

Resistive Index (RI) in Febrile Urinary Tract Infection: New Predictive Value

Haia Nasser¹, Nakhoul Farid⁴, Susan Nasser¹, Jerdev Michael², Abo Zaid Said¹, Soboh Soboh³, Boshra N⁴ and Wael Nasser^{4*}

¹Department of Pediatrics, Baruch Padeh Poriya Medical Center, Lower Galilee, Israel

²Department of Radiology, Baruch Padeh Poriya Medical Center, Lower Galilee, Israel

³Department of Internal Medicine, Baruch Padeh Poriya Medical Center, Lower Galilee, Israel

⁴Nephrology & Hypertension Division, Baruch Padeh Poriya Medical Center, Lower Galilee, Faculty of Medicine in Galilee, Azrieli University, Israel

*Corresponding author: Wael Nasser, Nephrology & Hypertension Division, Baruch Padeh Poriya Medical Center, Lower Galilee, Faculty of Medicine in Galilee, Azrieli University, Israel, Email: wael-nasser@hotmail.com

Question

Can the Resistive Index (RI) replace cystography in predicting functional kidney disease following urinary tract infection?

Findings

Patients in the study were divided according to their age, In the group under 2 years old we found a medium correlation between the RI and DMSA study, and there was a strong correlation between RI and cystography. In the group above 4 years, we found a strong correlation between RI to both DMSA and cystography.

Meaning

The test is of predictive value, and there is room for further investigation, with an emphasis on increasing the number of participants.

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Abstract

Background and Objective: Urinary tract infection is the most common bacterial infection in the pediatric population. The upper urinary tract infection involves the kidney parenchyma and may cause scarring and permanent damage that will proceed to cause hypertension and decreased kidney function.

Almost third of cases will relapse following the first infection in one year. There are different imaging techniques that can help to detect children at risk for future infections, kidney scarring or other systemic complications.

The Ultrasonography of bladder and kidneys: is a relatively cheap, non-invasive and fast test that enables to find children with anatomical anomalies that can be corrected to avoid future infections or complications. Also, this test does not pose the risk of radiation exposure.

Voiding cystourethrogram: is the test of choice to establish the presence of vesicoureteral reflux that is a major risk factor for future infections and scarring. This test has a radiation exposure risk, it is invasive and relatively complex to perform.

DMSA scintigraphy test: may be performed to determine acute pyelonephritis or to investigate kidney scarring. This test has a greater radiation exposure risk. But it cannot distinguish between dysplasia of a kidney or scarring.

With the development and improvement of the imaging capabilities of Doppler ultrasonography, we can measure the Resistive Index, which is a sonographic value to assess the kidney function.

The normal value of the resistive index is 0.6 and the normal upper limit is 0.7.

The increase in this value is related to kidney artery stenosis, extreme hypertension, infants, and intrinsic kidney disease.

Importance: In this work, we want to measure if the Resistive Index can predict kidney scarring.

Participants: We followed after 71 cases of kids from 0 to 11 years old that was admitted to our hospital Baruch Padeh Medical Center, Poriya, in the diagnosis of Urinary tract infection. 71 children participated in the full evaluation.

56 children were under 2 years of age, 8 were aged 2 to 4 years, and 7 were over 5 years or older; 18 were males and 53 were females.

Design: The diagnosis was made on the base of clinical presentation, laboratory blood analysis, urinary analysis, and urinary cultures.

We measured the Resistive index in all of these patients. And they did the ordinary US of kidney parenchyma, the DMSA study and a cystography by the accepted protocols of our department.

Settings: All patients underwent Doppler within 72 hours of hospitalization. Before our conclusions, we divided the patients in the study by their age.

Main outcome: In the first group under 2 years old, we found a moderate correlation between the RI and DMSA study. And there was a strong correlation between RI and cystography. In the second group above 4 years, we found a strong correlation between RI both to DMSA and cystography.

Results: In all the age groups we examined there is a strong correlation between RI and positive findings in cystography to find reflux.

Keywords: *Urinary tract infection; Resistive index; DMSA study; Cystography; Pyelonephritis*

Introduction

Urinary tract infection is the most common bacterial infection in children: 3-5% among girls and 1% among boys [1]. About 5-12% of infants with fever aged 2 months to 2 years suffer from urinary tract infections. Thirty percent of these children will develop repeat infection with a peak incidence in the six months to one year following the first infection [2].

Upper urinary tract infection damage renal parenchyma and can cause scarring in the future, the effects of which are the development of high blood pressure and decreased kidney function [3].

A renal scar develops as a result of pyelonephritis, which is a chain of processes of bacterial spread in renal tissue that stimulates phagocytosis by macrophages and secretion of cytokines that produce a chemotactic effect that leads to damage and microthrombosis formation in the kidney capillaries [4].

