Urol Res (1990) 18:53–56

Urological Research

Side-effects of extracorporeal piezoelectric shock wave lithotripsy (EPL)

W. Vahlensieck Jr.[1], H.-J. Kürz[1], H. Steinhauer[2], H. Friedburg[3], and H. Sommerkamp[1]

Departments of [1]Urology, [2]Nephrology, and [3]Diagnostic Radiology, University of Freiburg, FRG

Accepted: June 30, 1989

Summary. In the Department of Urology, University of Freiburg, West Germany extracorporeal piezoelectric shock wave lithotripsy (EPL) has been used in the treatment of urinary and biliary stones since November 1987. The first 85 treatments (in 71 patients) for renal stones were evaluated with regard to complications and side effects. There was no need for any anesthesia. Urinary obstruction was observed in 12% of the cases. Aside from the urinary obstruction and urosepsis (2%) no serious complications were seen. Endourological auxiliary measures were applied in 32% (27% prophylactically). The temporary glomerular damage which appeared in some patients vanished within 6 days after treatment. Because of possible asymptomatic ureteral obstruction a close follow up by ultrasound is recommended. EPL was found to be a useful method of treatment for renal calculi with few side effects.

Key words: Extracorporeal piezoelectric lithotripsy (EPL) – Clinical complications – Laboratory changes

The technique of piezoelectrically generated extracorporeal shock wave lithotripsy was developed by Ziegler and coworkers who started clinical treatments in 1985 [12, 18].

At the Department of Urology, University of Freiburg, West Germany the "Piezolith 2300" (Richard Wolf GmbH, Knittlingen, West Germany) has been used since November 1987 to disintegrate urinary and biliary stones. The lithotripter consists of a mobile table above a small water basin. The shock waves are generated at the bottom of this basin and reach the patient through an opening on the table's surface. Piezoelectrically generated shock waves can be well focussed to a small volume of about $4 \times 4 \times 8$ mm [12]. The basin can be moved in three directions to focus directly on the concrement. Disintegration of the calculus can be continuously observed by using one of the two 4 MHz ultrasound units, which are integrated into the system [12].

Possible clinical compliations and side effects to the tissue exposed to the piezoelectric shock waves during this procedure were examined prospectively in this study.

Material and methods

In this prospective study 85 EPL treatments on 71 patients (41 females, 30 males) (14 patients with 2 treatment episodes) have been included (mean age: 49 years, range: 20–75). Patients with hemostatic disorders, impaired renal function (serum creatinine ≥ 3 mg%) and children under 14 years were excluded.

Clinical symptoms ($N = 85$), endourological auxiliary procedures ($N = 85$), urine culture ($N = 58$), sonography ($N = 85$) (Kretz, 4.0 MHz) and Magnetic Resonance Imaging (MRI) of the treated kidneys ($N = 20$) (transversal sections, T_1 and T_2 weighted images, Bruker 0.23 Tesla magnet BMT 1100) were noted before and on the day after EPL.

Urine cultures following the EPL were used to detect bacteria which had been primarily impacted in the stone and subsequently freed by therapy. These bacteria can cause secondary urinary tract infection (UTI) or even urosepsis.

Sonography and MRI were used to detect urinary obstruction, hematoma, extravasation or other morphological changes that were possibly present.

Fifty-five out of 71 patients representing 63 of 85 (74%) treatments were followed 1–5 months after treatment by a questionnaire sent to the family doctor.

The questionnaire referred to clinical complaints, endourological auxiliary procedures and renal function. If the questionnaire was not sent back within 30 days the family doctor was telephoned and asked directly about the patients outcome.

Laboratory values (glutamate oxaloacetate transaminase GOT, $N = 53$; lactate dehydrogenase LDH, $N = 53$; creatine kinase CK, $N = 48$; total bilirubin, $N = 50$ and creatinine, $N = 54$) were determined photometrically before and on the 1st and on the 6th day after EPL. GOT (to indicate myolysis and liver cell damage especially to mitochondria), LDH (to indicate hemolysis, spleen damage, liver cell damage and myolysis), CK (to indicate myolysis and liver cell damage), total bilirubin (to indicate hemolysis and liver damage) and creatinine (to indicate reduced kidney function and myolysis) were determined to detect possible tissue damage from the penetrating shock waves [16].

