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Renal and Ureteral Stone Treatment by Extracorporeal Shock Wave Lithotripsy

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ABSTRACT

Extracorporeal shock wave lithotripsy (ESWLs) results can be enhanced by the application of specific technological concepts and the selection of advantageous instances. This study's goal is to analyze the mechanisms of action of ESWL., indications and contraindications, success predictors, and consequences. ESWLs & "calculi" were used as topics in a search between Jan. 1984 and Oct. 2013 in the Pubmed® database. Only human-conducted studies with a sufficient level of evidence, including clinical trials or reviews/meta-analyses, were considered for inclusion. To optimize the seek for the ESWL results, many technical factors, including the kind of ESWLs apparatus, the intensity & frequency of the impulses, the connecting of patients to the device, the position of the stones, as well as the type of anesthesia, should be taken into consideration. Other patient-related variables, such as the density & size of the stone, skin-to-stone distance, anatomy of the excretory system, and renal anomalies, are also significant. The insertion of a routine double J stent before the procedure is not typically advised, nor is antibiotic prophylaxis required. For stones larger than 10 mm, alpha-blockers, in particular, tamsulosin, are helpful. Following ESWL, minor problems are possible but often respond favorably to therapeutic therapy. It is unclear how ESWL affects those with diabetes or hypertension.

KEY WORDS: Renal colic, kidney stone, ESWL, ureter stone, lithotripsy.

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INTRODUCTION

One of the most common interventions options is extracorporeal shock wave lithotripsy (ESWLs) which is used in the treatment of from ureteral &/or renal stone, it was brought into clinical practice during the 1980s. Notwithstanding, its applicability have been reduced because of the advancement of endourology & minimally-invasive surgery and those procedures' excellent success rates. From that point on, it has become important to look for the ideal specialized boundaries and cautious determination of contender for ESWL to advance its outcomes and legitimize its usage. This study is designed to review the way that ESWL acts, indications of its use and its contraindications, prescient variables for progress, & its complications (early and late complications). [1]

TECHNICAL TENETS

ESWLs involves shattering of the stone using pulsed acoustic waves that are aimed at the stone from an external source of power known as a lithotripter. These waves are high intensity and low frequency. Numerous technical factors, including device manufacturer [2], the energy content, the impulses frequency, the degree of coupling between the patients & ESWLs device, point of focus, stones location, & the type of anesthesia, must be taken into account in order to optimize the results of ESWL.

Each pulse should begin with a low level of energy (13–14 KV) and then gradually increase in energy [3]. As a result of the consecutive shock waves, formation of cavitation bubbles surrounding the stone as well as direct shearing forces are applied to it. As these bubbles break, energy is released which accelerates stones' disintegration [4]. Currently, rates between (60 and 90) shock/min. was used, enhancing stone fragmentation and lowering procedure morbidity with a constant increment in energy [5,6].

According to a recent meta-analysis, ESWLs with a rate of 60 compared to 120 pulses per minute was more effective [5]. And as Abood *et al.* demonstrated [7], this improvement is most obvious in calculi exceeding 10 mm.

The success of ESWL is increased by the proper connection of patients to lithotripsy machines. The efficiency of shock waves is negatively related to the amount of air in their passage [8-10]. In order to maximize the delivery of shock waves, the focal zone has also been studied. According to recommended guidelines, ureteral calculi should be treated with a focus zone (28 x 6 mm) and renal stones with a larger one (50 x 9 mm) [4].

In order to properly evaluate the patient prior operation, non-contrast spiral computed tomography is a preferred examination since it offers the most important data regarding the indication and prognosis [11]. Prior to the surgery, coagulation patterns & urinary cultures should be examined. Normally, the patient is positioned supine, however in cases of pelvic kidney, horseshoe kidney, or distal ureter calculi, shifting to a ventral posture creates a better "window" that is clear of the iliac crest. Either fluoroscopy or ultrasonography are used to identify the calculus depending on its size, density, and location. With the latter method, low density renal and ureteral stones can be more accurately identified without the use of ionizing radiation.

