VALUE OF RENAL DOPPLER IN DIFFERENTIATING OBSTRUCTIVE FROM NON-OBSTRUCTIVE HYDRONEPHROSIS BY MEASUREMENT OF RENAL ARTERY RESISTIVE INDEX

By

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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 (HN) by renal arterial resistive index (RI) measurements.*

Objective: *The main aim of our study to determine the utility of RI in distinguishing between obstructive and non-obstructive hydronephrosis (HN) in pediatric age group.*

Methodology: *This a case control study was carried out on a sample of 20 youngsters diagnosed with hydronephrosis, along with 10 individuals who were selected as healthy controls. The participants were recruited from Hussien& Bab Alshieria Al-Azhar University Hospitals. The research was carried out from December 2022 to September 2023. All the studied cases were subjected to comprehensive medical history, thorough physical examination, laboratory and radiological assessment. 20 patients were taken after applying including criteria and undergone Renal Doppler assessment for evaluation of hydronephrosis and differentiating obstructive from non-obstructive HN.*

Results: *Mean Ri (0.740±0.05) for obstructive HN was significantly higher than the mean RI (0.31±0.05) for non-obstructive HN. The determination of RI useful for differentiating obstructive from non-obstructive HN. Also, the mean venous impedance (0.31±0.02) was significantly higher in obstructive HN than non-obstructive HN.*

Conclusion: *The RI of the renal artery at hilum significantly high in obstructive HN so, can be effectively used to distinguish obstructive from non-obstructive hydronephrosis.*

Keywords: *Hydronephrosis (HN), Pediatric, Renal artery, Resistive index (RI), mean venous impedance (MVP).*

INTRODUCTION

Hydronephrosis (HN) is the dilatation of the renal collecting system of the kidney as a result of the restriction of urine outflow in any section of the urinary tract.

It may occur alone or in conjunction with ureter dilation, resulting in hydroureteronephrosis.

HN may appear unilaterally or bilaterally, acutely or chronically, at any age **(Patel & Batura, 2020)**. HN and hydroureter may occur alone or simultaneously. They affect people of all ages. The symptoms might be chronic or acute, pathologic or physiologic, and bilateral or unilateral **(ElSheemy, 2020)**. The best modality available for the diagnosis and monitoring of both postnatal and prenatal HN is urinary US. It is non-invasive, widely accessible, quick, affordable, and can be done right at the bedside without any kind of radiation. It displays the kidneys' size, thickness, and parenchyma's appearance (cortical cysts, corticomedullary differentiation), ureteral dilatation, the degree of HN, and the anatomy of the urinary bladder **(Dy et al., 2018 and Kazlauskas et al., 2022)**. In addition to providing anatomical information, the US may also provide some functional clues regarding the urinary system. As a result, it offers favorable accuracy for diagnosis **(Leo et al., 2017 and Sternberg et al., 2016)**. Ultrasound has two significant advantages: It rapidly identifies the degree of HN and the timing and requirement of additional investigations **(Kebriyaei et al., 2021)**.

Doppler ultrasound (DU) has given researchers new insights into kidney physiology, allowing the identification of pathological diseases. These alterations may be the identification of minor renal blood flow changes related to different semi-quantified, by determining the Intrarenal Vascular Resistive Index **(Nuraj & Hyseni, 2017)**. It has been used for the evaluation of renal arteries of children with congenital HN. In

addition to being non-invasive and non-ionizing, it has been declared that renal arterial RI measurements may assist in distinguishing between non-obstructive and obstructive HN **(Pepe, 2013 and Zulpi & Sarin, 2022)**.

Sample size calculation:

MedCalc® version 12.3.0.0 program "Ostend, Belgium" was used for calculations of sample size, statistical calculator based on 95% confidence interval and power of the study 80% with α error of 5%, According to a previous study **(Nadzri et al., 2015)**, showed that the mean of RI in obstructive hydronephrosis was 0.78±0.04 and non-obstructive hydronephrosis was mean 0.70±0.07, with a p-value of 0.04. So, it can be relied upon in this study, based on this assumption, the sample size was calculated according to these values, producing a minimal sample size of 16 cases, but the number was increased to 20 to show appropriate results.

