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Effects of stone density on alteration in renal resistive index after extracorporeal shock wave lithotripsy for non-obstructed kidney stones

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ABSTRACT

Aim: The doppler-based renal resistive index is a recently proposed technique for measuring changes in renal perfusion and predicting acute kidney damage. The purpose of this study was to look at the influence of stone density on the renal resistive index (RI) after extracorporeal shock wave lithotripsy (ESWL) in patients with non-obstructed kidney stones.

Material and Method: Between May 2020 and July 2021, 48 consecutive patients with unilateral renal calculi of ≤ 20 mm were treated with ESWL monotherapy. The patients' non-contrast computed tomography (NCCT) images were processed and grouped into two groups using Hounsfield units (HU) (Group 1, n=27, ≤ 1000 HU; Group 2, n=21, > 1000 HU). The same radiologist performed Doppler ultrasonography on all cases before, one hour, and one week following ESWL. Measurement of the RI taken in the remote region (at least 20 mm from the stones). Patient age, gender, BMI, stone laterality, stone size, and stone position were investigated as potential predictors.

Results: The average stone size for Group 1 was 11.7±3.3 mm and 12.1±2.8 mm for Group 2. The mean RI values before ESWL for Group 1 and Group 2 were 0.54 and 0.53, respectively. On comparing the pre-treatment data with the 1 hour after ESWL, a statistically significant increase was recorded in the RI value for both groups. However, there was no significant difference in RI values between groups 1 and 2 1 hour and 1 week following lithotripsy therapy. After one week, the mean RI returned to pretreatment levels, according to a follow-up doppler investigation. There was no association between stone density and RI ($p > 0.05$).

Conclusion: High stone densities detected with NCCT were not associated with a significant change in RI. Post-ESWL therapy alterations are present and reversible one week after the treatment.

Keywords: Resistive index, stone, kidney

INTRODUCTION

Urinary stones are one of the most frequent urological disorders, affecting millions of people globally and putting a substantial strain on the healthcare system. Extracorporeal shock wave lithotripsy (ESWL) is a well-established minimally invasive therapy for stones in the upper urinary system (1). It employs an extracorporeal lithotripter to repeatedly target and generate shock waves to break up the stones and pass through the urine. The global SARS-COV-2 pandemic may promote ESWL use since it does not require general anesthesia and so avoids its potential repercussions in COVID-19 patients (2).

Although radiological imaging is effective at locating the kidney stone, there can still be localized problems with ESWL. The main vascular hemorrhage is the most common ESWL-related damage (3, 4). After ESWL, 29% of patients developed renal hematomas, which was initially expected to be 1% (5-7).

Renal trauma also triggers an inflammatory response, leading to tissue remodeling and scar tissue formation (7). According to research, canine subjects undergoing ESWL experienced dose-dependent renal fibrosis (8). Renal tissue fibrosis can result in a loss of function in

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the affected area, either partially or completely. The resistive index (RI) is a non-invasive approach for assessing changes in renal vascular resistance caused by vascular compliance (9). The RI, which is independent of transducer angle and position and determines the ratio of peak systolic velocity (PSV) to end-diastolic velocity (EDV) in peripheral vessels (RI=(PSV - EDV)/PSV), enables accurate and repeatable measurements (10). Because the RI is evaluated at an artery in the renal parenchyma, it is raised in tubulointerstitial or vascular disorders.

It has been reported that one of the factors affecting the success of ESWL is the average stone density. Stone density >1000 Hounsfield unit (HU) was accepted as predictive for ESWL failure (11). To our knowledge, there are not enough studies in the literature evaluating the relationship between the mean stone index and the resistive index formed after ESWL. Therefore, this study aimed to determine whether there was a correlation between changes in stone density and RI levels in patients receiving ESWL for the treatment of kidney stones.

MATERIAL AND METHOD

The study was carried out with the permission of Fırat University Non-interventional Clinical Researches Ethics Committee (Date: 26.05.2022, Decision No: 2022/07-40). Data from 48 patients who had ESWL for kidney stones between May 2020 and July 2021 were evaluated retrospectively. All procedures were carried out by the ethical rules and the principles of the Declaration of Helsinki. The patient's age, gender, stone dimension, HU, and stone positions were all analyzed. Stones were determined by computed tomography before treatment. According to their HU, patients were classified into two groups (HU) (Group 1; 1≤ 1000 HU, Group 2; > 1000 HU). The study included total patients with normal renal functioning and no hydronephrosis. Patients with ureteral stones, hypertension, parenchymal disease, urinary system infections, diabetes, renal masses, or a record of kidney operation were excluded from the study. Patients were examined on the 1 hour and 7th days after the ESWL process. The RI is a modern, non-invasive diagnostic tool for assessing circulatory system alterations. The benefit of the RI is that it is not impacted by the doppler angle.