Since the effectiveness of ESWLs depends on the exact location of the calculus, a good option for ESWLs is to reduce breathing movements by high frequency ventilation and low current volume [12,13]. Fluoroscopy-based automated tracking devices or expanding the focal zone both aid in the proper shock wave delivery to the calculus [4]. The treatment can start following sedation or general anesthesia, which is favored because of improved results [14]. Approximately 3,000 pulses are used in the majority of services, and the entire treatment takes about an hour.

The technical parameters that have an impact on the ESWL outcomes are included in **Table (1)** together with their corresponding evidence levels and recommendation grades.

TABLE 1 Technical factors impacting the extracorporeal shock wave lithotripsy results

Factor	Evidence	Study type	Level of evidence	Grade of recommendation	Authors
Lithotripsy device	There is no difference between lithotripters (electrohydraulic, electromagnetic or piezoelectric) in the treatment of kidney stones	Case control	III	B	Alanee S
Energy	Start with low energy and increase gradually	Prospective, randomized	Ib	A	Lambert EH
Frequency of pulses	A lower frequency (60Hz) performs better than the high frequency (120Hz)	Meta-analysis of randomized clinical studies	Ia	A	Li K
Coupling	The presence of air in the path of the shock wave negatively affects the results of ESWL	*In vitro* study/Series of cases	III	B	Pishchalnikov YA and Jain A /Li G
Location of the *calculus*	Kidney movements during respiration negatively affect ESWL. High frequency ventilation can optimize the results	Retrospective cohort study	III	B	Warner MA and Cormack JR
Anesthesia	General anesthesia shows better results than sedation	Retrospective cohort study	III	B	Sorensen C

INDICATIONS

With a rate of success of 33 to 91%, ESWL is currently regarded as the primary intervention for renal calculi < 2.0 cm. Use of Lithotripsy in the treatment of stones larger than 2 cm has already been documented in several series, however, the low success rates and need for numerous sessions to improve results are limiting factors [15]. Because of how minimally invasive treatment is, ESWL is also suggested for use with ureteral stone [16]. According to a recently meta-analysis, the overall stone-free percentage following emergency Lithotripsy for ureteral calculi is 78% (75% - 82%), with rates of 79 % (61% - 95%) for proximal ureteral stone, 78% (69% - 88%) for mid ureteral stone, & 79% (74% - 84%) for distal ureteral stone [17].

CONTRAINDICATION OF ESWL

Pregnancy, untreated urosepsis or UTI, decompensated coagulopathy, uncontrollable tachyarrhythmia, & abdominal aortic aneurysms larger than 4 cm are an official contraindications to ESWL [18]. Alternative treatments should be suggested if any of these symptoms are present.

PREDICTORS OF SUCCESS

A number of variables, including the calculus' size, location, composition, density, calyceal diverticula, horseshoe kidney, ectopic kidney/renal fusion, obstruction/stasis, stenosis of the ureteropelvic junction, hydronephrosis, and patient-related variables, can affect the outcome of ESWL (renal failure, obesity, skin to stone distance).

Result is presented by ESWL in an inverse relationship to calculus size. ESWLs does have a rate of success of (33, 56, & 74) % for renal calculi greater than 2 cm , 2 cm , & up to 1 cm respectively, according to meta-analysis by Lingeman *et al.* [15] which conducted in 1994.