Ethical Consideration:

Approval by the ethical committee of the Pediatrics department at the Faculty of Medicine at Al-Azhar University under the registration number: 000488 was obtained before the study.

- Patients were enrolled in the study after taking informed oral and written consent from their parents.
- Patient data confidentiality was preserved during all study procedures.
- The patient and parents have the right to withdraw any time.
- There was no conflict of interest regarding the study or publication. There is no financial support or sponsorship.
- We ensure that the participants are not physically or psychologically harmed during the study.

Inclusion Criteria:

- Children aged from 1 year to 16 years old who were referred for a renal ultrasound and found to have hydronephrosis. (20 patients)
- Apparently, healthy Children with age and sex-matched with the patients were included as a control group. (10 persons)

Exclusion Criteria:

- Critically ill children.
- those who have hypertension
- Children with multi-organ dysfunctions.

- Children with kidney disease other than hydronephrosis.
- Those without consent from the parents.

PATIENTS AND METHODS

A case control study was conducted on 20 children recruited from Al Azhar University Hospitals. Twenty children were diagnosed with hydronephrosis by U.S with regular follow-up at the Pediatric urology and nephrology Clinic during the period from December 2022 to September 2023 and 10 apparently healthy children as control group.

All the studied patients and control group was subjected to the following:

Detailed history including:

- Age and onset of the disease.
- Similar condition in the family.
- Family history of renal disease.
- History of diseases other than the kidney.
- History of operations and hospital admission.
- Perinatal history.
- Symptoms suggesting other systems affection.

Clinical examination including:

- Vital signs, especially blood pressure.
- Anthropometric measurements.
- Detailed general and local examinations of all body systems.

Investigations included the following:

- Urine analysis and culture (automated).
- CBC, CRP (automated).
- Blood urea and serum creatinine (colorometry).
- Conventional renal ultrasound (GE logicE8).
- Renal Doppler ultrasound (GE logic P9).

The results were calculated and statistically analyzed.

Statistical analysis:

- The collected data was gathered and statistically analyzed using the SPSS program (Statistical Package for Social Sciences) software version 23.0.
- Descriptive statistics were done for numerical parametric data as mean SD (standard deviation) and minimum & maximum of the range and for numerical non-parametric data as median and 1st& 3rd interquartile range, while they were done for categorical data as number and percentage.

- Inferential analyses were done for quantitative variables using an independent t-test in cases of two independent means with parametric data and Mann Whitney U in cases of two independent means with non-parametric data.
- Inferential analyses were done for qualitative data using the Chi- square test for independent categories. The level of significance was taken at P value <0.050 is significant, otherwise is non-significant. The p-value is a statistical measure of the probability that the results observed in a study could have occurred by chance.

RESULTS

Our results will be demonstrated in the following tables:

Table (1): Age and gender of studied cases and controls

	Cases (n=20)	control (n=10)	P-value
Age Mean SD Median Range	5.93 4.68 4.25 (3.7-8.1)	5.9 4.98 3.5 (2.3-9.4)	0.989
Gander Male Female	 11 9	 7 3	1.00

This table shows that, there was no statistically significant difference according to age and gender between cases and controls (p value: 0.989, 1.00 respectively).

Table (2): Presenting symptoms of the included cases

Presenting symptoms	Cases (n=20)
-Flank pain	4(20%)
-Hematuria	5(25%)
-Lower abdominal pain	5(25%)
-Renal colic	6(30%)

This table shows that renal colic was the main complain in the studied cases.

Table (3): Centile for mean arterial blood pressure of the included cases and controls

Centile	Cases (n=20)	control (n=10)
5-10th	0	0
10-25th	0	0
25-50th	0	0
50-75th	16(80%)	10(10%)
75-90th	4(20%)	0

According to mean arterial blood pressure centile; sixteen patients in the case group were in (50-75) centile and four cases were in (75-90) centile. All control group were in (50-75) centile.

