# RENAL PARAMETERS DURING INFANCY

**K.P. Mehta**
**S.R. Karnik**
**A. Sathe**
**R. Pant**
**R. Khatwani**
**A. Bhise**

**ABSTRACT**

*In a prospective study we estimated common renal parameters in 48 full term normal neonates, of which 15 were also tested at 6 months and 12 months of age. The mean levels of serum creatinine, were high at birth (0.73 mg/dl) but normal for age at 6 and 12 months; uric acid followed a similar trend. The blood pH and bicarbonate were low at birth (7.28 and 20.36 mEq/L, respectively) reached normal adult values by 12 months; chloride levels were high at birth (110 ± 5 mEq/L) and normal at 6 months. The plasma renin activity was higher than normal all throughout the first year (27.1, 416.8, 64.8 ng/ml/hr by RIA). Plasma aldosterone values were high at birth (1387.5 pg/ml) and reached normal level (301.6) at 12 months. Renal length and volume as assessed by ultrasonography compared well with American standards. Urinary constituents were variable due to breast feeding up to 6 months and varied diet during the weaning period. This study shows that mild metabolic acidosis and hyperchloremia due to immaturity of renal acidification mechanism and high renin and aldosterone levels due to partial nonresponsiveness of distal tubules are normal variables in babies from birth to 6 months. The levels of serum creatinine and uric acid are high at birth and in assessing renal functions this should be borne in mind.*

**Key words:** *Kidney function tests, Infancy.*

Soon after birth the "dormant" neonatal kidneys have to perform the functions of maintaining body homeostasis. The maturation of renal functions continues postnatally till the normal adult values are reached by 2 years of age(1-4). The renal functions in normal neonates may be reduced and under perinatal stress can result in acute renal failure.

The process of maturation of kidneys has been extensively studied in animal experiments but there is paucity of data in normal neonates even in the western literature(1-4). In Indian literature few studies of GFR and tubular functions in preterm and term neonates are published(5,6). Indian babies are smaller in size and consume a diet which differs from infants of developed countries, hence it is imperative to have our own values of renal parameters for normal neonates and infants. This prospective study was designed to estimate renal parameters in normal infants from birth to 12 months.

## Material and Methods

Forty eight full term normal neonates delivered at Jaslok Hospital entered this study which was approved by the ethical committee of the hospital.

Investigations done on cord blood and urine (collected by urinary bags on day 1) included serum creatinine, urea nitrogen, uric acid, sodium, potassium, chloride by autoanalyser SMA, blood pH and bicar-

*From the Departments of Pediatrics and Pathology, Jaslok Hospital and Research Centre, Bombay 400 026.*

*Reprint requests: Dr. K.P. Mehta, Consulting Pediatrician, Department of Pediatrics, Jaslok Hospital and Research Centre, Bombay 400 026.*

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bonate using blood gas analyser (radiometer); serum and urinary osmolality using osmometer by freezing point method, urine pH by pH meter, excretion of sodium and potassium by flame photometer and creatinine, calcium, phosphate and uric acid by autoanalyser SMA. Plasma renin activity (PRA) and aldosterone were estimated by RIA.

Glomerular filtration rate (GFR) in ml/min/1.73 $m^2$ was measured by

$$\text{Schwart's formula} = \frac{\text{Height in cm}}{\text{S. creatinine}} \times 0.45(7,8).$$

Renal dimensions were measured by ultrasonography; the volume (cu cm) was calculated as product of length, breadth and thickness multiplied by 0.5223(9,10).

These neonates were followed up in a Well Baby Clinic, 15/48 consented for repeat tests at 6 ± 1 months and 12 ± 2 months. All were breast fed during the first 6 months and were advised weaning at 6 months after which the diet varied widely.

## Results

The gestational age, birth weight and height of the 48 newborns ranged from 37-40 weeks, 2.6-4.2 kg and 47-50 cm, respectively. On follow up they maintained 50th-60th centile for weight and height at 6 and 12 months.

