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CLINICAL STUDY

Renal Vascular Doppler Resistance after Extracorporeal Shock Wave Lithotripsy

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Abstract

Objectives: Extracorporeal shock wave lithotripsy (ESWL) is mainly an alternative for other therapeutic methods such as surgery and endourology to treat urinary tract calculus. Although it is safe and effective, it has undesirable effects on renal function. Diagnostic techniques such as color Doppler ultrasonography create a new attitude toward renal function. The aim of this study was to evaluate renal vascular resistance change before and after extracorporeal shock wave lithotripsy. *Methods*: During the present study, vascular resistive index (RI) of renal intralobar artery was measured before, 30 min, and 1 week after ESWL using Doppler ultrasonography. *Results*: Thirty minutes after ESWL, RI was significantly increased from primary value of 0.62 ± 0.05 to 0.66 ± 0.06 ($p = 0.0001$). There was no correlation between increase of RI and patients' age. Following up the patients revealed that mean RI did not return to pretreatment level after 1 week ($p < 0.05$). The RI level in the old patients (3 patients who were 60 years or older) was higher than that of the younger ones (19 patients who were younger than 60 years) after 1 week (0.76 ± 0.05 vs. 0.64 ± 0.06). There was no meaningful relationship between ESWL voltage or number of shocks and RI variation before and after ESWL. *Conclusion*: Following ESWL, patients are at risk of renal tissue damage due to increase of primary RI level. Measuring RI variations using ultrasound techniques after ESWL may provide helpful information to clinical detection of renal tissue damage.

Keywords: extracorporeal shock wave lithotripsy, vascular resistive index, ultrasound

INTRODUCTION

Lithotripsy is a noninvasive alternative to surgery for the treatment of kidney stones. It uses carefully focused, high-energy shock waves to disintegrate the kidney stones. Once the stone is disintegrated, the sand-like fragments pass out of the body in the urine. Large stones may require more than one lithotripsy treatment.[1,2] Different effects of lithotripsy on kidney have been tested in animal models. Although the primary studies conducted by Chaussy et al. indicated the lack of pathological variations in dogs' kidney following lithotripsy, the subsequent researches demonstrated that different variations may be developed.[3,4] There are several reports about renal hemorrhage, which may be perirenal, subcapsular, and inter-parenchyma.[5] Thin-wall vessels are sensitive to shock wave damage. Mainly, hemorrhage extent is directly related to the used kilo voltage and number of shocks of the prescribed wave.[6] Some studies refer to the effects of lithotripsy on renal tubules and glomerulus cells. Desai et al. indicated the revocable variations in the form of proteinuria following lithotripsy using lithoclast with electrohydraulic generator.[7] Similarly, revocable variations of urinary level of materials such as *N*-β-acetylglucosaminidase, β-galactosidase, δ-glutamyl transferase, creatine phosphokinase, lactate dehydrogenase, and α2-macroglobulin have been demonstrated in human and animal models. These materials may be used as indicators that are helpful in determining the least possible damage following extracorporeal shock wave lithotripsy (ESWL).[8] ESWL is a noninvasive treatment of kidney stones and biliary calculi using an acoustic pulse. It is estimated that more than one million patients are treated annually with ESWL in the United States alone.[9] The effects of sound shock

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waves on other tissues have also been evaluated. Pulmonary hemorrhage and crush have been reported in animal models. Intestine small submucous and posterior liver hematoma may be seen due to adjacency of kidneys with digestive system.[10] Li et al. studied the effects of lithotripsy on blood cells and elements. The results referred to hemolysis at laboratory and lack of any effect on living dogs.[11] Although reliability and efficiency of the method has been proved, some studies have referred to lithotripsy complications. However, there are very few life-threatening complications.[12] Several techniques, such as measuring the resistive index (RI) of kidney inter-lobar arteries with Doppler, are used to demonstrate the effects of lithotripsy on kidneys. It is a noninvasive method.[13] It is assumed that determining vascular RI variations is a way to early diagnosis of renal damage.[14] In 1995, Fu et al. measured vascular RI variations in 76 treated patients. The results indicated the high risk of renal tissue damage in old patients.[15] The study conducted by Wang et al. demonstrated that vascular RI of understudy patients was increased 3 h after lithotripsy and returned to its pretreatment level 2 weeks after lithotripsy.[16] The present study aimed at evaluating vascular RI variations before and after ESWL using Doppler sonography.

