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ORIGINAL ARTICLE

Dynamic susceptibility contrast perfusion imaging in biopsy-proved adult medulloblastoma

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KEYWORDS
Medulloblastoma;
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Summary
Purpose: Medulloblastoma (MB) is a high-grade rare brain tumor in adults, with heterogeneous imaging features and variable enhancing patterns. Diffusion and spectroscopy multimodal imaging have already been described in adult MB, yet perfusion has not been explored. This study aimed to evaluate vascularity in adult classic and desmoplastic MB, using perfusion-weighted dynamic susceptibility contrast (DSC) MRI and histopathology.
Methods: Six histologically proved MB patients were classified as classic ($n = 3$) and desmoplastic ($n = 3$). DSC perfusion MRI was performed in three centers and retrospectively evaluated. Postprocessing included automatic arterial input function, motion and contrast leakage correction. Region of interest (ROI) delineation was performed on three perfusion slices to obtain a total of three cerebral blood volume ratios (rCBV) that were averaged to serve as the main rCBV. Permeability was evaluated on K2 maps.
Results: Low rCBVs were observed in all cases (mean rCBV = 1.19 ± 0.39). rCBV values were lower than 2 for classic MB and lower than 1 for desmoplastic MB. All cases showed an increase of permeability on K2 maps.

Abbreviations: DSC, dynamic susceptibility contrast; MB, Medulloblastoma; PA, Pilocytic Astrocytoma; rCBV, Cerebral Blood Volume ratio; ROI, Region of Interest; WHO, World Health Organization.

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Conclusions: Our preliminary results suggest that MB exhibits rCBV values close to 1 and increased permeability on DSC perfusion imaging, especially in desmoplastic cases, which could be explained by fibrous matrix. This type of perfusion pattern contrasts with those given by other enhancing subtentorial tumors such as metastasis, high-grade gliomas or hemangioblastomas.

Introduction

According to the World Health Organization (WHO), medulloblastoma (MB) is a highly malignant neuro-epithelial tumor of the cerebellum [1]. It is classically described as a hypercellular tumor with small, blue, and round cells. Mainly common in pediatric patients, it also occurs in adults (less than 1 case per million) [1—3].

MB shows either classic histologic features or variants of non-classic subtypes: desmoplastic MB, MB with extensive nodularity, large cell or anaplastic MB [1,4]. Desmoplastic subtype is more frequently found in adult patients (20—40%) and has better survival outcome [1,4,5].

The heterogeneous features of adult MB are especially pronounced on conventional MRI. Classic MB appears hypointense on T1WI and hyper-intense on T2WI, whereas desmoplastic MB tends to have low T1 and iso-T2 signals due to their higher cellularity in areas with desmoplasia [6,7]. On postcontrast images, patchy and marked enhancements have been reported. Indeed, classic MB showed marked enhancement in 65% of cases, while desmoplastic MB showed nodular enhancement in 50% of cases [7—9]. However, no distinct enhancement patterns were identified between classic and desmoplastic MB [10].

Concerning multimodal MRI, hypercellular nature of MB has been reported on diffusion and spectroscopy. On diffusion imaging, MB shows restricted diffusion [1,7,11,12], while on proton MR spectroscopy, it shows a prominent choline peak and reduced NAA, suggestive of actively proliferating cells, with increased membrane turnover and low neuronal viability [13—15].

Perfusion-weighted dynamic susceptibility contrast (DSC) MRI has showed the utility of cerebral blood volume ratio (rCBV) measures in differentiating histopathologic brain tumors. It also helps in the differentiation of post-treatment changes from tumor recurrence [16]. Two pediatric studies using perfusion imaging in brain tumors, reported wide perfusion variability of MB [17]. They also underlined the ability of perfusion imaging to differentiate true tumor progression from pseudo progression [18]. To our knowledge, no perfusion studies have been performed in adult MB. Hence, this study aimed to evaluate tissue and vascular perfusion characteristics in adult MB, using perfusion-weighted DSC MRI. Firstly, rCBV values were measured and compared by histological subtype. Secondly, a review of differential diagnoses for adult posterior fossa intra axial masses was performed, with a focus on perfusion characteristics.

Materiel and methods

Subjects

Six patients with an established histological diagnosis of MB were studied in this multicentric (3 centers) retrospective study between 2010 and 2014. Different centers were asked to participate because of the rarity of MB in adults. Patients were divided in two subgroups according to histological subtype: group 1 included patients with classic MB ($n = 3$) and group 2 patients with desmoplastic MB ($n = 3$).

MR acquisitions

MRI acquisitions were performed on five different 1.5 and 3 Tesla MR Systems (Philips Medical Systems, Einhoven, Holland & Siemens, Erlangan, Germany). The MRI protocol consisted in the acquisition of morphological, spectroscopy, diffusion and perfusion sequences. Morphological sequences included T1WI with and without gadolinium administration and T2WI (SE, TSE or FLAIR). Proton single voxel spectra were acquired also with short echo time. Diffusion WI was performed with b values of 0 and 1000 s/mm^2. Acquisition parameters for the previous sequences are summarized in Supplementary tables A.1, A.2, A.3 and A.4. Perfusion-weighted DSC imaging was performed for every case. Perfusion parameters are summarized in Table 1 for each patient.

Table 1 Dynamic susceptibility contrast-enhanced MR perfusion parameters.

Patients	MR System	Protocol	Rate of injection (ml^2/s)	TR (ms)	TE (ms)	Flip (°)	Slice thickness (mm)	Voxel size (mm)	Matrix
Patient 1	Philips Ingenia 3T	PERF T2* 0.9 SENSE	4.5	1952	25	70	4	0.9 × 0.9	244/241
Patient 2	Philips Achieva 3T	PRESTO_HR SENSE	6	17	24.8	7	3.5	1.8 × 1.8	88/84
Patient 3	Philips Ingenia 1.5T	PERF HR SB SENSE	6	2011	40	75	5	1.3 × 1.3	160/158
Patient 4	Philips Achieva 1.5T	PERF SENSE	6	506	30	40	5.5	1.8 × 1.8	128/73
Patient 5	Siemens Avanto 1.5T	EPI PERFUSION IPAT	6	1550	30	90	5	1.8 × 1.8	128/128
Patient 6	Philips Achieva 1.5T	PERF SENSE	6	506	30	40	5.5	1.8 × 1.8	128/73