*Table I-III* and *Figs. 1 & 2* give details of investigations and comparison with normal values(11). Mean S. creatinine levels were high (0.73 mg/dl) at birth (equivalent to maternal values). When repeated at 6 and 12 months, these reduced to 0.48 and 0.57 mg/dl, respectively. S. uric acid followed the same trend. Mean values of blood pH and bicarbonate lower than normal at birth and 6 months reached normal values at 12 months, and urine pH was between 6-6.9. GFR increased from 33.2 ml/min/1.73 $m^2$ at birth to 70.4 ml/min/1.73 $m^2$ at 12 months.

Serum sodium, potassium and urea nitrogen values were within normal range and serum chloride high at birth, but normal at 6 months (*Table 1*).

S. osmolality was in normal range, but urinary osmolality was low in random samples at birth and 6 months and normal at 12 months (*Fig. 1*). Plasma renin levels were high all throughout the first year. S. aldosterone was very high at birth and reached normal levels by 12 months (*Fig. 2*).

Excretion of creatinine steadily increased with growth. Uric acid excretion diminished with reduction in S. uric acid levels. Sodium, calcium and phosphate excretion increased rapidly after 6 months when weaning foods which increased the solute load were started (*Table II*). Mean values of renal length and renal volume using ultrasonography when compared with American values were lesser probably due to smaller size of Indian babies, but were not statistically significant (*Table III*).

## Discussion

Although nephrogenesis is completed by 34th–35th weeks of gestation, glomerular and tubular functions do not reach normal values till 1-2 years postnatally(1-4). Hence, in normal neonates and infants the renal parameters and urinary constituents fall in abnormal ranges when compared with the normal adult values even though corrected for size.

The main differences between our study and others from western literature are blood pH and bicarbonate values which continued to remain low upto 12 months and were accompanied by higher chloride values and high urine pH. This can be fur-

**TABLE I**—*Mean Blood Values (SD) at Birth, 6 and 12 Months*

| Parameter | Normal range | | Present study | | |
|---|---|---|---|---|---|
| | Adult | Newborn | Birth (n = 48) | 6 ± 1 month (n = 15) | 12 ± 2 months (n = 15) |
| pH | 7.38-7.45 | 7.11-7.36 (cord blood) | 7.28 (0.84) (7.13-7.4) | 7.28 (0.1) (7.19-7.42) | 7.45 (0.1) (7.42-7.46) |
| Bicarbonate (mEq/L) | 21-28 | Base excess (-10)-(-2) | 20-36 (2.6) (15.7-24) | 21.12 (3.5) (13-24) | 22.2 (3.1) (15-26) |
| Sodium (mEq/L) | 139-146 | 134-146 | 140 (3.05) (137-144) | 138.3 (4.19) (133-149) | 139 (1.4) (137-141) |
| Potassium (mEq/L) | 3.5-5.0 | 3-6 | 4.8-(0.41) (4.1-5.6) | 4.32 (0.29) (3.8-4.8) | 4.38 (0.22) (4.0-4.6) |
| Chloride (mEq/L) | 98-106 | 96-104 | 110 (4.9) (95-115) | 99.1 (4.65) (92-110) | 99.6(0.91) (98-102) |
| Creatinine (mg/dl) | 0.8-1.5 | .3-1.0 | 0.73(0.14)*** (0.5-1.5) | 0.48 (0.14) (0.3-0.7) | 0.57 (0.12) (0.4-0.8) |
| Urea nitrogen (mg/dl) | 7-18 | 21-40 | 105 (1.62) (8-14) | 9.3 (3.66) (6-14) | 11.3 (3.7) (5-16) |
| Uric acid (mg/dl) | 3-7.7 | 1.7-5.8 | 6.11 (1.36)** (4-9.2) | 3.37 (0.85) (1.8-4.6) | 4.45 (1.17) (2.3-6.1) |
| GFR (creatinine clearance ml/min/1.73 $m^2$) | 133 (27) | 40.6 (14.8) | 33.2 (11.3) (23-45.8) | 59.4 (17) (33-78) | 70.4 (21) (42-89) |
| Osmolality (mOsm/kg) | 275-295 | 275-295 | 283 (24.6) (253-303) | 279.5 (15.3) (266-304) | 284 (16) (272-300) |
| Renin activity (ng/ml/h) | <4.3 | <16.6 | 27.1 (12.8)*** (15.2-53.2) | 416.8 (154)*** (14.7-1143) | 64.8 (47)** (12.4-148) |
| S. aldosterone (pg/ml) | 30-300 | 50-600 | 1387.5 (409)** (549-2701) | — | 301.6 (31) (50-1125) |

