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Sonographic assessment of normal renal parenchymal and medullary pyramid thicknesses among children in Enugu, Southeast, Nigeria

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ABSTRACT

Background: Renal parenchymal thickness (RPT) and renal medullary pyramid thickness (MPT) are important renal size parameters. This study was aimed at establishing normograms for RPT and MPT with respect to age and somatometric parameters among children.
Methods: This was a cross sectional study done in Enugu, Nigeria between May 2013 and April 2014. The subjects were 512 children aged 1–17 years scanned with ultrasound equipment with 3.5 MHz and 5 MHz curvilinear transducers. The RPT was measured perpendicularly to the long axis of the kidney from the medullary papilla to the renal capsule and MPT was measured from the apex to the base of the medullary pyramid on the same plane. The age and somatometric parameters of the subjects were recorded.
Results: The mean ± SD of RPT and MPT for the right kidney were 12.62 ± 1.67 mm and 7.10 ± 0.92 mm and the left kidney were 12.81 ± 1.7 and 7.23 ± 0.94 mm respectively. There was a significant difference between the right and left RPT and MPT ($p < 0.05$). The right and left RPT correlated strongly with age, body surface area (BSA), height, and weight but moderately with body mass index (BMI). A moderate positive correlation was observed between MPT and age, BSA, height, and weight. However, a weak correlation was observed between MPT and BMI.
Conclusion: Normograms of RPT and MPT in relation to age could be useful for grading hydronephrosis in children.

Introduction

Renal pathology may affect both the morphology and size of the kidney due to parenchymal atrophy or hypertrophy leading to an overall reduction or enlargement of renal size.[1] The renal parenchyma consists of renal cortex and medullary pyramid which can be assessed using ultrasonography, computed tomography (CT) or magnetic resonance imaging (MRI). Computed tomography and MRI are more accurate methods for the measurement of renal parenchymal thickness and volume.[2–4] However, sonography is the modality of first choice in children because of long examination time during MRI and the high dose of radiation during CT examination.[3,4] Sonography is a simple non-invasive method for estimating renal size and volume in vivo.[2] It is also readily available, cheap and requires no special patient preparation or sedation.[2]

Renal parenchymal thickness has been shown to correlate with renal function in a number of studies.[4,5] It has also been observed that the measurement of renal parenchymal thickness provides a more accurate estimation of renal function compared to the one-dimensional measurement of renal length.[6] "The thickness of the renal parenchyma is related to the volume of renal mass which contain millions of nephrons in the renal parenchyma".[7] "Renal parenchymal thickness appears to be a more accurate parameter than renal length for the assessment of renal function as proven by CT studies".[8]

Renal medullary pyramid thickness which is the distance between the apex and the base of the renal medulla may be reduced in some pathological conditions. For instance, blunting of the apices of the pyramid occurs in hydronephrosis and the renal pyramids eventually become cupped and if left untreated may obliterate the

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pyramid and the cortex may be thinned out.[9] Thus, clinicians can use changes in the renal medullary pyramid and measurement of renal parenchymal thickness to grade hydronephrosis.[9–11]

Kidney measurements by ultrasonography have been shown to correlate with somatic parameters in a number of previous studies.[1,12–15] The renal measurements by ultrasound have also been found to correlate well with the measurements obtained from CT scan.[4,16] Grading of hydronephrosis is usually based on the degree of dilation of the pelvis and calyces and measurement of renal parenchyma. Thus, knowledge of normal range of renal parenchymal and medullary pyramid thicknesses could be important parameters in grading hydronephrosis[10] and in the diagnosis and follow-up of renal diseases.[10,17] A lot of studies have been done on kidney morphometrics in children which include renal length and volume[3,13–15] with few studies on renal parenchymal thickness[7,10,11] and renal medullary pyramid thickness measurements.[10] The available literatures on renal parenchymal and medullary pyramid thicknesses in children were carried out among the Caucasian population and none has been done in our black population to the best of our knowledge. Since there is racial variation in kidney dimensions,[12,18] there is need to establish normative values for renal parenchymal and medullary pyramid thicknesses for our children population. This study was, therefore, aimed at establishing normal values for renal parenchymal thickness (RPT) and renal medullary pyramid thickness (MPT) with respect to age and somatometric parameters among children in a Nigerian population.