A kidney scar develops at the inflammatory position in 35% to 50% of cases of pyelonephritis [5]. Acute pyelonephritis diagnosis or scar search performed by mapping Kidney DMSA usually does not differentiate kidney dysplasia from a real scar, which is usually at the upper or lower renal pole that corresponds to the reduced physiological mechanism of renal function in these areas [5].

The incidence of vesicoureteral reflux in the population is 1% with a family bias and has 5 levels. The contribution of reflux to the development of secondary scar due to infections has not been proven until now [6,7]. Contrary to popular opinion, reflux has not been shown to be a risk factor for recurrence of infections.

Recently, children with reflux have not shown any therapeutic benefit regarding the frequency of infections, scarring, and renal function, and therefore the importance of reflux detection is questionable.

With the development of the X-ray system and the efficiency of new renal Doppler imaging, the Resistive Index (RI) can be calculated (Figure 1). This index is considered a radiographic index of renal function, prediction of scar development, prediction of unbalanced blood pressure, and predictive of unbalanced diabetes, and even precedes microalbuminuria as a measure of renal impairment [8,9].

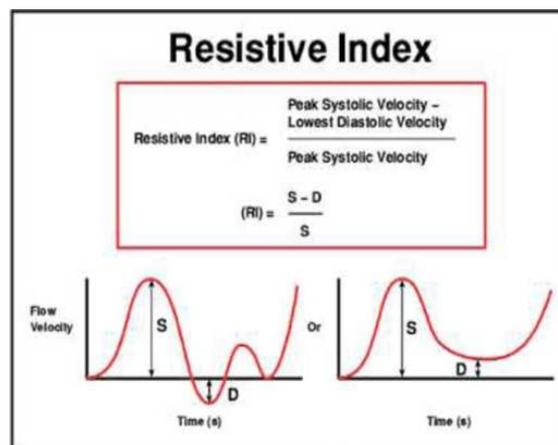


Figure 1: Resistive Index formula.

RI is an important measure of renal resistance, a radiographic index enabling a rapid diagnosis without radiation and without anesthesia [9,10].

The value of RI during acute pyelonephritis in infants is 0.744, while the normal value is 0.703. The RI value in children up to 4 years of age during acute pyelonephritis is 0.745, while the normal value for children younger than 4 years is 0.696. Over the age of 5 years, the values of RI at the time of pyelonephritis is 0.733, while the normal value for five years and older is 0.65. When an RI value is 0.71 in a 4-year old child, it is a measure of involvement of tissue infection in the kidney with high specificity and sensitivity.

RI is a very effective radiological value in children with upper urinary tract infection more than with lower urinary tract infection; it is capable of predicting the formation of a future scar. RI can be used as a diagnostic radiographic index without radiation and possibly in the future will replace cystography [9-12]. In adult medicine, too several studies rely on RI to monitor renal function.

Our aim is to investigate whether an RI can predict future renal scarring and whether RI is associated with other commonly accepted tests such as cystography and DMSA mapping.

Materials and Methods

The study was conducted prospectively, with 71 children hospitalized in the Pediatric Department at the Poriya Medical Center With a clinical picture and laboratory signs of upper urinary tract infection and pyelonephritis, complete blood count with leukocytosis, high CRP, fever and chills, and positive urine culture.

Participants were divided into three age groups: infant up to two years of age, children from two to four years old, and children from the age of five to eleven years. All patients underwent Doppler within 72 hours of hospitalization after hydration and calculating RI.

If there was recurrent inflammation in the past six months or suspicion of reflux, a DMSA mapping test was performed according to the procedure accepted in the department prior to the study.

Children with congenital anatomical malformations such as U-shaped kidney, dysplastic kidney, or PUV were not included.

The variables in the study

Physical examination findings: fever, vomiting, stomachaches, chills, urgency, frequency, and burning urine.

Laboratory test results: Urine culture. Inflammatory measures (leukocytes, CRP), total renal function (creatinine, urea), determination of the bacteria if any grew in the culture.

The results of the imaging tests: findings in renal ultrasound, renal mapping, cystography kidney Doppler.

Statistical Analysis

Quantitative data is described using mean and standard deviation, median and range. High-quality data is described using frequency and percentage.

As a rule, the relationship between quantitative/grading variables and the RI variable was examined by means of the Spearman correlation coefficient test.

Results

Participants: 71 children participated in the full evaluation. Fifty-six children were under 2 years of age, 8 were aged 2 to 4 years, and 7 were over 5 years or older; 18 were males and 53 were females (Figure 2).