* Reference(11); ** $p<0.001$; *** $p<0.05$

ther aggravated by factors causing tubular damage as asphyxia, infection, hypotension, dehydration, *etc.* resulting in prolongation of acidosis requiring alkali therapy for a long time to prevent growth failure and metabolic bone disease(12).

In our study serum sodium, potassium urea nitrogen and osmolality were well within normal range though western studies mention hyperkalemia (potassium 7.8 mEq/L; range 5.6-12 mEq/L) as a common but transient finding in neonates due to limitation of potassium excretion. This becomes clinically relevant only if potassium is excessively ingested or administered to a neonate and in interpreting potassium values in the diagnosis of hyperkalemia(13).

In this study, at birth, urinary potassium excretion was low (8.4 mEq/L), but

**TABLE II**—*Mean Values (SD) of Urinary Excretion of Sodium, Potassium, Calcium, Phosphate, Creatinine, Uric Acid and Urine pH at Birth, 6 Months and 12 Months*

| Parameter | Birth | | 6 ± 1 months | | 12 ± 2 months | |
|---|---|---|---|---|---|---|
| Sodium (mEq/L) | 20.8 | (21.0) | 22.8 | (12.5) | 74.0 | (56)* |
| Potassium (mEq/L) | 8.4 | (4.1) | 23.8 | (24.1)* | 25.3 | (14.4) |
| Calcium (mg/L) | 6.8 | (5.6) | 6.0 | (2.58) | 20.7 | (27.6)* |
| Phosphate (mg/L) | 13.9 | (13.8) | 35.6 | (23.6) | 55.6 | (22.2)* |
| Creatinine (mg/L) | 26.1 | (15.6) | 29.6 | (24.4) | 36.3 | (23.9) |
| Uric acid (mg/L) | 87.7 | (48.5) | 371.0 | (222.3)* | 56.8 | (15.32) |
| Urine pH | 6.1 | (0.84) | 6.0 | (0.53) | 6.9 | (0.95) |

* $p < 0.001$ significantly increased compared to previous age group.

**TABLE III**—*Mean Values (SD) of Renal Length and Volume by Ultrasonography*

| Age | Renal length (cm) | | | | Renal volume (Cu cm) | | | |
|---|---|---|---|---|---|---|---|---|
| | Our study | | American study(9) | | Our Study | | | |
| | | | | | Right | | Left | |
| 1– 7 days | 4.28 | (0.8) | 4.48 | (0.31) | 9.43 | (1.8) | 10.48 | (2.5) |
| 3– 6 mo | 5.18 | (0.85) | 6.15 | (0.67) | 16.70 | (2.8) | 16.6 | (2.2) |
| 10–14 mo | 5.72 | (0.7) | 6.23 | (0.54) | 24.00 | (3.2) | 22.00 | (4.2) |

