Marked changes of motor strategy in a complex manual dexterity task after permanent lesion of the primary motor cortex hand area assessed by chronic EMG recordings in non-human primate

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Introduction

Precise quantification of motor function is necessary to test the efficiency of possible treatments enhancing functional recovery after CNS lesions such as stroke. In addition, manual dexterity and precision grip express the highly specialised feature of cortical motor control via the corticospinal system, specific to primates. We therefore analysed and compared the muscle pattern needed to perform a complex manual dexterity task before and after a permanent lesion of the hand representation of the primary motor cortex in non-human primates.

Methods

Surgery:

Chronic implantation of a Tenectec® chamber containing tenectec® grid electrodes as well as tungsten microwire electrodes to elicit ICMS or ibotenic acid infusion in the primary motor (M1) cortex hand area in one adult female macaque monkey.

Chronic implantation of eight hand and arm muscles showing modulation of electromyographic (EMG) activity during the different phases of the “reach and grasp drawer” task (AbPB: abductor pollicis brevis, EDC: extensor digitorum communis, FCU: flexor carpi ulnaris, FDS: flexor digitorum superficialis, Tri: triceps and AD: anterior deltoid).

Cortical stimulation (Fig Ia): administration of excitotoxic ibotenic acid at multiple sites in M1 (Fig I) where ICMS elicited single joint finger movements (ICMS-intracortical microstimulation: train of 6 pulses 0.2 ms at 100 Hz).

Behavioral assessment of manual dexterity (Fig II):

A 5-minute “reach and grasp drawer” task was performed. Thumb and index finger precision grip was used to access monkey’s manual dexterity. It consists for the animal to pull a drawer against different levels of resistance to the opening and to retrieve a food pellet located inside the drawer.

Results

Stability of EMG activity in the four presented muscles before the cortical lesion in the different phases of the behavioral task, such as the grasping phase and the picking phase, with a high success rate (total of attempt/total of successfully retrieved pellets).

In the chronic phase, despite a similar sequence pattern, the EMG activity of the distal muscles such as AbPB significantly decreased, partly compensated by an increased EMG activity in the intermediate muscles such as PL and EDC.

As a higher level of resistance to the opening, the animal was unable to perform the task in the acute phase and showed dramatic remaining impairments in the chronic phase.

Conclusions and perspectives

The “reach and grasp drawer” behavioral task is an adequate behavioral task to challenge manual dexterity before and after cortical lesion involving hand representation of M1. Further analysis is needed to assess different changes of distribution of activation network in the spinal cord, integrating the consequences of a sudden interruption of the supra-spinal influence over the motoneurons involved in manual dexterity, including the role of proprioception among others.