

Sodium homeostasis in term and preterm neonates

II Gastrointestinal aspects

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SUMMARY Eighty five 24 hour balance studies were performed on 70 healthy newborn infants of gestational age 27-40 weeks; dietary intake and stool losses of sodium were measured. There was a relation between gastrointestinal sodium absorption and conceptional age (the sum of gestational and postnatal age), whether expressed as absolute stool sodium losses or as the ratio of stool sodium to dietary sodium intake. The stool K:Na ratio rose appreciably with maturation, although stool content of potassium was not greatly increased. These findings suggest that intestinal sodium absorption is inefficient in immature babies and that the degree of malabsorption is inversely related to conceptional age.

Hyponatraemia is common in very immature infants and since gastrointestinal absorption is one factor in sodium homeostasis, changes that occur in intestinal sodium reabsorption during postnatal development may be important in the pathogenesis of hyponatraemia. Little is known, however, about intestinal sodium reabsorption during early postnatal life. Investigation in vitro has shown progressive changes with age in intestinal ultrastructure, mucosal enzymes, and transport processes.¹ Ducker *et al.*² recently showed that the small intestine matures during the perinatal period, and that intrauterine growth retardation may impair intestinal absorption. Defective intestinal sodium absorption in the immature intestine is therefore a possibility and has been investigated in this study.

Patients and methods

Patients. Eighty five balance studies were performed on 70 healthy newborn infants in the nurseries and special care baby unit of this hospital. Their gestational ages ranged from 27-42 weeks and birthweight from 800-4200 g. Gestational age was estimated from the mother's menstrual history and physical assessment of the infant using the criteria of Dubowitz *et al.*³ All the infants were in good condition at the time of the study. None required mechanical ventilation, or other major procedures. Preterm infants, kept in their incubators throughout, were fed through a nasogastric tube and term

babies were breast or bottle fed by their mothers. Informed consent was obtained from the parents before each study period.

Methods. Each balance study lasted for 24 hours. The volume of all feeds was recorded and a sample of milk from the same batch was analysed for sodium and potassium concentrations. The sodium content of any drugs given during the period of the study was included. Stools were collected on plastic sheets on which the babies rested and these were immediately replaced after each stool was passed. All stools were frozen and stored for subsequent analysis. Laboratory methods for estimating sodium and potassium concentrations in stools and milk have been described.⁴

Results

The effect of maturation on intestinal sodium absorption is shown in Figs. 1 and 2. Stool sodium fell (Fig. 1) significantly with increasing post-conceptional age ($P < 0.005$). Fig. 2 compares the relation between stool sodium output, expressed as a fraction of intake, and conceptional age in 2 groups of infants of similar conceptional ages but different postnatal ages (5-6 and 26-68 days). The slopes of the two lines are not significantly different ($0.5 < 2P < 0.6$) but a greater proportion of ingested sodium appeared in the stool in the 5-6 day group at all conceptional ages ($2P < 0.01$). Sodium intake was, however, higher in the 26-68 day infants than in the 5-6 day infants. The respective

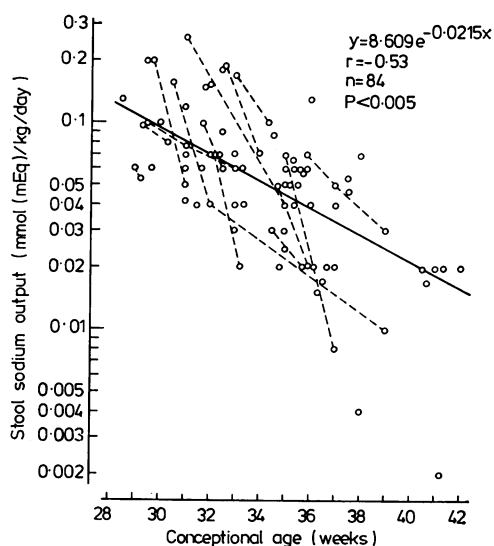


Fig. 1 Absolute stool losses (mmol (mEq)/kg/day) plotted against conceptual age. The solid line is the calculated regression line; broken lines connect studies performed on the same infants on different days.

mean \pm SD for the 2 groups was 1.93 ± 0.94 and 1.25 ± 0.43 mmol (mEq)/kg/day ($2P < 0.02$). The stool K:Na ratio rose significantly with maturation, (Fig. 3) ($P < 0.0025$) but the stool content of potassium did not increase appreciably.

