METABOLIC BALANCE STUDIES OF SODIUM, POTASSIUM, NITROGEN AND PHOSPHORUS IN PREMATURE NEONATES

C P Chee
K Somasundaram
K L Lam
C K Toh
C W Wang

Faculty of Medicine
University of Malaya
Kuala Lumpur
Malaysia

C P Chee, MBBS, MRCS, LRCP, FRCS (Ed), FRCS (Glas)
Lecturer and Neurosurgeon

K Somasundaram, MBBS, FRCS, FRACS, FRCS (Ed)
Professor of Surgery

K L Lam, MBBS, DCH, MRCP (Glas)
Professor of Paediatrics

C K Toh, MBBS, MRCP
Lecturer in Paediatrics

C W Wang, B Sc, PhD
Lecturer in Biochemistry

SYNOPSIS

A metabolic balance study was performed in neonates born prematurely with gestational age between 32 and 35 weeks in the Departments of Surgery and Paediatrics of the University Hospital, Kuala Lumpur from June 1981 to June 1983. Four essential nutrient elements: sodium, potassium, nitrogen and phosphorus were measured in the first 10 days of life and then between the 10th and 20th day of life. There was positive balance in each of the elements, except for sodium in the first week of life. There was also significant correlation between input and retention of each of the elements except for sodium and potassium in the first 10 days of life. This is probably due to the anatomical and physiological immaturity of the neonate kidney during this period.

INTRODUCTION

It was well-known since the time of John Hunter that the major causes of death of children before the fifth birthday were disease, dirt, malnutrition, cruelty and neglect. With the improvement in socio-economic status, education, control of disease and improved nutrition and housing, the mortality rate of children after the first year of life has decreased remarkably. A better understanding of nutritional requirements in the neonatal period has further decreased the mortality rate. Yet, the nutritional requirements for the premature neonate are not precisely defined. It was for this reason that a metabolic balance study in the premature neonates was carried out by the Departments of Surgery and Paediatrics, University Hospital, Kuala Lumpur.

MATERIAL AND METHOD

Selection of Neonates and Definition

Prematurity in this study is defined both by dates and assessment. There were two categories of premature neonates selected for this study: first category consisted of three premature neonates in their third day of life and the second category, three premature neonates after the tenth day of life (11th, 12th and 15th day of life). Neonates with congenital abnormalities requiring any operation or neonates having diarrhoea were excluded from this study. All the neonates were nursed in the Special Care Nursery of the University Hospital, Kuala Lumpur, the nursing staff of which were specially trained for the nursing of the premature neonates, collection of specimens and recording of data. Each neonate was studied for a period of seven full days. Each full day during the duration of the study refers to the 24 hours period from 6 a.m. of one day to 6 a.m. of the next.

All together six neonates were accepted into this study: three neonates at 3rd day of life and three neonates between 10th to 15th dHy of life. Only neonates who were born prematurely at 32 to 35 weeks were accepted into the study. Neonates having diarrhoea or repeated vomiting and those requiring operative intervention were excluded.

Collection of Specimens and Recording

Each neonate was weighed daily in the nude in the morning before the first milk feed of the day.

The milk powder formula used in this study was "Nan" prepared in the recommended strength. The amount of milk consumed during each feed was recorded. At the end of the day, the feeding bottle from which the milk feeds were taken together with the remaining milk was sent to the laboratory for analysis. The spilled milk on the blouse was also measure from its washing.

All medications given were recorded accurately. If the neonate was given intravenous fluid, the fluid given was recorded and samples collected for analysis.

All urine in the urine bag was aspirated as soon as noticed by a plastic syringe into an iron-free container. THe same syringe which was used for the whole 24 hour period was sent for analysis together with the urine aspirated and nappies soiled with urine. Stool excreted per day was analysed from stool collected into an iron free beaker and from the soiled nappy. Specimens of urine and stools were pooled together 6 hourly and kept in the freezer to await collection at 9 a.m. every day on completing the period of study. Any vomitus was collected in a same manner.

