The previous work showed that the shifted intracellular calcium formed a new binding state[10]. In the examination by CCEPXMA and ion shower milling, the location of the shifted calcium was suggested to be at the inner surface of the cell membrane[9]. The above findings suggest that the intramembraneous particles treated with PTZ are in a different state from those in the normal neuronal membrane. The significance of this change is at present completely obscure and requires further study.

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Colon absorption of water and NaCl in the rat during lactation and the possible involvement of prolactin[1]

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Summary. The absorption of water and NaCl by the ascending colon of female rats was significantly increased by prolactin treatment in virgin rats and during suckled lactation. Bromocriptine treatment of lactating rats resulted in decreased colonic absorption, suggesting that increased prolactin secretion may be responsible for the enhanced colonic absorption seen during lactation.

The mammalian colon plays an important role in the maintenance of body fluid and electrolyte balance[4,5], by protecting the animal against excessive enteric losses of water and salts[6-9]. The possibility has been raised that variations in the endocrine status of the female mammal occurring during pregnancy and lactation[10-12] may be responsible for, or could contribute to, the observed hypertrophy and the elevated absorptive functions in the small intestine[11-13]. Since lactation is known to impose an additional burden on the water requirements of the mother, changes aimed at water and mineral ion conservation may be expected to occur in transporting epithelia such as the kidney tubule and gut during lactation[10]. However, information on the absorptive functions of the mammalian colon, during lactation seems to be lacking. Since prolactin has been shown to increase water and NaCl absorption in the ascending colon of rats[14], the elevated circulating levels of this hormone seen in lactation may contribute significantly to colonic absorption of water and ions in suckling animals.

The present study was therefore undertaken to investigate the influence of lactation and that of bromocriptine (CB-154), a potent prolactin secretion inhibiting agent[15,16], on the ability of the rat colon to absorb water and ions.

Materials and methods. The experiment was carried out using adult virgin mixed cycle and lactating Sprague Dawley rats (Charles River Breeding Laboratories, Wilmington, MA) with body weights varying from 250 to 350 g. They were maintained on regular Purina rat chow and water was given ad libitum. Lactating rats were received 7 days before delivery, and at birth the litter size for each rat was adjusted to 9 or 10.

Each virgin rat was injected s.c. either with 1.0 mg ovine prolactin (oPRL:NIH-P-S10, 26 IU/mg) for 2 days or with hormone vehicle 48 and 24 h before absorption rates were studied.

Each lactating rat was also injected s.c. for 6 days beginning day 0 postpartum, with either 1.0 mg CB-154 per day or with the drug vehicle. Bromocriptine (CB-154) (Sandoz Ltd, Basel, Switzerland) was pepared for injection by dissolving the weighed amount in a small volume of 95% ethanol, into which an equal weight of tartaric acid was added, and warming gently. This was then diluted in a 1:20 ratio with 0.9% NaCl.

From nembutal-anesthetized animal 10-cm long everted colonic sacs were prepared from the ascending colon beginning 5 cm from the caecal-colonic junction.

Each sac was weighed empty and after it had been filled with aerated Krebs bicarbonate Ringer solution containing 10 mM D-glucose. Incubation of the sacs was done in 20 ml of the Ringer contained in a 50-ml Erlenmeyer flask, placed in a metabolic incubator and shaken at 80 oscillations/min. The contents of each flask were continuously bubbled with 95% O_2 : 5% CO_2 and maintained at 37 °C for 1 h.

Effect of ovine prolactin (oPRL), lactation and bromocriptine (CB-154) on the absorption of water, sodium and chloride by the rat ascending colon (mean ± SEM)

Treatment and number of animals	Mucosal fluid transport (ml/g wet wt/h)	Mucosal Na^+ transport (μEq/g wet wt/h)	Mucosal Cl^- transport (μEq/g wet wt/h)
Virgin rats			
Saline (5)	0.82 ± 0.04	146.6 ± 7.4	153.5 ± 6.3
1.0 mg oPRL (6)	1.14 ± 0.10[a]	194.4 ± 16.1[a]	204.9 ± 13.4[a]
Lactating rats			
Saline (11)	1.26 ± 0.04[b]	230.8 ± 8.9[b]	215.7 ± 6.5[b]
1.0 mg CB-154 (8)	0.80 ± 0.08[c]	150.1 ± 14.5[c]	145 ± 12.8[c]

[a] and [b] are significantly different from control virgin rat values ($p < 0.05$ and $p < 0.001$, respectively) [c] significantly different from control lactating rat values ($p < 0.001$).

