# Effects of Extracorporeal Shockwave Lithotripsy on Renal Vasculature and Renal Resistive Index (RI)

**Mustafa Hiros, Mirsad Selimovic, Hajrudin Spahovic, Sabina Sadovic**
**Urology Clinic, Clinical Center University Sarajevo, Bosnia and Herzegovina**

ORIGINAL PAPER
SUMMARY
Objective: It is known that ESWL can promote acute renal injuries and long–term complications of renal vasculature. Effects on renal vasculature can be evaluated by color Doppler ultrasonography measuring renal resistive index (RI). This prospective study aimed to determine the influence of number of delivered SW-s, used kV and changes in renal resistive index. Patients and Methods: Total of 60 normotensive patients, 38 males (63%) and 22 females (37%), with renal stones 6-18 mm in size were included in this study. Median age was 42.3 years (range 22-55). RI was measured at interlobar artery before, 1, 3, 5 and 30 days after treatment on treated and contra lateral non-treated kidney. Patients were divided in two groups: Group I (N=25) received 2000SWs; 0-2 units; (0,5 unit each 500SWs) Group II (N=35) received 4000SWs, 0-4 units; (0,5 unit each 500SWs). Results: In treated kidneys RI significantly increased first and second day after treatment from 0,62±0,05 at baseline to 0,67±0,05, p<0,001 at first and 0,66±0,05, p<0,007 on the second day after treatment. Increase of RI seven days after treatment is not significant (0,62±0,05). The contra lateral, non-treated kidney showed significant changes in RI only first day after treatment (0,64±0,05), p<0,01. One month after the treatment RI is on normal values in both kidneys. Conclusions: Resistive index -RI is important parameter in evaluation of renal vasculature. Patients treated by ESWL showed a temporary increase in RI two days after the treatment and only first day in contra lateral non-treated kidney - probably caused by release of substance with vasoconstriction properties (need further investigations).

**Keywords:** **extracorporeal shock-wave lithotripsy, renal stones, color Doppler ultrasonography, renal resistive index**

## 1. OBJECTIVES

Extracorporeal shock wave lithotripsy (ESWL) hase become a routine methode for treatement of upper urinary tract stone disease. It is effective and minimal invasive treatment for the most urinary stones, but also with significant acute renal injuries and long-term complications (1,2,3). At present, extracorporeal shock-wave lithotripsy (ESWL) is used in the treatment of 90% of all renal stones . Although its reliability and efficacy have been demonstrated, there are a number of studies concerning post-ESWL complications (4,5). However, major life-threatening complications are rare in either the early or late phase. Many techniques have been used to investigate the effects of ESWL on the kidneys, one of which involves measurement of the resistive index (RI) in the renal interlobar arteries using Doppler, a non-invasive diagnostic technique (6). In this study, colour Doppler ultrasonography was used to determine whether interlobar RI values were affected in patients treated with ESWL for renal stones.

## 2. MATERIALS AND METHODS

The study group comprised 60 normotensive patients 38 males(63%) and 22 females(37%) with renal stones size 6-18mm, who underwent ESWL. Their ages ranged from 22 to 55 years, with mean ages of 42,3 years. Stones were diagnosed by means of i.v. urography (IVU), X-ray and ultrasonography. Patients with normal kidney function on IVU and normal parenchyma echo on ultrasonography were included in the study. Patients with diabetes mellitus, renal parenchyma disease or urinary system infections were excluded. Patients with hypertension (diastolic blood pressure 90 mmHg and/or systolic blood pressure 140 mmHg) and patients receiving hypertensive therapy were also excluded. Among patients with renal stones (calyceal and pelvis renal stones), those with ecstasies in the collecting system were excluded. ESWL was performed using a Siemens Multiline lithotripter. The average number of shock waves per patient was 2000 to 4000 SW-s. The mean maximum 0 to 4 units (energy steps loaded in kV, voltage was 21.6 kV (range 19–22 kV). Colour Doppler examinations were performed on a Siemens Sonoline G40 using a 3.75-MHz convex transducer. In the study group, measurements were made in the renal interlobar arteries before, first, second, seventh and thirty days after ESWL. For renal stones, measurements were made in the vicinity of the stones (nearby region), at a distance of at least 2 cm from the stones (remote region) and in the contra lateral kidney. Measurements were made when three similar waves were registered sequentially. Measurements were repeated three times for each region, and the RI value recorded for each region was the arithmetic mean of these three measurements. Vascular resistance was determined at an artery of renal parenchyma with the help of pulsed wave Doppler ultrasound. To eliminate the problem of angle correction the RI was calculated by the equation: (systolic peak velocity-end diastolic peak velocity) / systolic peak velocity.