An enzyme immunoassay was used to analyse a 24 hour urine sample from before the EPL, a 6 hour urine sample from the day following the EPL and another 24 hour urine sample 6 days post

Table 1. Complications of 85 treatments the 1st day after EPL[a]

Colics (requiring spasmoanalgesics)	15 (18%)
Prolonged macrohematuria	2 (2%)
Urinary tract infection (UTI)	1 (1%)
Urosepsis	1 (1%)
Steinstrasse	1 (1%)
Obstruction	8 (9%)
Deaths	0
Total complication rate	21 (25%)

[a] 5 experienced a combination of two complications, and 1 a combination of three complications

Table 2. Auxiliary endourological procedures in 85 treatments before and the day after EPL

Double-J ureteral stent	25 (29%)
pre EPL (prophylactically)	23 (27%)
post EPL (change with obstruction)	2 (2%)
Percutaneous nephrostomy and litholapaxy	1 (1%)
Ureteral stone removal (forceps)	2 (2%)
Total endourological procedure[a]	26 (31%)

[a] after 2 treatments 2 endourological procedures

Table 3. Side effects of 63 treatments during follow up 1–5 months after EPL

Medication:	
spasmoanalgesics	9 (14%)
antibiotics	6 (10%)
Kidney function:	
no data	21 (34%)
unchanged	33 (52%)
improved	7 (11%)
worse	2 (3%)
Complaints:	
no data	3 (5%)
no complaints	53 (84%)
colics	3 (5%)
flank pain	4 (6%)
Complications:	
urosepsis/steinstrasse	1 (2%)
obstruction	2 (3%)
Instrumentation:	
percutaneous litholapaxy + double-J ureteral stent	1 (2%)
ureteral sling	1 (2%)

EPL for albumin ($N=39$) and beta-2-microglobulin ($N=36$). Albumin in the urine indicates either glomerular damage (because most of the serum albumin does not pass the intact glomeruli), or urothelial bleeding when in combination with hematuria [15].

Beta-2-micro-globulin in the urine indicates either tubular damage (because although in passes the glomeruli totally it is normally almost completely reabsorbed in the renal tubules), or, urothelial bleeding when in combination with hematuria [15]. Also in 10 patients a SDS-polyacrylamid-gel-electrophoresis of the urinary proteins was carried out.

Results

After 18% of the treatments the patients suffered renal colic during the 1st post therapy day and needed spasmoanalgesics (Table 1). Macrohematuria for longer than 24 hours occurred after 2 treatments (2%) and neither case required any further treatment (Table 1).

Before 5% ($N=4$) of the treatments patients showed primary UTI and underwent shock wave lithotripsy after antibiotic therapy. The day after treatment 1 (1%) E. coli-UTI occurred and 1 (1%) E.-coli-urosepsis despite a sterile urine culture before EPL (Table 1). The patient with the urosepsis had a percutaneous nephrostomy after insertion of a double-J ureteral stent had failed. This together with antibiotics controlled the infection.

Of the 8 ureteral obstructions (9%) the day after EPL 2 did not need any treatment; after 3 treatments the ureteral double-J stent was obstructed by fragments requiring stent removal (1 case) or stent changes (2 cases); a steinstrasse was removed in 1 case by ureteroscopy. 2 of the 8 obstructions with prevesical fragments required removal, by stone forceps in 1 and in the other by nephrostomy for concomitant urosepsis (see above) followed by percutaneous litholapaxy (PNL) with spontaneous passage of a distal ureteral fragment remaining after PNL.

A double-J ureteral stent was inserted before 23 treatments (27%) for stones with a maximum diameter more than 1.5 cm (Table 2). Endourological measures were indicated in 27 treatments (32%) before or after treatment (27% before and 5% after EPL) (see Tables 2 and 3) (3 × instrumentation during outpatient follow up). Sonography ($N=85$) and MRI ($N=20$) detected neither subcapsular hematoma nor any other intrarenal lesion.