Numerous articles looking at ESWL success predictors have been published. In a retrospective study including 427 participants undergoing ESWL for stone size up to 3 cm, Al-Ansari *et al.* [19] reported a success rate about (78 %) after 3 months. However, More than 1 session was necessary for 53.1% of these individuals, & 8.4% have their therapy supplemented with different method (percutaneous nephrolithotomy, flexible ureteroscopy or double-J stenting). The number, size, and location of calculi, in addition to renal anastomosis and congenital abnormalities, all had an effect on the success rate in this sample of patients. 90% of calculations less than ten mm were successful, while 70% of calculations greater than ten mm did so ($p < 0.05$). The success rate for calculi in the upper pole and renal pelvis was 87.3 and 88.5%, respectively, but the success rate for calculi in the lower pole were 69.5% ($p < 0.05$). A solitary kidney stone have a 78.3% success rate, but many kidney calculi had a 62.8% success rate ($p < 0.01$). The success rate for kidneys without dilatation was 83%, however, 76% of kidneys stone with hydronephrosis were successful ($p < 0.05$). Compared to congenital kidneys defects, which have a success rate of 54%, patients without abnormalities had a rate of success of 79% ($p < 0.03$).

In a broader analysis of 2,954 patients who underwent ESWL for calculi smaller than 3 cm, treatment with lithotripsy demonstrated a 86.7% stone-free rate after a three months follow-up. Size, position, stones quantity, congenital abnormalities, & renal anatomy were all reliable indicators of succeed, according to a logistic regression analysis.

The features of the calculus as well as the patient have been examined in certain research. Perks *et al.* [20] revealed 40% stone-free rate & 24 % full fragmentation in a retrospective study involving 111 patients with calculi < 2.0 cm who had ESWL. Stone composition, size, location, body mass index, attenuation, & skin-to-stone distance (SSD) were all included in the multivariate analysis. The results revealed that these variables are significantly and independently related to the outcomes of complete fragmentation.

Wiesenthal *et al*. [21] investigated 422 participant having kidney or ureter stone sizing 2 cm or less through an effort to develop a therapeutic nomogram to predict the effectiveness of Lithotripsy in the treatment of kidney & ureter stone. In a 3-month follow-up, the rate of success with one ESWL session is 70.2% for renal calculi & 60.3% in case of ureter stone, respectively. With regard to ureteral calculi, BMI & the size of the stone are indicators to ESWL successful in logistic regression. In a separate investigation, Kanao *et al*. [22] examined (435) individuals who had kidney & ureter stone & created a nomogram that included position, size (renal pelvis vs. renal calyx vs. proximal vs. distal ureter), & stone number into account as an indicator of successfulness. Proximal ureter stone up to 5 mm had the best success rate (93.8%), while numerous calycine calculi more than 21 mm had the lowest success rate (10.5%).

There are few ongoing studies examining the lithotripsy in renal urinary stone success predictors. A three-month computed tomography follow-up for 120 patients having kidney stone size (0.5 - 2.5) cm who underwent lithotripsy revealed positive outcomes, 87.5% of individuals are stone free or having residual stone up to 4 mm. In a study of multivariate analysis revealed that the BMI ($p = 0.04$) & densities of the stones more than 1000 Hounsfield units ($p = 0.02$) are indicators of successfulness [11].

It is still debatable whether ESWL is appropriate for lower calyx calculi, because renal anatomy—specifically, the infundibular calicinal angle, infundibular length, width, and height—can have a detrimental effect [23-25].

Table 2. lists the primary contributing causes to a poor prognosis for the success of ESWL along with the evidence and recommendation.

TABLE 2 Predictors of the success of extracorporeal shock wave lithotripsy

Factor	Evidence	Study type	Level of evidence	Grade of recommendation	Authors
Size of the calculus	Size is inversely proportional to the ESWL result	Meta-analysis of cohort studies	IIa	B	Lingeman JE
calculus density	High density calculi present worse results (>1000 UH)	Prospective cohort study	IIb	B	El-Nahas AR
Location of the calculus	Lower pole renal calculi present worse results than mid-pole and upper pole calculi. Calycine calculi have worse outcomes compared to renal pelvic and ureteral stones.	Retrospective cohort study	III	B	Al Ansari A and Kanao K
Skin-to-stone distance	Distances over 9 cm negatively affect ESWL	Retrospective cohort study	III	B	Perks AE and Wiesenthal JD
Anatomy of the excretory path	Unfavorable anatomy (infundibulopelvic angle <90°, infundibular length > 3.0 cm and infundibular width of <4-5 mm) negatively affect ESWL	Retrospective cohort study	III	B	Elbahnasy
Kidney anomalies	Kidneys with congenital anomalies have lower elimination rates	Retrospective cohort study	III	B	Al Ansari A

