1110-5704
African Journal of Urology

Vol. 10, No. 4, 2004
224 -229

ORIGINAL ARTICLES

CHANGING THE WINDOW OF SHOCK WAVE APPLICATION HOW IT IMPROVES THE RESULTS OF ESWL FOR RENAL CALCULI

A.M. ABDEL MONIEM
Urology Department, Assiut University Hospital, Assiut, Egypt

Objectives: The aim of this work is to study the impact of using multiple windows of shock wave application on the results of ESWL therapy for renal calculi.

Patients and Methods: Between January 1996 and October 2002, 676 patients with single pelvic stones ≤ 2.5 cm and either no or mild back pressure changes were treated by lithotripsy using the Dornier MPL 9000 with ultrasonic localization. Our patients were divided into two groups according to the total stone burden (<15 mm and 15 – 25 mm) Every group was divided into two subgroups: the first subgroup was treated by a single window of shock wave coupling and the second subgroup by changing the window of shock wave coupling every 500 SW from the posterior to the postero-lateral and to the lateral side of the patient. The results were recorded and statistically evaluated.

Results: For stones <15 mm we found no difference between the two subgroups regarding the total SW energy, number of sessions, pattern of disintegration and the complication and clearance rate. But the need for additional doses of analgesia was significantly decreased for the patients who were treated by multiple windows. For stones sized 15 - 25 mm, we found a statistically significant decrease in the total SW number, in the number of sessions and the need for additional doses of analgesia when multiple windows of coupling were adopted. Changing the window of coupling also resulted in a statistically significant improvement in the pattern of disintegration of the stones. The rate of complication, clearance and auxiliary measures was comparable in all subgroups.

Conclusion: Changing the window of SW application improves the pattern of disintegration, reduces the number of shock waves necessary for effective treatment, decreases the number of sessions and the need for additional doses of analgesia when ESWL is done for renal pelvic stones > 15 mm.

Key Words: renal calculi, ESWL

INTRODUCTION

ESWL is considered the first line of management for renal calculi, especially when the stone burden is < 20 mm. Since Shock Wave (SW) therapy has been found to induce not only renal but also extrarenal tissue damage, all efforts must be done to decrease these SW-related side effects by decreasing the SW energy either by reducing the energy of the individual shock wave and / or the total SW number[1-4]. This raises the question as to whether there is any way to decrease the total shock wave energy without affecting the success of ESWL therapy.

In this prospective work we tried to find an answer to this question by studying the impact

Table 1: Results of ESWL Treatment for Patients with Stones < 15 mm

Parameter	Treatment by Single Window		Treatment by Multiple Windows		P Value
Number of patients	142		237		
Average number of shock waves	2800 ± 463.7		2650 ± 436.5		0.232
Average number of sessions	1.36		1.32		0.432
Average time of session (min.)	28.7 ± 9		30.3 ± 8		0.611
Need for additional dose of analgesia	25	17.50%	20	8.40%	**0.023***
Complete disintegration	137	96.47%	232	97.90%	0.618
Pattern of disintegration:					0.470
Powdering	42	29.57%	78	32.90%	
≤ 3 mm	86	60.56%	145	61.18%	
> 3 mm	9	6.33%	9	3.80%	
Clearance rate	132	92.95%	223	94.10%	0.456
Complication rate	18	12.60%	23	9.70%	0.171
Auxiliary measures	5	3.5%	10	4.20%	0.378

P < 0.05 = significant

of using multiple windows of shock wave application on the results of ESWL therapy for renal calculi.

PATIENTS AND METHODS

Out of all patients that presented to the ESWL unit, Assiut University Hospital, Assiut, Egypt between January 1996 and October 2002, 676 patients with single renal pelvic stones ≤ 25 mm were included in this study. Their age ranged from 18 to 62 years (mean: 32.4 years). Patients with gross obesity, bone deformity or stones suspected to consist of cystine or pure calcium oxalate monohydrate were excluded from the study.

