Hemodynamics of the hippocampus and perilesional cortex in the acute and sub-acute phases after traumatic brain injury in rats

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Introduction

Traumatic brain injury (TBI) is a leading cause of mortality and morbidity, particularly in young people (1). It has been hypothesized that adaptations in cerebral blood flow (CBF) or blood volume (CBV) in subregions of the brain are responsible for secondary injury after the initial TBI impact. This study aims to characterize the hemodynamics of the hippocampus and the perifocal area surrounding the trauma lesion over 14 days after TBI in rats.

Methods

Male Sprague Dawley rats (n=10, 280-380 g) received lateral fluid-percussion brain injury as described previously (2). Sham operated control rats (n=5) received surgery without percussion injury. MRI was performed at 4.7 T with a Varian Inova console. CBF was quantified using continuous arterial spin labelling (3) and fast spin echo read out (FOV=4 cm , 128x128, thk=2 mm, TR=6 s, echo spacing=7 ms, 6 pairs of label and control images) from one hippocampal slice. Absolute CBF was calculated in the ipsilateral hippocampus and perifocal area 6 h, 24 h, 2 d, 7 d and 14 d after injury. Relative CBV changes were calculated in the same subregions from T_2 weighted images (TE=70 ms, TR=2500 ms) acquired 2 d and 14 d post-injury, before and after iv administration of MION contrast agent (6 mg/kg, Sinerem, Geurbet).

Results

CBF decreased at 6 h after TBI by 40 ± 5 ml/100 g/min in both the perifocal area and ipsilateral hippocampus (Figures 1-2). By 24 h, this decrease had returned to control levels in the hippocampus, only to decrease again (-20 ml/100 g/min) at day 2 yet gradually return to control values over 2 weeks. In the perifocal area, the initial hypoperfusion normalized and CBF became significantly elevated at 24 h. After this, a prolonged, gradual CBF decrease was observed over 2 weeks. CBV (Figure 1E) showed a similar trend to CBF but changes in the ipsilateral hippocampus and perifocal area were not statistically significant.

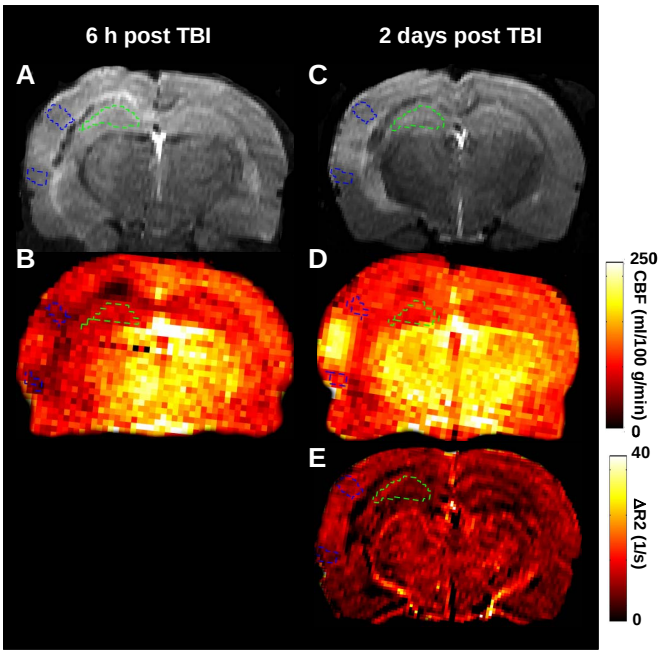

Figure 1. Representative MR images and quantitative maps acquired after TBI. The green outline encapsulates the ipsilateral hippocampus and the blue outline surrounds the perifocal area. **A**) T_2 weighted image acquired 6 h after TBI. **B**) CBF map acquired 6 h after TBI. **C**) T_2 weighted image from 2 days after TBI. **D**) CBF map acquired 2 days after TBI. **E**) CBV map calculated 2 days after TBI.

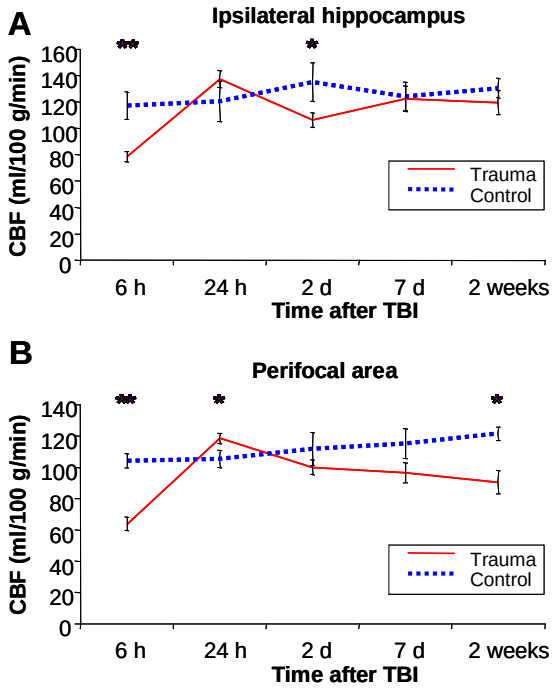

Figure 2. CBF in the (**A**) ipsilateral hippocampus and (**B**) perifocal area at 5 time points over 2 weeks after TBI. Error bars represent ±SEM. *=p value < 0.05, **=p value < 0.01 (Student's t-test).

Conclusions

CBF in subregions near the trauma lesion initially decreased, then elevated briefly, then normalized in the hippocampus but decreased again gradually in the perifocal area over 2 weeks after TBI. Structural MRI findings in the same model show a similar pattern; structural decline at 1-2 days post trauma, followed by transient normalization and secondary variations 1-2 weeks later (4). Importantly, hemodynamic changes precede structural changes, supporting the idea that hemodynamic variations play important roles in secondary damage cascades after TBI.

References

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