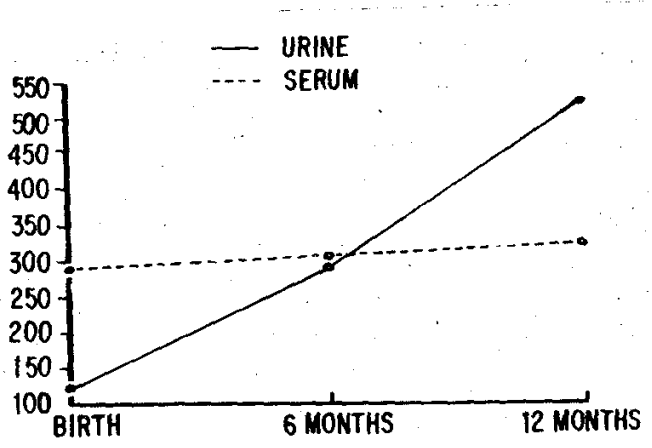


*Fig. 1. Serum and urinary osmolality at birth, 6 months and 12 months.*

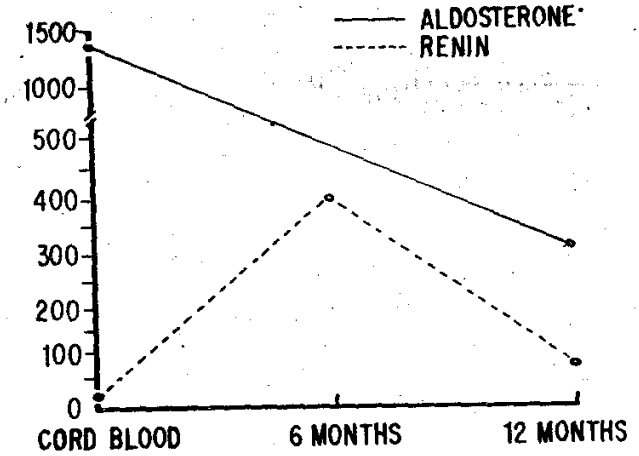


*Fig. 2. Plasma aldosterone and renin levels at birth (cord blood), 6 and 12 months.*

increased rapidly during 6 months (22.9 mEq/L). The sodium potassium ratio in urine changed from 2.47 at birth to 1 at 6 months and 2 at 12 months due to increase in sodium intake and reduction in serum aldosterone levels.

Increased blood creatinine and uric acid levels at birth reflect maternal values. In the first week interpretation of S. creatinine values requires caution and diagnosis of acute renal failure should be based on serial measurements rather than a single value. Though creatinine values reach normal levels by 1-2 weeks, glomerular filtration rate values reach normal by 2 years (1-3). In our study glomerular filtration rate increased from 33.2 to 70.4/ml/min/1.73 $m^2$ from birth to 12 months, still less than 90-110 ml/min/1.73 $m^2$ which may be reached by 2 years. Schwartz's formula used to calculate GFR compares well with endogenous creatinine clearance or inulin clearance and eliminates the need of accurate timed collection of urine(7,8).

Increased aldosterone levels in infancy are due to stimulation by renin levels probably in an attempt to stimulate distal nephron which is partially nonresponsive to the action of aldosterone in infancy. Plasma renin levels were high at birth, 6 months and even at 12 months, and aldosterone levels high at birth reached normal at 12 months along with alteration in sodium and potassium excretion.

The urinary constituents of newborn are qualitatively different from those of adult urine, primarily because of lower degree of proximal tubular function which is responsible for increased proteinuria and aminoaciduria and diet which plays an important role in urinary excretion of calcium, phosphate, uric acid and osmolality. The infants in our study were predominantly breast fed till 6 months, when cereals, grams, vegetables and fruits were started resulting in increased excretion of solute and increase in urinary osmolality from 115 to 512 mOsm/kg. Urinary creatinine excretion steadily increased due to increase in muscle mass during growth. Uric acid excretion reduced after 6 months, however, the alkaline pH of urine kept it in solution. Uric acid crystallization results in pink diaper syndrome and uric acid nephropathy which are common problems in neonates.

Renal length as judged by ultrasonography was lesser when compared with the American standards(9) probably due to the small size of Indian infants. However, the numbers are too small to derive firm conclusions. Whether renal volume is more reliable than renal length for assessing renal size is yet to be established(10).

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## NOTES AND NEWS

### THIRD ANNUAL IAP HARYANA CHAPTER CONFERENCE

The Third Annual IAP Haryana Chapter Conference is to be held on *December 20, 1992* at Sonepat. Free papers are invited from the members of Haryana Chapter.

For further details please contact:

**Dr. O. P. Paruthi,**
Opp. Batra Petrol Pump,
Sonepat.