ULTRASOUND EVALUATION OF KIDNEY DIMENSIONS IN NEONATES

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ABSTRACT

This study was done to measure normal renal dimensions of neonatal kidney at various gestational ages sonographically. Knowledge of these measurements may allow earlier diagnosis of a variety of abnormalities. Kidney dimensions (maximum longitudinal length, width, and anteroposterior diameter) were measured within 48 h after birth in 100 healthy neonates with gestational ages from 26.14 to 41.28 weeks and birth weights from 540 to 3250 g using a real time sector scanner with a 7.5 mHz transducer. Renal volume was calculated by volume (V) = $L \times W \times T \times 0.5233$. Total body surface area (BSA) was determined by BSA = $Wt^{0.425} \times Lt^{0.725} \times 71.84$. Ponderal index was determined by PI = $Wt\ (g) \times 100/(Ht[cm])^3$. On linear regression analysis, a highly significant correlation was found between renal dimensions and body surface area, gestational age, body weight and length of the baby ($p<0.05$). On step wise regression analysis, renal dimensions correlated only with body surface area and the gestational age of the neonate. Regression equations have been provided for rapid computation of renal length, width, and thickness in a given case based on body surface area and the gestational age. Mean (± 2 SD) renal volume and renal length were determined based separately on gestational age and body surface area. The data provided can be valuable for evaluating renal abnormalities in preterm neonates.

Key words: *Preterm neonates, Kidney size, Ultrasound.*

Sonography is a valuable tool for evaluating congenital renal anomalies. Knowledge of normal renal dimensions is of paramount importance when confronted with a newborn infant with suspected renal malformations. It is well known that changes in kidney dimensions may precede renal echotexture changes in certain renal diseases(1). Normal standards established for kidney length in term infants and children, as measured by ultrasound, have facilitated accurate evaluation of abnormal kidneys(2-9).

In premature infants, normal standards for detailed renal dimensions have not, to our knowledge, been established. Few studies, however, have determined standards for only kidney length in premature neonates(6-9). We have measured renal dimensions (length, width, thickness and volume) in 100 neonates to establish normal standards for this population and to correlate them with gestational age and body size.

Material and Methods

This study was conducted in the Neona-

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tal Division of Safdarjang Hospital, New Delhi. The study population comprised of 71 preterm (<37 wk gestational age) appropriate for gestational age (PTAGA) and 29 term AGA (TAGA) inborn neonates from January to April, 1992. Fifty four neonates were male. An informed consent statement approved by the Hospital Research Committee was signed by the parents of all neonates who were participants in the study. Patients were recruited within 48 h after birth if they had no obvious congenital anomalies, normal Apgar Scores, a normal physical examination, were free of sepsis and had not received aminoglycoside administration. Gestational age was determined by maternal dates and confirmed by neurological and physical criteria as described by Ballard(10). The length and body weight were recorded at the time of ultrasonic evaluation.

Sonograms were done by one of the authors (AKG) who was unware of the gestational age, using a real time sector scanner (SIM 5000) with a 7.5 MHz transducer, in prone and supine oblique positions. Maximum renal length in the longitudinal axis, width and anteroposterior dimensions of both kidneys were recorded. Images were obtained on polaroid camera. Renal volume (V) was calculated by the formula: $V(mm^3)\ L \times W \times T \times \pi/6$(11). Total body surface area (BSA) was determined by the formula: BSA (cm^2) = $Weight^{0.425} \times Length^{0.725} \times 71.84$(6). Ponderal index (PI) was determined by PI = Weight (g) × 100/$Length^3$ (cm). Linear regression functions were plotted for mean renal volume and length against independent variables (gestational age, weight, length, BSA and PI). Step-wise multiple regression method (SPSS-PC) was used to identify the variable(s) most significantly determining renal length and volume.