The paired *t*-test, a parametric test, was used to compare RI values at 1,2,7 days and 30 days post-ESWL with pre-ESWL values in the renal stones group. The paired *t*-test was also used to compare RI values in the nearby and remote regions with those in the contra lateral kidney for the pre-ESWL measurement and both post-ESWL measurements.

## 3. RESULTS

Mean blood pressure in patients with renal stones was 118/79 mmHg before and 124/83 mmHg after ESWL. No significant changes were found between

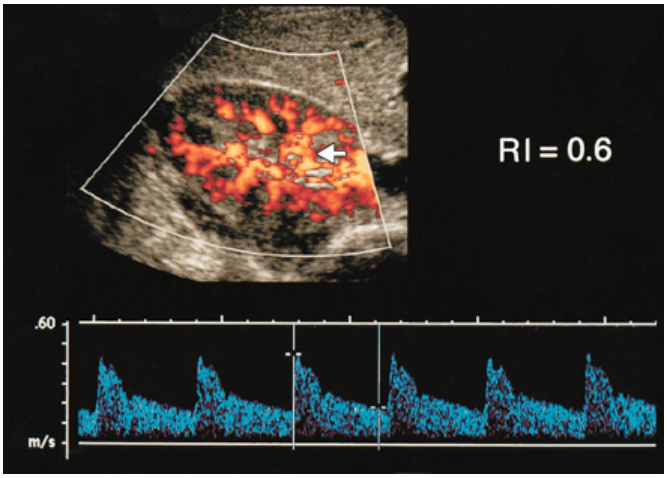


**Figure 1.** Calculation of renal resistive index (RI) A peak systolic velocity; B peak end diastolic velocity. RI=(A-B)/A

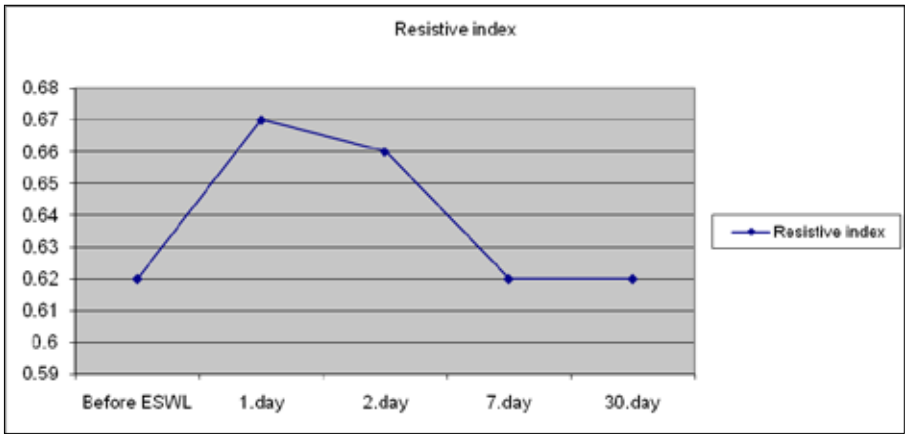


**FIGURE 2.** Changes in resistive index (RI) in treated kidney. (Data were presented by mean ±SD 0,005)

pre- and post-ESWL means blood pressures. No correlation was found between mean maximum voltage or average number of shock waves and changes in RI at 1, 2,7days and 30 days post-ESWL. In patients with renal stones, RI (mean kidney before ESWL, there were, however, significant differences 1 day and 2 day after ESWL. There was also a significant difference 1 day after ESWL between RI values in the contra lateral kidney. RI was measured in all patients with

