Neural connections among primary motor, primary sensory and supplementary motor areas: evaluated by cortico-cortical evoked potential

Kiyohito TERADA, Naotaka USUI, Tadahiro MIHARA, Koichi BABA, Kazumi MATSUDA, Syuichi UMEOKA, Keiko USUI, Fumihiro NAKAMURA, Yushi INOUE

Shizuoka Institute of Epilepsy and Neurological Disorders, Shizuoka, JAPAN

Background and Objective: Functional mapping is important in epilepsy surgery. However, it is sometimes difficult to delineate eloquent areas by standard cortical stimulation. Matsumoto *et al*[1] reported a new method (cortico-cortical evoked potential: CCEP) to investigate the inter-areal connections in vivo in human. They demonstrated bidirectional connections among Broca's, Wernicke's and basal temporal language areas. In this study, we tried to clarify the neural connections among primary motor (MI), primary sensory (SI) and supplementary motor areas (SMA) by using CCEP.

Methods: We studied 10 patients (age 12-35 years) with intractable frontal lobe epilepsy who had chronic subdural electrode implantation for the presurgical evaluation. MI, SI and SMA were identified by standard cortical stimulation and somatosensory evoked potentials. The electrodes placed over MI, SI and SMA were stimulated, and were also used as the recording electrodes in the current CCEP study. To evoked CCEP, constant current square pulse of 0.3ms duration was applied at a frequency of 1Hz between two adjacent electrodes. The intensity was set to 80% of the motor/sensory thresholds for the standard cortical stimulation. To reduce the artifacts, stimuli were given with bipolar fashion. CCEPs were obtained by averaging electrocorticograms recorded from the target areas.

Results: MI stimulation evoked triphasic activities in the contralateral MI with a latency of 9.2-14.9ms for the initial positive peak. The latencies of the second negative and the third positive peaks were 25.4-33.0ms and 45.0-65.8ms, respectively. This response was not recorded when non-MI electrodes, but next to the MI electrode, were stimulated. MI stimulation also evoked bifid positive peaks in somatotopically corresponding SI area with latencies of 2.0-3.2ms and 3.3-4.0ms. They were followed by 2 bigger negative peaks with latencies of 4.8-7.7ms and 12.5-18.0ms. SI stimulation sometimes showed small negative peak at MI at 1.4-2.7ms. MI stimulation also demonstrated bifid peaks followed by 2 bigger peaks with opposite polarity in SMA. Latencies were 2.0-2.6ms and 3.1-4.0ms for the bifid peaks and 6.1-7.1ms and 16.0-18.3ms for the 2 later peaks. SMA stimulation also demonstrated the similar waveforms in MI with latencies of 1.5-2.5ms and 2.8-3.7ms for the bifid peaks and 3.7-6.7ms and 13.1-17.2ms for the 2 bigger peaks. For the areas of the upper limbs, the initial peaks were negative for both MI and SMA stimulations, but, for the areas of the lower limbs, they were positive for both stimulations.

Conclusion: The presence of bidirectional neural connections among MI, SI and SMA were demonstrated. Judged by their latencies, the recorded peaks may reflect the direct neural pathways between these areas. CCEP using subdural electrodes is clinically useful to identify these eloquent areas.

Reference

1. Matsumoto R, Nair DR, LaPresto E, Najm I, Bingaman W, Shibasaki H & Lüders H. Functional connectivity in the human language system: a cortico-cortical evoked potential study. *Brain* 2004; 127: 2316-30.