Precautions were taken to prevent contamination of samples of urine, stool, milk feed, vomitus and intravenous nutrient solution (1).

ANALYSIS

Analysis of sodium and potassium were determined according to the flame photometric method (2). Phosphorus estimations were performed by colorimetric method according to the British Standard (3). The nitrogen content was determined by Kjeldahl method (4).

Data from the balance studies of each element for each neonate was presented. The equation to linear regression line and the correlation coefficient have been calculated (5).

RESULTS

Premature Neonates at First Week of Life

The results of the metabolic balance for the neonates at the first 10 days of life were presented in Figure 1 (a), (b) and (c).

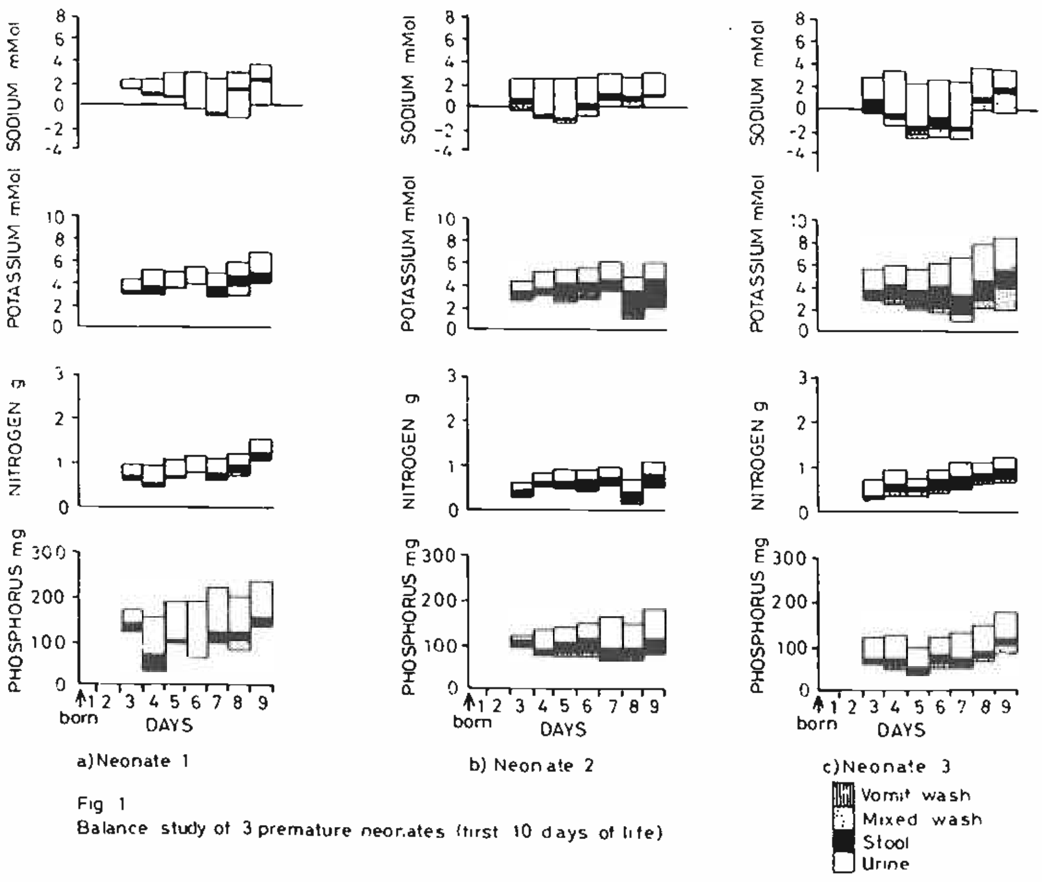

Fig 1
Balance study of 3 premature neonates (first 10 days of life)

It was found that there was positive balance in potassium, nitrogen and phosphate. For sodium there was negative balance on the 4th to 7th day of life. This negative balance corresponded with an increase in both the volume of urine and its sodium concentration (Fig. 2). The later return to positive balance of sodium corresponded to a decrease in the sodium concentration in urine rather than the volume of urine.