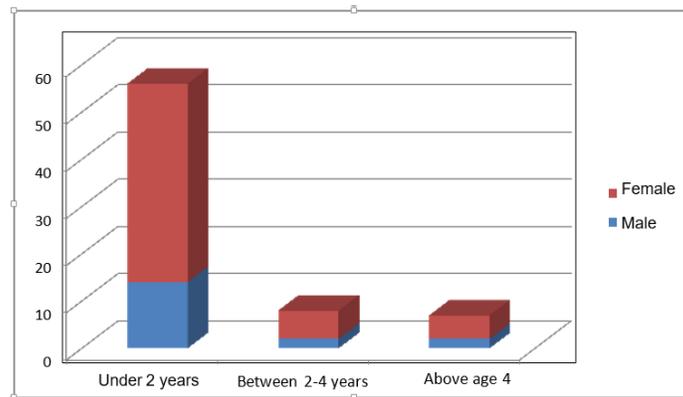


Figure 2: The participants.

From (Figure 2) we can see that most of the children with urinary tract infections who were hospitalized in our institutions were below two years of age and the incidence of infections was mostly among girls.

Characterization of Infections

Urine cultures were performed for the vast majority of children hospitalized with urinary tract infection. In 60% of the cases, there was a growth of *Escherichia coli*, *Klebsiella* spp. grew in 5%, in 12% of cases the culture returned without bacterial growth, and 23% were lost (figure 3).

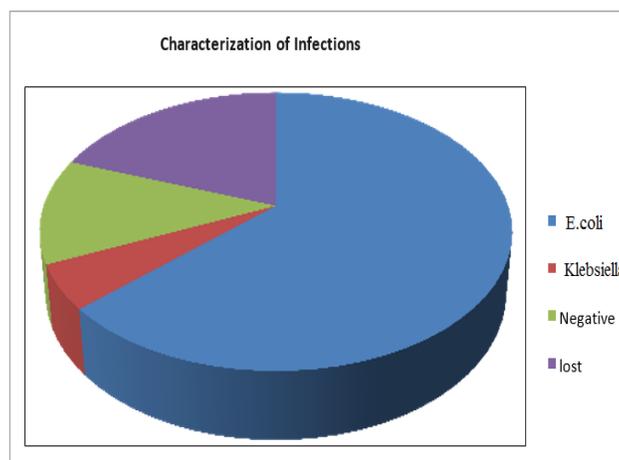


Figure 3: Urine culture bacterial infections.

The results of the study according to imaging tests

Ultrasound showed hydronephrosis in 63% of cases, the remainder were normal.

Cystography was done in 57 of the participants. Of the 33 that were considered, 46% of participants had Reflux.

DMSA mapping was done for 59 of the participants in the study out of which 34 from all the participants - that they considered to be 48% of all participants they had pathological absorption (Figure 4).

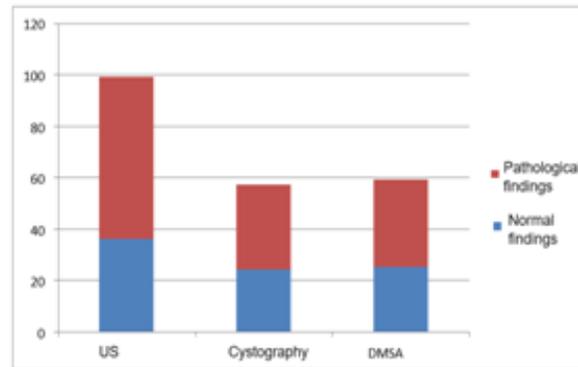


Figure 4: Imaging tests.

Resistive Index (RI)

The study was conducted for all participants in the study around 72 hours after the diagnosis of upper urinary tract infection (Table 1). The average RI is 0.70 and the standard deviation is 0.038.

Age	Average RI	Standard Deviation
0-2	0.7	0.037
02-Apr	0.69	0.037
> 4 years	0.67	0.047

Table 1: Resistive Index according to age.

In order to establish a relationship between RI at the time of pyelonephritis, US DMSA mapping, and cystography, the Spearman adapter was performed.

	US	DMSA	Cystography
RESISTIVE INDEX	**r=0.30	**r=-0.36	R=-0.54
		N=71	N=71

Table 2: Correlation results.

Note: P<0.05**

From (Table 2), we can see that the RI and the US test are moderately correlated with a probability of less than 0.05.

In addition, a moderate correlation was found between RI and DMSA mapping as well, with a probability of 0.05 (Figure 5).

