Urolithiasis (2016) 44:441–444
DOI 10.1007/s00240-015-0857-2

ORIGINAL PAPER

The success of shock wave lithotripsy (SWL) in treating moderate-sized (10–20 mm) renal stones

Vera Y. Chung[1] · **Benjamin W. Turney**[1]

Received: 30 September 2015 / Accepted: 22 December 2015 / Published online: 7 January 2016

Abstract Many centres favour endourological management over shock wave lithotripsy (SWL) in the management of moderate-sized (10–20 mm) renal stones. International guidelines support all available modalities for the treatment of these stones. The aim of this study was to evaluate the efficacy of SWL in the treatment of 10- to 20-mm renal stones. From January 2013 to October 2014, all patients with a renal stone measuring between 10 and 20 mm in maximum diameter on CT scan that were eligible for lithotripsy were included. 130 consecutive patients were evaluated. Demographics, location of stone within the kidney, number of SWL sessions and treatment outcomes were analysed. Treatment success was classified into complete stone clearance and the presence of clinically insignificant residual fragments <4 mm (CIRF). 119 patients (92 %) completed treatment and radiological follow-up. Eleven patients were excluded due to incomplete follow-up data. The mean age was 56.8 (23–88). Male to female ratio was 1.9:1 (78:41) and the mean BMI was 28.4 (17.9–58). The mean stone size was 12.8 mm (10–14 mm: $n = 87$; 15–20 mm: $n = 32$). The mean number of treatments was 2.14 and 2.82 for stones 10–14 and 15–20 mm, respectively. Overall treatment success was 66.4 % (combined complete stone clearance and CIRFs). Subdivided by stone size <15 mm and ≥15 mm, the success rate was 70.4 and 53.1 %, respectively. The treatment success by stone location was 65, 64 and 70 % for upper, middle and lower pole stones, respectively and 67 % for PUJ stones. For those who failed SWL treatment, the majority 50 % ($n = 20$) were managed expectantly, 42.5 % ($n = 17$) required URS, and 7.5 % ($n = 3$) required PNL. This study suggests that SWL has an efficacy for treating larger renal stones (10–20 mm) that is equivalent to success rates for smaller stones in other series. As a low-risk and non-invasive procedure SWL should be considered a first-line treatment for these stones.

Keywords Shock wave lithotripsy · Renal stones · Efficacy · Complication

Introduction

In the modern era of management of renal stones, the preferred first-line treatment of stones less than 1 cm is shock-wave lithotripsy (SWL) whereas treatment for stones more than 2 cm is most commonly percutaneous nephrolithotomy (PNL). There is most controversy in the management of kidney stones between 1 and 2 cm. International guidelines agree that SWL, ureteroscopy (URS) and PNL are all acceptable treatment options for these stones [1].

Recent literature favours PNL for 1- to 2-cm lower pole stones [2]. The recent miniaturisation of PNL (e.g., mini-perc, ultra-mini-PNL, and micro-perc) has made PNL an even more attractive option because of reduced morbidities and high stone-free rate [3–5]. Flexible URS is also promoted by others as a promising technique for these calculi. Given the choice of endourological options available, urologists need to balance the outcomes of these technologies against the success of low-risk, non-invasive techniques

✉ Vera Y. Chung
chungyeungvera@gmail.com

Benjamin W. Turney
ben.turney@nds.ox.ac.uk

[1] Oxford Stone Group, Department of Urology, Churchill Hospital, Nuffield Department of Surgical Sciences, University of Oxford, Headington, Oxford OX3 7LE, UK

such as lithotripsy to provide patients with accurate information for consent.

In this study, we have reviewed the efficacy of SWL in treating larger kidney stones (10–20 mm) with regard to stone location and size.

Patients and methods

Since 2013 all patients undergoing SWL in our unit were entered into a prospective database. Patient demographics including gender, age and body mass index (BMI) were recorded. Treatment details such as stone size, location, number of shock waves, energy delivered and treatment success were documented.

From January 2013 to October 2014, all patients with a single, radio-opaque renal stone measuring between 10 and 20 mm in maximum diameter on non-contrast enhanced computer tomography (NCCT) were included. 130 consecutive patients were eligible and evaluated. The SWL was carried out as outpatient procedures. All lithotripsy treatments were performed on an on-site Modulith SLX-F2 lithotripter and by experienced dedicated radiographers. Fluoroscopy was used for stone targeting. All patients received the same pre-procedure analgesia, antiemetic and prophylactic antibiotics (pethidine 100 mg intramuscularly, diclofenac 100 mg per rectum, prochlorperazine 3 mg buccally, nitrofurantoin 100 mg orally). Our patients were not routinely stented before lithotripsy treatment except under the circumstances that a ureteric stent was inserted due to uncontrolled pain. We aim to deliver 4000 shock waves for each treatment session and this was reduced if the patient could not tolerate the pain or the stone was adequately fragmented. The patients were reviewed by urologists after every two treatments to decide if further lithotripsy treatment was warranted. No routine medical expulsive therapy was given post-treatment.