A complete work up of routine investigations was done before ESWL treatment. All patients received 10 mg morphin sulphate and one ampoule of NSAI 20 minutes prior to ESWL. When the patient felt pain, an additional dose of I.V. analgesia was given. Using the Dornier MPL9000 lithotripter, the stones were localized by the ultrasonic system in the supine position. The shock waves were delivered by the ECG trigger mode starting at an energy level of 14 KV. Then the energy level was increased in a stepwise manner until a maximum of 20 KV was reached according to the patient's tolerance and suspected stone fragility.

The ESWL session was completed in the initial setting in 263 patients (142 patients with stones <15 mm and 121 patients with stones 15 -25 mm), while in 413 patients (237 patients with stones <15 mm and 176 patients with stones 15 – 25 mm) the coupling window of shock wave application was changed every 500 SW by either changing the patient's position from the supine to the oblique and then to the lateral position or by rotating the therapy head to change the coupling window from the posterior surface to the postero-lateral and then to the lateral side. When the patient needed another session the treatment was completed by the same coupling protocol used in the first session. The data about the ESWL therapy were recorded for all patients.

The patients were scheduled for routine clinical, radiological and laboratory follow up at

Table 2: Results of ESWL Treatment for Patients with Stones sized 15 – 25 mm

Parameter	Treatment by Single Window		Treatment by Multiple Windows		P Value
Number of patients	121		176		
Average number of shock waves	4570 ± 597.3		3740 ± 563.7		**0.001***
Average number of sessions	2.23		1.65		**0.021****
Average time of session (min.)	30 ± 9.1		31.3 ± 10		0.453
Need for additional dose of analgesia	22	18.20%	14	7.90%	**0.031****
Complete disintegration	108	89.25%	165	93.75%	0.081
Pattern of disintegration:					**0.016****
Powdering	30	24.79%	77	43.75%	
≤ 3 mm	70	57.85%	96	54.55%	
> 3 mm	21	17.35%	3	1.70%	
Clearance rate	103	85.12%	158	89.77%	0.439
Complication rate	22	18.18%	30	17.0%	0.326
Auxiliary measures	7	5.78%	7	3.9%	0.206

$P < 0.01^*$, $P < 0.05^{**}$ = significant

the end of one week, two weeks, one month and three months after the ESWL session. The degree and pattern of disintegration was determined by both plain KUB and ultrasonic examination. ESWL failure was considered when two ESWL sessions had failed to disintegrate the stone. When there was residual gravel > 3 mm, another ESWL session was done. The patient was considered stone-free when complete clearance of all gravel, whatever its size, had been achieved by three months after the last ESWL session. Any patient that had developed obstructive pyelonephritis was treated by PCN. When there was prolonged obstruction lasting longer than two weeks, other procedures like ureteroscopy, ureteric stent or PCN were resorted to.

RESULTS

Our patients were divided into two groups according to the total stone burden (< 15 mm and 15 – 25 mm) and every group was again divided into two subgroups according to the number of windows of coupling of the therapy unit (single window and multiple windows).

Results of ESWL for 142 patients with stones < 15 mm treated by a single window:

The average shock wave number was 2800 ± 463.7. The average number of sessions was 1.36 with an average time of 28.7 ± 9 min / session. Twenty-five out of 142 patients (17.5%) needed additional doses of analgesia. Complete disintegration was achieved in 137 patients (96.47%); 42 of them (29.57%) did not collect any gravel but small amounts of powder and became stone-free. Eighty-six patients (60.56%) collected gravel ≤ 3 mm proved by KUB films and sonography. Only 9 patients (6.33%) collected gravel > 3 mm. Complete clearance 3 months after the last session was achieved in 132 out of 142 patients (92.95%). After the ESWL sessions, complications occurred in 18 patients (12.6%) in the form of persistent renal colic (n=8), fever (n=3) and persistent obstruction for more than two weeks (n=7). Only five of these complicated cases (3.5%) required auxiliary measures in the form of PCN in one patient, ureteroscopy for the removal of obstructing gravel in two and introduction of ureteral stents to relieve the obstruction in two patients. (Table 1)