Results

Ultrasound examinations were done at a mean (SD) age (gestational age plus age after birth) of 33.9 (4.4) wk (range 26.1-41.3 wk). The mean (SD) weight of the studied children was 1623.1 (685.5) g, (range 540-3250) g); length 41.5 (6.1) cm, (range 28-54 cm); BSA 24634.9 (6912.8) cm^2 (range 11663.4-39720.0 cm^2; and PI 2.2 (0.3) (range 1.1-3.2). Seventy one neonates were prematures including 34 babies with gestational age below 32 wk.

Initial analysis showed no significant difference in mean (SD) renal volume between right and left kidneys [8842.4 (6045.1) and 8660.1 (6164.9) mm^3, p = 0.22). Similar findings were observed with renal length [27.9 (7.4) and 27.6 (7.3) mm, p = 0.83]. No significant difference was found between the renal dimensions in boys and girls. Therefore, the dimensions of all 200 kidneys were measured as a single group.

Renal length and volume [mean (2 SD)] related to gestational age, body length, weight, and total body surface area are shown in *Figs. 1-8.*

On linear regression analysis (*Table I*), a significant positive correlation was observed between renal dimensions and conceptional age, length, weight, and BSA.

On step-wise multiple regression, when renal length was kept as a dependent variable, the first variable selected and hence highly correlated to renal length was BSA (r^2 = 0.69, p = 0.0000). In step two, gestational age was entered and value of r^2 increased to 0.71. Other variables, however, were not significant and hence not selected for the regression model. Renal length can be predicted by the regression model: length (mm) = −1.7307 + 0.4068 × gesta-

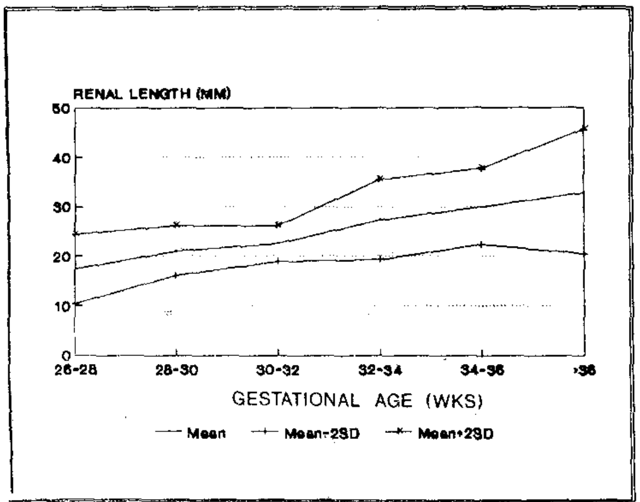

Fig. 1. Renal length versus gestational age.

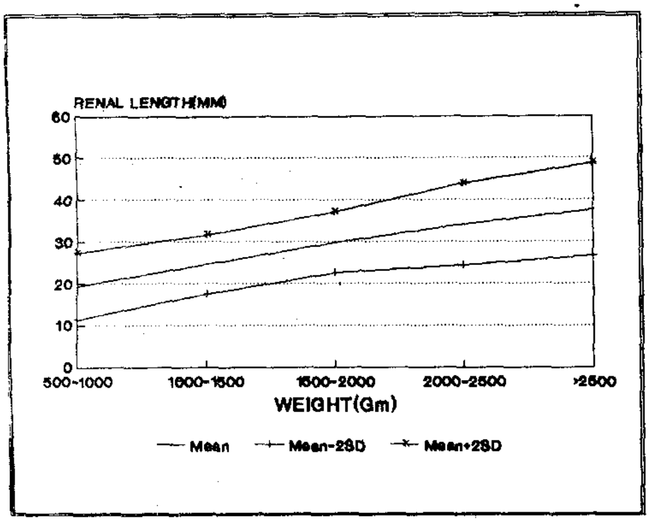

Fig. 2. Renal length versus birth weight.