ADJUVANT ELEMENTS FOR ESWL

Antibacterial are not required with Lithotripsy for individuals having sterile urine. The prevalence of fever or urine infection was not decreased by antibiotic prophylaxis, according to meta-analysis of 9 studies including 1,364 individuals.

Routine double-J stenting before Lithotripsy would not raise percentage of individuals who are stone-free or with lower complications, hence it should not be promoted. The operation without a ureteral catheter is possible even in patients with one kidney, although careful candidate selection is necessary [26]. A systematic review [27] that examined the outcomes and risks of ESWL in the treatment of upper urinary tract calculi with or without double-J stenting prior to the intervention evaluated the sources including the PubMed®, Embase®, and Cochrane databases. The rate of stone-free response, steinstrasse, hematuria, symptoms of the lower urinary tract, infection, discomfort, fever, vomiting, & nausea, as well as requirement of analgesics & adjuvant intervention for the removal of the stone, were all examined. A randomized 8 studies with 876 participants subdivided into 453 catheterized individuals and 423 catheter-free patients were found. The meta-findings analysis's revealed no discernible difference between the groups. With the exception of one research, incidence of steinstrasse was comparable between both groups (with & without catheter). However, patients who had a catheter had a significantly greater prevalence of lower urinary tract signs.

There is strong evidence that alpha-blocker medication therapy, particularly tamsulosin, has advantages for post-ESWL care. Tamsulosin has been shown to be truly effective in patients undergoing ESWL according to a recent meta-analysis, which found that the medicine raises average stone eradication rates about 16% (5–27%) & reduces average stone eradication times about 8 (3–20) days. As a supplement to ESWL treatment, other drugs like nifedipine have also shown promise, although they come with a high risk of adverse effects like hypotension and dizziness [28].

COMPLICATIONS

After ESWL, a number of minor problems may arise. Analgesics are required in up to 40% of patients due to the prevalence of flank pain, presence of petechiae or subcutaneous bruises in the entry & departure site of the waves, and these symptoms. Nearly all patients have microscopic hematuria, while only around one-third of patients have extensive hematuria [29]. The most frequent complications were renal colic (40%), gross hematuria (32%), urinary obstruction (30.9%), and perirenal hematoma or subclinical subcapsular hematoma (4.6%), according to a prospective analysis including 3,241 individual having stone bigger than 4 mm who underwent lithotripsy (7,245 sessions). Additionally, in 9.7% of instances, bacteriuria with symptoms was identified. Most of the time, pain patients can be properly treated with anti-inflammatory &/or anti-spasmodic medications without the need for additional interventions such recurrent ESWL or ureteroscopies.

Patients with gross hematuria show spontaneous recovery in 85% of instances after 48 hours and in practically 100% of cases within 10 days [30]. Up on size, quantity, & location of the stone, patients with urinary blockage may be treated either medically by alpha-blockers or with surgery by ureteroscopy or double-J stenting. When perirenal hematomas are substantial in size, imaging tests and hemoglobin and hematocrit control should be used to monitor them. There have only been a few reports of post lithotripsy renal explosion documented, & yet in those situations, conservative therapy could be necessary. Intraoperative hypertension & utilization of antiplatelet/anticoagulant medication were found to be significant risks factor that could cause perirenal hematoma as reported by a study including 6,172 lithotripsy sessions by Razvi *et al.* [31].