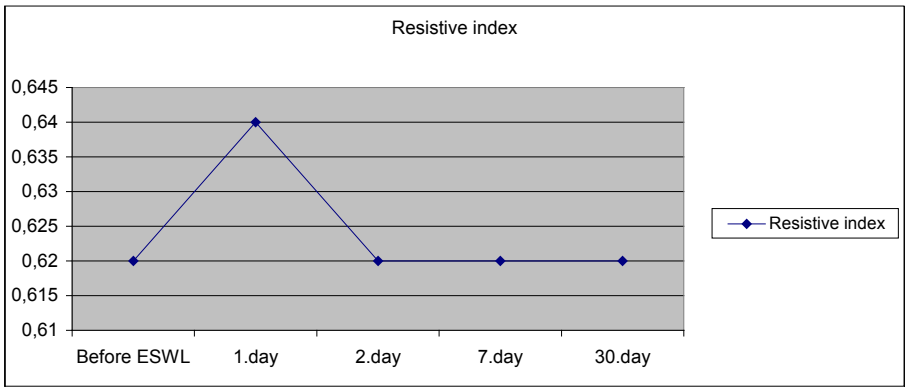


**FIGURE 3.** Changes in resistive index (RI) in contra lateral-not treated kidney. (Data were presented by mean ±SD 0,005)

±SD) in the nearby region was 0.62 ± 0.05 before ESWL, increasing to 0.67 ± 0.05 at 1 day; to 0.66 ± 0.05 at 2 day and to 0,62 ± 0.05 at 7 day post-ESWL. Both post-ESWL values first and second day were significantly different from the pre-ESWL values ($p$ =0.001). RI was at base line 30days after ESWL 0,62 ± 0,05. There was an increase in RI after ESWL in the contra lateral kidney. This difference was significant at first day after ESWL 0,64 ± 0,05.

Differences between pre- and post-ESWL values in the contra lateral kidney are shown in Fig.4. There were no significant differences between RI in the nearby or remote regions and in the contra lateral renal stones 30 days after ESWL. There were no statistically significant differences between RI values in the nearby or remote regions and those in the contra lateral kidney either before or 30 days after ESWL. RI values in the nearby region and contra lateral kidney 1, 2 and 7 days after ESWL did not differ significantly from those before ESWL. However, values recorded in the remote region 1 week after ESWL were not significantly higher than those recorded before ESWL.

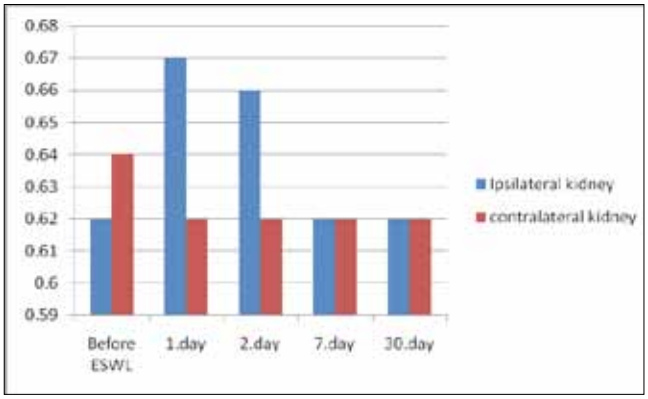


**FIGURE 4.** Sequent changes in RI in ipsilateral and contra lateral kidney

There was also no statistically significant difference in the contra lateral kidney between pre-ESWL and 2,7 and 30 days post-ESWL values ($p$ > 0.05), but there was a significant difference between pre-ESWL and 1 day post- ESWL values 0,64 ± 0,05. No significant difference in RI values was determined in the ipsilateral and contra lateral kidneys before and 2,7 days and 30 days after the ESWL procedure in patients with renal stones ($p$ > 0.05). RI was measured in all patients with renal stones 30 days after ESWL; there was no statistically significant difference between these values and pre-ESWL values in either the ipsilateral or contra lateral kidney.

## 4. DISCUSSION

The safety and efficacy of ESWL has been proved by a number of studies investigating acute renal injuries from ESWL by various techniques (7,8,9,10). ESWL has been used since the 1980s for the treatment of urolithiasis, and its efficacy and reliability have been established. A number of methods have been used to investigate post-ESWL changes in the kidney, including IVU, ultrasonography, CT, MRI, radionucleide renography and serum and urine analyses. Although complications necessitating surgery, such as hematoma, are rare, MRI studies have revealed post-ESWL change rates as high as 74%. In studies of the effects of ESWL on renal RI using Doppler ultrasonography, a non-invasive method, measurements have been made at different times post-ESWL (11,12,13).

The present study demonstrated that the RI of treated kidneys significantly increased after ESWL. As result of cellular infiltration and oedema formed around the peripheral branches of renal arteries, perivascular tissue thickening may occur and vascular resistance may therefore increase (14,15).