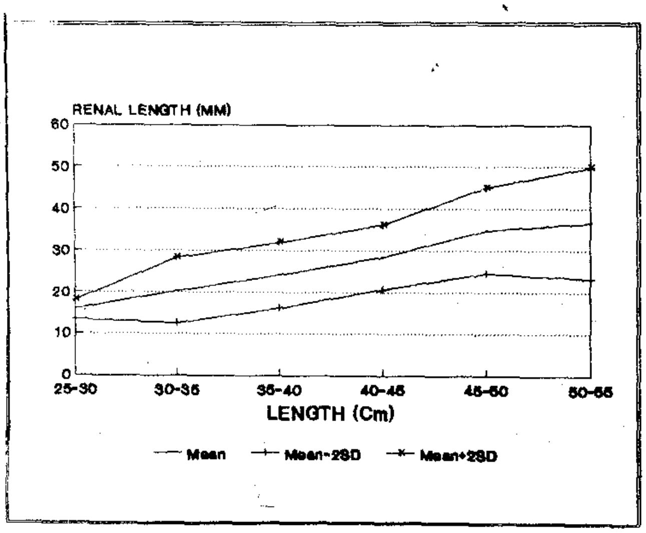

Fig. 3. Renal length versus crown-heel length.

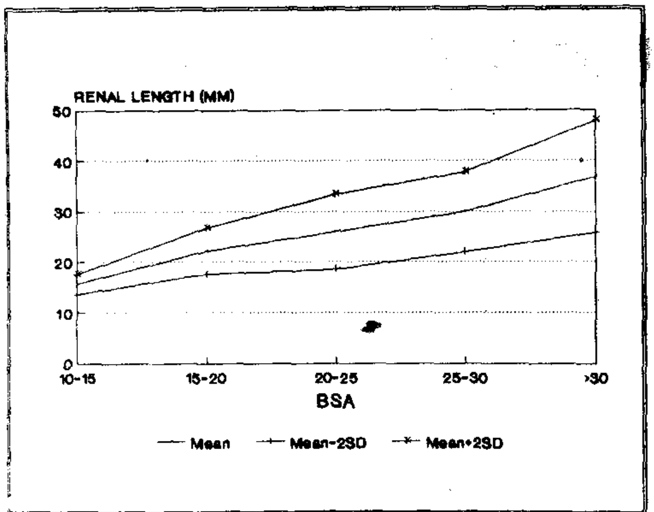

Fig. 4. Renal length versus body surface area [BSA, expressed as thousands (cm^2)].

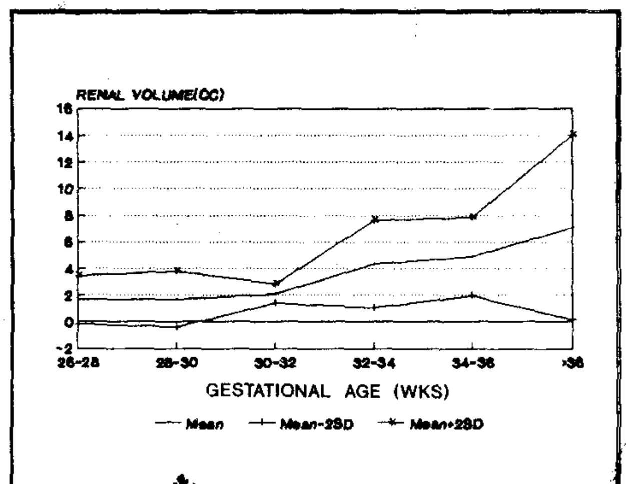

Fig. 5. Renal volume versus gestational age.