A number of papers have attempted to show a connection between Lithotripsy and the onset of diabetes and hypertension in relationship to late complications. Chew *et al*. [32] didn't discover a high prevalence of those disorders in a research grouping in comparison with population mean in a retrospective evaluation including 727 individuals having ESWL. Krambeck *et al.* [33] as well discovered no connection between Lithotripsy & high blood pressure in both univariate & multivariate analyses, involving gender, age, & obesity in a study including 4,782 participants having kidney stones without hypertension followed by an average of 8.7 years. However, in a study that gathered prospective data via a questionnaire being sent and answered by 2,041 patients undergoing ESWL, B arbosa *et al.* [34] found a significant yet slight increase in the incidence of elevated blood pressure in such patients in comparison with controls matched by gender, age, & BMI.

In a research that was identical to the one stated above that included_1,869 participants who underwent lithotripsy, it was not discovered that these individuals had a greater prevalence of diabetes than controls who were comparable for gender, age, & BMI. In both univariate and multivariate analysis, involving gender, age, & obesity, a study including 5,287 individuals having stone but not diabetic who were followed for a mean of 8.7 yrs. observe no correlation between lithotripsy & the onset of diabetes [35]. Studies with high levels of evidence are required to confirm or disprove the relationship between lithotripsy & the onset of chronic diseases (such as hypertension and diabetes). Last but not least, in regards to a potential worsening of renal function after lithotripsy, El-Assmy *et al.* [36] observe no changes in creatinine levels in a study of 156 patients with a single kidney who underwent ESWL and an average follow-up of 3.8 years, illustrating the safety of this method at least in the medium term.

CONCLUSION

When treating ureteral calculi, ESWL is an alternate to ureteroscopy and has good outcomes for renal stones size up to 2 cm. The optimization of outcomes depends on a number of technical parameters, and the likelihood of success is influenced by the patient as well as the stone's characteristics, including size, density, skin-to-stone distance, excretory system anatomy, and renal abnormalities. It is not necessary to put a double J stent or administer antibiotic prophylaxis before the treatment. Success rates could rise with alpha-blockers. While late complications have not yet been proved, early and significant complications are uncommon.

CONFLICT OF INTEREST

The authors declared that there is no conflict of interest regarding the publication of this paper and declare that they have no known competing financial interests OR non-financial interests, OR personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

I. Torricelli FC, Danilovic A, Vicentini FC, Marchini GS, Srougi M, Mazzucchi E. Extracorporeal shock wave lithotripsy in the treatment of renal and ureteral stones. Rev Assoc Med Bras (1992). 2015 Jan-Feb;61(1):65-71. doi: 10.1590/1806-9282.61.01.065. Epub 2015 Jan 1. PMID: 25909212.

II. Alanee S, Ugarte R, Monga M. The effectiveness of shock wave lithotripters: a case matched comparison. J Urol. 2010;184:2364-7.

III. Lambert EH, Walsh R, Moreno MW, Gupta M. Effect of escalating *versus* fixed voltage treatment on stone comminution and renal injury during extracorporeal shock wave lithotripsy: a prospective randomized trial. J Urol. 2010;183:580-4.

IV. Rassweiler JJ, Knoll T, Kohrmann KU, McAteer JA, Lingeman JE, Cleveland RO et al. Shock wave technology and application: an update. Eur Urol. 2011;59:784-96.

V. Li K, Lin T, Zhang C, Fan X, Xu K, Bi L, et al. Optimal frequency of shock wave lithotripsy in urolithiasis treatment: a systematic review and meta-analysis of randomized controlled trials. J Urol. 2013;190:1260-7.

VI. Mazzucchi E, Brito AH, Danilovic A, Ebaid GX, Chedid Neto E, Azevedo JR, et al. Comparison between two shock wave regimens using frequencies of 60 and 90 impulses per minute for urinary stones. Clinics. 2010;65:961-5.

