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Original Article

Renal Doppler Assessment in Differentiating Obstructive from Non-Obstructive Hydronephrosis in Pediatric Age Groups

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Abstract

Background: Doppler Ultrasound has provided a new insight into the physiology of kidney, enabling detection of subtle renal blood flow changes associated with various pathophysiological conditions. Apart from being non-ionizing and non-invasive, it has been reported to help in differentiating obstructive from nonobstructive hydronephrosis by renal arterial RI measurements.

Objectives: Overall objectives are to determine the normal values and ranges of RI of the renal artery at hilum in healthy children of different age groups; to assess the utility of RI in distinguishing between obstructive and nonobstructive upper urinary tract dilatation in paediatric age groups.

Methodology: 64 patients aged within 12 yrs were taken after applying criteria and undergone Renal doppler assessment for evaluation of hydronephrosis.

Result: Mean RI for obstructive HDN (0.77±0.04) was significantly higher than the mean RI for non-obstructive HDN (0.68±0.03). the determination of RI for differentiating obstructive from non-obstructive HDN was found to be 95.65% sensitive and 83.33% specific. Its PPV was 91.67% and NPV was 90.91%.

Conclusions: The RI of the Renal artery at hilum can be effectively used to distinguish obstructive from non-obstructive hydronephrosis.

Key words: Hydronephrosis(HDN), Pediatric, Renal artery, Resistive index(RI)

INTRODUCTION

Hydronephrosis refers to the dilation of the pelvicalyceal system. This condition is not same as obstruction of the urinary tract, and only a portion of children with hydronephrosis subsequently show true obstruction due to structural or functional abnormalities.[1,2] Hydronephrosis is usually detected on prenatal ultrasound (US), while some may occasionally present with a palpable abdominal mass or complications of obstruction.[3] US remains the first-line imaging modality for investigating hydronephrosis and for determining the degree of dilation and the level of obstruction in children.[4] Most of the congenital anomalies of the urinary tract present with hydronephrosis. In neonates the most common cause of hydronephrosis is transient or physiological which accounts for about 50% of cases.[5,6] This type of hydronephrosis is usually resolves spontaneously within a short time frame. However, some may persist and most of these are pathological.While conventional US is upto 98% sensitive in detecting dilatation of the upper urinary tract as reported in earlier studies.[7] It lacks the ability to

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provide significant physiological data on renal status and, hence cannot specifically assess the cause of the dilatation. This lack is especially relevant in the paediatric age group, when proper management depends on detecting the underlying cause of dilatation. Experimental studies on the pathophysiology of obstruction have shown that obstruction causes a decrease in renal blood flow due to an increase in vascular resistance.[7] The fact that increase in vascular impedance alter the resistive index in renal allografts undergoing rejection has been reported.[8] Doppler Ultrasound (DU) has provided a new insight into the physiology of kidney, enabling detection of subtle renal blood flow changes associated with various pathophysiological conditions. These changes may be semi quantified by calculating the Intrarenal Vascular Resistive Index.It has been used in the assessment of renal arteries in children with congenital hydronephrosis. Apart from being non-ionizing and non-invasive, it has been reported to help in differentiating obstructive from nonobstructive hydronephrosis by renal arterial RI measurements. It is hoped that the results of this study would support the use of Doppler ultrasound as an alternative non-ionising investigation in the assessment of hydronephrosis in children, other than MCUG and DTPA which use ionising radiations.

AIMS AND OBJECTIVES

To determine the usefulness of Doppler ultrasound measurement of resistive index (RI) in differentiating obstructive from non-obstructive hydronephrosis in paediatric age groups.

GENERAL OBJECTIVES

- To determine the normal values and ranges of RI of the renal artery at hilum in healthy children of different age groups
- To assess the utility of RI in distinguishing between obstructive and nonobstructive upper urinary tract dilatation in paediatric age groups.