The results of the follow-up 1–5 months after EPL are shown in Table 3. Antibiotics were given after 10% of treatments ($N=6$), and spasmoanalgesics after 14% ($N=9$). A mild increase of serum creatinine occurred only in 2 cases.

Ureteral colic was reported after 3 treatments (5%). Mild flank pain occurred after 4 treatments (6%).

One patient with septicemia and steinstrasse required a double-J ureteral stent. The other two obstructions were mild and did not require intervention.

One non-obstructing distal ureteral fragment could not be removed by an ureteral sling and was destroyed by EPL in situ. One renal pelvic stone was removed by percutaneous litholapaxy after several EPL treatments were unsuccessful.

The total complication rate after 85 treatments was 28% (25% mild, 4% severe).

Mean GOT-, LDH-, CK-, bilirubin-, and creatinine-values showed no significant changes either before, or on the 1st and 6th days after EPL (Table 4). Also, there was no single individual with marked increase in the various plasma levels mentioned above.

Table 4. Laboratory results of patients treated with EPL. Laboratory values (± standard deviation)

	Before	1st day post	6th day post
GOT U/l ($N=53$)	11.3 ± 3.0	10.6 ± 2.7	11.0 ± 4.3
LDH U/l ($N=53$)	164 ± 39	165 ± 42	169 ± 43
CK U/l ($N=48$)	40.0 ± 20.3	33.3 ± 18.5	36.3 ± 20.4
Bilirubin mg/dl ($N=50$)	0.61 ± 0.33	0.67 ± 0.40	0.48 ± 0.28
Creatinine mg/dl ($N=54$)	0.99 ± 0.33	1.06 ± 0.31	1.02 ± 0.30

Table 5. Urinary protein values of patients treated with EPL (± standard deviation)

	Before	1st day post	6th day post
Albumin mg/d ($N=39$)	66.5 ± 147.4	476.8 ± 698.2	84.8 ± 129.9
Beta-2-micro-globulin µg/d ($N=36$)	75.2 ± 73.2	164.0 ± 196.8	92.2 ± 76.8

The average urinary concentrations of albumin and beta-2-microglobulin showed a marked increase the first day after EPL but decreased to nearly pre-treatment values 6 days later (Table 5).

14 patients without concomitant microhematuria had no rise in beta-2-microglobulin. The marked increase of albuminuria the first day after EPL returned nearly to pre-treatment values on the 6th day after EPL (Table 6).

In the 10 SDS-electrophoretic studies 8 patients showed a glomerular proteinuria together with a microhematuria, 3 patients had tubular proteinuria before and after the treatment, and 1 patient developed a slight tubular proteinuria after treatment together with microhematuria.

Discussion

Because of the high cost of the measurement or of compliance problems not all the patients in this study were followed by all the methods used.

Although high risk patients were included in this study neither death nor serious *clinical complications* occurred in any of the patients studied. None of the patients needed general or spinal anesthesia. Only after 2 of 85 treatments an oral sedative had to be used. Some of the typical clinical complications associated with extracorporeal shock wave lithotripsy (ESWL) like arrhythmia and anesthesia problems (about 10% ileus, vomiting, skin petechiae) [3, 13]

Table 6. Urinary protein values of patients treated with EPL (± standard deviation) without concomitant microhematuria ($N=14$)

	Before	1st day post	6th day post
Albumin mg/d	9.3 ± 12.3	124.0 ± 156.0	24.0 ± 28.0
Beta-2-micro-globulin µg/d	57.3 ± 64.1	47.0 ± 54.7	52.2 ± 49.0

were not seen with EPL in this and in other EPL-studies [8, 10, 18].

Nearly all of our patients observed a transient macrohematuria not requiring treatment, and lasted longer than 24 hours in only 2 patients.

Not all of the 12% of the patients with ureteral obstruction after treatment (9% the 1st day after EPL, 3% during follow up) had clinical symptoms, so that all patients need a close follow-up with ultrasound after EPL. Riehle et al. [13] reported 30% endourological auxiliary measures in 518 ESWL treatments which correlates with the results of this study (32%). Our 27% rate of pretreatment double-J ureteral stenting slightly exceeds the 23% reported by Riehle et al. [13] and the 24% quoted by Coptcoat et al. [3].