VII. Abood, Mohammed Khalid, Wasan Abdul Kareem Abass, and Kadhim Ali Kadhim. "Comparative Study for the Effect of Tamsulosin on Biomarkers between Renal and Urethral Stone Lithotripsy." International Journal of Pharma Sciences and Research (IJPSR), Vol 6, no. 10 (Oct 2015): 1274-1287

VIII. Pishchalnikov YA, Neucks JS, VonDerHaar RJ, Pishchalnikova IV, Williams JC Jr., McAteer JA. Air pockets trapped during routine coupling in dry head lithotripsy can significantly decrease the delivery of shock wave energy. J Urol. 2006;176:2706-10.

IX. Jain A, Shah TK. Effect of air bubbles in the coupling medium on efficacy of extracorporeal shock wave lithotripsy. Eur Urol. 2007;51:1680-6.

X. Li G, Williams JC Jr, Pishchalnikov YA, Liu Z, McAteer JA. Size and location of defects at the coupling interface affect lithotripter performance. BJU Int. 2012;110:E871-7.

XI. El-Nahas AR, El-Assmy AM, Mansour O, Sheir KZ. A prospective multivariate analysis of factors predicting stone disintegration by extracorporeal shock wave lithotripsy: the value of high-resolution noncontrast computed tomography. Eur Urol. 2007;51:1688-93.

XII. Warner MA, Warner ME, Buck CF, Segura JW. Clinical efficacy of high frequency jet ventilation during extracorporeal shock wave lithotripsy of renal and ureteral *calculi*: a comparison with conventional mechanical ventilation. J Urol. 1988; 139: 486-7.

XIII. Cormack JR, Hui R, Olive D, Said S. Comparison of two ventilation techniques during general anesthesia for extracorporeal shock wave lithotripsy: high-frequency jet ventilation *versus* spontaneous ventilation with a laryngeal mask airway. Urology. 2007;70:7-10.

XIV. Abood, Mohammed Khalid, and Ammar Fadil. "Effect of Tamsulosin on Biomarkers after Ureteral Stones Lithotripsy." *Al Mustansiriyah Journal of Pharmaceutical Sciences* 15, no. 2 (2015): 13-20.

XV. Lingeman JE, Siegel YI, Steele B, Nyhuis AW, Woods JR. Management of lower pole nephrolithiasis: a critical analysis. J Urol. 1994;151:663-7.

XVI. Lindqvist K, Holmberg G, Peeker R, Grenabo L. Extracorporeal shock-wave lithotripsy or ureteroscopy as primary treatment for ureteric stones: a retrospective study comparing two different treatment strategies. Scand J Urol. 2006;40:113-8.

XVII. Picozzi SC, Ricci C, Gaeta M, Casellato S, Stubinski R, Ratti D, et al. Urgent shock wave lithotripsy as first-line treatment for ureteral stones: a meta-analysis of 570 patients. Urol Res. 2012;40:725-31.

XVIII. Streem SB. Contemporary clinical practice of shock wave lithotripsy: a reevaluation of contraindications. J Urol. 1997;157:1197-203.

XIX. Al-Ansari A, As-Sadiq K, Al-Said S, Younis N, Jaleel OA, Shokeir AA. Prognostic factors of success of extracorporeal shock wave lithotripsy (ESWL) in the treatment of renal stones. Int Urol Nephrol. 2006;38:63-7.

XX. Perks AE, Schuler TD, Lee J, Ghiculete D, Chung DG, D'A Honey RJ, et al. Stone attenuation and skin-to-stone distance on computed tomography predicts for stone fragmentation by shock wave lithotripsy. Urology. 2008;72:765-9.

XXI. Wiesenthal JD, Ghiculete D, Ray AA, Honey RJ, Pace KT. A clinical nomogram to predict the successful shock wave lithotripsy of renal and ureteral *calculi*. J Urol. 2011;186:556-62.