Extracorporeal Shock Wave Lithotripsy Procedure

ESWL was performed with an EMD E-1000 electro-hydraulic lithotripter. The device includes X-ray fluoroscopic focus systems. The patients received one to four (mean: 1.65) sessions of ESWL. The mean number of shocks per patient was 1000 to 2000, with shock severity ranging from 10 to 20 kV. (mean, 16 kV).

Doppler Assessment of Kidneys

All US examinations were performed separately by the same radiologist before, one hour after, and one week after ESWL procedures. The ultrasonograph EsoateMyLab 70 was used to assess intrarenal blood vessels using doppler. Each kidney was evaluated in three projections: superior, middle, and inferior. Doppler tests used a pulse wave method with a convex-type head. In all measurements, the Doppler angle was less than 60 degrees. The flow spectrum in the renal interlobular arteries the RI was calculated. In enrolled patients, the flow in the interlobular arteries of the ipsilateral kidney was measured.

Statistical Analyses

In both groups, the paired t-test, a parametric test, was employed to compare RI values one hour and one week after ESWL to pre-ESWL values. The RI values for the two groups were contrasted using the Mann-Whitney U-test. The outcomes are displayed as means SD.

RESULTS

We included 10 (20.8%) women and 38 (79.1%) men in the study. Group 1 (4 women, 17 men) had a mean age of 42.9±13.7, a mean stone size of 11.5±3.35 mm, 2580±1414 (1000-4500) shocks, and a mean number of sessions of 2.1±0.8. In Group 2 (6 women, 21 men), the mean age was 44.3±9.8, the stone size was 12.1±2.8 mm, the number of shocks was 2375±1103 (1200-3750) and the number of treatments was 2.3±0.6. The stones were anatomically placed in the upper calyx (20), mid-calyx (19), and inferior calyx (9). Evaluation of the success rates after 1 month did show that patients in group 1 had a higher rate of stone-free status when compared with group 2 (87.4 vs 67.1%, p=0.043). There were no significant differences in process amount, pre-ESWL RI value, and sessions between groups 1 and 2 (p=0.886).

The mean RI value for Group 1 (0.54±0.13 to 0.64±0.18) and Group 2 (0.53 ±0.11 to 0.66±0.19) significantly increased 1 hour after ESWL treatment. One hour after the RI value, there are no significant differences in Group 1 compared with Group 2 (p=0.93), (**Figure 1**). Although both groups had a significant increase in the RI after the ESWL there is no difference in RI values at 1 week after ESWL between groups (p= 0.92). In both groups, the 1-week ESWL RI values were considerably lower than the 1-hour values. Furthermore, no statistically significant difference in RI values was seen before and after ESWL (**Table**).

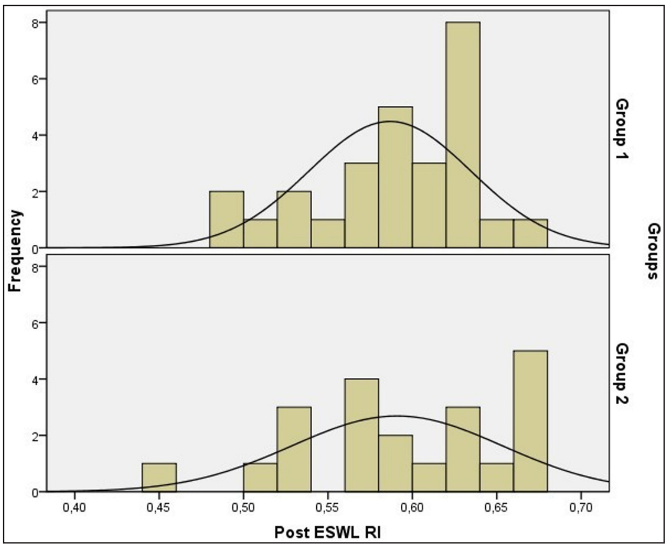

Figure. The number of cases that showed Resistive Index changes before and 1 hour after Extracorporeal shock wave lithotripsy

Table. Comparison of demographic characteristics and renal resistive index changes of study groups