It is essential to exclude concomitant *UTI* before any shock wave therapy starts. If an urine culture is positive as before 5% of the treatments in this study the patient has to be treated with appropriate antibiotics for at least 48 hours.

Under this regimen we noted only 1% UTI and 2% urosepticemia after EPL (1% the 1st day after EPL, 1% during follow up) which correlates well with the 0.5%–3% urosepsis quote reported in the literature after ESWL [1, 3, 4].

Despite prophylaxis with trimethoprim, Coptcoat et al. [3] still reported 0.5% urosepsis after ESWL. We did not use any antibiotics prophylactically and saw only 2% urosepsis. Both cases with urosepsis were treated successfully by renal drainage and antibiotics. Both our own and Coptcoats [3] results demonstrate that prophylactically administered antibiotics in all patients seem to be unnecessary in extracorporeal shock wave lithotripsy. Exceptions are known infective stone disease and high risk patients, with heart valve disease or immune defiencies for example. Kroneman et al. reported a case of endocarditis after lithotripsy [7]. A close follow up of all patients after EPL and ESWL for early detection of infectious complications is recommended.

To assess *cellular or functional damage* some screening serum and urine analyses were performed in this study. ECG-monitoring is not necessary in patients undergoing EPL. We did not find any peaks in several cellular enzymes after EPL (GOT, LDH, CK, bilirubin) as it was found after ESWL by Kishimoto et al. [6] and Marcellan et al. [9]. Such peaks would indicate hemolysis and renal or muscle damage by ESWL. Due to higher energy, a larger focus and more scattered shock waves ESWL possibly causes more cell destruction than EPL.

Although albumin and beta-2-microglobulin in the urine were raised after EPL, there were only 14 patients with a marked increase of albumin and none with a marked increase of beta-2-microglobulin without microhematuria which would indicate glomerular or tubular damage. All the other patients showed a concomitant hematuria indicating urothelial bleeding as the source of the hyperalbuminuria or hyper-beta-2-microglobulinuria [15].

Albuminuria and beta-2-microglobulinuria allow estimation of the extent of glomerular or tubular damage after shock wave therapy only it concomitant microhematuria as a source of albumin and beta-2-microglobulin in the urine is excluded. The results of SDS-electrophoresis of the urine proteins showed the same problem of possible serum admixture in samples with microhematuria.

No *morphological changes*, except ureteral obstruction after 12% of treatments were found by sonography or MRI after EPL. This data are in accordance with the results of Marberger et al. [8], Neisius et al. [10] and Ziegler et al. [18].

By contrast, after ESWL ultrasound detected subcapsular fluid in 2.4% hyper- or hyposonic areas in 2.1%, subcapsular hematomas in 0.9% and hemorrhage in renal cysts in 0.8% [5].

Also MRI after EPL revealed no morphological changes in this study. With MRI after ESWL 25.6% showed subcapsular fluid, 63% showed loss of corticomedular junction, 18% showed hyperdense and 7.7% showed hypodense areas [2].

While after ESWL mild or moderate renal trauma can be detected in about 70% by imaging procedures no such changes are found after EPL indicating that this is a less traumatic procedure than ESWL [2, 5, 8, 10, 11, 14, 18].

Conclusions

1. Extracorporeal piezoelectric shock wave lithotripsy (EPL) does not require any anesthesia.
2. Prophylactical antibiotics are only necessary in high risk patients. However, any pre-exsisting UTI must be treated before EPL.
3. By use of some serum marker enzymes and morphological methods no serious complications relating to blood, muscle, spleen, liver or kidney tissue could be detected after EPL, except for urinary obstruction and urosepsis.
4. Because of the possibility of an asymtomatic obstruction, EPL patients should by closely followed with ultrasound until they are completely free of stones.
5. No tubular damage was detected after EPL treatment. Although, some patients did show temporary glomerular damage, this disappeared within 6 days.
6. EPL is a method with tolerable side effects and few risks. It is therefore suitable for the treatment of all urinary calculi, especially in high risk patients.