XXII. Kanao K, Nakashima J, Nakagawa K, Asakura H, Miyajima A, Oya M, et al. Preoperative nomograms for predicting stone-free rate after extracorporeal shock wave lithotripsy. J Urol. 2006;176:1453-6.

XXIII. Elbahnasy AM, Clayman RV, Shalhav AL, Hoenig DM, Chandhoke P, Lingeman JE, et al. Lower-pole caliceal stone clearance after shockwave lithotripsy, percutaneous nephrolithotomy, and flexible ureteroscopy: impact of radiographic spatial anatomy. J Endourol. 1998;12:113-9.

XXIV. Tuckey J, Devasia A, Murthy L, Ramsden P, Thomas D. Is there a simpler method for predicting lower pole stone clearance after shockwave lithotripsy than measuring infundibulopelvic angle? J Endourol. 2000;14:475-8.

XXV. Sampaio FJ, DAnunciacao AL, Silva EC. Comparative follow-up of patients with acute and obtuse infundibulum-pelvic angle submitted to extracorporeal shockwave lithotripsy for lower caliceal stones: preliminary report and proposed study design. J Endourol. 1997;11:157-61.

XXVI. Kumar S, Sakthivel A, Chacko KN, Kekre NS, Ganesh G. Shock wave lithotripsy in solitary functioning kidneys: is prophylactic stenting necessary? Urol Int. 2006;77:179-81.

XXVII. Shen P, Jiang M, Yang J, Li X, Li Y, Wei W, et al. Use of ureteral stent in extracorporeal shock wave lithotripsy for upper urinary *calculi*: a systematic review and meta-analysis. J Urol. 2011;186:1328-35.

XXVIII. Vicentini FC, Mazzucchi E, Brito AH, Chedid Neto EA, Danilovic A, Srougi M. Adjuvant tamsulosin or nifedipine after extracorporeal shock wave lithotripsy for renal stones: a double blind, randomized, placebo-controlled trial. Urology. 2011;78:1016-21.

XXIX. Sofras F, Karayannis A, Kostakopoulos A, Delakas D, Kastriotis J, Dimopoulos C. Methodology, results and complications in 2000 extracorporeal shock wave lithotripsy procedures. BJU Int. 1988;61:9-13.

XXX. Salem S, Mehrsai A, Zartab H, Shahdadi N, Pourmand G. Complications and outcomes following extracorporeal shock wave lithotripsy: a prospective study of 3.241 patients. Urol Res. 2010;38:135-42.

XXXI. Razvi H, Fuller A, Nott L, Méndez-Probst CE, Leistner R, Foell K, et al. Risk factors for perinephric hematoma formation after shockwave lithotripsy: a matched case-control analysis. J Endourol. 2012;26:1478-82.

XXXII. Chew BH, Zavaglia B, Sutton C, Masson RK, Chan SH, Hamidizadeh R, et al. Twenty-year prevalence of diabetes mellitus and hypertension in patients receiving shock-wave lithotripsy for urolithiasis. BJU Int. 2012; 109:444-9.

XXXIII. Krambeck AE, Rule AD, Li X, Bergstralh EJ, Gettman MT, Lieske JC. Shock wave lithotripsy is not predictive of hypertension among community stone formers at long-term followup. J Urol. 2011;185:164-9.

XXXIV. Barbosa PV, Makhlouf AA, Thorner D, Ugarte R, Monga M. Shock wave lithotripsy associated with greater prevalence of hypertension. Urology. 2011;78:22-5.

XXXV. De Cógáin M, Krambeck AE, Rule AD, Li X, Bergstralh EJ, Gettman MT, et El. Shock wave lithotripsy and *diabetes mellitus*: a population-based cohort study. Urology. 2012;79:298-302.

XXXVI. El-Assmy A, el-Nahas AR, Hekal IA, Badran M, Youssef RF, Sheir KZ. Long-term effects of extracorporeal shock wave lithotripsy on renal function: our experience with 156 patients with solitary kidney. J Urol. 2008;179:2229-32.