Alteration in Resistive Index of Renal Vasculature Following Extracorporeal Shock Wave Lithotripsy for Renal Stones

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Authors' contributions

This work was carried out in collaboration between all authors. Author RJ designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors JC and SN managed the literature searches, analyses of the study and authors RSB and AG managed the experimental process. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: Extracorporeal Shockwave lithotripsy (ESWL) may be associated with both anatomic and functional injuries to the kidney when used in the management of uncomplicated kidney stones. Assessment of the resistive index (RI) is a non-invasive diagnostic modality for studying changes in the arterial system. RI, which is measured by color doppler ultrasonography, reflects resistance of intrarenal arteries that indirectly shows the renal blood flow. 

Aim: To assess changes in intrarenal RI following ESWL in the ipsilateral and contralateral kidneys & to study correlation of alteration in resistive index with age of the patient.

Methodology: A total of 38 patients with solitary renal calculus, who underwent extracorporeal shockwave lithotripsy were included in the study. The patients were evaluated for the RI in
ipsilateral (diseased) and contralateral kidneys; before, 3 hrs after and 1 week after ESWL. Serum creatinine levels & creatinine clearance were measured pre ESWL and 4 weeks after ESWL.

**Results:** RI in ipsilateral kidney pre ESWL was 0.590 and post ESWL (3 hrs after ESWL) was 0.646, it showed a statistical significant increase with a p value of <0.001. 1 week post ESWL resistive index values were comparable to pre ESWL value with no significant difference. ESWL had no effect on serum creatinine & creatinine clearance measured pre ESWL & 4 weeks post ESWL.

**Conclusion:** Doppler studies of the kidneys treated with ESWL have shown a transient rise of RI in our study, the long term effect of rise in RI after ESWL still remains to be evaluated.

**Keywords:** RI; ESWL; color doppler ultrasonography.

1. INTRODUCTION

Patients with uncomplicated kidney stone can be successfully treated with the least invasive modality, i.e., Extracorporeal Shockwave Lithotripsy (ESWL) [1]. ESWL may be associated with injuries to the kidney, both anatomic and functional [2]. Assessment of the resistive index (RI) using color doppler ultrasonography is a non invasive diagnostic modality for studying changes in the arterial system. RI, which is measured by color doppler ultrasonography, shows the renal blood flow which indirectly reflects resistance of intra-renal arteries [3]. RI has proved to be a sensitive tool for monitoring vascular injuries of the kidney. In all these conditions, RI levels greater than 0.7 are considered to indicate pathologic change [4]. In the past, researchers have tried to assess the changes in the RI after ESWL but there are still controversies about the pattern and timeline of RI changes [5].

1.1 Aim

The aim of the study is to assess changes in intra-renal RI following ESWL in the ipsilateral and contralateral kidneys & to study correlation of alteration in RI with age of the patient.

2. MATERIALS AND METHODS

The prospective study was conducted in the Department of Surgery, Maulana Azad Medical College and Lok Nayak Hospital, New Delhi from October 2011 to December 2012. The study population consisted of 38 patients with a solitary renal calculus of size 8 mm -20 mm in renal pelvis or calyx, undergoing ESWL. Patients with impaired kidney function tests, multiple stones, associated hydronephrosis, renal parenchymal disease, diabetes mellitus, hypertension, distal ureteral obstruction, coagulopathy and pregnancy were excluded from the study. A written informed consent was obtained from all the patients. Pre-procedural work up included:

1. Clinical history and physical examination.
2. All patients had the following pre operative investigations:
   - Hemoglobin, Total Leukocyte Count (TLC), hematocrit, blood urea, serum creatinine, serum electrolytes, urine for routine & microscopy, urine for blood sugar-fasting, X-ray KUB, Intravenous Urogram (IVU), Ultrasound KUB (when necessary).

RI of inter-lobar arteries was measured before ESWL using color doppler ultrasonography. Color doppler machine used for the study was PHILIPS HD 11 using low frequency probe of 3.5 MHz. RI was measured in ipsilateral (within 2cm distance of calculus) and corresponding area in contralateral kidney. Three measurements were taken and the algebraic mean of the values was calculated as RI.

