MRI texture analysis as a non invasive tool to show cerebral structural changes after herbicide ingestion in mice

S. Même[1], W. Même[2], B. Doan[1], and J-C. Beloeil[1]
[1]CNRS CBM UPR4301, Orléans, France, [2]Université d'Orléans

INTRODUCTION

Glufosinate ammonium (or phosphinothricin PPT) is the active element of herbicides widely used in agriculture or truck farming . Lots of transgenic plants resistant to that herbicide have been developed [1]. Significant quantities of PPT are present in plants and so consequently, in animal or human food which can lead to chronical intoxication. PPT also interacts with the cerebral glutamatergic system in mammalians and can, even with low dose, lead to important neurological disorders [2, 3]. The aim of this study was to use Magnetic Resonance Imaging (MRI) coupled with Texture Analysis (TA) [4, 5] as a non invasive tool to evaluate the effect of PPT treatment with different doses on mice central nervous system (CNS).

MATERIAL AND METHODS

20 mice were included in the study. They were divided into four experimental groups of 5 animals each. PPT-treated groups were injected 3 times a week with a single dose of PPT solution (2.5, 5 or 10 mg/kg bw intraperitoneally) during 10 weeks. The dose was 50 µL/g of mouse. Control animals received a comparable i.p. injection of 0.9% saline.
MR images were performed on a 9.4 T horizontal magnet (94/21 USR Bruker Biospec, Wissembourg, France). A first series of sagittal images was recorded with a 8 echoes-RARE sequence (FOV=1.5*1.5 cm, matrix size = 256*256, slice thickness=1 mm, TE=46 ms, TR=5s) leading to an in plane spatial resolution of 59*59 µm. Then, 15 axial images were acquired with the same sequence but with a slice thickness of 0.5 mm.
Seven areas (ROIs) were chosen on the axial images. They corresponded to visual, auditive, motor, somatosensorial cortex, hippocampus, thalamus, striatum. They were analyzed with 4 texture analysis methods. Following these image analyses, each ROI was characterized with its own texture profile defined with the calculated texture parameters such as contrast, homogeneity, entropy… All the profiles (control, 2.5 mg/kg, 5 mg/kg, 10 mg/kg) were analyzed with Correspondence factorial Analysis (CFA) and Hierarchical Ascending Classification (HAC) for each of the 7 brain structures.

RESULTS

Results of the texture profiles comparisons two by two (control vs 2.5 mg/kg, control vs 5 mg/kg, control vs 10 mg/kg, 2.5 mg/kg vs 5 mg/kg, 2.5 mg/kg vs 10 mg/kg and 5 mg/kg vs 10 mg/kg) for all mice are presented in *table 1*. Texture profiles were statistically different ($p<0.05$) except for auditive cortex, hippocampus and striatum for dose 5 mg/kg vs dose 10 mg/kg and for visual, auditive, motor, thalamus, striatum between control and dose 2.5 mg/kg.
The various CFAs made it possible to eliminate the redundant texture parameters and to keep only the ones most relevant ones for discrimination between the different ROIs with a statistical p value of 0.05. 204 parameters were available after computing the various texture analysis methods, but only 4 of them were kept: contrast, sum average, sum variance (from the cooccurrence matrix), run length distribution (from run length matrix). The best results were given with 2-clusters CFA. One cluster gathers texture profiles of control and dose 2.5 mg/kg. The other cluster aggregates the texture profiles of the dose 5 mg/kg and 10 mg/kg mice.

	χ^2 test
control vs 2.5 mg/kg	p<0.05 for somatosensorial cortex and hippocampus
control vs 5 mg/kg	p=0.0001
control vs 10 mg/kg	p=0.0001
2.5 mg/kg vs 5 mg/kg	p=0.001
2.5 mg/kg vs 10 mg/kg	p=0.0001
5 mg/kg vs 10 mg/kg	p<0.05 p=0.47 for auditive cortex p=0.31 for hippocampus p=0.31 for striatum

Table 1: Comparison of texture profiles after 2-classes HAC

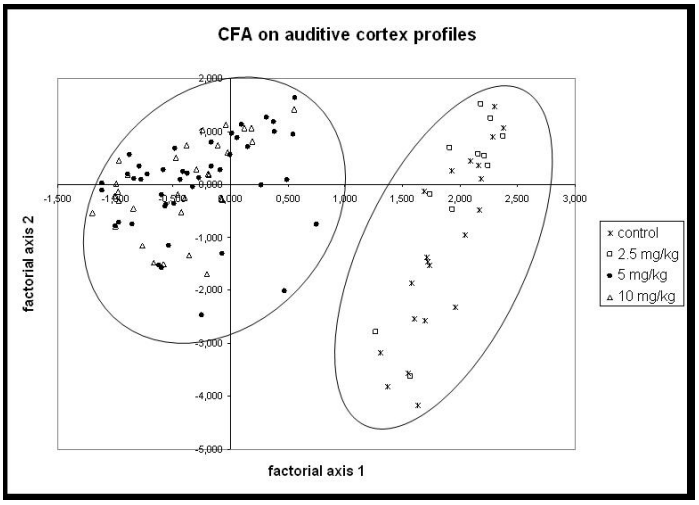

Figure 1: CFA performed on the auditive cortex as a function of dose

CONCLUSION

This study showed the capacity of texture analysis coupled with TA as a non- invasive method of tissue characterization substitutive to histology. In fact small structural changes, invisible on MR images were highlighted for several areas in mice brain after a chronic treatment to PPT. to characterize on MR images small structural changes in mice brain following chronic phosphinothricin treatment in several brain structures. Moreover, we have shown that a dose between 2.5 mg/kg and 5 mg/kg could be considered as a limit to detect those small changes with TA.

REFERENCES

[1] Kishchenko E.M. et al ; Cell Biol Int, 29 (2005) 15-9. [2] Lapouble E. et al ; Brain Research, 957 (2002) 46-52. [3] Eid T. et al Lancet, 363 (2004) 28-37. [4] Herlidou-Même S. et al ; Magn Reson Imaging 2003;21(9):989-93. [5] Haralick R. M et al ; Proceedings of the IEEE, 1979;67:786-804.