Results of ESWL for 237 patients with stones < 15 mm treated by multiple windows:

The average shock wave number was 2650 ± 436.5. The average number of sessions was 1.32 with an average time of 30.3 ± 8 min / session. Twenty out of 237 patients (8.4%) required additional doses of analgesia. Complete disintegration was achieved in 232 patients (97.9%); 78 of them (32.9%) did not collect any gravel but small amounts of powder and became stone-free. One hundred and forty-five patients (61.18%) collected gravel ≤ 3 mm proved by KUB films and sonography. Only 9 patients (3.8%) collected gravel > 3 mm. Complete clearance three months after the last session was achieved in 223 out of 237 patients (94.1%).

After the ESWL sessions, complications were encountered in 23 patients (9.7%) in the form of severe renal colic (n=15), fever (n=4) and obstruction for more than two weeks (n=4). Only 10 of those complicated cases (4.2%) required auxiliary measures in the form of PCN in one patient, ureteroscopy and removal of obstructing gravel in six and introduction of ureteral stents to relieve persistent obstruction in three patients. (Table 1)

Results of ESWL for 121 patients with stones 15 – 25 mm treated by a single window:

The average shock wave number was 4570 ± 597.3. The average number of sessions was 2.23 with an average time of 30 ± 9.1 min / session. Twenty-two out of 121 patients (18.2%) needed additional doses of analgesia. Complete disintegration was achieved in 108 patients (89.25%); 30 of them (24.79%) collected a small amount of powder and became stone-free. Seventy patients (57.85%) collected gravel ≤ 3 mm proved by KUB films and sonography. Only 21 patients (17.35%) collected gravel > 3 mm. Complete clearance three months after the last session was achieved in 103 out of 121 patients (85.12%).

After the ESWL sessions 11 patients complained of persistent renal colic, two developed fever, and nine patients developed obstruction for more than two weeks. Only seven of these complicated cases required auxiliary measures in the form of PCN in one patient, ureteroscopy and removal of obstructing gravel in four and ureteral stents in the remaining two patients. (Table 2)

Results of ESWL for 176 patients with stones 15 – 25 mm treated by multiple windows:

The average shock wave number was 3740 ± 563.7. The average number of sessions was 1.65 with an average time of 31.3 ± 10 min / session. Fourteen out of 176 patients (7.9%) needed additional doses of analgesia. Complete disintegration was achieved in 165 patients (93.75%); 77 of them (43.75%) did not collect any gravel but small amounts of powder and became stone-free. Ninety-six patients (54.55%) collected gravel ≤ 3 mm proved by KUB films and sonography. Only 3 patients (1.7%) collected gravel > 3 mm. Complete clearance 3 months after the last session was achieved in 158 out of 176 patients (89.77%).

After the ESWL sessions 19 patients complained of severe renal colic, six patients developed fever, and five patients complained of persistent obstruction for a period of more than two weeks. Only seven of those complicated cases necessitated auxiliary measures in the form of PCN in one patient, ureteroscopy and removal of obstructing gravel in four and introduction of ureteral stents in two patients. (Table 2)

Statistical significance of the results of ESWL for the patients with stones <15 mm:

We found a statistically significant decrease in the requirement of additional doses of analgesia in patients where multiple windows of coupling were applied. No statistically significant difference between the two subgroups was found when we compared the other parameters of ESWL therapy. (Table 1)

Statistical significance of the results of ESWL for the patients with stones 15-25 mm:

When comparing the different ESWL parameters of the two subgroups, we found that there was a statistically significant decrease in the average number of shock waves, the average number of sessions and the requirement of additional doses of analgesia when multiple windows of coupling were adopted. The pattern of disintegration improved towards more powdering when the coupling of the therapy unit was changed. The rates of clearance, complications and auxiliary measures of both subgroups are not statistically different. (Table 2)