When regression lines were plotted (Figures 3a, 3b, 3c, 3d), the correlation between input and retention was significant at the 0.1% level for nitrogen and phosphorus (r = 0.884 and 0.591, respectively) but not for sodium and potassium (r = 0.245 and 0.294, respectively). The retention was 88% for nitrogen but only 48% for phosphorus.

Premature Neonates between 10 to 20 Days of Life

There was positive balance in all the nutrient elements in the neonates born prematurely between 10 to 20 days of life (Fig. 4). The volume of urine and its sodium concentration remained relatively constant throughout the period of study for all the three neonates.

There was very little scatter of points about the regression lines for all the nutrient elements (Figures 5a, 5b, 5c, 5d). The correlation between input and retention was significant at the 0.1% level for all the 4 elements (sodium r = 0.905, potassium r = 0.787, phosphorus r = 0.581 and nitrogen r = 0.918). The retention for the elements are: sodium 68%, potassium 80%, nitrogen 91% and phosphorus 84%.

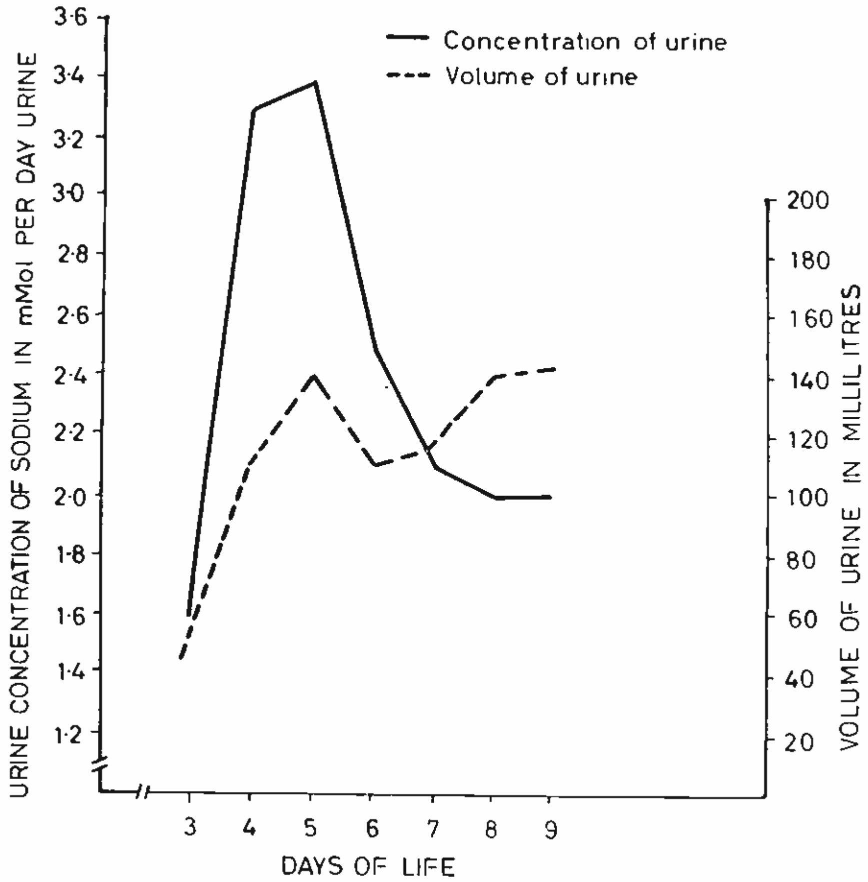

Fig. 2

Volume of urine excreted per day and the urinary sodium concentration

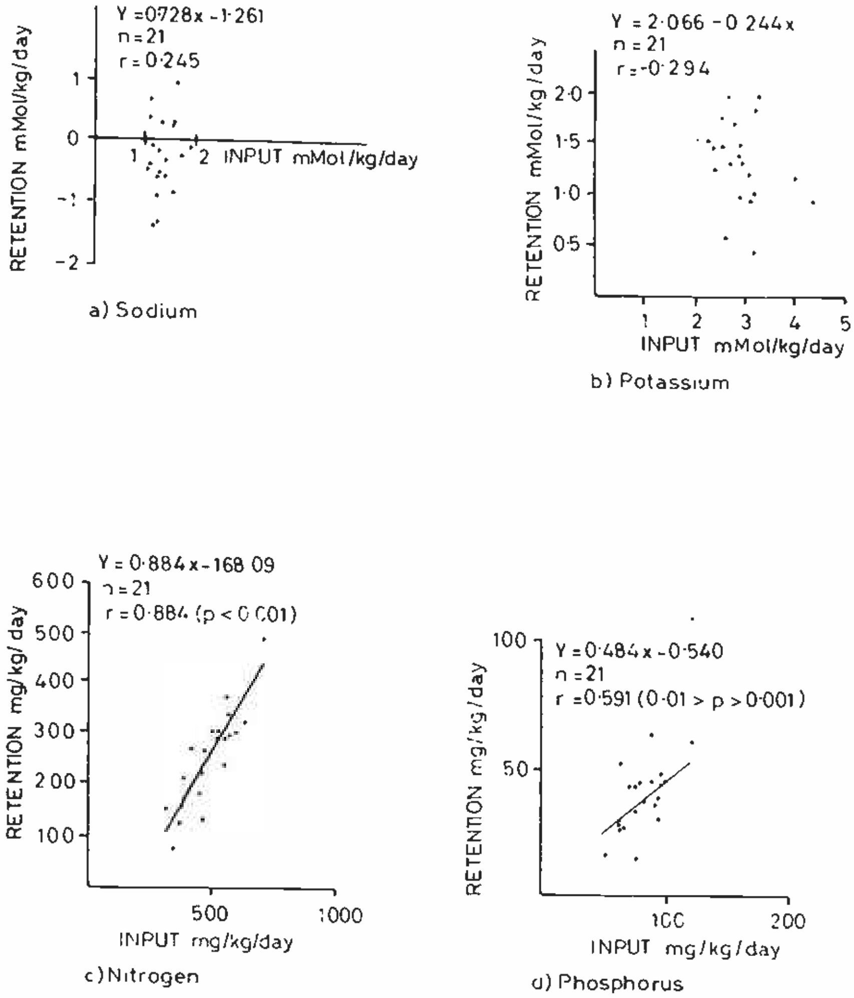

Fig.3
Regression lines of input versus retention of premature neonates during the first 10 days of life