MATERIALS AND METHODS

This is a prospective study conducted at the urology and radiology departments of Tabriz Imam Reza Hospital from July 2011 to July 2012. The study was approved by the ethics committee of Tabriz University of medical sciences. Written consent was obtained from all the patients. The study evaluated 70 patients suffering from renal or urinary tract calculus, of which 15 cases referred to measure renal vessel RI just before lithotripsy and were automatically excluded from the study. The patients comprised 38 males and 17 females with the age range of 8–75 years. Before the study, all patients were evaluated considering blood pressure and entered the study if their blood pressure was normal. Diastolic pressure <90 mmHg and systolic pressure <140 mmHg were regarded as normal pressure criterion. Otherwise, it was considered as hypertension and such patients were excluded from the study. Vascular RI is calculated using the following formula: RI = (maximum velocity in systole − minimum velocity in diastole)/(maximum velocity in systole). Measurement of renal vessels RI was repeated for three times in 22 patients: immediately before lithotripsy (30 min before), immediately after lithotripsy (30 min later), and 1 week after treatment. In the remaining patients, renal vessels RI were measured only two times (immediately before and immediately after lithotripsy). All indexes were measured using Doppler ultrasound machine (Hitachi Medical Corp, Tokyo, Japan) with convex probes of 3.5 and 7.5 MHz by one sonologist. Vascular RI of the affected kidney was measured and considering inter-lobar arteries. ESWL was conducted using Lithostar set (Siemens, Germany). The mean shock power of the set used in this study was 18.74 ± 0.57 kV and the mean number of the shocks was 2903.6 ± 0.25. After completing this stage and collecting the related data, the rest data were collected from the files available at the lithotripsy ward. The data included patients' age, number of shocks of the lithoclast, and power of each shock.

Statistical analyses were performed using SPSS version 16.0 for Windows software package (SPSS, Chicago, IL, USA). The results are presented as mean values and standard deviations. All cases mentioned at the objectives section were evaluated considering their relationship with vascular RI variations. The present study used paired *t*-test, Pearson correlation coefficient, chi-square test, and independent sample *t*-test. The results were considered significant when the *p*-value was <0.05.

RESULTS

The study consisted of 55 patients (69.1% male and 30.9% female) with mean age of 40.9 ± 15.93 years and age range of 8–75 years. Considering age, 47 (85.5%) patients were younger than 60 while there were 8 (14.5%) 60-year-old or older patients. Generally, out of 55 kidneys, 31 (56.4%) and 24 (43.6%) cases underwent lithotripsy from left and right sides, respectively. The mean shock power was 18.74 ± 0.57 kV (the minimum and maximum were 16.3 and 19 kV, respectively). The mean number of the shocks was 2903.6 ± 257.4.

Vascular RI Variations Before and 30 min After Lithotripsy

The mean vascular RI was RI-2 = 0.66 ± 0.06 after 30 min of lithotripsy. The difference was significant considering the values obtained before lithotripsy ($p = 0.0001$).

Vascular RI Variations Before and 1 week After Lithotripsy

The mean vascular RI was RI-3 = 0.65 ± 0.07 1 week after lithotripsy. It was obtained from 22 patients participating in this stage. There was no meaningful relationship between it and RI related to before lithotripsy, that is, RI-1 = 0.63 ± 0.05 ($p > 0.05$).

Vascular RI Variations in Younger-than-60-years Patients

There were 47 patients in this study who were younger than 60 years. The mean renal vascular RI before lithotripsy was calculated as RI-1 = 0.61 ± 0.05 for this group. Renal vascular RI immediately after lithotripsy was RI-2 = 0.65 ± 0.06. It showed a significant increase ($p = 0.001$). There was not any meaningful difference between renal vascular RI before and 1 week after lithotripsy in 19 patients referred to 1 week later ($p > 0.05$). The calculated mean vascular index was as follows: RI-1 = 0.63 ± 0.05 and RI-3 = 0.64 ± 0.06.

Table 1. Vascular resistive index level measured in patients with calculus treated with ESWL.

	Number	Before ESWL	30 min after ESWL	p
Treated kidneys				
Patients younger than 60 years	47	0.61 ± 0.05	0.65 ± 0.06	0.0001
Patients older than 60 years	8	0.65 ± 0.04	0.71 ± 0.03	0.002

Note: ESWL, Extracorporeal shock wave lithotripsy.

Vascular RI Variations in Patients Older than 60 years

The mean vascular RI before and 30 min after lithotripsy was calculated as RI-1 = 0.65 ± 0.04 and RI-2 = 0.71 ± 0.03 for 8 patients constituting this group. It indicated a significant increase ($p = 0.002$). Out of these patients, 3 cases referred again 1 week later. The calculated vascular RI, that is, RI-3 = 0.76 ± 0.05, significantly increased in comparison with the index related to before lithotripsy, that is, RI-1 = 0.64 ± 0.03, ($p = 0.022$) (Table 1).

There was no relationship between renal vascular RI and patients' age ($p > 0.05$).

There was no relationship between age and renal vascular RI variations (the difference between vascular RI before and after lithotripsy) ($p > 0.05$).

RELATIONSHIP BETWEEN RENAL VASCULAR RI AND SHOCK POWER (KV)

There was no correlation between shock power and vascular RI variation before and after lithotripsy ($p > 0.05$). In fact, increasing shock power resulted in decrease of vascular RI difference before and after lithotripsy and a reverse relationship was observed in this regard.