DISCUSSION

In this work, the idea of multiple windows of coupling of shock waves for the treatment of renal calculi is based on several facts. The first fact is that the trauma to the renal tissue caused by the shock waves is directed to the plane of the shock waves and directly related to the total shock wave energy applied to the affected tissue[5-7]. The second fact is that the disintegration of the stone occurs at the stone surface where the shock wave enters and exits the stone[8]. The third fact is that the shock wave may be hindered when a rib is present in the path of the shock wave which causes intolerable pain.

Delivering the shock waves through different windows of coupling has the following advantages:

- The total shock wave energy is distributed on a large area of renal tissue and hence, every part would be exposed to a small amount of shock wave energy below what is suspected to cause tissue damage. Or at least, if damage occurred, it would be of a minor degree.
- A large surface area of the stone is exposed to the shock waves allowing rapid disintegration.
- By changing the window of coupling the interference of the rib with the passage of the shock waves to the stone can be avoided by selecting windows of coupling away from the rib.

Regarding a stone burden of less than 15 mm, we found no statistically significant difference between the two groups with respect to the total shock wave energy needed, the rate of successful disintegration, the pattern of disintegration, the stone free rate, the complication rate and the need for auxiliary measures. These findings are comparable with the results of most of the data reported by other researches [9-16]. The only difference is that there is a statistically significant decrease in the requirement of additional doses of analgesia when multiple windows of shock wave application are used.

The situation is different when the stone burden is between 15 and 25 mm, where we found a statistically significant reduction of the total shock wave energy required, a decreased requirement of additional doses of analgesics and a significant improvement of the pattern of disintegration when the window of coupling of the shock waves was changed during the ESWL session. However, the time needed for the ESWL session was not different between the two subgroups. These finding can be explained as follows: changing the windows of shock wave application enhances disintegration of the stone into powder or small gravel as a result of increasing the stone surface area that is exposed to the shock waves. Like this, the number of primary cracks and, accordingly, the number of the secondary minute cracks causing rapid disintegration of the stone into very small gravels is increased. Consequently, less energy is required. At the same time, the need for additional doses of analgesia is significantly reduced because changing the coupling windows allows for selecting a pathway for the shock waves that is devoid of intervening bone which usually is the primary cause of pain.

From this work we conclude that changing the window of application of the shock waves can improve the results of ESWL therapy for large renal calculi by reducing the total energy needed, the number of sessions and the need for analgesia without increasing the time needed for the sessions. This technique can be applied using all types of ESWL machines, either by changing the patient position or by changing the angle of the therapy head. When the stone is small, changing the window of shock wave application is not necessary, except when the stone cannot be localized in the usual supine position, when a rib is present in the path of the shock waves or when the patient feels intolerable pain.

REFERENCES

1. Clayman Rv, McDougall EM, Nakada SY. *Percutaneous therapeutic procedures.* In: Walsh PC, Retik AB, Vaughan ED, Wein AJ (eds.): *Campbell's Urology*, 7th ed., Philadelphia:WB Saunders, 1998, pp. 2809-2828.
2. Cass AS. Comparison of first generation (Dornier HM3) and second generation (Medstone STS) lithotriptors: Treatment results with 13.864 renal and ureteral calculi. *J Urol* 1995, 153:588.
3. Renner CH, Rassweiler J. Treatment of renal stones by extracorporeal shock wave lithotripsy. *Nephron* 1999, 81:71.
4. Logarakis NF, Jewett MAS, Luymes J, Honey RJ. Variation in the clinical outcome following shock wave lithotripsy. *J Urol* 2000, 163:721.

5. Rigatti P, Colombo PR, Centemero A *et al.* Histological and ultrastructural evaluation of extracorporeal shock wave lithotripsy-induced acute renal lesions: preliminary report. *Eur Urol* 1989, 16:207.

