International Journal of Urology (2004) **11,** 831–836

Original Article

Stones in anomalous kidneys: Results of treatment by shock wave lithotripsy in 150 patients

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Abstract ***Objective***: To determine the efficacy of shock wave lithotripsy (SWL) in anomalous kidneys.
Methods: From October 1990 to October 2002, 150 patients (93 men and 57 women) with anomalous urinary tracts, including 45 horseshoe kidneys, 57 duplex kidneys, 30 malrotated kidneys, 14 pelvic and four crossed ectopic kidneys were treated with SWL for urolithiasis at the Gazi University Faculty of Medicine. Shock wave lithotripsy was performed with Siemens Lithostar plus (Siemans, Erlanger, Germany) device and all procedures were carried under fluoroscopic control.
Results: The mean shock wave number and intensity received by the patients was 3770 (range, 1380–4100) shocks and 18.4 (range, 16.1–19) kV per session, respectively. The minimum success rate was obtained in patients with lower calyceal (50%) followed by middle calyceal (60%) calculi. The stone-free rate decreased and the number of sessions per patient increased with increasing stone diameter (dm). In patients with a stone dm > 30 mm, only 34% could be stone-free, compared to a rate of 92% for calculi dm < 10 mm. The overall stone free rate at the third month was 68%. The best stone-free rates were obtained in patients with ureteral duplication (80.7%). The stone-free rates in horseshoe, malrotated, pelvic and crossed ectopic kidneys were found to be 66.7%, 56.7%, 57.2% and 25%, respectively.
Conclusion: Shock wave lithotripsy might be an effective and minimally invasive treatment alternative in stone-bearing anomalous kidneys. The type of anomaly, stone burden and localization seem to be the main parameters effecting the treatment success.

Key words anomalous kidneys, shock wave lithotripsy, urolithiasis.

Introduction

Calculus formation is a well-known sequela of congenital abnormalities of the urinary tract. The abnormal position of the ureteropelvic junction, aberrant vasculature and the presence of an isthmus might result in urinary stasis and resultant stone disease, especially in the presence of infection and additional metabolic abnormalities.[1–4] Shock wave lithotripsy (SWL) has become the most widely accepted and used initial treatment method for most urinary tract calculi since 1982, as it is relatively less invasive than other treatment methods, such as ureteroscopy or percutaneous lithotripsy. However, the associated urinary stasis could hamper clearance of stone fragments after shock wave lithotripsy. Despite accumulating data with larger series, there is still debate regarding the treatment of calculi in anomalous kidneys. The stone-free rates after SWL in horseshoe kidneys, the most common anomaly of fusion, vary widely among institutions ranging from 28% up to 80%.[5–7] The reported incidence of stone formation in duplex systems is approximately 7%.[4] Together with pelvic and crossed ectopic kidneys, there is still limited published data on the treatment of stones in this group of patients. Recent data concerning SWL treatment in ectopic kidneys complicated by urolithiasis provided good stone-free rates up to 100%.[8–10] In this respect, we would like to present the updated 12 years of experience in SWL treatment of calculi in anomalous kidneys.[11]

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Received 24 July 2003; accepted 16 March 2004.

Patients and methods

From October 1990 to October 2002, 150 patients (93 men and 57 women) with anomalous urinary tracts, including 45 (30%) horseshoe kidneys, 57 (38%) duplex kidneys, 30 (20%) malrotated kidneys, 14 (9.3%) pelvic and four (2.6%) crossed ectopic kidneys were treated in our clinic with SWL for urolithiasis.

None of the patients had more than one anomaly, despite five patients having bilateral renal stones (two patients with horseshoe kidney with SWL treatment to only one renal unit and three patients with normal contralateral kidneys not included). One patient had stones in both the pelvis and ureter. Stone location according to kidney anomaly is shown in Table 1.