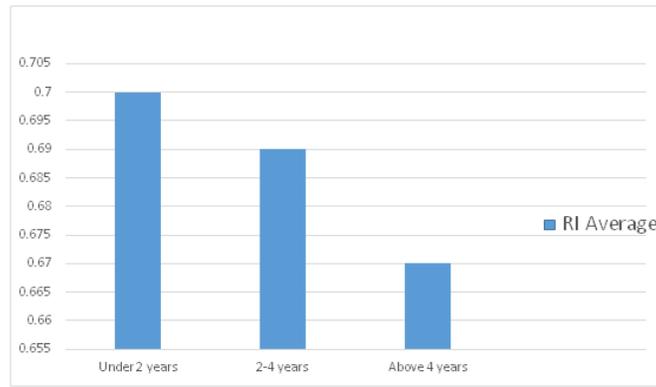


Figure 5: RI according to age.

According to (Table 3), we can see that: Under 2 years of age, a moderate correlation was found between RI and DMSA, as well as a strong correlation between RI and cystography. Over the age of four, there was a strong correlation between RI and DMSA mapping as well as a strong correlation between RI and cystography. There were weak correlations between the ages of two and four.

Cystography	DMSA	US	Ages
R=-0.52	R=-0.37	R=0.17	Under age 2
N=56	N=56	N=56	
R=-0.28	R=0.19	R=0.43	2-4 years
N=8	N=8	N=8	
R=-0.68	R=-0.68	R=-0.86	Above age 4
N=7	N=7	N=7	

Table 3: Spearman Adapters between Resistive Index and US, mapping, and cystography according to age.

We can see in (Figure 6) that in all the age groups we examined there is a strong correlation between RI and positive findings in cystography to find reflux. In addition, in the 2-4 year age group, we found no convincing findings against the use of the RI, whereas for the prediction of an RI to the findings in DMSA we found a strong correlation in children over age 4 and moderate correlation in children up to the age of two years.

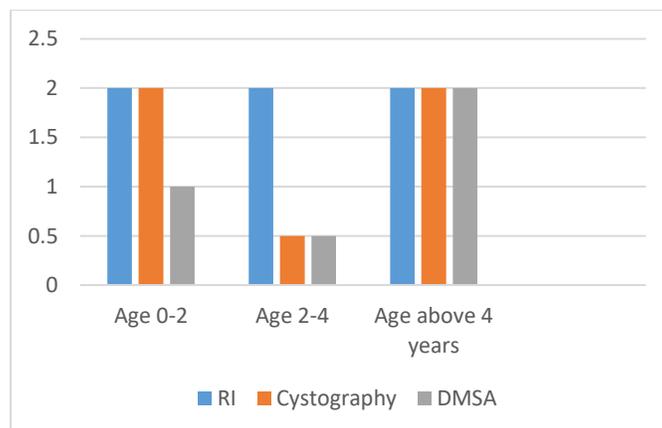


Figure 6: The intensity of RI-ion correlation in cystography and mapping.

We chose to check whether an RI, a test that is not in use, could predict kidney function following urinary tract infection accompanied by fever. We learned that there is a correlation between reflux RI and mapping results for children after upper urinary tract infections. It can be said that the test is of predictive value, and there is room for further investigation.

Discussion

As described, urinary tract infection is very common, especially in the population of infants up to age two years. Apart from treating the acute stage of the disease, doctors should know how to identify and help patients who are at risk of developing recurrent infections or complications.

The usual ways to identify these patients today are based on family history, the severity of the infection and its clinical course, bacterial types, and simulations. In this study, we wanted to examine and present a method of imaging that is not used daily in hospitals and outside the hospitals - an index of resistance of the kidneys diagnosed with the US, and to examine whether it can predict future renal function.

The advantages of the test are cost, availability, and lack of dangerous radiation, as well as relative simplicity of the test, which can be seen from the data mainly from children under the age of two years.

The disadvantage of this test is the lack of practical experience, and the lack of information available today to make therapeutic decisions according to the results of the examination.

Over the past year, we have followed most of the cases of children who came to our institution with upper urinary tract infection and the examination of the resistive index was performed by a single physician.

We continued to collect prospective data on the patients and followed up on any of them who had completed a scan cystography and DMSA mapping of the kidneys.

In a Spearman statistical correlation, we learned that there is a correlation of different strengths between RI and other imaging findings - ultrasound, cystography, and mapping, and the data are detailed in the study results.

Conclusion

We chose to check whether an RI, a test that is not in use, can predict functional kidney disease following urinary tract infection accompanied by fever.

We prospectively followed 71 children hospitalized with urinary tract infection and learned that there is a correlation between reflux RI and mapping results for children after upper urinary tract infections.

It can be said that the test is of predictive value, and there is room for further investigation, and comparing this index to the development of hypertension, albuminuria, or kidney scars.

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