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

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1. OBJECTIVES
Extracorporeal shock wave lithotripsy (ESWL) has become a routine method for treatment 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 6-18 mm, 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
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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 hematomata, 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 either the ipsilateral or contra lateral kidney.

4. DISCUSSION

There was also no statistically significant difference in the contra lateral kidney 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 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.

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 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 renal stones 30 days after ESWL.

Values recorded in the remote region 1 week after ESWL were not significantly higher than those recorded before ESWL.

There was 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.

### Figure 2
Changes in resistive index (RI) in treated kidney. (Data were presented by mean ±SD 0.005)

### Figure 3
Changes in resistive index (RI) in contra lateral-not treated kidney. (Data were presented by mean ±SD 0.005)

### Figure 4
Sequential changes in RI in ipsilateral and contra lateral kidney

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, 7 days and 30 days post-ESWL. In patients with renal stones, RI (mean ±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 30 days 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.

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5. CONCLUSION

The RI has proved to be a sensitive tool for monitoring vascular and tubulo-intestinal diseases of the kidney. It is widely used to detect intrarenal oedema, which occurs in 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 marked first day following ESWL. RI values return to normal within 7 day and 30 day after ESWL in ipsilateral kidney and for contra lateral kidney RI values returns to baseline 2 day post ESWL. ESWL did not indicate pathological RI changes in treated and non treated kidney.

REFERENCES


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