

# Changes in Intrarenal Resistive Index Following Electromagnetic Extracorporeal Shock Wave Lithotripsy

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**Introduction:** Our aim was to study the changes in resistive index (RI) of the ipsilateral and contralateral kidneys following electromagnetic extracorporeal shock wave lithotripsy (SWL) of the kidney calculi.

**Materials and Methods:** Using color Doppler ultrasonography, the RI was determined in 21 patients with unilateral caliceal and pelvic kidney calculi. The RI of the interlobar renal arteries were measured for the regions near and far from the calculi (distance, less and more than 2 cm), before, 30 minutes after, and 1 week after SWL. The same measurements were carried out for the contralateral kidney. Changes in the RI values and their relation with age were evaluated.

**Results:** The RI near the calculi increased 30 minutes after SWL from  $0.594 \pm 0.062$  to  $0.620 \pm 0.048$  ( $P = .003$ ; 95% confidence interval, 0.020 to 0.073), but returned to the pre-SWL values 1 week later. The RI values of the region remote from the calculus and in the contralateral kidney did not change significantly. There was a weak correlation between age and the RI far from the calculus before and 1 week after SWL. There were no relationships between the RI and age, sex, weight, blood pressure, and smoking.

**Conclusion:** The results suggest that SWL of the kidney calculi changes the RI only near the calculus which is immediate, transient, and not age-related.

Keywords: lithotripsy, kidney calculi, vascular resistance, ultrasonography

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## INTRODUCTION

Extracorporeal shock wave lithotripsy (SWL) is a commonly used procedure in urology. However, despite its widespread use, some of its effects and complications are still unknown, one of them being changes in renal blood flow.<sup>(1,2)</sup> The decrease in the renal blood flow is important, because it may cause kidney failure after SWL, especially in patients with a single kidney.<sup>(3,4)</sup> Resistive index (RI), which is measured by color Doppler ultrasonography (CDU), reflects resistance of intrarenal arteries that indirectly shows the renal blood flow.<sup>(5,6)</sup> Some researchers have tried

to follow the changes in the RI after SWL, but there are still controversies about the pattern and timeline of RI changes,<sup>(2-5,7-10)</sup> and no study has used electromagnetic generator. Although most studies reported that the intrarenal RI increased immediately after SWL, which returned to the pre-SWL levels one week later, what happens to the contralateral kidney has remained unclear. In this study, we investigated the changes in intrarenal RI following electromagnetic SWL in the ipsilateral (nearby and remote from the calculus) and contralateral kidney and also looked for the age-related differences.

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## MATERIALS AND METHODS

This study was approved by ethics committee of Tehran University of Medical Sciences and the patients provided informed consent. Between January 2005 and January 2007, patients with unilateral kidney calculi who had been referred to our SWL unit were enrolled in the study. History, physical examination, laboratory data, and imaging characteristics of the patients were recorded. Those with 2-cm or smaller kidney calculi in either the renal pelvis or the calyces, and those with 1-cm or smaller lower caliceal calculi were included. Patients with diabetes mellitus, hypertension, renal parenchymal disease, hydronephrosis, abnormal corticomedullary echo, and kidney failure were excluded. Patients taking vasopressor drugs during the past 30 days were excluded, as well. Strict adherence to the inclusion and exclusion criteria was made; therefore, even patients with mild hydronephrosis did not enter the study.