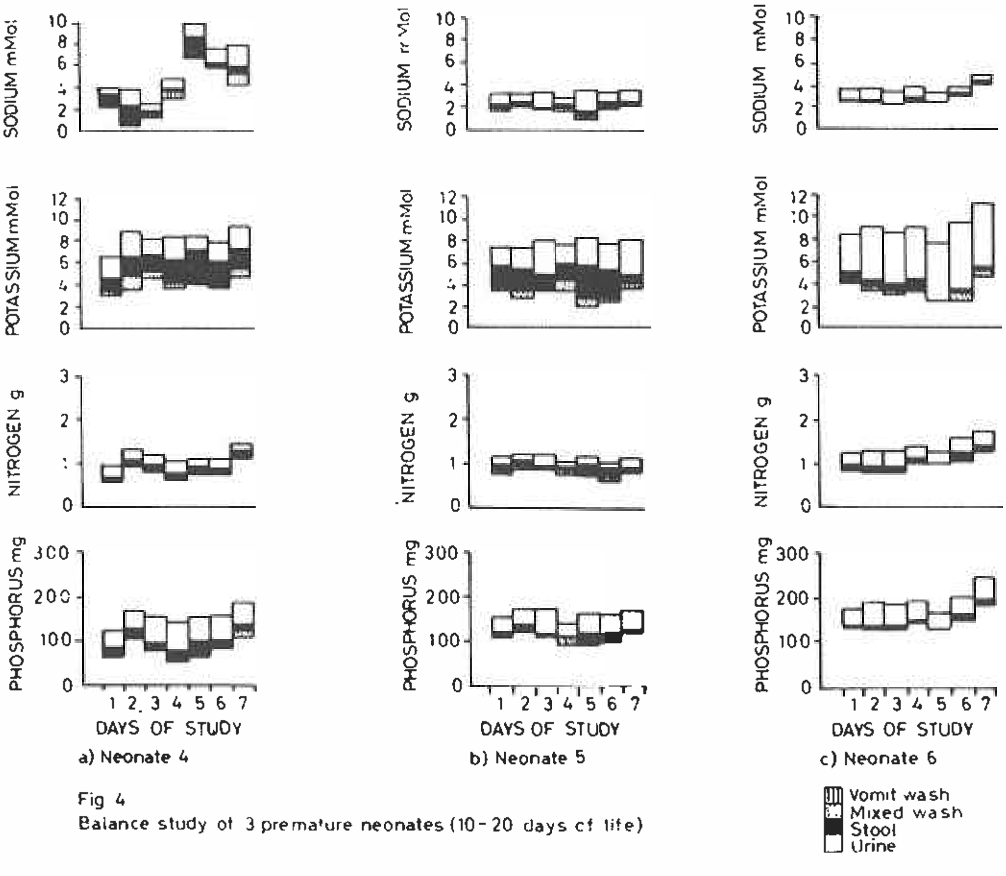

Fig 4
Balance study of 3 premature neonates (10-20 days of life)