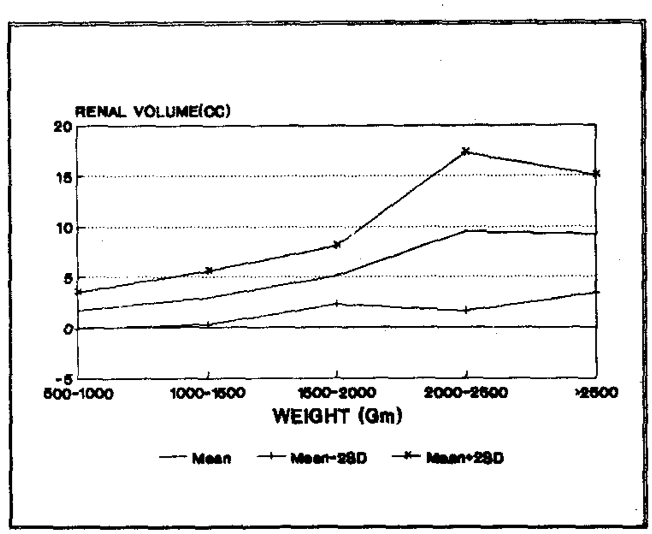

Fig. 6. Renal volume versus birth weight.

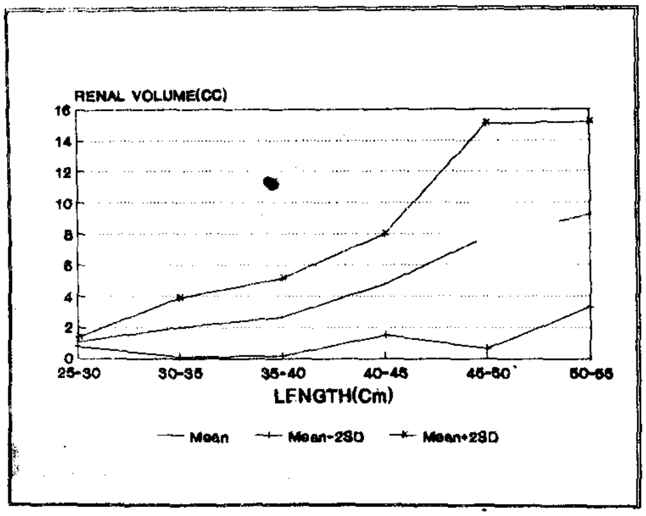

Fig. 7. Renal volume versus crown-heel length.

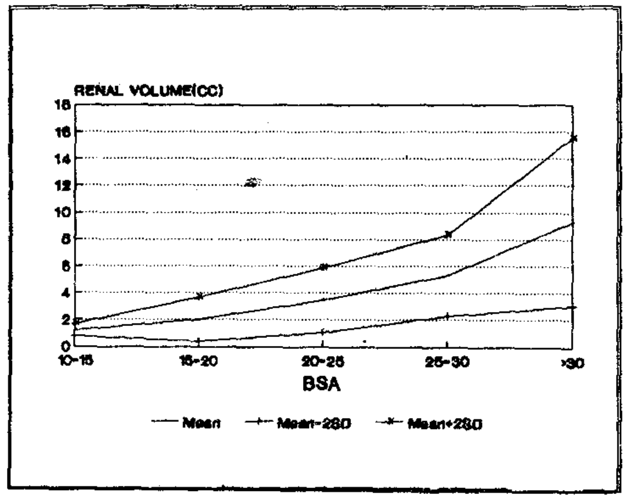

Fig. 8. Renal volume versus body surface area [BSA, expressed as thousands (cm^2)].

TABLE I–*Linear Regression Correlation Coefficients*

Parameter	Gestational age	Length	Weight	BSA	PI
Renal length	0.7922	0.8209	0.8164	0.8355	–0.06
Renal width	0.7326	0.7338	0.7532	0.7609	–0.03
Renal thickness	0.6815	0.7080	0.7087	0.7222	–0.08
Renal volume	0.7374	0.7622	0.7946	0.7924	–0.03

BSA = Body surface area; PI = ponderal index.

tional age (wk) + 0.0062 × BSA (cm^2). Similarly, when renal width was kept as the dependent variable, the first variable selected was BSA (r^2 value = 0.58, p = 0.0000) followed by gestational age (r^2 value = 0.59). Renal width can be predicted by the model: width (mm) = 0.2192 + 0.2541 × gestational age (wk) + 0.003 × BSA (cm^2). In the same way, when renal thickness was taken as a dependent variable, BSA (r^2 = 0.52, p = 0.0000) followed by gestational age (r^2 = 0.53) were found significantly explaining the variation of renal thickness in the study population. Renal thickness can be predicted by the regression model: thickness (mm) = 2.4249 + 0.1943 × gestational age (wk) + 0.003 × BSA (cm^2).

Discussion

During the last few years ultrasound has been increasingly used for evaluating kidney anatomy in the neonatal period. Normal renal parameters (length, width, thickness and volume) are essential for an accurate evaluation of abnormal kidneys including conditions like polycystic disease, renal hypoplasia or dysplasia, renal vein or artery thrombosis, hydronephrosis, and renal scarring. Certain conditions are known to affect kidney size without much affecting renal echotexture. Examples of such conditions include Beckwith-Wiedmann Syndrome, renal vein thrombosis and infants of diabetic mothers(12-14). Accurate evaluation of such abnormalities might not be possible in the absence of gestation specific normative data for various renal dimensions in neonates.

Prior to the development of ultrasound as an imaging tool for measuring renal dimensions in older infants and children, standards had been established for renal length with excretory urography(15). There are numerous advantages for US determined renal dimensions that have established it as the preferred method for evaluation of renal size. These advantages include lack of radiation exposure, lack of need for magnification, absence of diuretic effect of contrast agents, and versatility of scanning orientation with real-time sector scanners. The use of ultrasound in the neonatal period is also advantageous because it can be performed at the bed side and it avoids problem of poor contrast obtained with excretory urography.

Although, normal standards for renal dimensions as measured with ultrasound have been established for older infants and children(2-5), similar standards for all renal dimensions are not available for premature neonates. Few studies, however, have provided standards for renal length in premature neonates(6-9). To confirm our measurements, we correlated our figures with published antenatal and postnatal studies. As evident (*Fig. 9*), our values for renal length are much lower than that reported previously. Some of these studies(16,17) are prenatal studies. The difference in findings may reflect inaccuracies in *in-utero* measurements due to difficulty in obtaining the longest longitudinal dimension of the kidney secondary to fetal motion or difficulty in distinguishing renal

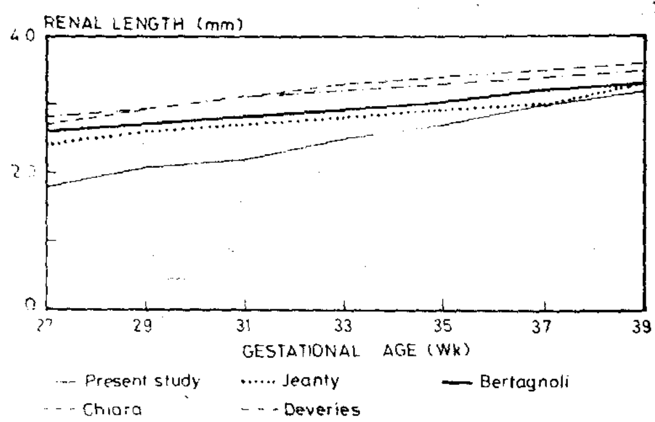

Fig. 9. Gestation-specific renal length as reported from the literature.

margins from adjacent gastrointestinal structures. However, our findings are also lower than previously reported figures for renal length in premature infants(7-8), when US evaluations were done postnatally as in this study. This may be explained on the basis of birth weight which is higher in babies from the West compared to our population. In the present study, renal dimensions correlated best with the body surface area and gestational age rather than the birth weight. The role played by racial or genetic factors in determining the renal size can not be ruled out.

The present study provides a valuable baseline gestation specific normative data for various renal dimensions in the Indian neonates. Renal length, width and thickness can be rapidly estimated from the derived regression equations.

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