Before the SWL, we measured the RI of the interlobar arteries using CDU (Dynaview II, SSD-1700, Aloka, Tokyo, Japan). The RI was calculated as (peak systolic velocity - peak end diastolic velocity)/peak systolic velocity.<sup>(4)</sup> The measurements were done in 2 regions of the ipsilateral kidneys: near the calculus (in 2-cm distance or less, *nearby region*) and far from the calculus (farer than 2 cm, *remote region*). The RI was also determined in the contralateral kidney. In each area, at least 3 measurements were done and the algebraic means of the values were calculated as the RI. Lithotripsy was done by SWL (Dornier Medical Systems, Marietta, Georgia). Our protocol was to use at least 3000 shock waves with increasing voltage to 19 kV, unless the patient could not tolerate the pain or the clinical condition imposed limitations. Thereafter, at least 30 minutes after the SWL, we repeated CDU and measurement of the RI in the aforementioned areas. The follow-up visits of the patients were arranged for 1 week after the procedure and the RI of the ipsilateral and contralateral kidney was measured for the third time. All of the

RI measurements were done by 1 experienced radiologist.

The collected data were analyzed using the paired *t* test for comparison of the pre-SWL and post-SWL values of the RI, independent-sample *t* test for comparison of the RI values between men and women, the Pearson correlation test for evaluation of the relation between the RI and the clinical and demographic parameters, and the Kolmogorov-Smirnov test for examination of data distributions.

## RESULTS

We studied on 21 patients who underwent SWL at our center. The median age of the patients was 46.5 (range, 24 to 71 years) and they were 13 men (61.9%) and 8 women (38.1%). Their mean body weight was  $69.1 \pm 10.5$  kg. The calculi were located in the upper, middle, and lower calyces in 3 (14.3%), 2 (9.7%), and 9 (42.8%) of the patients, respectively, and 7 (33.4%) had calculi in the renal pelvis. The median calculus size was 12.6 mm. The clinical and SWL parameters are shown in Table 1. Serum creatinine level did not increase after the SWL.

In the contralateral kidney, the RIs remained steady after SWL, while in the ipsilateral kidney, the RIs measured near and far from the calculus had a slight increase immediately after SWL, which returned to their pre-SWL values 1 week after the procedures. These values had normal distributions and were demonstrated as mean  $\pm$  standard deviation (Table 2).

**Table 1.** Characteristics of Shock Wave Lithotripsy (SWL) and Clinical Parameters

| Variable                                | Median Value |
|-----------------------------------------|--------------|
| Number of shock waves                   | 3290         |
| Shock wave voltage, kV                  | 18.73        |
| Total energy, kV                        | 57000        |
| Pre-SWL systolic blood pressure, mm Hg  | 118          |
| Pre-SWL diastolic blood pressure, mm Hg | 70           |
| Pre-SWL serum creatinine, mg/dL         | 1.10         |
| Post-SWL serum creatinine, mg/dL        | 1.10         |

**Table 2.** Mean RI Values Before, 30 Minutes After, and 1 Week After Shock Wave Lithotripsy (SWL)

| Location of RI           | Time of RI        |                      |                   |
|--------------------------|-------------------|----------------------|-------------------|
|                          | Before SWL        | 30 Minutes After SWL | 1 Week After SWL  |
| Nearby the calculus      | $0.594 \pm 0.062$ | $0.620 \pm 0.048$    | $0.594 \pm 0.061$ |
| Remote from the calculus | $0.590 \pm 0.056$ | $0.621 \pm 0.068$    | $0.595 \pm 0.069$ |
| Contralateral Kidney     | $0.597 \pm 0.065$ | $0.582 \pm 0.040$    | $0.582 \pm 0.061$ |

No significant difference was detected in the RIs between the men and the women. Only the RIs nearby the calculus before and immediately after SWL were significantly different with the post-SWL being higher ( $P = .003$ ; 95% confidence interval, 0.020 to 0.073). There were weak correlations between the age and the RI remote from the calculus before and 1 week after SWL ( $r = 0.03$  and  $r = 0.02$ , respectively). There were no significant correlations between age and RI in other areas or between the RI and weight, systolic and diastolic blood pressures, numbers of the shocks, voltage of the shock wave, and total energy applied.