Variables	Groups	Mean	Std. Deviation	Std. Error Mean	P value
Age (years)	Group 1	42.96	13.7	2.63	0.643
	Group 2	44.33	9.81	2.14	
Height (cm)	Group 1	171	8.17	1.57	0.974
	Group 2	170.23	10.21	2.23	
Weight (kg)	Group 1	82.14	10.03	1.93	0.735
	Group 2	85.38	7.32	1.59	
Stone diameter (mm)	Group 1	11.73	3.35	0.64	0.854
	Group 2	12.19	2.8	0.61	
Stone density (HU)	Group 1	643.48	193.81	37.3	**<0.001**
	Group 2	1217	152.71	33.32	
ESWL session (n)	Group 1	2.1	0.8	0.14	0.131
	Group 2	2.3	0.6	0.08	
Pre ESWL RI	Group 1	0.54	0.13	0.1	0.886
	Group 2	0.53	0.11	0.11	
Post ESWL 1-hour RI	Group 1	0.64	0.18	0.11	0.935
	Group 2	0.66	0.19	0.13	
Post ESWL 1 week RI	Group 1	0.58	0.18	0.009	0.928
	Group 2	0.59	0.12	0.136	

The significance of the differences in the values before and after ESWL was evaluated with the help of the Student's paired t-test. ESWL – Extracorporeal shock wave lithotripsy, RRI – Renal resistive index, HU – Hounsfield Unit,

DISCUSSION

European Association of Urology Guidelines recommends ESWL or endourology treatments for stones less than 2 cm as first-line therapy. Even though ESWL is a safe and effective treatment for kidney stones, it might induce problems because shock waves can damage the renal parenchyma (12). Several studies have been conducted to study the morphologic and functional alterations that occur due to ESWL, as well as the underlying causes and potential protective measures. It is thought that the change in RI after ESWL is due to cellular infiltration and edema occurring around the peripheral branches of the renal artery and swelling of the perivascular tissue, which in turn causes an increase in vascular resistance (13). Most investigators have found that these changes resolve rapidly. RI is a non-invasive method that can be used to evaluate changes in renal vascular resistance caused by vascular compliance after ESWL.

According to Derchi et al. (14), although the increase in RI values in calyx stones was not statistically significant 1 hour after ESWL, it decreased to the pre-ESWL level. Knapp et al. (15) suggested utilizing color doppler ultrasonography as a non-invasive approach for determining changes in renal vascularisation after ESWL. They reported an increase in RI, particularly among the elderly (those over the age of 60). Similarly, Janetschek et al. (16) (Age groups: <40 years, 40–59 years, and >60 years) found that RI values were significantly higher in the region around the stone within 3 hours after the ESWL procedure in the third group, but this was not observed in the first two groups. It was thought that this condition developed due to sclerosis of the renal vessels and loss of elasticity. It has been stated that due to the low tolerance of elderly patients, changes related to the same amount of energy may be greater than in younger patients. Nazaroglu et al. (17) found a transient increase in RI in both kidneys within hours after the procedure in patients undergoing ESWL for kidney stones. They stated that this increase was highest in the vicinity of the stone and that it was the least in the healthy kidney and returned to normal values within 2 weeks.

As evaluated by HU on CT, stone density has been examined as a possible predictor of treatment effects in various ways. Indeed, stone density >1000 HU on CT was accepted as a predictor for ESWL failure (17). However, to date, no study has evaluated the relationship between stone density and RI changes. Our findings revealed that there is no relationship between RI alterations and stone density. The current investigation shows a transient increase in RI values in the treated kidney after ESWL. Within a week, RI levels in the surrounding area revert to normal. A comparison of the findings with those of other studies confirms that ESWL therapy did not affect RI value in the long term. Because some studies have indicated that untreated kidneys had no substantial RI alterations, we did not plan to measure RI in the contralateral untreated kidney (18).

The most significant drawback of our study was the small number of patients included in subgroup comparisons. We could attain more solid findings by splitting the cases into density groups and stone site subgroups if we had access to a large enough number of patients. Secondly, renal tissue changes following ESWL were not histopathologically verified.

CONCLUSION

In our study, the stone density implication of RI changes induced by electro-hydraulic lithotripter remains to be answered. However, the clinical significance of our findings should be investigated further.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Fırat University Non-interventional Clinical Researches Ethics Committee (Date: 26.05.2022, Decision No: 2022/07-40).

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The author has no conflicts of interest to declare.

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