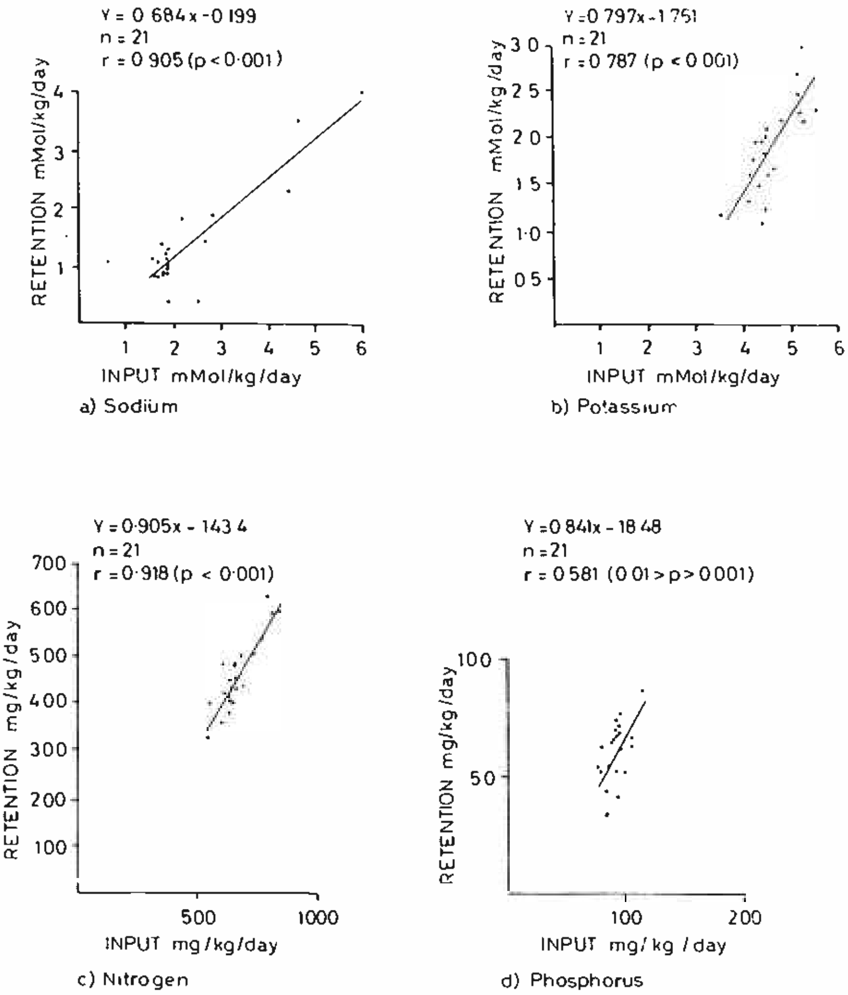

Fig 5

Regression lines of input versus retention of premature neonates between 10 to 20 days of life

DISCUSSION

Since the premature neonate continues to grow rapidly to maintain the rate of growth predicted by the intrauterine growth curve, it is essential for it to receive an adequate supply of calories, nitrogen and other essential elements. On the other hand, the newborn has a limited capacity to excrete water, electrolyte or hydrogen ion load, a limited ability to produce a concentrated urine or to react to antidiuretic and aldosterone hormones. Its glomerular filtration rate is also small. In a stress situation especially in newborn born prematurely; the functional immaturity of these performances will be fully exposed. The capacity to excrete a water load reached maturity within one month (6) while the concentration mechanism matures at three months (7). The glomerular filtration rate reaches maturity at 12 to 18 months (8).

While the metabolic balance of electrolytes for full term baby is quite well understood (9), that of neonates born prematurely is not yet determined to date. From this study, it was found that throughout the first one month (of life) of neonates born preterm with gestational age of 32 to 35 weeks, there was positive balance for nitrogen and phosphorus. This was not unexpected since these two elements are required for growth of soft tissue and skeleton. From the regression line, plotted for these two elements, it was found that there was significant correlation between input and retention and a minimal input requirement for each elements is possible to be derived below which there will be negative balance.

For sodium, there was negative balance between the 4th and 7th day of life which corresponded to an increase in both the urinary sodium concentration and the volume of urine. This greatly significant finding is in accordance with the findings of Aperia et al (10) that the the natriuretic response to an oral salt load of premature neonates born with 29 to 35 weeks gestation was considerably higher. It might be due to the anatonomical development in which the immature kidney has a relatively larger glomerular apparatus than the tubules for reabsorption. Our study further showed that such negative balance of sodium reverted to positive balance together with a decrease in urinary sodium concentration after the seventh day of life. This would indicate that the kidney has acquire the ability to reabsorb sodium at this stage. This was further confirmed by the positive sodium balance in the neonates between the 10th and 20th day of life.

For potassium, altough there was positive balance throughout the first month of life, there was no correlation between input and retention in the first week of life. This is probably due to the fact that there is poor intrinsic control of potassium metabolism in the premature newborn at that stage. Keital (11) found that although potassium was readily excreted by the premature neonate in urine, a higher intake of potassium would increase the plasma potassium concentration with a direct correlation.

There has not been any significant change in body weight nor any change in the urine volume indicating dehydration in all the neonates of both study groups. Serial collections of the blood for serum osmolarity and element concentrations are not desirable because of the limited blood volume of these neonates.

The concentration of all the neonates in the special care nursery formed a nearly constant environment for all the neonates and eliminated errors arising from perspiration and respirations to a large extent. Dermal element loss measurement is desirable but not practicable.

The meticulous care taken in the collection, storage and analysis of samples of urine, stool, vomitus and nutrient solutions prevented contamination and aimed at eliminating error in the study.

In summary, the metabolic balance in neonates born prematurely at 32 to 35 weeks gestation was determined at the first week and between 10 to 20 day of life. There was positive balance in all elements except for sodium in the first week of life. There was also significant correlation in all elements except for sodium and potassium in the first 10 days of life. The study would form a basis for further study of metabolic balance of neonates born prematurely and facing stressful conditions including surgical intervention of the gastrointestinal and other systems.

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