Standard evaluation of the patients before SWL included renal function tests, urinalysis, urine culture and intravenous pyelography (IVP). Patients with urinary tract infections were treated according to urinary cultures with appropriate antibiotics. Contraindications of SWL treatment were coagulation disorders, acute pyelonephritis, obstruction distal to calculi and nonfunctional kidney. Shock wave lithotripsy was performed with a Siemens Lithostar plus (Siemans, Erlanger, Germany) device and all the procedures were carried under fluoroscopic control. The device is a second-generation lithotripter in which shock waves are delivered by an undertable electromagnetic shock head module in the supine (for horseshoe and malrotated kidneys) or prone (for pelvic, crossed ectopic kidneys and ureteral calculi) position. The treatment was performed under the prone position when there was difficulty in localizing the stone in horseshoe kidneys, especially for lower pole calculi. All treatments were performed as an outpatient procedure without any form of anesthesia. Fifteen patients required intravenous analgesics during the treatment session. The stone burden was found by multiplying the largest length and width of the individual stones measured from the abdominal plain X-ray. In presence of more than one calculus, the burden is accepted as the sum of the all stones. Stone diameter (dm) is accepted as the largest diameter of the individual stone measured from the plain X-ray. The follow up after SWL consisted of plain abdominal radiographs usually taken 1–2 weeks after treatment and continued according to disintegration and clearance. Retreatments were done minimally after 3 weeks for the same location. Complete stone clearance was accepted as stone-free status and confirmed with IVP in all patients. A successful treatment outcome was defined as a patient being stone-free at follow up or having residual stone fragments less than 4 mm (sufficient fragmentation) in size. Insufficient treatment was accepted as fragments greater than 4 mm or no fragmentation at all.

In 23 patients with a large (dm > 20 mm) initial stone diameter, a double-J stent was inserted before treatment (including 11 horseshoe kidneys, four malrotated kidneys, and eight duplex system kidneys) to prevent post treatment obstruction. Likewise, after treatment, five patients required the insertion of ureteral stents for the relief of obstruction due to stone-street formation or insufficient stone fragmentation.

Results

The mean age of the patients was found to be 42.6 ± 14.9 (range, 14–76) years. Four of our patients

Table 1 Location of calculi and success rates according to the type of anomaly

	Pelvis	U calyx	M calyx	L calyx U calyx	Pelvis + M calyx	Pelvis + L calyx	Pelvis + ureter	Ureter	Pelvis
Horseshoe kidney	23	3	1	3	3	5	4	3	0
Malrotated kidney	11	3	3	3	3	1	1	5	0
Pelvic kidney	7	1	0	1	1	2	1	1	0
Ureteral duplication	11	3	1	6	2	0	3	30	1
Crossed ectopy	3	0	0	1	0	0	0	0	0
Total (%)	55 (36%)	10 (6.6%)	5 (3.3%)	14 (9.3%)	9 (6%)	8 (5.3%)	9 (6%)	39 (26%)	1 (0.6%)
Success rate (%)	90%	100%	60%	50%	88.8%	75%	77.8%	92.3%	0%

M, middle; L, lower; U, upper.

were children. One of them was 14-year-old girl with a malrotated right kidney. She had a 22-mm (burden, 2.6 cm^2) renal pelvic stone and a 7-mm (burden, 0.6 cm^2) lower calyceal stone on the right. After two sessions of SWL, she had large residual fragments accumulated at the lower calyx and no additional treatment was offered as she was asymptomatic. The second child, a 16-year old boy, had complete ureteral duplication on the left side and a 7-mm (burden, 0.77 cm^2) lower calyceal stone in the same renal unit. After three sessions of SWL, the patient had only a 2-mm residual stone fragment that was considered insignificant. The third patient was a 15-year-old girl with a left duplicated kidney and a 15 × 10 mm calculus in the pelvis renalis of the upper unit that was completely cleared after one session of SWL. The final case was a 14-year-old boy with a horseshoe kidney and a 10 × 11 mm right pelvic renal stone and was stone free after one session.