6. Brewer SL, Atala A, Ackerman DM *et al.* Shock wave lithotripsy damage in human cadáver kidneys. *J Endourol* 1988, 4.333.

7. Rossler W, Steinbach P, Nicolai H *et al.* Effects of high-energy shock waves on the viable human kidney. *Urol Res* 1993, 21:273.

8. Chaussy CG, Schmidt E, Jocham D *et al.* First clinical experience with extracorporeally induced destruction of kidney stones by shock waves. *J Urol* 1982, 127:417.

9. Drach GW, Dretler S, Fair W *et al.* Report of the United States Cooperative Study of Extracorporeal Shock Wave Lithotripsy. *J Urol* 1986, 135:1127.

10. Lingeman JE, Newman D, Mertz JHO *et al.* Extracorporeal shock wave lithotripsy: Methodist Hospital of Indiana experience. *J Urol* 1986, 135:1134.

11. Politis G, Griffith DP. ESWL: Stone-free efficacy based upon stone size and location. *World J Urol* 1987, 5:255.

12. El-Damanhoury H, Schärfe T, Rüth J *et al.* Extracorporeal shock wave lithotripsy of urinary calculi: Experience in treatment of 3.278 patients using the Siemens Lithostar and Lithostar Plus. *J Urol* 1991, 145:484.

13. Mobley TB, Myers DA, Grine WB *et al.* Low energy lithotripsy with the Lithostar: Treatment results with 19.962 renal and ureteral calculi. *J Urol* 1993, 149:1419.

14. Segura JW: The role of percutaneous surgery in renal and ureteral stone removal. *J Urol* 1989, 141:780.

15. Clayman RV, McClennan BL, Garvin TJ *et al.* Lithostar: An electromagnetic acoustic shock wave unit for extracorporeal lithotripsy. *J Endourol* 1989, 3:307.

16. Psihramis KE, Jewett MAS, Bombardier C *et al.* Lithostar extracorporeal shock wave lithotripsy: The first 1000 patients. *J Urol* 1992, 147:1006.

RESUME

Changer la fenêtre d'application de l'onde de choc. Comment améliore-t-il les résultats d'ESWL pour le traitement du calcul rénal?

Objectifs : Etudier l'impact d'utiliser de multiples fenêtres d'application de l'onde de choc sur les résultats d'ESWL pour le traitement du calcul rénal. **Patients et Méthodes:** Entre janvier 1996 et octobre 2002, 676 patients présentant une lithiase pyélique unique ≤ 2,5 cm avec ou sans obstruction ont été traités par lithotripsie par le Dornier MPL 9000 avec repérage échographique. Nos patients ont été divisés en deux groupes d'après la masse calculeuse totale (<15mm et 15-25mm). Chaque groupe a été divisé en deux sous-groupes d'après le nombre de fenêtres de couplage de l'unité thérapeutique (le premier sous-groupe a été traité par une seule fenêtre d'onde de choc et le deuxième sous-groupe en changeant la fenêtre de couplage d'onde de choc chaque 500 coups du postérieur au postéro-latéral et au côté latéral du patient). Les résultats ont été enregistrés et statistiquement évalués. **Résultats:** Pour les lithiases <1.5 centimètre nous n'avons trouvé aucune différence entre les deux sous-groupes considérant l'énergie délivrée totale, le nombre de sessions, le modèle de desintégration et les complications et le taux de clairance. Mais le besoin pour des doses supplémentaires d'analgésique a été diminué considérablement pour les patients qui ont été traités par les fenêtres multiples. Pour les lithiases de 1,5-2,5 cm, nous avons trouvé une baisse statistiquement significative du nombre de coups et l'énergie délivrée totale, du nombre de sessions et le besoin en doses supplémentaires d'analgésique quand les fenêtres multiples d'accouplement ont été adoptées. