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A Study on the Value of Measuring Resistive Index of the Intrarenal Arterial Blood Flow for diagnosing the Acute Unilateral Obstructive Uropathy

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Abstract

The accurate diagnosis of the acute obstructive uropathy is vital because it will be followed by complications such as urinary infections, blood pressure, and renal failure. Normal sonography, plain abdominal radiography, kidney under bladder (KUB), intra venous urography (IVC), and CT are the common diagnostic methods for the mentioned disease; however, the certain diagnosis of it is not possible. Being exposed to the ionizing radiation is hazardous for the fetus, therefore, KUB, IVC, and CT cannot be used for the pregnant women. Regarding the normal sonography, the pelvis dilatation and renal calyces (hydronephrosis) are the symptoms of obstruction. Over the pregnancy, the hydronephrosis is observed at the right side as a result of the uterine pressure on the ureter. Therefore, it is not possible to understand whether hydronephrosis is normal in a case or abnormal. Since RI reversible complications of obstruction associated with pregnancy are caused in a short period of time, it is necessary to diagnose this kind of obstruction accurately and quickly. IVU is forbidden for patients who are sensitive to the contrast material. Sometimes, stones are not observed in KUB, and ultrasonography has also some limitations. The present paper investigates role of duplex Dopplerultrasonography(US) via intrarenal arterial resistive index (RI) in the diagnosis of the acute obstructive uropathy. The common methods have limitations; therefore, it is essential to apply another diagnostic method. In the population under study, the mean resistive index (RI) was 0.68∓0.07 for the group with obstruction, and it was 0.62∓ 0.07 for the group with normal kidney. The average of index difference was 0.058∓ 0.07. Factors of specificity, sensitivity, accuracy, positive predictive value, negative predictive value, positive likelihood ratio, and negative likelihood ratio have been measured at five threshold levels of index (0.55, 0.6, 0.65, 0.7, 0.8), the results are presented in the present paper.

Keywords: Obstructive uropathy, resistive index, hydronephrosis, ultrasonography.

Introduction

The duplex Doppler ultrasonography could be used as a method of diagnosing obstruction for patients for whom the other methods cannot be used (especially pregnant women), however, the following conditions are needed. The mean RI and ΔRI of the obstructed kidney increase to a point more than the standard mean RI and ΔRI and the difference is significant, statistically. Moreover, the sensitivity and specificity values are considerable[1].

The obstructive uropathy is a common disease in the world and is main cause is stone. According to the results of the autopsy, %3 of the adults and %2 of the children have had obstruction. The quick and accurate diagnosis of the obstruction leads to rapid treatment, and a decrease of complications such as urinary infection, blood pressure, and renal failure. KUB, standard renal ultrasonography, IVU, and CT are the common diagnostic methods. Each of the mentioned methods has some limitations which would be briefly discussed. %5 of stones was not observed in KUB. Sometimes, stones are in a part of the ureter which is in contact with the pelvic bone and is hardly recognizable. Moreover, the stone might wrongly be considered as flebolit[2-7].

Ultrasonography is an uninvasive diagnostic method which is rapid and economical. It is usually the first diagnostic method for subjects suspected of having obstruction. Hydronephrosis is the important symptom of obstruction within the method of ultrasonography, however, the symptom is not accurate as a result of having many false positive and negative cases. The hydronephrosis which is normally observed as a result of the uterine pressure over pregnancy and the normal out-of- kidney pelvis are the false positive cases[8]. Renal cysts, full bladder, vesicoureteral reflux, the congenial great size of calyx, the presence of dilatation after the addressing of obstruction, acute pyelonephritis, and diabetes insipidus might cause a condition similar to hydronephrosis. However, there are acute obstructions in some cases, while no hydronephrosis is observed (the false negative case). It consists of cases such as observation error, lack of hydronephrosis at the beginning of obstruction, technical factors such as obesity that makes the patient's abdomen unobservable, intermitted obstruction, and fornix rupture that causes hydronephrosis disappearance[9]. Over pregnancy, IVU is forbidden as a result of renal failure and being sensitive to the contrast material[10] CT is an accurate diagnostic method, however, it is expensive and also hazardous for the pregnant women and fetuses as a result of the radiation exposure.