## DISCUSSION

Shock wave lithotripsy is a commonly used procedure for the treatment of urinary calculi. Although it is noninvasive and a safe option, complications do occur after SWL.<sup>(7,8)</sup> These are conveniently grouped under structural and functional injuries. Structurally, SWL can cause renal hematoma and contusions, like other renal traumas.<sup>(8,9)</sup> From the functional perspective, SWL has the potential of causing or aggravating kidney failure.<sup>(10-12)</sup> This is, at least, in part due to vasoconstriction and reduction in renal blood flow. This complication can be monitored by measuring the RI of the intrarenal arteries using CDU.

There are some published studies that followed the RI after SWL, but our study is the first in using the electromagnetic lithotripter. Electromagnetic lithotripters have small focal points relative to electrohydrolic and piezoelectric lithotripters, which are responsible for greater risk of subcapsular hematoma formation in the former.<sup>(13,14)</sup> Also, the pattern and timeline of RI values are controversial, as is its correlation with age.

Beduk and colleagues<sup>(2)</sup> used Dornier MPL 9000 (electrohydrolic generator) to perform SWL and found no significant changes in RI of the treated kidney 24 hours after the procedure. Earlier measurements showed increased RI in other studies; Kataoka and coworkers<sup>(3)</sup> treated 23 patients with Dornier MPL 9000. They made measurements immediately after SWL and found a significant increase in the treated kidneys immediately after SWL. Measurement of the RI 3 hours after SWL with electrohydrolic lithotripter demonstrated similar

age-related results.<sup>(4)</sup> Aoki and associates<sup>(5)</sup> measured the RI 30 minutes and 1 week after SWL with EDAP LT-01 (piezoelectric generator) in 70 patients. A significant increase was noted in the treated kidneys which was not age-related. The authors also reported the RIs in the contralateral kidneys indicating significant increases in elderly patients. In other studies, no significant changes in the contralateral kidneys were reported.<sup>(3,4)</sup>

Using a Nova lithotripter (electrohydrolic generator), Nazaroğlu and colleagues<sup>(6)</sup> measured RI before, 30 minutes, 3 hour, and 2 weeks after SWL in the nearby and remote regions of the ipsilateral and contralateral kidneys in 43 patients (30 with kidney calculi). In patients with kidney calculi, the RI increased 30 minutes and 3 hours after SWL in the nearby and remote regions, and more markedly in the former. In the contralateral kidney, there was an increase in the RI only at 3 hours, which was less than the ipsilateral kidney. The RI at 2 weeks post-SWL in the nearby region and the contralateral kidney did not differ from the pre-SWL values. In our study, the RI increased in the nearby region immediately and returned to the pre-SWL levels 1 week after SWL. This was in accordance with the results of the previous studies.<sup>(3-5)</sup> However, we have not seen the RI changes in the remote region as Nazaroğlu and colleagues noted.<sup>(6)</sup> Also, the RI did not increase in the contralateral kidneys as other researchers stated.<sup>(5,6)</sup>

Although some weak correlations existed between the RI in the remote region and age, we did not find age-related changes as Knapp and coworkers found.<sup>(4)</sup> Our study cohort was relatively young and this may be why we had no strong age-related changes. Overall, our results agree with those of Kataoka and colleagues.<sup>(3)</sup> These differences may be due to small focal point inherent to electromagnetic lithotripters, so that the RI changes occur only in the nearby region which is the focus of SWL. Also, lack of correlations between the RI and weight, sex, blood pressure, and shock wave characteristic may point to independent mechanism of shock-wave-induced injuries. We propose that monitoring the changes in the RI after SWL may be useful for investigating the protective and prophylactic effects of the drugs (eg, sympatholytics or diuretics) to reduce post-SWL renal injuries and kidney failure, especially in patients with a single kidney.

## CONCLUSION

We showed that after electromagnetic SWL of the kidney calculi, intrarenal RI value increases in the vicinity of the calculus immediately, but it returns to the pre-SWL values 1 week later. This response is unrelated to the age and does not occur remote from the calculus or in the contralateral kidney.

## CONFLICT OF INTEREST

None declared.

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