SPECIFIC OBJECTIVES

- Mean RI in obstructive hydronephrotic kidneys
- Mean RI in non obstructive hydronephrotic kidneys
- Mean RI in healthy kidneys in each age group
- Sensitivity and specificity of RI in obstructive hydronephrosis
- Positive Predictive Value (PPV) and Negative Predictive Value (NPV) of RI in obstructive hydronephrosis

MATERIALS AND METHODS

a) Study design
Cross sectional study.

b) Study period: January 2018 to June 2019.

c) Place of study
Department of Radiology
Nilratan Sircar Medical College and Hospital, Kolkata.

d) Study population
- Children, aged 1 day to 12 years referred for USG of the renal system and found to have hydronephrosis and
- Children in the same age group with healthy kidneys referred for the USG of systems other than the renal system were included in the study.

e) Sample size: 64

f) Sample technique: Purposive sampling

g) Inclusion criteria:
- Children, aged 1 day to 12 years referred for USG of the renal system and found to have hydronephrosis and
- Children in the same age group with healthy kidneys referred for the USG of systems other than the renal system were included in the study

h) Exclusion criteria
- Children with lethal abnormalities
- Critically ill children
- Children with kidney disease other than hydronephrosis
- Kidneys with equivocal and inconclusive results on DTPA study
- Those without consent from the parents

i) Study tools:
- Ultrasonography machine – Philips HD 7 machine and Alpinion Ecube 8 with3.5-5MHz curvilinear probe probe. Study was started on Philips HD 7 machine but due to non functioning of the machine in mid session, the rest of the study was carried out on Alpinion Ecube 8.
- Predesigned, pretested proforma for recording patient particulars, clinical presentation, radiological and other investigation findings.

Study procedure

After explaining the purpose of the study to the guardian of the patient in detail, informed consent was taken and proforma was filled up with the relevant clinical findings

and routine investigations. The required reports were collected from the patient.

Ultrasonography was performed. Gray scale assessment was done followed by Doppler assessment. Patient was examined in supine position.

The RI measurements were taken at renal hilar level. Ultrasound was performed without sedation or breath holding. The ultrasound transducer and Doppler cursor were placed at sites where colour signal was optimum and scanning was performed continuously for a number of respiratory cycles. Since patients did not breath-hold, the Doppler tracings appeared and disappeared as the kidney moved with respiratory movements. After 'image freeze', the scrolling application was applied to review all images and acquire the best Doppler spectrum for RI measurements. A good Doppler spectrum acquisition was when at least three consecutive systolic-diastolic tracings were obtained. The RI was calculated by the existing ultrasound machine computer software.The measurement of RI was based on the formula:

$$RI = (PSV - EDV)/PSV$$

PSV= Peak Systolic Velocity; EDV= End Diastolic Velocity

Obstructive or non-obstructive hydronephrosis was determined by DTPA findings. The measured RI was tabulated. The RI values were compared between the obstructive or non-obstructive hydronephrosis groups. RI values greater than 0.7 were graded 'high', while those equal or less than 0.7 were graded 'low'. The choice of this cut-off value was calculated using mean RI of the normal kidneys ± 2SD.

Statistical Analysis was performed with help of Epi Info (TM) 7.2.2.2 EPI INFO is a trademark of the Centers for Disease Control and Prevention (CDC). $p<0.05$ was considered to be statistically significant.

STATISTICAL TEST

Collected data will be analysed using Microsoft Office Excel.Statistical Analysis was performed with help of Epi Info (TM) 7.2.2.2 EPI INFO is a trademark of the Centers for Disease Control and Prevention (CDC). Using this software, basic cross-tabulation, inferences and associations were performed. Chi-square test was used to test the association of different study variables. Z-test (Standard Normal Deviate) was used to test the significant difference between two proportions. t-test was used to compare the means. Diagnostic accuracy, sensitivity, specificity, positive predictive value and negative predictive value were calculated to compare the findings of different diagnostic tools. One way analysis of variance (ANOVA) was used to compare more than two means at a time. Tukeys Critical Difference followed by ANOVA was calculated to compare the means pairwise. $p<0.05$ was considered to be statistically significant.