Although increase of the number of shocks resulted in a trivial increase of the value, there was no relationship between the number of shocks of Siemens set and renal vessels RI variation before and after lithotripsy ($p > 0.05$). In this study, there was no significant relationship between gender and vascular RI variation before and after lithotripsy. Out of 22 patients who referred again after 1 week, 19 cases were younger than 60 years and renal vascular RI was less than 0.7 in 84.2% of these patients. It was equal to or higher than 0.7 in 15.8% of the cases. Also, there were 3 patients who were older than 60 years. The renal vascular RI was measured 1 week later and it was higher than 0.7. There was a meaningful relationship between age and renal vascular RI measured 1 week later ($p = 0.013$). Renal vascular RI was equal to or higher than 0.7 in 6 (27.3%) patients referred again 1 week later. It was less than 0.7 in 72.7% of the patients.

DISCUSSION

Although ESWL is a reliable and efficient way, some studies have referred to acute damages resulting from different techniques, including sonography, CT scan, MRI, radionuclide renography, and evaluating serum and urinary level of enzymes.[17,18]

Previous studies indicated parenchyma damage following lithotripsy. Vessels rupture, especially arched ones during lithotripsy, leads to in-between hematoma or hemorrhage.[19] In-between hemorrhage is found in all patients immediately after lithotripsy, which can be regarded as a cause of evident hematuria usually observed after lithotripsy. Hematoma is seen in about 0.2% of patients after lithotripsy. Chronic inflammation and cellular inflammation result in topical fibrosis and can be considered as a cause of hypertension in the long term.[20] Renal vessels damage is a basis to increase of vascular resistance and decrease of complete recovery. The conditions act as rennin–angiotensin system activator and result in hypertension following lithotripsy.[21] It has been proved that vascular RI is used as a device to evaluate vascular diseases and renal tubulointerstitial. The index is widely used in the diagnosis of intrarenal edema created in transplantation repel, acute tubular necrosis, and obstructive pyelocaliectasis. Vascular RI was higher than 0.7 in all these conditions.[22] Previously conducted studies have referred to the relationship found between vascular RI and hypertension following lithotripsy.[23] In this study, we tried to determine the relationship between vascular RI variations and age, shock power, and number of shocks. In this study, vascular RI significantly changes before and after lithotripsy. In the study of Shouman et al., vascular RI increased from 0.65 ± 0.053 (before lithotripsy) to 0.68 ± 0.053 in 70 patients ($p < 0.0001$).[24] Also, the measured vascular RI was separately evaluated in two age groups and it was concluded that the vascular RI level of younger-than-60-years patients meaningfully increased after lithotripsy. It was true about those patients who were older than 60 years, except that the mean measured vascular RI in older-than-60-years patients was higher than that of the younger patients. However, there was no relationship between primary vascular RI level and the patients' age. It can be attributed to earlier diseases of the patients. In a previous study, Aoki et al. did not refer to any relationship between age and renal vascular RI level before and after lithotripsy. They concluded that the primary vascular RI level of older-than-60-years patients was higher than that of the younger patients ($p = 0.0047$). Although the vascular RI level of younger-than-60-years patients after lithotripsy significantly increased in comparison with its primary level, the vascular RI level was higher than 0.7 (vascular RI after lithotripsy) only in

9 patients (23% of younger-than-60-years patients).[25] In our study, the vascular RI level after lithotripsy was higher than 0.7 in 13 patients (27.6% of younger-than-60-years patients). It indicates a pathologic value that can be attributed to equal non-tolerance of the same amount of energy by individuals with different conditions, including elasticity of kidney tissue and renal vessels sclerosis. In this study, there was no meaningful relationship between vascular RI variations (the difference between vascular RI before and after lithotripsy) and age. This was inconsistent with the Knapp et al. study, in which the Dornier HM5 lithotripsy machine was used and then renal vascular RI was measured before and 3 h after lithotripsy. They indicated that the relationship was linear.[26] It can be justified as follows: (a) applying different lithoclast sets in these three studies, (b) the difference found between these three studies considering treatment method, number, and power of shocks, and (c) different measurement times of vascular RI in these studies. Nazaroglu et al. demonstrated that there was no meaningful relationship between the applied energy and increase of vascular RI.[27] In our study, no relationship was found between shock power and vascular RI variations (the difference between vascular RI before and after lithotripsy). Our study found a meaningful relationship between age and vascular RI measured after 1 week. This relationship was not evaluated in other studies.

CONCLUSION

ESWL leads to an immediate increase in renal vessel RI in all patients. Also, vascular RI measured 1 week after lithotripsy is averagely higher than the primary rate. Vascular RI has a predictive value about the complications of lithotripsy. The capability of vascular RI whose measurement is a noninvasive method and serves as an alternative for many imaging techniques has been approved in demonstrating vascular damages and tubulointerstitial. It is regarded a sensitive device in this regard. Measuring vascular RI using Doppler set may provide useful information in this regard.

***Declaration of interest*:** The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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