Table (4): Comparison between cases and controls regarding the kidney function tests (urea & creatinine)

	Cases group (n=10) **Mean ± SD**	Control group (n=10) **Mean ± SD**	P-value
Urea	45.7±19.19	35.4±11.29	0.710
S.creatine	1.1±0.6	1.0±0.15	0.647

This table shows that: there was no statistically significant difference between the two groups regarding to urea and S. Creatine (P value: 0.710 & 0.647 respectively).

Table (5): Ultrasound findings of included cases and controls

Findings	Cases (n=20)		control (n=10)		p-value
Conventional US	Abnormal	Normal	Abnormal	Normal	0.004
	20 (100%)	0	0	10	

According to Conventional ultrasound; there was significant difference between cases and controls (with p-value=0.004).

Table (6): Comparison between Mean resistive indices and venous impedance in obstructive and non-obstructive cases

	Mean resistive indices		Mean venous impedance	
	Range	Mean SD	Range	Mean SD
Obstructive (n=10)	0.7081 to 0.7759	0.74±0.05	0.3072 to 0.3128	0.31±0.002
Non obstructive (n=10)	0.6938 to 0.7602	0.42±0.05	0.3084 to 0.3118	0.32±0.001
P-VALUE	0.04		0.01	

This table shows that: According to Mean resistive index and mean venous impedance there was statistically significant difference between the obstructive and non-obstructive cases.

Table (7): Comparison between Mean resistive indices and venous impedance in included cases and controls

	Mean resistive indices (RI)		Mean venous impedance (MVP)	
	Range	Mean SD	Range	Mean SD
Cases (n=20)	0.7128 to 0.7562	0.73±0.05	0.3090 to 0.3112	0.31±0.002
Control (n=10)	0.5681 to 0.6099	0.58±0.03	0.4215 to 0.4243	0.42±0.001
P-value	p-value <0.001		p-value <0.001	

This table shows that: According to Mean resistive indices; there was statistically significant difference between the cases and controls with (p-value <0.001). Also, as regard to Mean venous impedance; there was statistically significant difference between cases and control (p-value<0.001).

ROC Curve for Mean resistive indices and venous impedance in included cases

	Mean resistive index	Mean venous impedance
AUC	**0.715**	**0.427**
p-value	**0.04**	**0.01**
95% C.I	**0.553-0.918**	**0.346-0.794**
Cut off	**>0.6**	**>0.3**
sensitivity	**79.25**	**67.5**
specificity	**83.71**	**79.71**
PPV	**86.7**	**83.3**
NPV	**80.0**	**66.7**

The sensitivity and specificity of our study according to ROC curve were; cut off value> 0.6, Sensitivity: 79.25, specificity: 83.71, PPV: 86.7, NPV: 80.0.

DISCUSSION

Bilateral or unilateral hydronephrosis is an aseptic dilatation of the renal pelvis and calyces that is filled with urine. It is known as hydroureteronephrosis when it occurs in conjunction with ureteral dilatation **(Sibley et al., 2020)**.

Hydronephrosis can classified into: Obstructive hydronephrosis, non-obstructive hydronephrosis.

There are many causes of obstructive hydronephrosis, such as: pelvi ureteric junction obstruction (PUJ) and Ureteric calculi, posterior urethral valve…etc. The main causes of non-obstructive hydronephrosis are: Neurogenic bladder; Vesico-ureteral reflux; Post-operative **(Lu et al., 2019)**.

Doppler ultrasound, a non-ionizing modality, is a tool that can offer helpful information concerning kidney hemodynamics. It has been established that obstruction results in a reduction in vascular flow because vascular resistance rises. The most valuable duplex index utilized in obstructive renal conditions is the resistive index (RI). It has been investigated how successfully RI can diagnose hydronephrosis in both adults and children. An increased RI in intra parenchymal arteries in infants with unilateral obstruction may be a remarkable finding **(Solomon et al., 2019)**.

Recent researches suggest that color Doppler imaging of the kidneys should be used to assess individuals with renal colic rather

than only gray-scale sonography. These investigations showed that one of the variables evaluated using this approach, the renal resistive index (RI), is higher in the presence of HN and that there is a strong association between the index and the severity and duration of the urinary tract obstruction **(He et al., 2018 and Pates & Dashe, 2006)**.

