Electrophysiological study of the nociceptive responses in the anterior cingulate cortex in rats

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The anterior cingulate cortex (ACC) is known to be involved in processing of nociceptive information. However, the transmission pathway between ACC and peripheral noxious stimulation is still unclear. In the present study, electrophysiological properties of neurons in the ACC were investigated when peripheral noxious stimulations were applied.

Sprague Dawley rats were anaesthetized with halothane (1.5~2%) and craniotomy was performed for electrophysiological recording. Single unit activities of ACC neurons were recorded by glass micropipettes. High intensity electrical current was delivered to the sciatic nerve, and noxious mechanical stimuli were applied to the hind paw and tail. The characteristics of neuron responses were indicated by post-stimulus histogram and field potentials.

Eighty-seven neurons were recorded in medial prefrontal cortex in 9 rats. 41 neurons were responded to electrical stimulation, among which 36 had excitatory responses and 5 had inhibitory responses. 8 neurons were responded to noxious mechanical stimuli bilaterally (6 neurons were excitatory and 2 neurons were inhibitory). The locations of 40 responsive neurons were identified by histological method. 38% of neurons were distributed in the cingulate cortex area 1 (Cg1) and another 38% were distributed in the secondary motor cortex (M2) while the rest were located in the infralimbic cortex (IL) and the prelimbic area (PrL). In the cortical layer distribution, 58% and 30% of neurons were located in layer 5 and layer 3 respectively, and the rest were located in layer 2 and layer 6. The latency of the negative field potential was 64.51±3.22 ms, and the amplitude was -0.093±0.008 mV.

Comparing with the responses in the somatosensory cortex evoked by the same stimulation, the unit activities of ACC neurons were more slowly evoked, having a latency of 220.66±24.94 ms, and longer lasting in duration. The threshold of the ACC responses was 10 to 20 times greater than that in the somatosensory cortex. Higher concentration of halothane reduced the basal activity of neurons in ACC as well as evoked responses to noxious stimulation.
Intravenous injection of morphine (5mg/kg) reduced evoked response of ACC neurons. This effect was reversed by naloxone (2mg, i.v.).

Present results demonstrated that there are nociceptive neurons in the ACC. The properties of the late of long lasting evoked responses indicated that the ACC neurons may play a role in the affective aspect of nociceptive information processing.