Therefore, the common diagnostic methods are not practical in some cases. According to the studies which have not still confirmed, the Doppler ultrasonography could be applied. Probably, the intrarenal arterial blood flow with obstruction will be influenced. Fairly, diastolic blood low decreases more than the systolic blood flow, as a result, RI increases. If the increase of RI is confirmed, it will be used along with other findings of the ultrasound to diagnose the acute renal obstruction (especially for pregnancy and renal failure). Doctor Onur et al. worked on a research titled" role of RI in renal colic". In this study, 16 patients with acute unilateral obstruction were investigated. According to this study, mean RIs were as follows; $0.7 \leq$ mean RI and $0.08 \leq \Delta IR$. After doing the Doppler ultrasonography, mean RI of the obstructed kidney was 0.69 ∓ 0.04 and it was definitely more than that of the 16 healthy kidneys (0.61 ∓ 0.03), moreover, P was greater than 0.05 and ΔRI of the group was 0.07 ∓ 0.02. In another research titled "Doppler ultrasonography to diagnose urinary tract obstruction by stone", doctor Akar et al. (2004) studied 28 patients with renal colic. Mean RI of the obstructed kidney and the normal kidney were respectively 0.71 and 0.61. ΔRI was calculated 0.1 and it was significant, statistically[11].

In a study by doctor Haroun[12], 42 patients with the renal obstruction (whose obstruction was confirmed by IVU) were investigated. 14 of the patients has complete obstruction and mean RI was 0.7 ∓ 0.06 for them, while mean RI was 0.64 ∓ 0.06 for the patients with incomplete obstruction (28 people). Moreover, ΔRI was 0.09 ∓ 0.02 for the group with complete obstruction, and it was 0.03 ∓ 0.05 for the group with incomplete obstruction. In this research, RI threshold level and ΔRI were respectively 0.65 and 0.05, moreover, the sensitivity of them was 64 and 100 percent, and the specificity of them was 82 and 89 percent. The study confirmed that duplex Doppler ultrasonography would be recommended if IVN was forbidden.

Doctor Pepe et al.[13] studied 100 patients with renal colic from July of 2002 to June of 2003. $0.7 <$ RI and ΔRI equal to 10 percent were considered as diagnostic symptoms of the renal obstruction. Mean RI of the obstructed kidney was reported 0.73 and its sensitivity and specificity were respectively reported 98.9 and 90.9 percent. ΔRI was reported over 10 percent in comparison with the normal kidney.

In a research done by doctor Geavlete et al.[14], 306 patients with renal colic were studied from October 1998 to January 2001. The normal RI and ΔRI of the study were considered as follows; $0.7 \geq$RI and $0.06 \geq \Delta RI$. Mean RI was 0.76 for the patients, and $0.08 \leq \Delta RI$. Sensitivity and specificity of RI were respectively 75.5 and 92.5 percent. Moreover, sensitivity and specificity of ΔRI were respectively 80.7 and 95.7 percent. The study indicated that the Doppler test was sensitive and specific and it could be a good replacement for IVC. In a study done by doctor Miletic et al. (1998)[15], 54 patients with the acute unilateral renal obstruction were studied from December of 1993 to January of 1996. According to the study, normal value of mean RI was 0.64 ∓ 0.04 and ΔRI was 0.02 ∓ 0.01. In the obstructed kidney, mean RI was 0.72 ∓ 0.04 and ΔRI was 0.09 ∓ 0.04. The study recognized the parameters reliable in relation with the acute unilateral obstruction. Especially, it considered $0.06 \leq \Delta RI$ very accurate. In a study (1993), 23 patients with the acute unilateral renal obstruction were studied. Mean RI of the obstructed kidney was 0.77 ∓ 0.07 and this value was more than that of the normal kidney with RI of 0.06 ∓ 0.04. According to the study, Doppler was useful for cases of renal colic that had applied the ultrasonography as the selected investigation method. However, the valid resources do not still trust the role of RI in the acute unilateral renal obstruction[16].

Methodology

According to this cross-sectional study, 64 patients, who had the clinical symptoms such as acute abdominal pain (acute renal colic), nausea, and urinary retention, the RI symptoms were felt over 48 hours, and the RI acute unilateral obstruction was diagnosed by the methods such as ultrasonography, IVU, KUB, and CT, entered the study. The patients were separately studied by the project radiologist and resident with the application of the ultrasound device. After finding the intrarenal arteries, the RI specteroscopies were drawn and the RI was calculated by the device. RI was separately calculated in six points of each of the kidneys. If three RIs were successively equal, that value of RI would be considered as the renal RI. Also, ΔRI of the patient's two kidneys was calculated. In this research, the diagnosis of presence or absence of the acute renal obstruction was done regarding the symptoms and via ultrasonography, KUB, IVU, and CT. the methods were considered as the golden standards to calculate sensitivity and specificity of the increase of RI.

The gathered data consists of demographic information, RI value, ΔRI, duration of symptoms emergence, and presence of hydronephrosis. In this research, the gathered data entered the statistical software of STATA 8, and then the mean of arterial resistance related to the normal kidney was compared with the mean of arterial resistance related to the obstructed kidney via t-test and test of Man-Withney. Moreover, according to the standard determined for the arterial resistance, the sensitivity, specificity, NPV, positive LR, negative LR, accuracy, and confidence interval of 95 percent were calculated.

