were obtained during the first pass of the standard dose of bolus injection using the following parameters: TR/TE = 2000/45, FOV = 22 × 22 cm^2, in-plane resolution = 1.72 × 1.72 × 3 mm^3, and 20 slices covering the brain. Leakage corrected and uncorrected CBV maps were computed using Nordic ICE (Nordic Imaging Lab). K^{trans}, plasma volume (Vp) and volume of the extravascular extracellular space (Ve) were estimated using first-pass pharmacokinetic modeling (FPPM)[5]. Contrast-enhanced T1 weighted images, FLAIR, K^{trans}, Ve, Vp, corrected and uncorrected CBV maps were co-registered and all the perfusion parameters were measured from the enhancing region. An unpaired student t test was used to test the difference between atypical and typical, fibroblastic and meningothelial subtype meningiomas.

Results

Representative perfusion images are shown in Fig. 1. There was a significant difference in the measurement of corrected rCBV between atypical and typical meningiomas, but not in uncorrected rCBV (Table 1). K^{trans} and Ve from meningothelial meningiomas are significantly higher compared with fibroblastic subtypes (Fig 1, Table 2).

Discussion

CBV measurement can be problematic in meningiomas due to the high leakage. Our result showed that corrected rCBV is helpful in differentiating atypical from typical meningiomas. However, K^{trans} measurements didn't show any significant difference between atypical and typical meningiomas, which is inconsistent with previous report[2]. This may be due to possibly different compositions of typical meningioma subtypes. Previous study reported that fibroblastic meningiomas have the lowest perfusion compared with other subtypes[3-4]. In our study, corrected rCBV didn't demonstrate any significant difference between Grade I typical meningiomas. But K^{trans} and Ve are much lower in fibroblastic than other subtypes. Our study suggested that leakage correction of rCBV is important in characterization of meningiomas. Quantitative measurement of permeability and rCBV can help in grading and subtyping of meningiomas.

References

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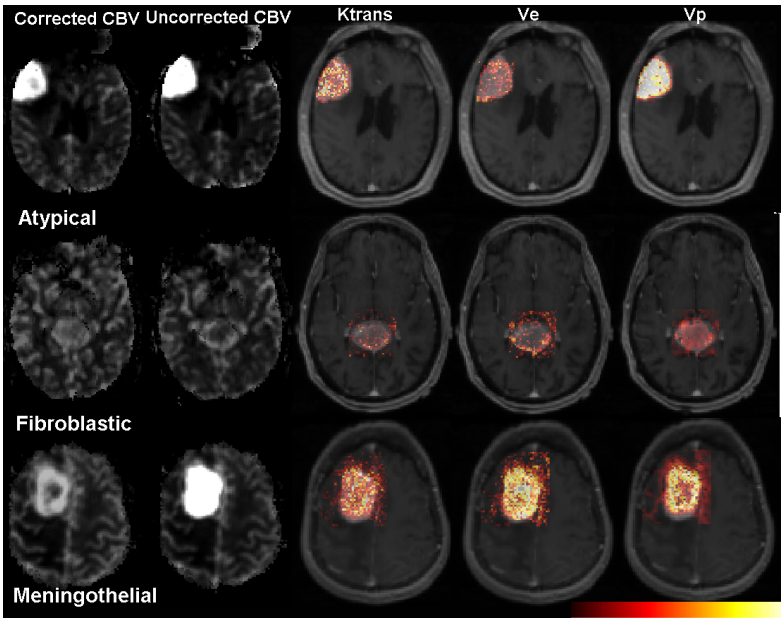

Fig 1. Representative perfusion images of atypical, fibroblastic and meningothelial meningiomas. K^{trans}, Ve and Vp maps are overlaid on contrast-enhanced T1 weighted images.

Table 1: Perfusion parameters between atypical and typical meningiomas

	Corrected rCBV	Uncorrected rCBV	$K^{trans}(min^{-1})$	Ve	Vp
Atypical (n=11)	7.13±4.20*	9.97±3.99	0.55±0.14	0.23±0.12	0.06±0.03
Typical (n=17)	4.53±1.90	7.66±3.83	0.49±0.15	0.22±0.14	0.05±0.02

*indicates statistically significant difference ($p < 0.05$)

Table 2: Perfusion parameters between different subtypes of typical meningiomas

	Corrected rCBV	Uncorrected rCBV	$K^{trans}(min^{-1})$	Ve	Vp
Fibroblastic (n=8)	4.00±1.62	5.67±1.87*	0.40±0.14*	0.15±0.10*	0.04±0.02
Meningothelial (n=9)	5.09±2.34	9.53±4.23	0.56±0.09	0.29±0.14	0.06±0.03
Angiomatous (n=1)	5.17	12.92	0.75	0.35	0.07

*indicates statistically significant difference ($p < 0.05$)