Acknowledgement. We thank G. A. Rose, MD for revising the paper.

References

1. Ad Hoc Committee of the American Urologic Association (1985) Report of the American Urological Association Ad Hoc Committee to study the safety and clinical efficacy of current technology of percutaneous lithotripsy and non invasive lithotripsy, sect. 2. American Urological Association, Baltimore, p 10
2. Baumgartner BR, Dickey KW, Ambrose SS, Walton KN, Nelson RC, Bernardino ME (1987) Kidney changes after ESWL: appearance on MR imaging. Radiology 163:531
3. Coptcoat MJ, Webb DR, Kellett MJ, Fletcher MS, McNicholas TA, Dickinson IK, Whitfield HN, Wickham JEA (1986) The complications of ESWL: management and prevention. Br J Urol 58:578
4. Drago JR, Nesbitt JA, Shah BN, Nelson JH, Wise HA (1987) Extracorporeal shock wave lithotripsy (ESWL). Int Surg 72:48
5. Kaude JV, Williams JL, Wright PG, Bush D, Derau C, Newman RC (1987) Sonographic evaluation of the kidney following ESWL. J Ultrasound Med 6:299
6. Kishimoto T, Yamamoto K, Sugimoto T, Yoshihara H, Maekawa M (1986) Side effects of extracorporeal shock-wave exposure in patients treated by extracorporeal shock-wave lithotripsy for upper urinary tract stone. Eur Urol 12:308
7. Kroneman OC, Brodsky MS, MacKenzie J, Hauser A (1987) Endocarditis after lithotripsy. Ann Intern Med 106:777
8. Marberger M, Türk Ch, Steinkogler I (1988) Painless piezoelectric extracorporeal lithotripsy. J Urol 139:695
9. Marcellan FJR, Servio LI (1986) Evaluation of renal damage in extracorporeal lithotripsy by shock waves. Eur Urol 12:73
10. Neisius D, Kopper B, Ziegler M (1987) Die Zertrümmerung von Nierensteinen mit dem Piezolith – klinische Erfahrungen. In: Ziegler M (ed) Die extrakorporale und laserinduzierte Stoßwellenlithotripsie bei Harn- und Gallensteinen. Springer, Berlin Heidelberg, New York, p 50
11. Newman RC, Bezirdjian L, Steinbock G, Finlayson B (1986) Complications of ESWL: prevention and treatment. Semin Urol 4:170
12. Riedlinger R, Ueberle F, Wurster H, Krauß W, Vallon P, Konrad G, Kopper B, Stoll HP, Goebbels R, Gebhardt T, Ziegler M (1987) Die Zertrümmerung von Nierensteinen durch piezoelektrisch erzeugte Hochenergie-Schallpulse. Urologe [A] 25:188
13. Riehle RA, Näslund EB, Fair W, Vaughan ED (1986) Impact of shockwave lithotripsy on upper urinary tract calculi. Urology 28:261
14. Rubin JI, Arger PH, Pollack HM, Banner MP, Coleman BG, Mintz MC, VanArsdalen KN (1987) Kidney changes after ESWL: CT evaluation. Radiology 162:21
15. Sarre H, Gessler U, Seybold D (1988) Nierenkrankheiten. Thieme, Stuttgart New York
16. Thomas L (1984) Labor und Diagnose. Medizinische Verlagsgesellschaft, Marburg
17. Vahlensieck W (1987) Harnsteinleiden. Springer, Berlin Heidelberg New York
18. Ziegler M, Kopper B, Riedlinger R, Wurster H, Ueberle F, Neisius D, Krauss W, Vallon P, Gebhardt T (1986) Die Zertrümmerung von Nierensteinen mit einem piezoelektrischen Gerätesystem. Urologe [A] 25:193

Dr. W. Vahlensieck Jr.
Urologische Klinik
Ludwig-Maximilians-Universität
Marchioninistrasse 15
D-8000 München 70
Federal Republic of Germany