Patients attended for a radiological follow-up by plain X-ray 2 weeks after completion of all lithotripsy sessions. Treatment success was defined as complete stone free or clinical insignificant residual fragments (CIRF) <4 mm. Complication rates including hospital attendance with renal colic, haematuria, urinary infection or steinstrasse (log-jam) were recorded. Need for any adjunctive surgical procedures was documented. For those patients that failed SWL, the long-term management plan was recorded.

Results

A total of 119 patients (92 %) completed lithotripsy treatment and radiological follow-up. Eleven patients were excluded due to incomplete follow-up data. Patient demographics are summarised in Table 1.

Overall treatment success was 66.4 % (combined complete stone clearance and CIRFs). The treatment success was similar by stone location (Table 2). Those with stone size <15 mm had a higher success rate (70.4 %) compared to size 15–20 mm (53.1 %) (Fig. 1). Regarding patients who failed SWL treatment, the majority 50 % ($n = 20$) were managed expectantly, 42.5 % ($n = 17$) required URS, 7.5 % ($n = 3$) required PNL (Fig. 2).

The overall complication rate including hospital admission for renal colic, urinary tract infection, haematuria, steinstrasse or auxiliary measures is summarised in Table 3.

Table 1 Patient demographics

Demographics	Mean
Age	56.8 (23–88) years
Male to female ratio	1.9:1 (78:41)
Body mass index	28.4 (17.9–58)
Stone size	12.8 mm (10–14 mm: $n = 87$, 15–20 mm: $n = 32$)
Number of treatments (10–14 mm)	2.14
Number of treatments (15–20 mm)	2.82

Table 2 Treatment success by stone location

Stone location	Total number of patients (%)	Complete stone free	CIRF (<4 mm)	Treatment success (%)
Upper pole	17 (15)	8	3	65
Mid pole	36 (30)	15	8	64
Lower pole	30 (25)	12	9	70
PUJ	36 (30)	19	5	67

CIRF clinical insignificant residual fragments, *PUJ* pelvi-ureteric junction

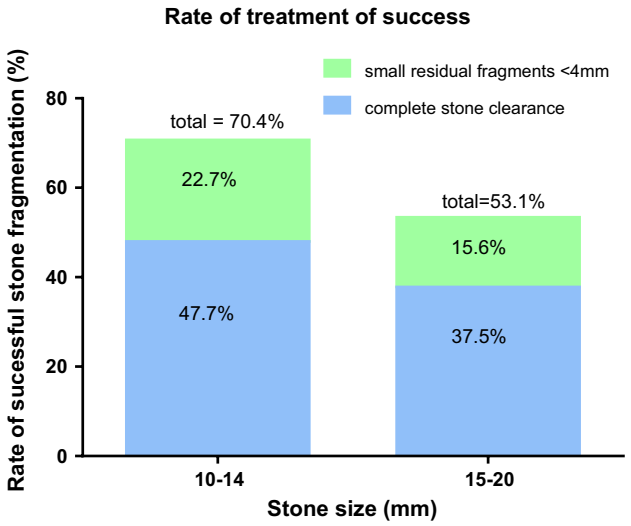

Fig. 1 Treatment success according to stone size

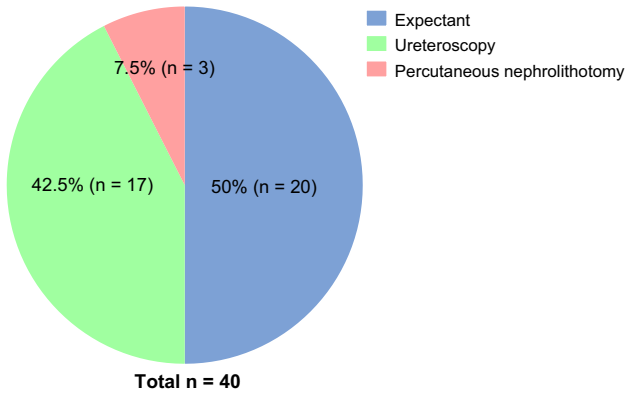

Fig. 2 Patient outcome if SWL has failed

Table 3 Complication rates

Admissions to hospital	Rate (%)
Renal colic	5 ($n = 6$)
Haematuria	0.8 ($n = 1$)
Urinary tract infection	0.8 ($n = 1$)
Emergency ureteric stent insertion or ureteroscopy	2.5 ($n = 3$)
Steinstrasse	2.5 ($n = 3$)

Discussions

Epidemiological data suggest a global trend away from SWL to flexible URS and PNL [6]. Recent studies continue to debate the relative merits and outcomes of SWL, URS and PNL [7, 8]. Randomised controlled trials that examine both stone-free status and quality of life are required to address these issues. However, SWL offers a non-invasive, low-risk option that can be delivered without anaesthesia.

