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Relationship of renal threshold for bicarbonate reabsorption to urinary sodium excretion in premature infants

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Renal threshold for bicarbonate reabsorption and urinary sodium excretion of nine healthy male premature infants with a mean birth weight of 1734 g (range 1650—1900) was determined on the 7th day of life, and subsequently weekly for 6 consecutive weeks, by applying a repeated NH_4Cl load. A close negative correlation was found between bicarbonate threshold and urinary sodium excretion ($p < 0.01$). It is suggested that the limited renal capacity to reabsorb sodium may account for the low bicarbonate threshold in premature infants.

During the first weeks of life the increasing acid input and the limited renal capacity to excrete hydrogen ions lead to metabolic acidosis in low-birth-weight neonates [7, 8]. The postnatal development of renal acidifying processes is considered to be the main factor in re-establishment of normal acid–base status [6, 7, 8, 12, 14, 15].

In a previous study we could demonstrate the rapid postnatal increase of the urinary hydrogen ion excretion in premature infants [6, 12]. The renal threshold for bicarbonate reabsorption was also found to increase from the very low value of 12 mmol/l in the first week to 17—18 mmol/l by the 4—6th week of life. No attempt was, however, made to explain the reasons for the low bicarbonate threshold in this early period of life.

In the light of the recent suggestion [2, 3] that besides functional nephron heterogeneity and alterations in the kinetics of the enzyme reactions underlying transport mechanisms, the phenomenon may be related to a low fractional reabsorption of sodium in the proximal tubule [4], we decided to reanalyse and complete our earlier data with a simultaneous measurement of urinary sodium excretion.

The present study was designed to investigate the relationship between renal bicarbonate threshold and urinary sodium loss in 1—6-week-old premature infants.

MATERIAL AND METHODS

Renal threshold for bicarbonate reabsorption of nine healthy male premature infants with a mean birth weight of 1734 g (range 1650—1900 g) was determined on the 7th day of life, and then weekly for 6 consecutive weeks, by applying a repeated NH_4Cl load.

The protocol of NH_4Cl administration, the timing of urine collection and blood

sampling, as well as the acid-base parameters of blood, and urinary hydrogen ion excretion have been described in detail [12].

Urinary sodium excretion was determined along with the bicarbonate threshold once weekly in urine samples which were collected during the control period of 12 hours preceding the administration of NH_4Cl. Sodium measurements were made by flame photometry.

The total CO_2 content of the blood at which hydrogen ion excretion was maximal was regarded as the renal threshold for bicarbonate reabsorption [2].

Statistical evaluation was performed by calculating the coefficient of correlation (r) and the equation of exponential regression (y).

Results

As it is shown in Figure 1, there was a close negative correlation between the renal bicarbonate threshold and urinary sodium excretion ($p < 0.01$). With a urinary sodium excretion of 10 μEq/min/1.73 m^2 the bicarbonate threshold was about 17—18 mmol/l, and with increasing sodium loss it decreased exponentially to reach a value of about 12 mmol/l at a urinary sodium excretion higher than 30 μEq/min/1.73 m^2.

Discussion

It has long been recognized that mineralocorticoid activity and renal sodium handling play an important role in the renal acidifying processes [9, 16].

In a series of papers we have shown that a close relationship existed between sodium homoestasis and acid-base regulation in premature infants during the first six weeks of life [6, 10, 11, 13, 14]. In support of

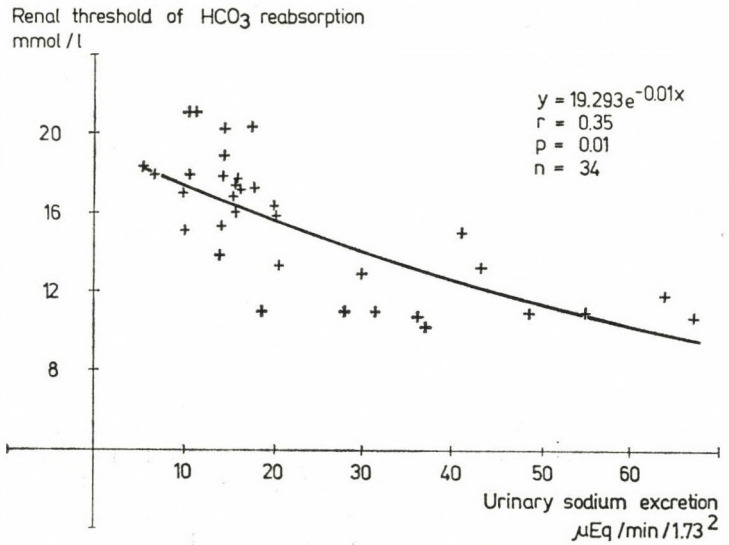

Fig. 1. Relationship between renal bicarbonate threshold and urinary sodium loss in 1—6 week-old premature infants

such a relationship the following findings are to be taken into account.

1. The initially low renal hydrogen ion excretion is associated with a high urinary sodium excretion but the development of renal capacity to excrete hydrogen ion results in a progressive increase in renal $Na^+ - H^+$ exchange [6].

2. Due to the increased urinary sodium excretion in the first two weeks of life, a negative sodium balance develops with subsequent hyponatraemia. The trend and time course of late metabolic acidosis and "physiological" hyponatraemia is similar.

In most cases it starts after the first week, becomes progressively more severe in the second and third weeks, and then corrects itself by the 5—6th weeks of life [10, 11].

3. In one-week-old newborn infants urinary sodium excretion decreases, hydrogen ion excretion increases parallel with birth weight, indicating the increasing rate of renal exchange of $Na^+ - H^+$ with maturity [13].

4. The present finding that the high urinary sodium excretion may, at least in part, account for the low renal threshold of bicarbonate reabsorption in premature infants may be interpreted as an evidence of the role of renal sodium handling in the maintenance of acid–base homeostasis.

The high urinary sodium excretion and the subsequent hyponatraemia with an increased activity of the renin-angiotensin-aldosterone system [1, 5] is characteristic of pseudohypoaldosteronism, which may be related to the functional and morphological characteristics of the immature kidney.

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