RESULTS

- The mean age (mean ± s.d.) was 3.110± 2.87 years with range 1 day - 12 years and the median age was 2.5 years.Most of them were with age ≤5 years (78%) years. Our study included 23 males and 6 females with normal kidneys. Our study included 17 males and 13 females with hydronephrotic kidneys.
- Though the mean length of kidney of the patients with normal kidney was higher than that of the patients with abnormal kidney, t-test showed that there was no significant difference in mean length of kidney of the two groups (t_{72}= 0.05;p=0.96)
- One way Analysis of variance (ANOVA) showed that there was significant difference in mean RI of the patients with different age groups ($F_{2,26}$=22.55;p<0.0001).
- **For Age <1 years:** The mean Resistive Index (mean ± s.d.) of the patients with normal kidney was 0.69±0.02 with range 0.67 -0.74 and the median was 0.68.
- **For Age- 1 – 5 years**: The mean Resistive Index (mean ± s.d.) of the patients with normal kidney was 0.64±0.02 with range 0.60 -0.69 and the median was 0.65.
- **For Age>5 years:** The mean Resistive Index (mean ± s.d.) of the patients with normal kidney was 0.61±0.02 with range 0.60 -0.69 and the median was 0.65.
- **For male:** The mean Resistive Index (mean ± s.d.) of the patients with normal kidney was 0.65±0.03 with range 0.59 -0.74 and the median was 0.65.
- **For Female:** The mean Resistive Index (mean ± s.d.) of the patients with normal kidney was 0.63±0.03 with range 0.60 - 0.67 and the median was 0.61.
- Our study included 23 obstructive and 12 non obstructive hydronephrotic kidneys.
- the mean RI of the patients with obstructive kidney was significantly higher than that of the patients with non obstructive kidney (t_{27}= 6.83;p<0.0001).(Table no 1)
- Diagnostic Accuracy = (TP+TN)/TOTAL CASES X 100 = 91.43%
- Sensitivity = TP/(TP+FN) x 100 = 95.65%
- Specificity = TN/(TN+FP) x 100 = 83.33%
- Positive Predictive Value = TP/(TP+FP) x 100 =91.67%
- Negative Predictive Value = TN/(TN+FN) x 100 = 90.91%

DISCUSSION

- There were 23 males and 6 females with normal kidney in our study. The ratio of male and female (Male: Female) was 3.3:1.0. Mean RI for males (0.65±0.03)(Figure no 1) was found to be significantly higher than the mean RI for females (0.63±0.03)in our study.

Table No 1: Shows Distribution of mean RI of the patient according to the type of hydronephrosis

Descriptive Statistics	Status of kidney		t-test (t_{33})	p-value
	Obstructive kidney (n=23)	Non- obstructive kidney (n=12)		
Mean±s.d.	0.77±0.04	0.68±0.03	6.83	<0.0001
Median	0.78	0.68		
Range	0.68 -0.89	0.62 - 0.75		

T-test showed that the mean RI of the patients with obstructive kidney was significantly higher than that of the patients with non obstructive kidney (t_{27}= 6.83;p<0.0001).

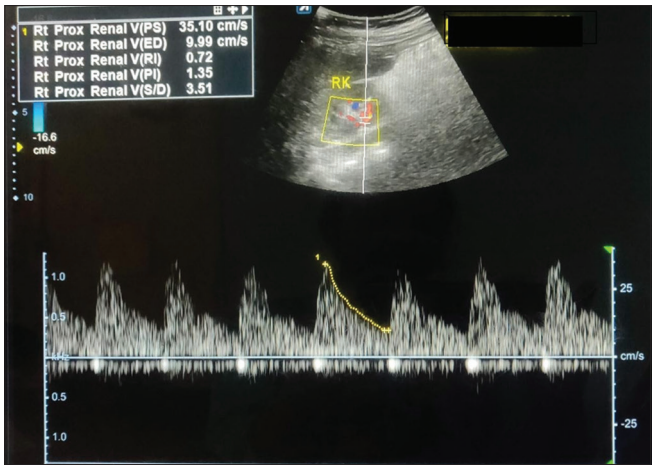

Figure no 1: shows Colour Doppler image showing an RI of 0.72 in a normal kidney in a 4mnth male

However, Sigirci A et al studied one hundred sixty- nine healthy children (72 girls and 97 boys), upto the age of 16yrs.They found that age had a negative correlation with RI whereas there was no statistically significant correlation between RI and sex.[1]

