Evaluation of Acute Post-Shock Wave Lithotripsy Renal Changes by Dynamic Magnetic Resonance Imaging: A Prospective Clinical Study

Khaled Z. Sheir,* Mohamed Abou El-Ghar, Ahmed M. Elshal, Mohamed M. Elsaadany, Diaa-Eldin Taha and Ahmed R. El-Nahas

From the Departments of Urology and Radiology (MAE-G), Urology and Nephrology Center, Mansoura University, Mansoura, Egypt

Purpose: We studied acute renal morphological and hemodynamic changes after shock wave lithotripsy of renal stones.

Materials and Methods: A total of 60 adult patients with a single renal stone 25 mm or less in a radiologically normal urinary tract were eligible for shock wave lithotripsy and included in analysis. Study exclusion criteria were hypertension, diabetes mellitus, previous recent stone management and other contraindications to shock wave lithotripsy. Renal perfusion and morphological changes were evaluated by dynamic magnetic resonance imaging before, and 2 to 4 hours and 1 week after lithotripsy.

Results: In all cases there was a statistically significant decrease in renal perfusion 1 week after shock wave lithotripsy compared to before and 2 to 4 hours after lithotripsy (66% vs 71% and 72% of the aortic blood flow, respectively, $p < 0.05$). At 1-week followup 39 unobstructed renal units (65%) showed no significant difference in renal perfusion at any time while 21 (35%) obstructed renal units showed a significant decrease in renal perfusion compared to before and 2 to 4 hours after lithotripsy (63% vs 76% and 75%, $p = 0.003$ and 0.005, respectively). Hematomas were observed in 7 cases (12%) 2 to 4 hours after lithotripsy, of which 5 were subcapsular and 2 were intrarenal. Three subcapsular hematomas resolved after 1 week. Localized loss of corticomedullary differentiation was observed in 2 patients (3.3%) with intrarenal hematoma 2 to 4 hours after treatment. Generalized loss of corticomedullary differentiation was observed 1 week after lithotripsy in 5 cases (8.3%).

Conclusions: Shock wave lithotripsy alone induces minimal, reversible acute renal morphological changes and does not induce significant changes in renal perfusion. Posttreatment obstruction has a major effect on renal perfusion on the treated side and must be managed urgently.

Key Words: kidney, ureteral obstruction, urinary calculi, lithotripsy, complications

Abbreviations and Acronyms

DCE-MRI = dynamic contrast enhanced MRI

MRI = magnetic resonance imaging

SWL = shock wave lithotripsy

Accepted for publication June 19, 2014.

Study received local ethics committee approval.

Supported by the Science and Technology Development Fund, Egypt.

* Correspondence: Department of Urology, Urology and Nephrology Center, Mansoura University, 72 Elgomhoria St., 35516, Mansoura, Egypt (telephone: +2050-2262222; FAX: +2050-2263717; e-mail: kzsheir3@hotmail.com).

ALTHOUGH extracorporeal SWL is noninvasive and the main force of shock wave energy is focused on the stone, the surrounding renal parenchyma is also subjected to trauma. The increasing tendency to repeat SWL sessions especially with new generation machines calls for knowledge of any side effects of clinical importance. SWL studies in animals and humans showed dose dependent short-term and long-term adverse

0022-5347/14/1926-1705/0
THE JOURNAL OF UROLOGY®

http://dx.doi.org/10.1016/j.juro.2014.06.074
Vol. 192, 1705-1709, December 2014
Printed in U.S.A.

effects secondary to the cellular and microvascular effects of trauma, hemorrhage, ischemia, free radical formation and impaired renal hemodynamics.[1–4] Scarring and loss of renal tissue function can develop due to acute renal damage.[5,6]

Acute changes in renal hemodynamics result in a temporary decrease in the glomerular filtration rate and renal plasma flow.[7,8] This decrease is severe, particularly during the first 4 hours, and it occurs with 2,000 shocks and 24 kV application.[9,10] Many studies suggest that hemodynamics are subject to change not only on the treated side but also in the other kidney.[5,11] While renal plasma flow decreases in the contralateral kidney, the glomerular filtration rate is not affected.[6,7]

We examined acute post-SWL morphological and hemodynamic renal changes as evaluated by DCE-MRI.

