Dynamics of global brain networks for recovery from spinal cord injury

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Spinal cord injury causes a devastating loss of sensory, motor and autonomic functions to the patients and therapeutic strategies to improve these functions is an urgent social demand. In many cases, the injuries are partial, therefore promoting the functions of the remaining neural systems is the key for recovery. We have been studying the recovery of reaching and grasping movements in the macaque model of the partial spinal cord injury. In case the injury is confined to the lateral funiculus which transected the lateral corticospinal tract, the monkeys can recover precision grip in several weeks through training. In this case, the spinal cord interneurons bridge the injury and work for the recovery, and on top of that, dynamic change in the circuit operation occurs globally in the supraspinal networks. In addition to the contralesional motor cortex, ipsilateral primary motor cortex (M1) is activated during the early stage (~1 month after injury) by the contralesional M1 via the corpus callosum and contribute to the recovery. In the later stage (3-4 months after injury), the bilateral premotor cortices (PM) contribute to the recovery. Furthermore, the nucleus accumbens facilitates the motor cortex and promotes recovery. On the other hand, in case of the large subhemisection injury, usually the recovery of hand movements is slow and poor even 6 months after injury. However, through intensive training and frequent extensive electrical stimulation of bilateral PM and M1, the coarse grip considerably recovered in several weeks after injury. In this case, the bilateral PM and M1 are highly disinhibited and positively interacted with each other, and the corticospinal tract from the contralesional M1 exhibited a massive re-routing; 20-30% of the corticofugal fibers became uncrossed at the pyramidal decussation, descended in the contralesional side, crossed the midline caudal to the lesion and reached the gray matter including the motor nuclei of the affected hand/arm muscles, amazing plasticity in the adult brain. Induction of such massive plasticity in the adult primate brain would be the key for development of the future therapeutic strategies against neuropsychiatric disorders.