RI is calculated by the equation [6]:

\[
\text{Systolic peak velocity} - \text{End diastolic peak velocity} / \text{Systolic peak velocity}
\]

ESWL was performed with Dornier-Compact Sigma Lithotriptor without anaesthesia. Patient was injected with an intramuscular injection of diclofenac sodium 50 mg before the start of the procedure. Stone localization was done by fluoroscopy. For study purpose a standard protocol of giving 3000 shocks at 4 KV per session was used in treatment. No pause was taken during the session of 3000 shocks. Post procedure patients were prescribed analgesics such as diclofenac oral twice daily with a proton pump inhibitor & prophylactic antibiotic (ciprofloxacin 500 mg twice daily) for 1 week. Double J stenting was not done in any patient. Tamsulosin was not advised to any patient.
Thereafter at 3 hrs of ESWL color Doppler ultrasonography was repeated and RI was measured in the before mentioned areas. Follow-up visit for patients having increased RI after ESWL was arranged for 1 week after the procedure and RI of the ipsilateral and contralateral kidney was measured for the third time. Stone Clearance was defined as absence of stone on X-ray KUB/NCCT or residual single stone fragment of size ≤ 4 mm.

Following parameters were evaluated

1. RI
2. Serum creatinine measured Pre ESWL and 4 wks after ESWL.
3. Creatinine clearance was calculated as (Cockcroft Gault Equation) [7]:

$$eC_F = \frac{(140 - \text{Age}) \times \text{Mass (in kilograms)}}{72 \times \text{Serum Creatinine (in mg/dL)}} \times \begin{cases} 0.85 & \text{if Female} \\ 1 & \text{if Male} \end{cases}$$

2.1 Statistical Analysis

The values obtained before and after treatment were analyzed statistically using the Paired t-test. The quantitative data was assessed by student t test, Wilcoxon Mann Whitney rank sum test. A 'p' value less than 0.05 was considered statistically significant.

3. RESULTS

There were total of 38 patients out of which 13 (34.2%) were female and 25 (65.8%) were male. The age of patients varied from 20 – 72 yrs with a mean age of 43.29 yrs. Out of 38 patients 21 (55.3%) patients had renal calculus on the left side and 17 (44.7%) had calculus in the right side. The minimum size of the calculus observed was 8 mm, maximum size of 20 mm with a mean size of 12.63 mm. Minimum sittings done for stone clearance was 1 (7 patients) and maximum sittings were 5 (5 patients) with a mean of 2.34. Thirty four patients out of the total of thirty eight patients were stone free after ESWL with a clearance percentage of 89.5%. Four patients had a poor response to ESWL and were not cleared of their stones even after 5 sittings of ESWL. All 4 failure had stone size ranging from 17 – 20 mm. Later 3 of these 4 patients were treated by laparoscopic retroperitoneal pyelolithotomy and one patient underwent open pyelolithotomy.

RI in intrarenal arteries of ipsilateral kidney measured before ESWL had a mean value of 0.590 ± 0.040. RI done 3 hours after ESWL had a mean value of 0.646 ± 0.036. RI measured 1 week after ESWL with a mean value of 0.594 ± 0.049 (Table 1). Pre ESWL RI values of ipsilateral kidney were compared with RI values of ipsilateral kidney three hours post ESWL using Paired t-test. The difference between the two was statistically significant with a p value of <0.001. RI values after 1 week of ESWL were compared with RI values pre ESWL using Paired t-test. The difference between the two was statistically insignificant with a p value of 0.189.

Similarly RI of intrarenal arteries of opposite kidney was measured with a mean value of 0.583 ± 0.047 before ESWL. Values measured 3 hours after ESWL had a mean of 0.581 and ± 0.048 and measurement done 1 week after ESWL had a mean value of 0.579 ± 0.049 (Table 1). There was no statistically significant increase in RI post ESWL and 1 week after ESWL in opposite kidney.

Pre ESWL serum creatinine and creatinine clearance values were 0.771±0.177 mg/dl and 111.38 ml/min respectively. Values measured 4 weeks post ESWL were 0.78±0.131 mg/dl and 111.60 ml/min. Changes in level of serum creatinine and creatinine clearance were found to be statistically insignificant with p value of 0.473 and 0.940 (Table 2).

A comparison of change in RI between patients aged <50 yrs and ≥50 yrs was done by dividing them into two groups, i.e., Group A consisting of 25 patients with age <50 yrs and group B consisting of 13 patients with age ≥ 50 yrs. Base

| Table 1. RI values in ipsilateral & contralateral kidneys |
|----------------------------------------------------------|
| **Ipsilateral kidney** (mean±std deviation) | **Contralateral kidney** (mean±std deviation) |
| Pre ESWL RI | 0.59 ± 0.040 | 0.58 ± 0.047 |
| 3 hrs Post ESWL RI | 0.64 ± 0.036 | 0.58 ± 0.048 |
| 1 week Post ESWL RI | 0.59 ± 0.049 | 0.57 ± 0.049 |
Table 2. Serum creatinine & creatinine clearance

|                          | Pre ESWL       | Post ESWL      | P value of the change |
|--------------------------|----------------|----------------|-----------------------|
| No. of patients          | 38             | 38             |                       |
| Serum creatinine (mg/dl) | 0.771±0.177    | 0.784±0.131    | 0.473                 |
| Creatinine clearance (ml/min) | 111.389±26.5 | 111.600±24.5  | 0.940                 |