With an ageing population, more urological patients present with medical co-morbidities posing increased surgical and anaesthetic risks. With the available options, it is important to balance the risk against the success rate of each procedure based on patient characteristics and surgeon expertise. In this study, half of the patients that failed treatment were managed conservatively mostly because of other significant morbidities that made surgery high risk.

In our series, the overall stone-free rate was 66.4 % for renal stones (10–20 mm) at all locations. The efficacy was comparable to larger series of smaller kidney stones [9–11]. Our outcomes for larger lower pole stones (10–20 mm) were favourable in comparison to previous studies [12] but comparable to more recent studies [13].

In our centre, NCCT is used for pre-treatment stone diagnosis and patients return for follow-up with plain X-ray 2 weeks post-treatment. Repeating NCCT as a routine follow-up carries excessive radiation for the patients, and therefore, is not performed. Admittedly, plain X-ray has a much less sensitivity than NCCT to detect residual fragments, which may lead to higher observed stone-free rate. In our unit, we assessed our patients relatively early post-SWL to detect early treatment-related complications. More spontaneous stone fragment passage and a higher treatment success will be expected, if we could review the patients at 3-month interval.

Need for retreatment is one of the disadvantages of SWL compared with retrograde intra-renal surgery, which allows a better chance to achieve stone free in a single session [14]. In our series, the average number of treatments was between 2.14 and 2.82 depending on stone size. The clinician needs to inform the patients of the possibility of multiple treatments in particular for larger renal stones.

In line with other studies [15], our study demonstrated low complication rates even with multiple SWL treatments. In this study, most complications were managed conservatively. Renal colic episodes were occasionally treated with additional SWL. Only 3 (2.5 %) patients required auxiliary procedures. These patients underwent emergency stent insertion or ureteroscopy due to inadequate pain control. This compares favourably with other series [15, 16]. The rate of steinstrasse was 2.5 %, which is consistent with the published literature for all stone sizes [17]. Despite the large stone size, we did not see an increase in post-SWL complications. The rate of haematuria and urinary tract infection (<1 %) was also comparable with larger series [18]. There were no incidences of renal hematoma or sepsis in this study.

This study supports other large international series that equivalent stone clearance rates are possible with SWL irrespective of stone site in the kidney. Further studies are

needed to establish if other factors such as stone to skin distance have an impact on the SWL treatment success rate.

In conclusion, our analysis suggests that SWL has an efficacy for treating moderate-sized renal stones that is equivalent to success rates for smaller stones in other series. As a low-risk and non-invasive procedure SWL should remain a first-line treatment option for 10- to 20-mm renal stones particularly in patients with other co-morbidities.

Compliance with ethical standards

Funding No funding is required for this study.

Conflict of interest Author Vera Chung declares that she has no conflict of interest. Author Benjamin Turney declares that he has no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