Results and Discussion

In this research, 64 patients with the unilateral obstructive uropathy were studied. 25 patients were female and 39 patients were male. The age mean was 37 years old, moreover, the average time of the onset of symptoms before referring to the health centers was 15.6 ∓ 12.5 hours. The frequency rate of the diagnostic methods was as follows: 33 subjects with KUB, 16 subjects with US, and 15 subjects with IVU. 50 patients with the obstructed kidney had hydronephrosis; however, 14 patients with the obstructed kidney did not have hydronephrosis.

Mean RI of the intrarenal arteries of the obstructed kidney (0.68∓0.07) was more that of the normal kidney (0.62∓0.07) ($p<0.001$). Moreover, mean ΔRI was 0.058∓0.07. With regard to the age factor, patients were categorized into two equal groups: 35 ≥ -1 and 35< -2, and then the impact of age on RI was studied. RI increases as a result of the increase of age. With regard to RI value, there was a significant difference between two age- groups of patients with the normal kidney and patients with the obstructed kidney ($p<0.05$). Furthermore, there was no relation between sex and RI ($p<0.05$). The mean of RI in the obstructed kidney with hydronephrosis was 0.68 ∓0.07 and in the obstructed without hydronephrosis was 0.68∓0.06. Therefore, there was not a significant relation between hydronephrosis and RI. In order to study the diagnostic value, five threshold levels were selected for RI. For instance, there were 121 subjects with 0.8>RI, 62 subjects did not have obstruction, while 59 subjects had urinary uropathy. However when it was indicated as 0.8≤RI, only 2 subjects from the group with normal kidney and 5 subjects from the group with the obstructed kidney were observed.

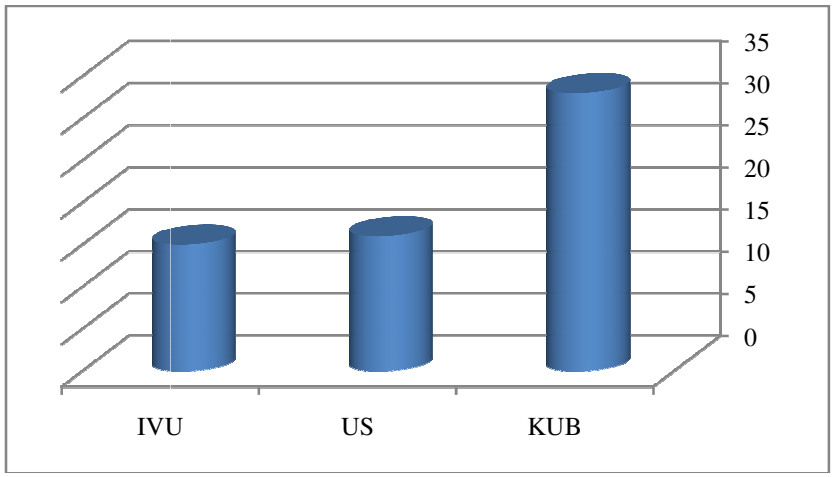


Figure-1
Frequency of diagnostic methods 13

Table-1
Mean RI of the intrarental arteries based on age[17]

Age(yrs)	Mean RI of Obstructed Kid.	Mean RI of Normal kid
>35	0.71±o.08	0.66±0.07

Table-2
Mean RI of the intrarenal arteries based on sex

Sex	Mean RI of Obstructed Kid.	Mean RI of normal Kid.
Male	0.67±0.07	0.61 ±0.08
Female	0.70±0.68	0.64±0.05

Table-3
Frequency of normal and obstructed kidneys when the threshold of RI is 0.8

	Normal kidney	Obstructed Kidney	Total
RI<0.8	62	59	121
	51.24%	48.76%	100%
	96.88%	92.19%	94.53%
RI≥0.8	2	5	7
	28.57%	71.43%	100%
	3.13%	7.81%	5.47%
Total	64	64	128
	50%	50%	100%
	100%	100%	100%

Table-4
Frequency of normal and obstructed kidneys when the threshold level of RI is 0.7

	Normal kidney	**Obstructed Kidney**	**Total**
RI<0.7	57	39	96
	59.38%	40.63%	100%
	89.06%	60. 94%	75%
RI≥0.7	7	25	32
	21.88%	78.13%	100%
	10.94%	39.06%	25%
Total	64	64	128
	50%	50%	100%
	100%	100%	100%

Table-5
Frequency of normal and obstructed kidneys when the threshold level of RI is 0.65

