Gardner-Medwin AR J Physiol 275: 66P

Measurements of extracellular potassium and calcium concentration during passage of current across the surface of the brain

By A. R. Gardner-Medwin* and C. Nicholson. *Department of Physiology and Biophysics, New York University Medical Center, New York 10016, and Department of Physiology, University College London, London WC1E 6BT**

When an electric current is passed across the surface of the brain there is a flux of K^+ between the tissue and the fluid bathing it which is greater than should be expected if K^+ moves through the brain primarily along the intercellular clefts (Gardner-Medwin, 1977). This suggests that much of the K^+ movement may be transcellular, possibly involving glial cells.

We have now used ion selective micro-electrodes (Nicholson, ten Bruggencate, Steinberg & Stöckle, 1977) to investigate the effects of current passage on the extracellular $[K^+]$ and $[Ca^{2+}]$ at various depths in the neocortex and cerebellar cortex of rats anaesthetized with urethane. Currents of approximately 20 $\mu A/mm^2$ at the surface of the brain were passed between an electrode in a cup containing artificial c.s.f. and an indifferent electrode elsewhere on the animal's head. The cup fluid was continuously replenished to maintain a constant composition (NaCl 140, KCl 3, $CaCl_2$ 1·6, Na_2HPO_4 4, NaH_2PO_4 2 mmole/l.; pH 7). Currents from the cup into the brain resulted in a gradual lowering of $[K^+]$ in the superficial 1 mm of tissue. The largest changes were seen within 100 to 300 μm of the surface, where the concentration reached values 0·8–1·5 mmole/l. below the normal ambient level (3–3·5 mmole/l.), after 400 sec of current passage. The opposite current for the same time produced increases in $[K^+]$ of 1·5–2·5 mmole/l. Similar results were obtained with both the cerebellum and neocortex, though the $[K^+]$ base-line levels in the cerebellum were more stable. Experiments on the cerebellum using Ca^{2+}-sensitive electrodes under identical conditions showed either no detectable $[Ca^{2+}]$ changes, or changes which were much smaller ($< 0{\cdot}25$ mmole/l.). Changes in neural activity seem unlikely to have been the cause of the $[K^+]$ changes, since these were still seen with tetrodotoxin (10^{-4} M) in the cup. Under the normal experimental conditions the Purkinje-cell firing rates were changed in either direction, mostly so as to increase during passage of current into the brain.

The results show that extracellular K^+ can be depleted or augmented in the superficial layers of the brain when currents are passed across the interface between the tissue and the fluid. Calcium levels, on the other hand, are almost unaffected. These results are to be expected if the brain possesses a specific mechanism for migration of K^+ with a higher transport number than c.s.f., such as a mechanism involving movement across cell membranes (Gardner-Medwin, 1977). Potassium would be removed from or added to the extracellular environment at the superficial sites in the tissue where there is net passage of current into or out of the cells. The results thus support the conclusion that transcellular migration of K^+ may contribute significantly to the movement and redistribution of K^+ through brain tissue.

W. Simon, Zürich, provided the Ca^{2+} exchanger. The work was supported by USPHS grant NS-13740-01, and a Royal Society Travel Grant to A.R.G.-M.