References

1. Ziemba JB, Matlaga BR (2015) Guideline of guidelines: kidney stones. BJU Int 116(2):184–189. doi:10.1111/bju.13080
2. Srivastava A, Chipde SS (2013) Management of 1–2 cm renal stones. Indian J Urol J Urol Soc India 29(3):195–199. doi:10.4103/0970-1591.117280
3. Karatag T, Tepeler A, Silay MS, Bodakci MN, Buldu I, Daggulli M, Hatipoglu NK, Istanbulluoglu MO, Armagan A (2015) A comparison of two percutaneous nephrolithotomy techniques for the treatment of pediatric kidney stones of sizes 10–20 mm: microperc vs miniperc. Urology 85(5):1015–1018. doi:10.1016/j.urology.2015.02.010
4. Hatipoglu NK, Sancaktutar AA, Tepeler A, Bodakci MN, Penbegul N, Atar M, Bozkurt Y, Soylemez H, Silay MS, Istanbulluoglu MO, Akman T, Armagan A (2013) Comparison of shockwave lithotripsy and microperc for treatment of kidney stones in children. J Endourol Endourol Soc 27(9):1141–1146. doi:10.1089/end.2013.0066
5. Tepeler A, Armagan A, Sancaktutar AA, Silay MS, Penbegul N, Akman T, Hatipoglu NK, Ersoz C, Erdem MR, Akcay M (2013) The role of microperc in the treatment of symptomatic lower pole renal calculi. J Endourol Endourol Soc 27(1):13–18. doi:10.1089/end.2012.0422
6. Srisubat A, Potisat S, Lojanapiwat B, Setthawong V, Laopaiboon M (2014) Extracorporeal shock wave lithotripsy (ESWL) versus percutaneous nephrolithotomy (PCNL) or retrograde intrarenal surgery (RIRS) for kidney stones. Cochrane Database Syst Rev. doi:10.1002/14651858.CD007044.pub3
7. Cecen K, Karadag MA, Demir A, Bagcioglu M, Kocaaslan R, Sofikerim M (2014) Flexible ureterorenoscopy versus extracorporeal shock wave lithotripsy for the treatment of upper/middle calyx kidney stones of 10–20 mm: a retrospective analysis of 174 patients. SpringerPlus 3:557. doi:10.1186/2193-1801-3-557
8. Estrade V, Bensalah K, Bringer JP, Chabannes E, Carpentier X, Conort P, Denis E, Dore B, Gautier Jr, Hadjadj H, Hubet J, Hoznek A, Lechevallier E, Meria P, Mozer P, Saussine C, Yonneau L, Traxer O (2013) Place of the flexible ureterorenoscopy first choice for the treatment of kidney stones. Survey results practice committee of the AFU lithiasis completed in 2011. Progres en urologie: journal de l'Association francaise d'urologie et de la Societe francaise d'urologie 23(1):22–28. doi:10.1016/j.purol.2012.09.003
9. White W, Klein F (2006) Five-year clinical experience with the Dornier Delta lithotriptor. Urology 68(1):28–32. doi:10.1016/j.urology.2006.01.031
10. Zehnder P, Roth B, Birkhauser F, Schneider S, Schmutz R, Thalmann GN, Studer UE (2011) A prospective randomised trial comparing the modified HM3 with the MODULITH(R) SLX-F2 lithotripter. Eur Urol 59(4):637–644. doi:10.1016/j.eururo.2011.01.026
11. Micali S, Sighinolfi MC, Grande M, Rivalta M, De Stefani S, Bianchi G (2009) Dornier Lithotripter S 220 F EMSE: the first report of over 1000 treatments. Urology 74(6):1211–1214. doi:10.1016/j.urology.2009.05.101
12. Elbahnasy AM, Clayman RV, Shalhav AL, Hoenig DM, Chandhoke P, Lingeman JE, Denstedt JD, Kahn R, Assimos DG, Nakada SY (1998) Lower-pole caliceal stone clearance after shockwave lithotripsy, percutaneous nephrolithotomy, and flexible ureteroscopy: impact of radiographic spatial anatomy. J Endourol Endourol Soc 12(2):113–119
13. El-Nahas AR, Ibrahim HM, Youssef RF, Sheir KZ (2012) Flexible ureterorenoscopy versus extracorporeal shock wave lithotripsy for treatment of lower pole stones of 10–20 mm. BJU Int 110(6):898–902. doi:10.1111/j.1464-410X.2012.10961.x
14. Zheng C, Yang H, Luo J, Xiong B, Wang H, Jiang Q (2015) Extracorporeal shock wave lithotripsy versus retrograde intrarenal surgery for treatment for renal stones 1–2 cm: a meta-analysis. Urolithiasis. doi:10.1007/s00240-015-0799-8
15. Neisius A, Wollner J, Thomas C, Roos FC, Brenner W, Hampel C, Preminger GM, Thuroff JW, Gillitzer R (2013) Treatment efficacy and outcomes using a third generation shockwave lithotripter. BJU Int 112(7):972–981. doi:10.1111/bju.12159
16. Al-Ansari A, As-Sadiq K, Al-Said S, Younis N, Jaleel OA, Shokeir AA (2006) Prognostic factors of success of extracorporeal shock wave lithotripsy (ESWL) in the treatment of renal stones. Int Urol Nephrol 38(1):63–67. doi:10.1007/s11255-005-3155-z
17. Madbouly K, Sheir KZ, Elsobky E, Eraky I, Kenawy M (2002) Risk factors for the formation of a steinstrasse after extracorporeal shock wave lithotripsy: a statistical model. J Urol 167(3):1239–1242
18. Skolarikos A, Alivizatos G, de la Rosette J (2006) Extracorporeal shock wave lithotripsy 25 years later: complications and their prevention. European urology 50(5):981–990. doi:10.1016/j.eururo.2006.01.045 **(discussion 990)**