	Normal kidney	**Obstructed Kidney**	**Total**
RI<0.65	41	24	65
	63.08%	36.92%	100%
	64.06%	37.5%	50.78%
RI≥0.65	23	40	32
	36.51%	63.49%	100%
	35.94%	39.06%	25%
Total	64	64	128
	50%	50%	100%
	100%	100%	100%

Table-6
Frequency of normal and obstructed kidneys when the threshold level of RI is 0.6

	Normal kidney	**Obstructed Kidney**	**Total**
RI<0.6	20	7	27
	74.07%	25.93%	100%
	31.25%	10.94%	21%
RI≥0.6	44	57	101
	43.56%	56.44%	100%
	68.75%	89.06%	78.91%
Total	64	64	128
	50%	50%	100%
	100%	100%	100%

Table-7
Frequency of normal and obstructed kidneys when the threshold level of RI is 0.65

	Normal kidney	**Obstructed Kidney**	**Total**
RI<0.55	8	1	9
	88.89%	11.11%	100%
	12.5%	1.56%	7.03%
RI≥0.55	56	63	119
	47.06%	52.94%	100%
	87.5%	98.44%	92.97%
Total	64	64	128
	50%	50%	100%
	100%	100%	100%

Table-8
Diagnostic value at five threshold levels of RI (rate of sensitivity, specificity, positive predictive value, negative predictive value, positive likelihood ratio, negative likelihood ratio, and accuracy)

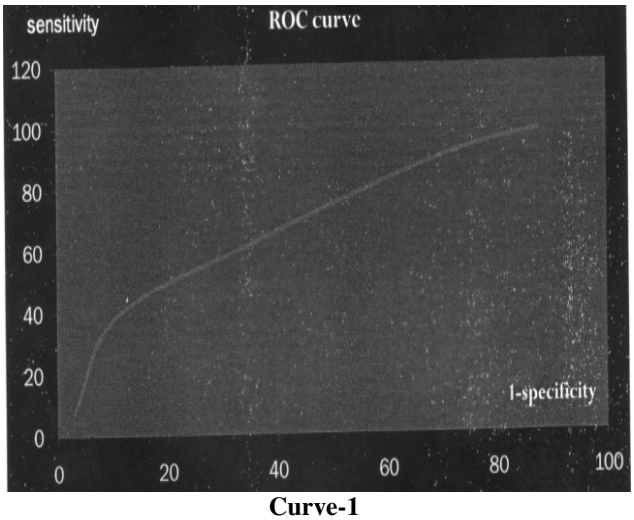
RI	**Sensitivity (%)**	**Specificity (%)**	***PPV (%)**	****NPV (%)**	**PLHR (%)**	**NLHR (%)**	**Accuracy (%)**
≥ 0.8	7.8	96.9	71	51	2.5	0.95	52
≥ 0.7	39.1	89.1	78	59	3.57	0.68	64
≥ 0.65	62.5	64.1	63	63	1.74	0.59	63
≥ 0.6	89.1	31.3	56	74	1.3	0.35	60
≥ 0.55	98.4	12.5	53	89	1.1	0.13	55

*PPV= Positive Predictive Value, **NPV=Negative Predictive Value, Positive Likelihood Ratio= Sensitivity/1-specificty

The ROC curve of the research has been drawn. As it is observed, when the sensitivity is high the specificity is low and vice versa. If the threshold level of RI is 0.8, the sensitivity and specificity will be at equal and average levels; this value could be assumed acceptable. Therefore, if it is as RI≥0.8 and also there are symptoms associated with renal colic, the patient will probably have the acute obstructiveuropathy. At this level, the accuracy of the test is 52 percent and the sensitivity and specificity are not satisfactory, therefore, it cannot be suggested as the reliable diagnostic threshold. Finally, it is concluded that the Doppler ultrasonography cannot diagnose the unilateral obstructive uropathy by itself, and if the obstruction is diagnosed by this method, it should be confirmed by the other methods.

Conclusion

According to this study, the increase of RI is not sufficiently accurate and reliable to diagnose the unilateral obstructive uropathy by itself, and if the obstruction is diagnosed by the method of ultrasonography, the other methods should be used to confirm it. Since the study has been done on a limited number of people, a broader research is needed to be done.



Curve-1
ROC22

Moreover, the importance of diagnosing obstruction in the pregnant women and the harmfulness of the radiation for the fetus, a specific study on this group has been suggested. If the accuracy of the test is high, the Doppler ultrasonography could be applied to rapidly diagnose the obstruction and prevent the irreversible effects of it. It has been found that the age affects RI, however, morestudies are needed to concentrate on the impact of age on RI. The majority of patients have hydronephrosis, but more studies are needed to indicate the impact of hydronephrosis on RI. The patients with renal colic use the painkillers such as NSAIDs to decrease their pain. Since the drugs probably affect the RI, a study with the purpose of investigating the impact of painkillers on RI should be done.

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