Visual System Recovery After Perinatal Stroke Evidenced by DTI and Event-Related fMRI

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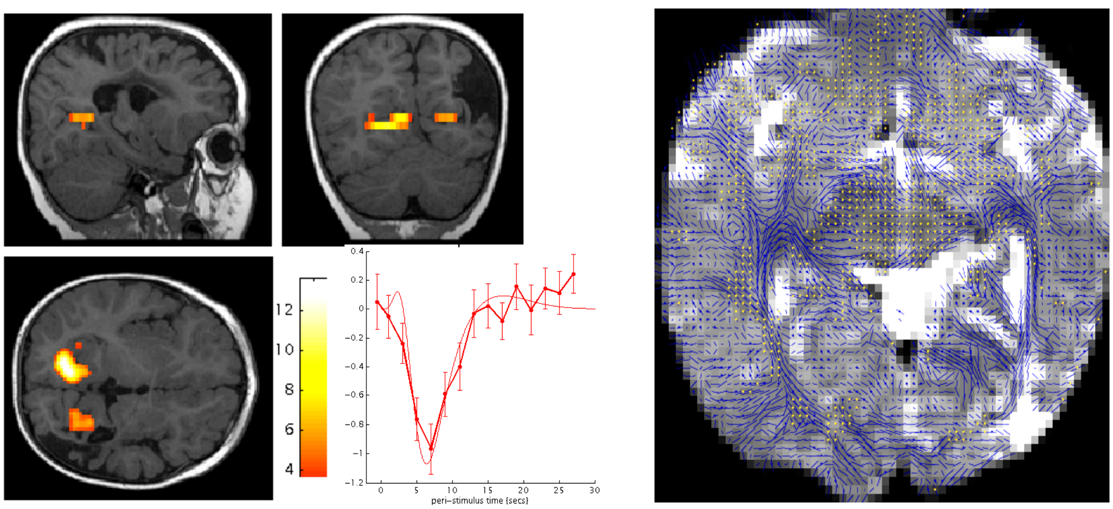
INTRODUCTION. Early assessment of the clinico-anatomic correlations after perinatal brain injury is of great importance to understand functional deficit and brain plasticity. Cortical visual impairment, defined as a visual deficit caused by a disturbance of the posterior visual pathways including the optic radiations, striate cortex, or prestriate cortex, remains difficult to assess clinically in the young infant. In this context, functional brain mapping with fMRI and structural integrity assessing with DTI have opened up the opportunity to study structure-function relationships non-invasively in pediatric population [1-3]. The aim of this case study was to assess recovery of the visual network after perinatal stroke in an infant with DTI and event-related fMRI (ER-fMRI).

METHODS. The male infant had presented with neonatal seizures on day 3 of life. MRI reduction of diffusivity was observed in the temporo-parieto-occipital region of the left hemisphere, compatible with hyperacute stage of middle cerebral artery infarction. The lesion evolved into tissue dissolution and local atrophy. At 3 month of age, fMRI had detected visual activation only in the intact right hemisphere [3]. At 20 month of age, the infant was reevaluated with ER-fMRI and DTI. For this examination, he was sedated with Propofolum (2.6 Disopropylphenol).
In ER-fMRI, the stimulus (visual flash at 2 Hz) was presented during 5 sec every 30 sec and repeated 15 times. Data acquisition consisted of an EPI 1.5T sequence (TR/TE/Flip=1000ms/40ms/80°). Data were then processed with SPM99 [4]. To determine temporal characteristics of the hemodynamic BOLD responses of the implicated foci, the averaged responses of the 15 trials were fitted with adjustable gamma function model [5], and time-to-peak and time-to-onset parameters were calculated. The diffusion tensor imaging used a SE-EPI sequence (FOV=250mm, TE=70ms, 32 contiguous 3mm slices, 4 averages) with 6 non-collinear high b-factors (700s/mm2). The tensor apparent-diffusion-coefficient was estimated and the three orthogonal eigenvectors and their related eigenvalues were calculated. The principal direction of diffusion is given by the eigenvector corresponding to the largest eigenvalue. The eigenvector was multiplied by the relative anisotropy for better visualization of the fiber tracts [6].

RESULTS. Visual stimuli have resulted in negative BOLD signal in the anterior part of the calcarine sulcus of the intact right hemisphere. Surprisingly, significant activation (p=0.00002 corrected) was also detected in the visual cortex of the injured left side (Figure). DTI vector map suggests recovery of parts of the left optic radiation in the vicinity of the lesion and the presence of fibers from the posterior forceps, one of the major interhemispheric connection tracts (Figure). Analysis of the temporal characteristics of the BOLD responses showed comparable temporal parameters, with time-to-onset of 3.5±1.7sec and 2.8±2.0sec for the right and left hemispheres respectively (p=0.05), and with time-to-peak of 8.9±0.8sec and 9.1±0.9sec for the right and left hemispheres respectively (p=0.17).



Left: ERfMRI map of negative BOLD responses in the visual cortex (p<0.0001, uncorrected). Right: DTI map showing intact fibers in the left injured hemisphere.

DISCUSSION&CONCLUSION. Previously, the infant had shown activation only in the right intact hemisphere with both block and event-related paradigms [3]. Here, ER-fMRI maps have shown responses in the left injured hemisphere that were not previously present, suggesting the role of some plasticity mechanisms that have occurred during brain development. The DTI now outlines some fibers in continuity with the optic radiation and immediately adjacent to the cystic lesion in the left occipital cortex, which could explain some of the observed functional responses. In addition there is presence of large fiber structures ventral to the optic radiation, joining the optic radiation, which might represent fibers of the rightsided visual system crossing through the interhemispheric connections, such as the major forceps and other commissural tracts. These fibers in the normal visual system usually innervate the central fovea. This modified connectivity indicates visual system recovery, manifested by strengthening of connections in the left visual system through crossing fibers from the right non- injured hemisphere, and resulting to significant functional activation with ER-fMRI in the left lesioned hemisphere.
In summary, the fMRI responses concur clearly with the visible projections of fibers in the DTI images of both hemispheres. Consequently, these findings propose relevant information for the cortical visual perception of this infant, and will help to elaborate the pertinent strategy in terms of recovery and rehabilitation.

REFERENCES. [**1**]-Born et al., 2000 Neuropediatrics; [**2**]-Sie et al., 2001 Dev. Med. Child Neurol.; [**3**]-Seghier et al., 2004 NeuroImage; [**4**]-Friston et al., 1995 NeuroImage; [**5**]-Cohen et al., 1997 NeuroImage; [**6**]-Huppi et al., 2001 Pediatrics.