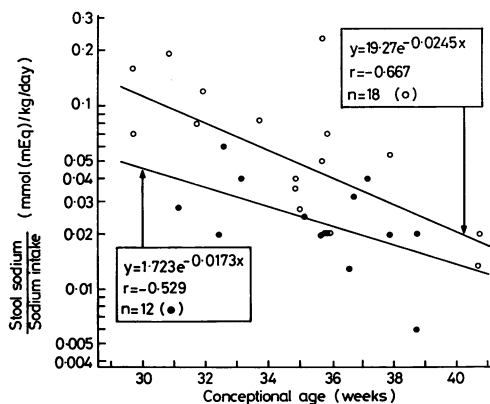


Fig. 2 Stool sodium, expressed as a fraction of ingested sodium, as a function of conceptual age. Open circles represent studies performed at 5–6 days postnatal age, closed circles those performed at 26–68 days. The separation of the regression lines is highly significant ($2P < 0.01$). The difference is not due to differences in intake, since the infants with the greater fractional stool loss (5–6 days) had the lower intake.

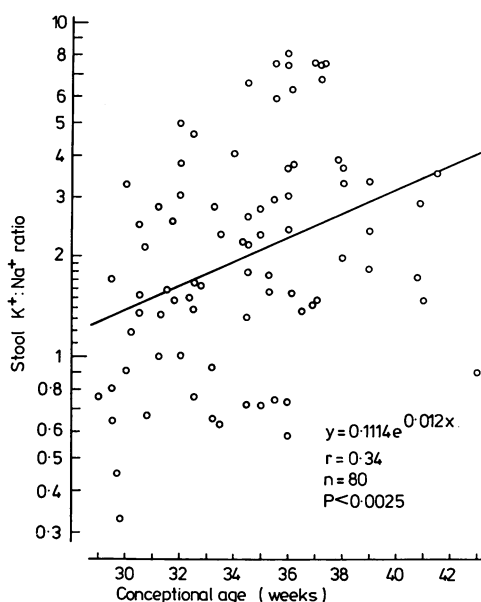


Fig. 3 The stool K:Na ratio plotted against conceptual age.

Discussion

Most studies of sodium homeostasis in the newborn have concentrated on the kidney^{4–12} as the organ pre-eminently responsible for the composition of the extracellular fluid. A contribution of the gastrointestinal tract remains a possibility, however, but this has never been studied systematically. If intrauterine growth rates are to be matched preterm infants need a plentiful supply of sodium. This presents no problems in utero since the maternal circulation through the placenta affords a virtually inexhaustible source. If, however, gastrointestinal absorptive capacity is limited due to immaturity the renal salt losing state reported⁴ becomes even more serious in its implications. This may be a particular problem in infants whose nutrition is deficient, since malnutrition is known to affect adversely the growth and development of intestinal tissues and to impair absorptive function.¹³

Our studies show that intestinal sodium absorption is inefficient in immature babies and that the degree of malabsorption is inversely related to conceptual age, irrespective of whether stool sodium losses are expressed in absolute terms or as a function of oral sodium intake. This relation has not been shown previously, although overall stool sodium losses have amounted to less than 10% of intake in most patients studied.^{6, 12}

The mechanism of impaired sodium absorption is unknown and has not been studied in humans. It is likely that the immaturity of the $\text{Na}^+\text{-K}^+$ ATPase (adenosine triphosphatase)—associated sodium transport system plays a part.¹⁴ Aldosterone stimulates both intestinal transport of sodium^{15 16} and the activity of $\text{Na}^+\text{-K}^+$ ATPase in epithelia.¹⁷ This fact coupled with the known high concentrations of circulating aldosterone in the newborn,^{5 8 18} raises the possibility that the hormone mediates the increase in sodium absorption that occurs after birth (Figs. 1 and 2). Although it is tempting to draw an analogy between the rising stool $\text{K}^+:\text{Na}^+$ ratio (Fig. 3) and the similar trend in urinary $\text{K}^+:\text{Na}^+$ ratio in premature babies^{4 5} this is probably misleading since the rising $\text{K}^+:\text{Na}^+$ ratio may be accounted for entirely by the fall in stool sodium, there being no concurrent rise in stool potassium.

We conclude that preterm babies are less able to absorb sodium from the gastrointestinal tract than are mature infants. In view of the known interdependence of epithelial transport of sodium and that of other substances studies of intestinal absorption of glucose and other nutrients are needed so that we can decide how best to feed premature babies.

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