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Experimental and Theoretical Analysis of K^+ Dynamics in the Cochlear Spiral Ligament Essential for Auditory System

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Summary

The endocochlear potential (EP) of +80 mV in the scala media, which is indispensable for audition, is controlled by K^+ transport across the lateral cochlear wall. This wall includes two epithelial barriers, the syncytium and the marginal cells. The former contains multiple cell types, such as fibrocytes, which are exposed to perilymph on their basolateral surfaces. The apical surfaces of the marginal cells face endolymph. The fibrocytes have a unique continuous depolarized membrane potential of +5~10 mV. Although the membrane potential seems to contribute to the EP, the mechanism remains uncertain. We previously found that the Na^+, K^+-ATPase in fibrocytes mainly contributes to the EP and K^+ transport in cochlea. Based on the studies, we first developed new mathematical model of the lateral cochlear wall and hair cells which form K^+-circulation in cochlea.

Simulation produced that the fibrocytes have large Na^+ permeability than the other ion permeability such as K^+ or Cl^-. We next performed the electrophysiological studies for confirming the results of the simulation. We examined the membrane potential of the fibrocytes of living guinea pigs with electrodes sensitive to potential and K^+ while perfusing into the perilymph artificial perilymph containing various ionic concentrations. Perfusing low Na^+ solution greatly decreased membrane potential of fibrocytes, to the contrary, perfusion of high K^+ or low Cl^- solutions did not make significant change. These experimental results are consistent with the simulation.