The mean shock wave number and intensity received by the patients was 3770 ± 380.3 (range, 1380–4100) shocks and 18.4 ± 0.7 (range, 16.1–19.0) kV per session, respectively. In 55 (36.6%) patients, calculi were located in the renal pelvis, in the renal calyces in 29 (19.3%) patients and both in the renal pelvis and one of the calyces in 26 (17.3%) patients. Although, 39 patients (26%) had calculi in one ureter, one patient had stones both in the pelvis and ureter of the same renal unit (Table 1).

Urinary tract infection, if present, was treated with the appropriate antibiotics in 16 patients according to urine culture results.

The results were evaluated 3 months after completion of the SWL treatments. The overall stone-free rate at 3 months after treatment was 68% (102 of 150 patients). The minimum success rate was obtained in patients with lower calyceal (50%) followed by middle calyceal (60%) calculi (Table 1). The best stone free rate was obtained in patients with ureteral duplication (80.7%) (Table 2). The current series also included four patients with crossed ectopia. One (25%) of the patients became stone-free, while two (50%) had sufficient fragmentation after lithotripsy. Treatment results according to the type of anomaly are given in Table 3 (68% stone-free and 23% sufficient fragmentation). The overall success rate was 91% with a mean stone burden of 1.96 ± 0.69 (range, 0.6–4.6) cm^2.

The stone-free rate decreased and the number of sessions per patient increased with increasing stone diameter. In patients with a stone dm > 30 mm, only 34% could be stone-free compared to a rate of 92% for calculi <10 mm (Table 3).

Shock wave lithotripsy treatment was unsuccessful in 13 (8.6%) patients, including one (0.6%) with crossed ectopic kidney, five (3.3%) with horseshoe kidneys, three (2%) with malrotated kidney, one (0.6%) with pelvic kidney and three (2%) with ureteral duplication.

Table 2 Treatment results according to the type of anomaly

Type of anomaly	Mean stone burden (range, cm^2)	Stone free rate (%)	Sufficient fragment (%)	Insufficient fragment (%)
Crossed ectopic kidney	3.00 ± 0.38 (2.4–3.4)	1 (25%)	2 (50%)	1 (25%)
Horseshoe kidney	2.24 ± 0.6 (0.9–4.1)	30 (66.7%)	10 (22.2%)	5 (11.1%)
Malrotated kidney	1.92 ± 0.55 (0.6–3.8)	17 (56.7%)	10 (33.3%)	3 (10%)
Pelvic kidney	2.35 ± 0.95 (1–4.6)	8 (57.2%)	5 (35.7%)	1 (7.1%)
Ureteral duplication	1.69 ± 0.80 (0.7–3.8)	46 (80.7%)	8 (14%)	3 (5.3%)
Total	1.96 ± 0.69 (0.6–4.6)	102 (68%)	35 (23.3%)	13 (8.7%)

Mean stone burden given as mean ± SD.

Table 3 Number of sessions per patient and stone-free rates according to stone diameter

Stone diameter (mm)	Number of sessions				Total	Stone-free (%)
	1	2	3	4		
0–10	41	14	4	4	63	58 (92)
11–20	16	13	4	2	35	22 (62)
21–30	1	10	10	2	23	12 (52)
>31	–	5	13	11	29	10 (34)
Total (%)	58 (38)	42 (28)	31 (20)	19 (12)	150 (100)	102 (68)

Treatment failures were managed by open surgical procedure in eight cases (as we did not had enough experience and equipment for endoscopic treatment of such patients) and ureteroscopic lithotripsy in five cases that had residual ureteral calculi.

Major complications related to SWL treatment were renal colic in 40 (26.6%) patients, acute pyelonephritis in eight (5.3%) cases (treated with appropriate antibiotics) and stone-street formation in six (4%) patients for whom a double-J stent or ureteral catheter was placed as an auxiliary procedure. The procedure was unsuccessful in two (1.33%) cases that were subjected to ureterorenoscopic stone extraction.