The Aim of this study was to determine the accuracy of renal Doppler in differentiating non-obstructive from obstructive hydronephrosis by measurement of renal artery resistive index.

Our study showed that: the main presenting symptoms were: renal colic in 6 cases (30%); change in urine colour in 5 case (25); flank pain:4 cases (20%) and lower abdominal pain:5 cases (25%); that was in harmony with **(Maryam tahzeeb et al., 2019)** who reported that the previous symptoms were the major symptoms of their patients, however vomiting during pain was present in (24.7%) of cases in that K8 study.

As regard to kidney function tests; in the case and control groups: there was no statistically significant difference between the two groups regarding to urea and S. Creatinine (P value: 0.710 & 0.647 respectively). Also, between the obstructive and non-obstructive cases: there was no statistically significant difference between the two groups (p value: 0.665, 0.566) respectively. That results disagree with **(Hassan et al., 2018)** who reported that the main serum creatinine value in obstructive group was higher than that of non-obstructive group averagely by 0.5 mg.

This difference can be attributed to difference in sample size; methods of selections and severity of cases between the two studies.

Concerning Conventional ultrasound; there was a significant difference between cases and controls(p-value=0.004). which agreed with **D y et al., 2017 and Kazlauskas et al., 2022)** who found that the best modality available for the diagnosis and monitoring of both postnatal and prenatal HN is urinary US. It is non-invasive, widely accessible, quick, affordable, and can be done right at the bedside without any kind of radiation. It displays the kidneys' size, thickness, and parenchyma's appearance (cortical cysts, corticomedullary differentiation), ureteral dilatation, the degree of HN, and the anatomy of the urinary bladder.

According to Mean resistive indices and venous impedance;

there was a statistically significant difference between the cases and controls with (p-value<0.001).

Our data are in agreement with those of **(Jurkiewicz et al., 2021)** who elaporated that Doppler is a non-invasive procedure and provides accurate results for the diagnosis of obstructive hydronephrosis.

Also, in agreement with our results; A study that was conducted on Mean resistive index as a prognostic tool for hydronephrosis in patients with acute renal colic. **(Michaux et al. 2018)**. They studied 84 patients with unilateral renal colic. Some patients were presented with nausea and vomiting. Bladder ultrasound was performed along with color Doppler to measure the resistive index. There were 41 cases of hydronephrosis in total, and all of them were positive for mean resistive index value. Thus, the specificity of the mean resistive index with color Doppler for diagnosis of HN was 90%. Around 95% of prediction was accurate with increased resistive index. They concluded that mean a resistive index is a good tool for the diagnosis of hydronephrosis **(Innes et al., 2021)**.

Also as regard to the RI and MVI between obstructive and non-obstructive cases of HN; there was a statistically significant difference between the two groups (p value <0.001). This data is in agree with those reported by **(Sibley et al. 2020)** who stated that RI is the main source of differentiation between normal and pathological resistance in flow as well as to differentiate obstructive and non-obstructive HN.

Again, in concordance with our study; **(Pepe & Pepe, 2013 and Zulpi & Sarin, 2022)** declared that renal arterial RI measurements has been used for the evaluation of renal arteries of children with congenital HN. In addition to being non-invasiv and non-ionizing, may assist in distinguishing between non-obstructive and obstructive HN.

The sensitivity and specificity of our study according to ROC curve were: cut off value>0.6_Sensitivity:79,25_specificity:83.71_PPV:86.7_NPV:80.0.

LIMITATIONS

1. The small number of cases included in our study.
2. Severe cases of HN represent only 25 % of patients which is reflected on the value of RI.
3. Doppler study is an operator dependant.

CONCLUSION

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-ionizing alternative to dynamic renal scintigraphy, especially beneficial in hospitals with no radio nuclear 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.

RECOMMENDATION

From this study we recommend the following:

- Any patient with urinary troubles or persistent renal colics should undergo urinary u.s to detect any urinary system abnormalities or congenital anomalies.
- Patients detected to have HN should undergo renal Doppler study for differentiation of obstructive from non-obstructive HN. Being non-invasive, widely accessible, quick, affordable, and can be done right at the bedside without any kind of radiation.

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