Following incubation each sac was reweighed to determine mucosal transfer and serosal and mucosal fluids collected for ion determination. Sodium concentration was determined using a Perkin-Elmer Atomic Absorption Spectrophotometer and chloride using the Buchler-Cotlore Chloridometer.

Mucosal transport was expressed as ml water or µg ion/g initial wet weight/h, in a 10-cm sac and values expressed as mean ± SEM. Statistical significance was determined using the unpaired Student's t-test.

Results. The results of this experiment are summarized in the table. The administration of 1.0 mg oPRL to adult nonreproductive female rats for 2 days significantly increased water ($p < 0.05$), sodium ($p < 0.05$) and chloride ($p < 0.05$) absorption in the ascending colon. Furthermore, lactating rats allowed to suckle their young for 6 days (8–9 pups/mother) also showed rates of water sodium and chloride absorption which were significantly greater than those of control virgin rats ($p < 0.001$). However, the lactating group of rats given bromocriptine for 6 days showed significantly inhibited water ($p < 0.001$), sodium ($p < 0.001$) and chloride ($p < 0.001$) absorption in the ascending colon.

Neither the prolactin treatment of virgin rats nor the bromocriptine treatment of lactating rats had any significant influence on the wet weight of the rat ascending colon. The mean wet weight of the colon from control virgin rats was 0.66 ± 0.02 g, whereas that of prolactin-treated rats was 0.66 ± 0.03 g. Similarly, the wet weights from control lactating rats were 0.90 ± 0.03 g and that from bromocriptine-treated rats was 0.84 ± 0.03 g.

Discussion. Available information on the physiological role of the mammalian colon in electrolyte homeostasis indicates a significant involvement of this organ in the absorption of water, sodium and chloride[7,8,17,18]. However, the rodent colon is usually divisible into 2 physiologically different regions, namely the ascending and descending colons[14,18–20]. The ascending colon which is more richly vascularized than the descending colon absorbs the bulk of the fluid and electrolytes presented to it by the ileum, whereas the descending colon is primarily concerned with sodium conservation and excretion of potassium and bicarbonate ions[8].

The present study has indicated that the ovine prolactin treatment of nonreproductive female rats resulted in significant increases in water and NaCl absorption in the ascending colon. Furthermore, lactation also resulted in elevated colonic water and NaCl absorption, when compared with control virgin rats. However, lactating rats treated with a prolactin secretion inhibiting agent (bromocriptine, CB-154) for 6 days showed significant reductions in colonic water and NaCl absorption as compared with those of control lactating rats.

The rationale for examining the efects of prolactin on the absorption of water and NaCl by the mammalian colon is based on the observation that prolactin is the only hormone whose circulating levels increase greatly during lactation[21,22]. Thus, although other hormones such as aldosterone and hydrocortisome[8,17,18,23,24], angiotensin[25–27], growth hormone and human placental lactogen[12] stimulate colonic water and NaCl absorption, only prolactin shows elevated secretion levels during lactation[22].

Salt depletion[28] and dietary regimes high in protein[29] have also been reported to augment colonic water and NaCl transport in the rat.

During lactation in the rat, a correlation has been demonstrated between small intestinal gut hypertrophy (increased wet and dry weights, nitrogen content, number of enterocytes) and absorptive capacity[10,11]. Previously, it was reported that CB-154 inhibited hypertrophy of the small intestine in lactating rats without drastically affecting the absorption of water and NaCl[12,13]. The present observations, on the other hand, suggest that in the ascending colon of rats, CB-154 effectively inhibits absorption without having an influence on colon hypertrophy. Notwithstanding the stimulatory effects of prolactin on the intestinal absorption of fluid and ions, the differences in the responses of the rat small intestine and colon to CB-154 suggest that the relationship between gut hypertrophy and absorptive capacity is rather complex.

Thus, in a lactating rat, increased circulating levels of prolactin may not be directly involved in bringing about colon hypertrophy, but may be responsible for the augmented absorption of water and NaCl by the mammalian colon.

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