Discussion

Since the introduction of shock wave technology, treatment of urinary tract calculi by SWL has rapidly become the treatment of choice for kidney and ureteral stones. With the accumulation of experience, the indications for SWL have been expanded so that stones located in anomalous kidneys are now managed with this minimally invasive technology. Although congenital anomalies are associated with an increased rate of stone formation because of their anatomic properties, these patients need detailed investigation and treatment should be considered on individual basis. Regarding the treatment alternatives, SWL can be considered as an initial treatment option in stone bearing anomalous kidneys, such as horseshoe kidneys, dupliex kidneys and other ectopic or fusion anomalies. However, data on the results of SWL mostly involves cases with horseshoe kidneys. In the present study, we investigated the success rates of SWL in 150 patients with stone bearing anomalous kidneys among the 8000 SWL treatments performed in our stone center.

We have previously reported our experience in normal kidneys. At the Gazi University Faculty of Medicine, between July 1996 and September 1998, 204 patients with renal pelvic stones were treated primarily by SWL and the overall stone-free and success rates (stone-free rate + sufficient fragmentation) were reported as 62% and 90%, respectively.[12] For lower calyceal stones, in a series of 165 patients, we achieved a stone-free rate of 53.33% after SWL.[13] Finally a success rate of rate of 71% was reported for 1580 patients treated for ureteral calculi with SWL at the Gazi University Faculty of Medicine.[14] Nearly half of the patients had lower ureteral calculi. The data for anomalous kidneys is comparable to the normal ones. The minimum success rate was obtained in patients with lower calyceal (50%) followed by middle calyceal (60%) calculi and the best rates were found in pelvic (90%), ureteral (92.3%) and upper calyceal (100%) stones.

When we evaluate the kidney anomalies, horseshoe kidney is the most commonly affected renal anomaly regarding the stone formation.[2,15] Up to two thirds of patients experience urinary stasis, hydronephrosis, infection or urolithiasis.[16] Stone-free rates after SWL for horseshoe kidneys vary widely, ranging from 28% up to 80%.[6,7,17–21] Kirkali *et al.* found a 78% fragmentation rate, although 28% of patients became stone-free at the end of follow-up.[7] In the present series, 66% of cases became stone free after SWL and with an additional 22% sufficient fragmentation rate, overall success approached 78%. Mean stone burden was 2.24 ± 0.6 cm^2 and 51% of stones were located in the pelvis alone without coinciding calyx stone. Currently, we know that the gravitational effect, especially in lower calyceal stones, prevents the passage of fragments to the ureter, thus localization of the stone becomes an important determining factor for the success of SWL treatment.

A great deal of consideration should be given to anatomical variations in the duplex system because endourological approaches to these patients could be difficult and dangerous. Bhatia *et al.* evaluated eight patients with urolithiasis in duplex systems and reported a 100% stone-free rate during 3 months of follow up.[22] However, the number of patients was too small to draw a conclusion. In the present study, the stone-free rate was 80% with a 14% sufficient fragmentation rate. Chen and associates revealed a stone-free rate of 50%,[5] while Semerci and associates concluded with a rate of 60%.[10] A recent report from Gallucci *et al.* gave a 55% 3-month stone-free rate incorporating 34 cases,[8] all suggesting SWL should be the preferred therapeutic option for duplex kidneys. The main problem that can be seen after SWL in duplex systems is insufficient spontaneous passage because of ectopic ureteral insertion or kinking and narrowing at the junction of two ureters that may prevent the complete clearance of stone fragments after treatment.