- The mean length of the hydronephrotic kidneys was 7.12±2.04cm with a range of 4.3 – 12.5cm and the mean length of the normal kidneys was 7.14±1.34 with a range of 4.7 – 10.0. Min-su Oh, Geol Hwang et al performed a study in children with age ranging from 3 days to 12.7 years with normal kidneys and found that the mean values of the right and left kidneys were 6.8 ± 1.5 cm and 7.0 ±1.5 cm, respectively, resembling the mean kidney length for normal kidneys in our study.[9]
- we found that the mean RI decreased significantly with the increase in age of the patients.Similar to our study Murat A et al also conducted a study to determine the relationship between age and renal resistive index (RI) in intrarenal arteries in healthy children. They divided the children in four groups (group 1) under 12 months of age, (group 2) between 12 and 35 months, (group 3) between 36 and 71 months and (group 4) between 72 months and 16 years. When age groups were compared, statistically significant differences were observed between age groups 1 and 2 (P = 0.007), 1and 3 (P = 0.00), 1 and 4 (P = 0.00) and 2 and 4 (P = 0.00). Nosignificant differences were observed between age groups 2 and 3 (P = 0.452), and 3 and 4 (P = 0.078). They concluded that the RI is age dependent; it is the highest at birth, from birth declines gradually with increasing age and stabilizes in a certain range (mean RI range regarded as normal for adults) by reaching adult levels.[10]
- The mean age for hydronephrotic kidneys in our study was 2.98yrs with a range from day1 to 11yrs. Fifty percent were aged less than 1 year, the largest among all age groups. This most likely resulted from

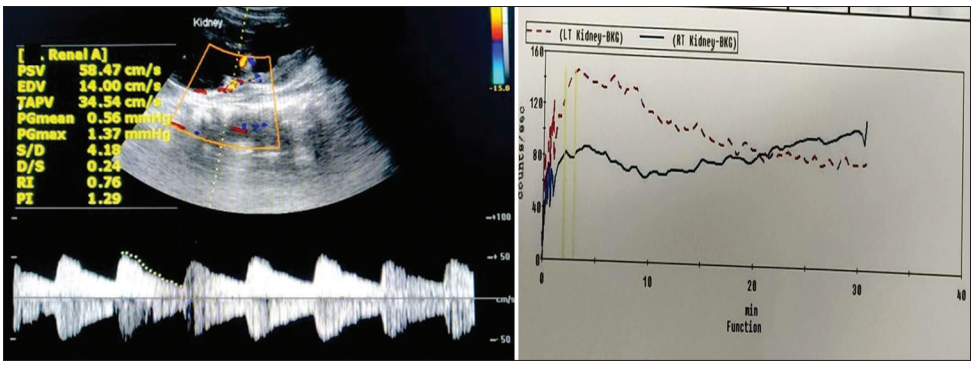

Figure no 2: shows Colour Doppler image showing an RI of 0.76 of the renal artery at hilum of the left kidney. DTPA study in this patient showed an obstructive pattern with no significant lasix washout response.Thus this was a true positive case, where the colour Doppler study findings correlated with the DTPA study in a case of obstructive hydronephrosis

early detection of congenital hydronephrosis during antenatal ultrasound.A similar study was conducted by Nadzri Misni et al. Their study included a total of 16 children with 19 kidneys (3 children had bilateral hydronephrosis). There age ranged from 1 month to 7 years old with mean age being 1.75 years.[11]

- In our study we found the resistive index of the renal artery at the hilum to be 95.65% sensitive and 83.33% specific for evaluation of the obstructive nature of HDN in children.(Figure no 2) Its positive predictive value and negative predictive value were found to be 91.67% and 90.91% respectively. This study conducted on adults (18 to 89yrs) by Joel F. Piatt et al showed the resistive index to have a sensitivity of 92%, a specificity of 88%.[12]
- Ensuring adequate hydration would enhance the diagnostic accuracy of RI in differentiating obstructive and nonobstructive hydronephrosis.[13] Lastly, in dealing with an uncooperative child, adequate sedation may be required for better evaluation of the kidney and the rest of the urinary tract.

