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Regulatory Mechanisms of K^+ Absorption/Secretion in the Gut

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Summary

Short-chain fatty acids (SCFAs), including acetate, propionate and butyrate, are fermented product from dietary fibers in the large intestine. They are not only known to be absorbed as nutrients, but also known as chemical stimuli inducing physiological gastrointestinal functions: peristaltic and secretory reflexes. In previous studies, it have been reported that SCFA-induced chloride (Cl^-) secretion in the rat distal colon. Although the data in the previous reports showed that potassium (K^+) secretion might also be evoked by propionate in addition to the Cl^- secretion, the authors seemed to neglect the responses. Thus in the present study, the SCFA-induced potassium (K^+) secretion on colonic epithelium was investigated by short-circuit current technique using human and rat colon. Segments of human sigmoid colon were obtained from patients undergoing colectomy for carcinoma, and the mucosa-submucosa preparations were mounted between halves of Ussing flux chambers. In human sigmoid colon, acetate, propionate, and butyrate induced a negative change in sort-circuit current (I_{sc}) and an increase in tissue conductance at $>10^{-3}$ M in a concentration-dependent manner. Application of 5 mM propionate to the cecum and middle and distal colon induced a transient positive changes in *Isc* identified as electrogenic Cl^- secretion, but not proximal colon. However, luminal propionate only in the distal colon induced a negative change in *Isc* before appearing the Cl^- secretion. The propionate (5-50 mM)-induced I_{sc} responseswere reduced by pretreatment of barium chloride (30 mM) or tetraethylammonium (30 mM) both in human and rat colon. Therefore, it was suggested that the propionate-induced response is due to the K^+ secretion. In immunohistochemistry, calcium (Ca^{2+})-activated big conductance $K_{Ca}1.1$ (BK) channel- and Ca^{2+} -activatedintermediate-conductance $K_{Ca}3.1$ (IK) channel-immunoreactivities were detected on apical, but not basolateral, membrane in the crypt epithelial cells both in human and rat colon. These results suggest that SCFAs stimulate mucosa and induce K^+ secretion through both apical BK and IK channels in crypt of the human and the rat distal colon.

We further investigated the basal and stimulated K^+secretion in K-loading rats. Two weeks feeding of high K^+-diet increased blood $K^+$and plasma aldosterone concentrations. Both the basal and luminal propionate (5 mM)-evoked K^+secretion were enhanced in the rectum and distal colon, but not in other colonic regions. These results suggest that segmental difference appeared in the contribution of K^+ transport, and that the mucosal treatment of short-chain fatty acids might be effective in active K^+ excretion from the large intestine even in the hyperkalemia.