In the present study, we found increased RI values at least 2 cm from the stones at 1 day and 2 day post-ESWL on ipsilateral kidney and 1.day on contra lateral kidney. Interestingly, although there was no difference between pre-ESWL and 7 days and 30 days post-ESWL values in the nearby region and the contra lateral kidney.

## 5. CONCLUSION

The RI has proved to be a sensitive tool for monitoring vascular and tubulointestinals diseases of the kidney. It is widely used to detect intrarenal oedema, which occurs transplant rejection, acute tubular necrosis and obstructive pyelocaliectasis. In all conditions RI levels greater than 0,7 are considered to indicate pathologic change.

In conclusion, there is a temporary increase in RI values in the first and second day following ESWL in the ipsilateral kidneys, which is most marked in the region near the renal stones. RI in contra lateral kidney is most market first day following ESWL. RI values return to normal within 7 day and 30 day after ESWL in ipsilatreal kidney and for contra lateral kidney RI values returns to base line 2 day post ESWL. ESWL did not indicate pathological RI changes in treated and non treated kidney.

## REFERENCES


1. Aoki Y, Ishitoya S, Okubo K, et al. Changes in resistive index following extracorporeal shock wave lithotripsy. Int J Urol, 1999;6:483-92.
2. Villanyi KK, Szekely JG, Farkas LM, et al. Short-term changes in renal function after extracorporeal shock wave lithotripsy in children. J Urol, 2001;166:222-4.
3. Karlsen SJ, Berg KJ. Acute changes in kidney function following extracorporeal shock wave lithotripsy for renal stones. Br J Urol, 1991;67:241-5.
4. Knapp PM, Kulb TB, Lingeman JE, et al. Extracorporeal shock wave lithotripsy-induced perirenal hematomas. J Urol, 1988;139:700-3.
5. Knapp R, Frauscher F, Helweg G, et al. Age-related changes in resistive index following extracorporeal shock wave lithotripsy. J Urol 1995;154:955-8.
6. Ulrich JC, York JP, Koff SA. The renal vascular response to acutely elevated intrapelvic pressure: resistive index measurements in experimental urinary obstruction. J Urol, 1995;154:1202-4.
7. Williams CM, Kaude JV, Newman RC, et al. Extracorporeal shock-wave lithotripsy: long-term complications. AJR Am JRoentgenol, 1988;150:311-5.
8. Webb JA. Ultrasonography and Doppler studies in the diagnosis of renal obstruction. BJU Int,2000;86(Suppl 1):25-32.
9. Dodd GD, Kaufman PN, Bracken RB. Renal arterial duplex Doppler ultrasound in dogs with urinary obstruction. J Urol, 1991;145:644-6.
10. Willis LR, Evan AP, Connors BA, et al. Relationship between kidney size, renal injury, and renal impairment induced by shock wave lithotripsy. J Am Soc Nephrol, 1999;10:1753-62.
11. Beduk Y, Erden I, Gogus O, et al. Evaluation of renal morphology and vascular function by color flow Doppler sonography immediately after extracorporeal shock wave lithotripsy. J Endourol, 1993;7:457-60.
12. Newman R, Hackett R, Senior D, et al. Pathologic effects of ESWL on canine renal tissue. Urology, 1987;29:194-200.
13. Nazaroglu H, Akay A. Ferruh, Bükte Yasar, Sahin Hayrettin et all. Scandinavian journal of urology and nephrology 2003, vol. 37. 408-2.
14. Karadeniz T, Topsakal M, Eksioglu A, et al. Renal hemodynamics in patients with obstructive uropathy evaluated by color Doppler sonography. Eur Urol, 1996;29:298-301.
15. Kaude JV, Williams CM, Millner MR, et al. Renal morphology and function immediately after extracorporeal shock-wave lithotripsy. AJR Am J Roentgenol, 1985;145:305-13.
16. Shokeir AA, Nijman RJ, el-Azab M, et al. Partial ureteral obstruction: role of renal resistive index in stages of obstruction and release. Urology, 1997;49:528-35.


**Corresponding author: Ass prof Mustafa Hiros, MD, PhD. Urology clinic. Clinical center of Sarajevo University. Bolnicka 25. E-mail: m.hiros@bih.net.ba**