CONCLUSIONS

The resistive index decreased significantly as a function of age and the doppler ultrasound measurement of resistive index is useful in differentiating obstructive from non-obstructive hydronephrosis. It can be used as a screening tool and provides a non-ionising alternative to dynamic renal scintigraphy(sensitivity of 83%[14]), especially beneficial in hospitals with no radionuclear scan facilities. With high level of sensitivity, Doppler studies would be able to detect the higher RI in an obstructed system and avoid unnecessary delay in intervention.

LIMITATIONS

1. The sample size for our study was small.
2. RI is a nonspecific parameter as obstruction is not the only cause of an elevated RI. Therefore, in the setting of known renal medical disease (RMD) an elevated RI could be either due to true obstruction or due to RMD with coexistent nonobstructive dilatation. However this potential limitation uncommonly presents a problem clinically, and it is erroneous to assume in advance that Doppler will be useless in the patient with RMD and dilatation.
3. Doppler study being an operator dependent study has its own limitations.

REFERENCES

1. Riccabona M. Assessment and management of newborn hydronephrosis. World J Urol 2004;22:73-78.
2. Epelman, M., Victoria, T., Meyers, K. E., Chauvin, N., Servaes, S., and Darge, K. (2012). Postnatal imaging of neonates with prenatally diagnosed genitourinary abnormalities: a practical approach. *Pediatric Radiology*, *42 Suppl 1*, S124-41.
3. Siegel MJ. Urinary tract. In: Siegel MJ, ed. Pediatric sonography. Philadelphia: Lippincott Williams and Wilkins, 2011;384-460.
4 Choi, Y. H., Cheon, J., Kim, W. S., and Kim, I. (2016). *Ultrasonography of hydronephrosis in the newborn : a practical review*. *35*(July), 198–211.
5. Belarmino JM, Kogan BA. Management of neonatal hydronephrosis. Early Hum Dev. 2006; 82(1): 9-14
6. Sharifian, M., Esfandiar, N., Mohkam, M., Dalirani, R., Taher, E. B., and Akhlaghi, A. (2014). *Diagnostic Accuracy of Renal Pelvic Dilatation in Determining Outcome of Congenital Hydronephrosis*. *8*(1), 26–30.
7. Ellenbogen, P. H., Scheible, F. W., Talner, L. B., and Leopold, G. R. (1978). Sensitivity of gray scale ultrasound in detecting urinary tract obstruction. *AJR. American Journal of Roentgenology*, *130*(4), 731–733.
8. Tublin ME, Bude RO, Platt JF. Review. The resistive index in renal Doppler sonography: where do we stand? AJR Am J Roentgenol. 2003; 180(4): 88592.
9. Oh, M.-S., Hwang, G., Han, S., Kang, H. S., Kim, S. H., Kim, Y. D.,… Han, K. H. (2016). Sonographic Growth Charts for Kidney Length in Normal Korean Children: a Prospective Observational Study. *Journal of Korean Medical Science*, *31*(7), 1089– 1093.
10. Murat A, Akarsu S, Ozdemir H, et al. Renal resistive index in healthy children. Eur J Radiol. 2005; 53(1): 67-71.
11. Misni, N., Hing, E. Y., Hamid, H. A., Zaki, F. M., Aziz, A. A., Yoganathan, K., and Annuar, Z. M. (2015). Renal doppler assessment in differentiating obstructive from non-obstructive hydronephrosis in children. *Medical Journal of Malaysia*, *70*(6), 346–350.
12. Patti G, Menghini ML, Todini AR, et al. The role of the renal resistive index ratio in diagnosing obstruction and in the follow-up of children with unilateral hydronephrosis. BJU Int. 2000; 85(3): 308-12.
13. Rawashdeh YF, Djurhuus JC, Mortensen J, et al. The intrarenal resistive index as a pathophysiological marker of obstructive uropathy. J Urol. 2001; 165(5): 1397-404.
14. Shore AM, Uehling DT, Bruskewitz A, Polcyn RE. Evaluation of obstructive unopathy with diuretic renography. Am J Dis Child 1983;1 37:236-240

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