PATIENTS AND METHODS

Patients

A total of 60 adult patients were prospectively enrolled in the study from August 2012 to August 2013. The local ethics committee approved the study protocol and patients were enrolled after providing informed consent.

Study entry criteria were adult patients with a single renal stone 25 mm or less in a radiologically normal urinary tract that was not previously treated and a normal laboratory profile in regard to serum creatinine, liver function tests, blood picture and coagulation profile. Patients were excluded from analysis if there was uncontrolled urinary tract infection, an obstructed urinary tract distal to the stone, a congenital abnormality or receipt of medication for hypertension or diabetes mellitus.

Patient Evaluation

Pretreatment evaluation included complete physical examination and laboratory tests, including urinalysis, urine culture, sensitivity test, coagulation profile and serum creatinine. Radiological investigation included plain x-ray of the kidneys, ureters and bladder, intravenous urogram to locate the stone site and study urinary tract anatomy, and DCE-MRI as the basal study before SWL.

MRI Technique

The radiologist responsible for DCE-MRI was blinded to patient data. All MRI studies were done on a 1.5 Tesla Signa Horizon LX Echospeed scanner (GE Medical Systems, Milwaukee, Wisconsin) using a phased array torso surface coil. The procedure began by obtaining a coronal localizer (scout image) to identify the kidneys, followed by a coronal T2-weighted sequence for the whole of each kidney. Dynamic MRI was then performed. We started with precontrast 6 coronal fast-spoiled gradient slices at the center of the kidney. Furosemide (0.1 mg/kg) was injected intravenously through the antecubital vein followed immediately by a bolus injection of 0.1 mmol/kg gadoteric acid (Dotarem® 0.5 mmol/ml). The coronal scan series was repeated each 30 seconds for 5 minutes.

Imaging parameters for coronal T2 were 5 mm thickness, no interslice gap, repetition time 8,000 to 10,000 milliseconds, echo time 75 to 95 milliseconds, field of view 40 × 40 cm and matrix 256 × 196. For coronal fast-spoiled gradient recalled imaging parameters were 4 mm thickness, no interslice gap, repetition time 30 to 40 milliseconds, echo time 2 to 3 milliseconds, flip angle 70 degrees, field of view 42 × 42 cm and matrix 256 × 196.

Image Analysis

Coronal T2 scans were used to assess renal size, and parenchymal and perinephric region abnormalities. For dynamic scans we started by visually interpreting the images. We compared the series before and after contrast medium administration to determine corticomedullary differentiation and the degree of parenchymal enhancement, and define any parenchymal defect. Renal excretory power was determined using the delayed 15-minute series.

A renographic dynamic MRI curve was generated by drawing regions of interests over the kidney, excluding the renal pelvis, using a functional software tool (GE Medical Systems) that merges all series. Thus, a curve resembling that of isotope renography was obtained. This curve plots enhancement units vs time and from the curve the time to the peak, absolute and relative maximum units of enhancement. It represents renal blood flow, calculated as total enhancement units per kidney minus total units on unenhanced scan. Response to the diuretic were determined. Circular regions of interests were obtained from the aorta to determine the peak of absolute and relative enhancement, representing aortic blood flow.

Treatment

The lithotripter used was the electromagnetic DoLi S with the EMSE 220F-XXP (Dornier MedTech, Wessling, Germany). A total of 3,000 shocks were delivered at each session at a rate of 80 per minute. The patient slowly received 1 mg/kg pethidine intravenously if needed during the session. Treatment began at machine power step 1, which delivered 49 MPa focal pressure and 0.35 mJ/mm^2. Power was gradually increased by 1 step for each 200 shocks up to step 4, which delivered 77 MPa and 0.7 mJ/mm^2.

Posttreatment Evaluation

DCE-MRI was repeated within 2 to 4 hours after treatment and 1 week after SWL to detect changes in parenchymal perfusion, loss of corticomedullary junction demarcation, hematoma, perirenal fluid collection and obstruction, which was diagnosed when there was dilatation of the ureter or pelvicalyceal system on MRI (fig. 1, *B*).

Statistical Analysis

Study power was calculated using G*Power (http://www.gpower.hhu.de/en.html) to determine adequate sample size. Using the a priori test with accuracy mode calculation and an effect size convention of 0.5 for the 2-tailed paired sample t-test with an α error protection of 0.05 provided 95% power for the sample size of 54 patients. SPSS®,