CHANGES IN EXTRACELLULAR POTASSIUM EVOKED BY LOCAL SURFACE STIMULATION OF THE CEREBELLUM IN RAJA ERINACEA.

M.E. Rice and C. Nicholson, Department of Physiology and Biophysics, New York University Medical Center, 550 First Avenue, New York, N.Y. 10016.

Electrical stimulation of populations of neurons within the central nervous system of several mammals results in elevation of the concentration of extracellular potassium, $[K^+]_o$. Such elevations are confined to values between the normal baseline of about 3 mM and a ceiling level of 10-12 mM except during pathophysiological phenomena such as spreading depression (SD) or anoxic depolarization, when $[K^+]_o$ can reach 30-60 mM. Our present experiments in the skate cerebellum confirm the existence of a $[K^+]_o$ ceiling in elasmobranchs.

Male skates, weighing about 1 kg, were anesthetized by injecting 20 mg/kg of sodium pentothal into the tail vein. Supplementary doses of this anesthetic and urethane (1.2-2.0 g/kg, intramuscularly) were administered at 3 hour intervals. Curare (1-3 mg/kg) was injected around the gills to supress resiratory artifacts. Seawater, 13-18° C and gassed with 99% $O_2$/ 1% $CO_2$ was gravity-fed from a storage tank through the spiricles of the skate. The water left the mouth and was collected and pumped back to the storage tank. This closed-cycle system isolated the animal from electrical noise inherent in the piped seawater/drain system. The cerebellum was exposed and irrigated with flowing skate saline (Nicholson and Rice, Bulletin MDIBL: 25, 54-55, 1985). A local bipolar stimulating electrode (LOC) was positioned on the surface and recordings made with a double-barreled ion-selective microelectrode (Nicholson and Rice, Bulletin MDIBL: 25, 54-55, 1985) containing a valinomycin-based liquid ion-exchanger.

Stimulation of the surface of the cerebellum excited the parallel fiber-Purkinje cell system (indicated by monitoring typical extracellular field potentials) and resulted in $[K^+]_o$ elevations that varied with frequency (Figure). Normally, these ionic excursions were below 12 mM, but in a number of cases, the $[K^+]_o$ would pause briefly in the neighborhood of this ceiling level and then rise rapidly to around 30 mM, then return to and undershoot the baseline (Figure). This behavior is characteristic of SD in other preparations. The transient loss of evoked extracellular field potentials during the secondary $[K^+]_o$ increase and the propagation of the event to a distant electrode confirmed the occurence of SD.

From 117 stimulations in 11 skates, we conclude that potassium homeostasis in elasmobranchs is quite similar to that described in other vertbrates, despite the facts that the sodium and urea content of the extracellular space are much greater than in other species and that the brain temperature is some 20° C below that of mammals.

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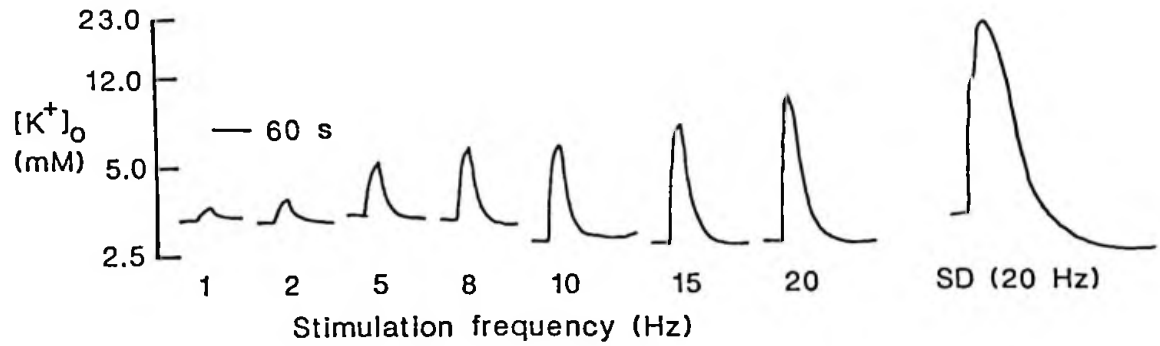


Figure. LOC stimulus-evoked $[K^+]_o$ in the molecular layer of the skate cerebellum. Stimuli were applied for 30 s at frequencies of 1-20 Hz. The evoked $[K^+]_o$ was elevated during the stimulus by amounts that increased with frequency, but in this example series did not exceed 10.7 mM, even at higher frequencies (not shown), except during SD. The lower baselines seen for some records were because the stimuli were given during the resting baseline undershoot following SD. In the last record on the right, a 20 Hz stimulus initiated SD, causing $[K^+]_o$ to exceed its ceiling to about 20 mM. The subsequent undershoot returned to baseline after 30 min.