Table 3. Comparison of RI according to age distribution

| Age group                | N   | Baseline RI (mean±std deviation) | 3 hrs Post ESWL RI (mean±std deviation) | Percentage change |
|--------------------------|-----|---------------------------------|----------------------------------------|-------------------|
| Group A (< 50 yrs)       | 25  | 0.572 ± 0.035                   | 0.628 ± 0.026                          | 9.8%              |
| Group B (>= 50 yrs)      | 13  | 0.623 ± 0.025                   | 0.681 ± 0.021                          | 9.4%              |

line (Pre ESWL) values of RI and change in RI in ipsilateral kidney after 3 hours of treatment were measured in the two groups. Baseline RI of patients equal to or above 50yrs of age was higher (RI-0.623) than the patients of age less than 50 yrs (RI-0.572). Percentage change in RI was calculated and compared between the two groups (Table 3). The difference between the two groups was not statistically significant with a p value of 0.630.

4. DISCUSSION

ESWL has a very distinct place in a surgeon’s armamentarium for treatment of renal stone disease. Although ESWL has been considered the least invasive procedure for the management of renal calculus, it is also associated with some adverse effects on human tissues. This study was done to assess the effect of ESWL on kidney by evaluating the changes in renal vasculature and functional assessment of the kidney. The study was performed measuring the changes in RI of the ipsilateral and contralateral interlobar renal arteries. The pattern and timeline of RI values are controversial, as is its correlation with age. Change in serum creatinine and creatinine clearance was measured to assess the functional changes.

The doppler study of renal vasculature in ipsilateral kidney showed a significant increase in RI 3 hours post ESWL treatment, indicating vascular compromise in the area where the shock waves were targeted. Y Aoki et al compared the mean of Resistive Index before (0.656 ± 0.053) and after ESWL (0.682 ± 0.052) and showed significant increase in treated kidney with a p value of <0.0001 [8]. In a study by Mohseni et al the resistive index nearby the calculus before and after ESWL (0.594 ± 0.062 and 0.620 ± 0.048) were significantly different with the post ESWL being higher (p value 0.003) [9]. Hiros M et al [10] studied the change in resistive index of the treated kidney form the baseline value of 0.62 ± 0.05 to 0.67 ± 0.05 post ESWL with a significant difference (p <0.001). Nazaroglu H et al observed a significant increase in resistive index at 30 min and 3 hrs after ESWL in the nearby region [11]. This might occur as a result of tissue damage including blood vessels. Doppler studies performed on patients 1 week after ESWL have shown reduction in RI in ipsilateral kidney reaching almost to the level of preprocedure values. This indicates the reversal of the damage to the renal vasculature and tissue suggesting the temporary nature of the adverse effect. Although few studies have shown the reduction in RI one week after ESWL, [8-10,12] there are studies in which RI has not returned to the pretreatment values even after 1 week suggesting there might be cases in which renal damage has not reversed and might require further assessment of the factors leading to delayed or non healing of the damage [5].

Many studies in past have shown the effect of shockwaves on the contralateral kidney in form of increase in RI [8,10,11,13,14] but Doppler study of contralateral kidney done in our patients did not show any increase in RI. Hence based on our study we can suggest that ESWL does not have an adverse effect on contralateral kidney. The baseline RI of renal vasculature in patients aged < 50 yrs was inferior in comparison to patients aged > 50 yrs suggesting age related change in vessels with increased resistance to the blood flow. The percentage change in RI after ESWL in the two groups was comparable with no significant difference. This finding might indicate ESWL safe even in elderly patients with
no extra risk of vascular compromise as compared to young patients.

Assessment of change in function by comparing serum creatinine and creatinine clearance 1 month post ESWL showed no significant difference which suggests that reversible damage to renal tissue and vessels did not exert any long term change in renal function.

5. CONCLUSION

Ultrasound doppler may help us in measuring the RI and assessing the vascular compromise caused by shock waves. Returning of RI to pretreatment levels can guide us with the useful information of when to repeat ESWL if needed. Although doppler studies of the treated kidneys have shown a transient rise of RI in treated kidney with no significant change in RI of contralateral kidney & no significant change in creatinine clearance in our study, the long term effect of rise in RI after ESWL still remains to be evaluated. In our study ESWL was found to be safe even in elderly patients with no extra risk of vascular compromise as compared to young patients.

6. LIMITATIONS

Our study had a small sample size of 38 patients. Further follow up of the patients is required to assess the long term effects of ESWL on kidney. More frequent assessment of RI could have been done to know more precise time of changes in RI following EWSL and its return to pre ESWL values.

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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