Imaging of the choroid plexus using perfusion MR imaging: is it possible?

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INTRODUCTION

The cerebrospinal fluid (CSF) present within the cranium has an important role not only in development but also in hydrocephalus or degenerative processes such as Alzheimer's disease. The CSF that undergoes a continuous turnover is produced in small structures located in the cerebral ventricles : the choroid plexus (CP). The highly vascularized CP are composed of fenestrated capillaries surrounded with ependymal cells. A rapid and safe method for evaluating CP functionality in vivo is still lacking. The goal of our study is to evaluate dynamic T_2*-weighted perfusion MR imaging as an exploration method for assessment of CP functionality and the age-related changes of associated parameters.

METHODS

Patients: Fifteen patients (40+/- 14 years old; range: 21-68) who were referred for cerebral contrast enhanced imaging with small intracranial tumors were retrospectively studied.

Imaging: MR Imaging was performed on a 3T HDx MR Scanner (GE Healthcare, Milwaukee, WI). Gradient-echo echo planar images were acquired after bolus injection of gadolinium-based contrast agent (0.5 mmol/ml). Acquisition parameters were: TR : 1500 ms, TE : 30 ms , Flip angle: 60°, FOV : 24×24 cm², Slice thickness: 5 mm, gap: 1 mm, Matrix: 128×128, 1 Nex , 65 volumes of 20-22 slices.

Data analysis: The software, developed in situ, uses the previously modeled MR signal in terms of the combined T1- and T2- effects of gadolinium-based contrast agent. In this model , the measured relaxivity change ΔR_2* can be approximated as a linear combination of whole brain average relaxivity in non-enhancing voxels and its time integral:

$$\Delta\tilde{R}_2^*(t) \approx K_1 \overline{\Delta R_2^*}(t) - K_2 \int_0^t \overline{\Delta R_2^*}(\tau) d\tau$$

The K_2 term reflects the effects of the capillary leakage characterized by the gadolinium T1 enhancement-effect observed in the EPI signal (figure 1-A). After semi-automatic segmentation of the CP (figure 1-B) using the T1 enhancement property, several maps were computed: permeability K_2, relative cerebral blood volume rCBV, mean transit time MTT, signal slope decrease SSD.

Statistical analysis: Pearson correlation tests were used.

RESULTS AND DISCUSSION

The mean volume of functional segmented CP was : 2124 +/- 504 mm^3 [1413-3206] and the permeability factor K_2 was: 0.033 +/- 0.18 s^{-1}. K_2 and SSD significantly decreased ($r=0.79$-$p<10^{-3}$ and $r=0.71$-$p=0.03$, respectively) with subject's age (figure 1-C) whereas MTT significantly increased with subject's age. No significant correlation was found for age-related changes in rCBV. The large decrease in CP permeability is in line with the age-related changes in CP recently observed in animal models in terms of CSF secretion. The MTT increase indicates significant structural changes as observed by Serot et al. in anatomopathological studies. The functional impact of these structural changes has been observed: decrease in transthyretin secretion and beta-amyloid clearance associated with reduced CSF turn-over.

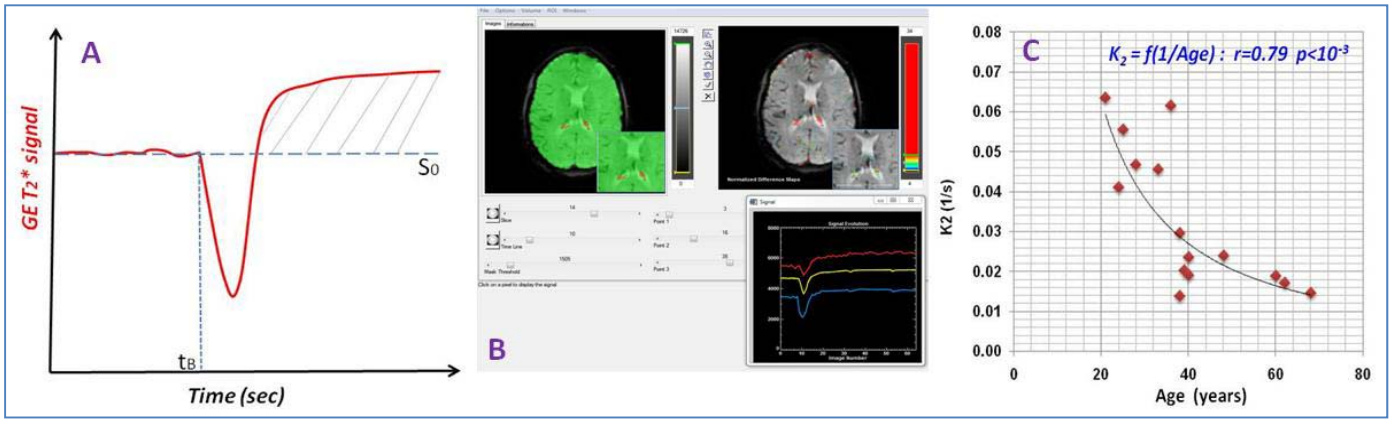

Figure 1: A- Gradient echo T_2* signal before and after passage of gadolinium based constrast agent (CA) in permeable tissue: after extravasation in the extracellular space, the CA T1-effect generates the observed signal enhancement. B- Software view showing the segmented plexus choroid with associated MR signal. C- Variations of permeability factor K_2 as a function of age.

CONCLUSION

Our feasibility study showed that dynamic T_2*-weighted perfusion MR imaging could be a useful tool for segmentation and assessment of functional parameters of choroid plexus. Clinical applications such as neurodegenerative diseases can be considered and specific functional studies of CP could lead to open new ways of research toward the comprehension of evolution mechanisms involved in Alzheimer's disease.

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