The incidence of pelvic kidney is estimated as between one in 2200 and one in 3000 in an autopsy series.[2] Regarding 17 ectopic kidneys, including four crossed ectopies, our overall stone free rate was 57%. Galucci *et al*. reported 77% stone-free rate, nevertheless they excluded patients with stones larger than 2 cm from their study.[8] However, in the present study, the mean stone burden of crossed ectopic kidneys and pelvic kidneys were 3 cm^2 and 2.3 cm^2, respectively. Semerci and associates published their stone free rate as 100% in ectopic kidneys, confirming the data from Theiss and associates.[9,10] However, these series only included four and three cases, respectively.

In malrotated kidneys, it is well known that clearance of the fragments after SWL may be impaired without urinary obstruction. An accessory or main renal artery compression and upper ureter or ureteropelvic junction distortion are the main causes of stone formation.[23] In the present study, our 56.7% stone free rate and 33.3% sufficient fragmentation rate seems to be lower than kidneys without any degree of malrotation, supporting the aforementioned hypothesis.

The overall stone-free rate at the third month was 68%. Best stone-free rates were obtained in patients with ureteral duplication (80.7%), consistent with the literature. The stone-free rates in horseshoe, malrotated, pelvic and crossed ectopic kidneys were found as 66.7%, 56.7%, 57.2% and 25%, respectively. However, the overall stone-free rate rose up to 92% in patients with stones smaller than 1 cm, illustrating the role of stone size in the success of SWL treatment. Better results may be possible when invasive techniques, such as percutaneous nephrolithotomy, ureterorenoscopy or open surgery, are used and are more relevant when the stone size is >3 cm in diameter.[24] The present study demonstrated that stone-free rates decreased with increasing stone burden. In patients with a stone burden >3 cm^2, only 34% could be stone-free, compared to a rate of 92% for calculi <1 cm^2. Although patients with larger stone burdens usually had residual fragments, the results in these patients were also acceptable, as the fragments were usually no longer obstructive. However, Lampel *et al*. showed that persistence of residual fragments led to the regrowth of these fragments into symptomatic stones in 86% of their patients,[20] indicating a high risk of stone recurrence in patients who retain residual fragments after SWL. Chen *et al*. also suggested that small stone burdens and patency of the upper urinary tract could have been the main factors contributing to better SWL results for these problem kidneys.[5] Therefore, we believe that patients who have stones >3 cm with horseshoe kidneys, malrotated kidneys and duplex systems are candidates for percutaneous nephrolithotripsy (PCN). Also, open surgery is an alternative treatment, especially for pelvic kidneys in which SWL remained unsuccessful. Again, if there is any evidence of anatomical obstruction, surgical correction of the obstruction should be necessary.

Although there is not enough clinical data comparing computed tomography (CT) scans with plain X-ray in anomalous urinary tracts to assess ureteral calculi, designed studies in normal urinary tracts are already being published. Narepalem *et al*. reported that non-contrast spiral CT gives similar measurements along the transverse dimension of renal calculi when compared to plain X-ray of the kidney-ureter-bladder.[25] However, it was not accurate for determining the craniocaudal dimension of these stones. Therefore, the accuracy of 3-D spiral CT has yet to be established in our opinion.

In conclusion, considering the low morbidity and high success rate, SWL is an effective method for stones <20 mm in all anomalous kidneys, with stone burden, stone localization and severity of the anomaly seeming to be the main parameters impacting on treatment success.[21] While best results can be achieved in ureteral duplications; horse-shoe, crossed ectopic and malrotated kidneys, especially those with a stone diameter >30 mm, can be considered as the candidates for other alternative strategies. In recent years, modified techniques, such as laparoscopic assisted percutaneous transperitoneal nephrolithotomy[26,27] and laparoscopic retroperitoneal pyelolithotomy[28] are described with hopeful results. However, all invasive techniques involve an increased risk of complications when compared with SWL treatment. Also, rates of complications and auxiliary measures in anomalous kidneys don't seem to be different from normal counterparts. In summary, SWL could be an effective and minimally invasive treatment in stone-bearing anomalous kidneys and should be considered as a primary option unless there is contraindication for SWL.

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