Methods

This was a cross sectional study done between May 2013 and April 2014 using convenience sampling technique. Five hundred and twelve children aged 1–17 years were studied. The subjects were examined by a pediatrician and selected based on the following criteria which will not affect the normal renal parenchymal and pyramidal thicknesses.

Exclusion criteria: Subjects with urinary tract symptoms, malignancy, underlying kidney disease, hydronephrosis or congenital renal anomalies were excluded. Inclusion criteria: Subjects with parental consent who had clear renal outline during the scan and who were cooperative were included.

Ethical clearance was obtained from the University of Nigeria Teaching Hospital, Enugu Ethical Committee (UNTH/CSA/329.VOL.5). Informed consent was obtained from parents of the children and authority of each of the selected schools which include Kingdom Heritage Model School, Enugu and University of Nigeria Secondary School, Enugu campus. The one year old children were recruited from day-care class at Kingdom Heritage Model School, Enugu which also has facilities for kindergarten, nursery, primary and secondary schools. Subjects' recruitment was based on school approval, parental consents, and completion of a mini questionnaire by parents of subjects for the assessment of subject's health as well as physical examination by a pediatrician.

Equipment

A real time grey-scale Chison digital ultrasound system, model 8100 with curvilinear probes of 3.5 and 5 MHz, was used for the evaluation of the kidneys. The choice of the probe frequencies was to give adequate penetration and resolution of the retroperitoneal located kidneys in both older and younger children respectively. All measurements were taken using the electronic calipers of the ultrasound machine. Weight was taken using weighing scale with a capacity of 0–190 kg and height with a meter rule of 0–198 cm capacity.

Scanning technique

All the subjects were examined in the prone position for this study which was quite convenient for the very young children. Renal parenchymal thickness was obtained between the cortex perirenal fat interface (capsule) and the sinus pyramid apex interface at the mid portion on long section of the kidney[19] (Fig. 1). Renal medullary pyramid thickness was measured as the distance between the apex and the base of pyramid at the mid portion of the kidney[19] (Fig. 1) on the same plane. These renal parenchymal and pyramidal measurements were taken in the anterior portion of the kidneys as it is not always visualized in the posterior part. Measurements were taken three times for each renal parameter and the mean of the three measurements were taken for RPT and MPT respectively. Weight was taken with the subject standing erect on the weight scale with the feet together in such a way that the body weight was equally distributed and the pointer got to a rest on the scale. The value was read directly from the calibrated scale in kilograms. Height was taken with the subject standing erect on bare feet, backing the meter rule which was held vertically from the floor, with the heels together touching the meter rule and eyes at water level (eyes looking forward at 90° to the vertical). A ruler was placed on the vertex to enable accurate reading of the value from the meter rule. The meter rule was calibrated in centimeters.

Reliability of renal measurements

Prior to the main study, twenty randomly selected subjects underwent sonographic examinations to determine the intra and inter-observer variations in the measurement of RPT and MPT. This pilot study was carried out by two experienced sonographers with eleven years of experience in abdominal sonography. The assessment of RPT and MPT were carried out independently by the sonographers using the same sonographic equipment and technique on the first day. On the second day, the subjects were again examined by the second sonographer and the measurements were compared with those obtained on the first day by the same sonographer for intra-observer variations. Paired two sample means 't' test was used to determine the intra and inter-observer variations in the measurements of renal parameters and there was no significant difference ($p > 0.05$) in RPT and MPT measurements obtained within and between sonographers (Tables 1a & 1b). For the safety considerations of scanning each subject twice, the sonographers minimized the scan time as much as possible to reduce local heating effects of the sound beam on the kidneys. Also the ages of the children were considered in this pilot study to ensure that all age ranges were covered. Unco-operative children were withdrawn from the study.

Statistical analysis

Descriptive statistics such as mean and standard deviation were done for both kidneys at various ages. Pearson's correlation and regression analysis were done to determine the relationship between renal parenchymal thickness and renal medullary pyramid thickness with age, height, body weight, body mass index, and body surface area. Body surface area was calculated using Haycock's formula: BSA $(m^2) = 0.024265 \times \text{Height (cm)}^{0.3964} \times \text{Weight (kg)}^{0.5378}$. Body mass index was calculated with the formula: Weight (kg)/Height $(m)^2$. Paired two sample means 't' test analysis was used to test for intra and inter observers' variations. Comparison of male and female renal parameters for statistical differences was done using Paired two sample means 't' test.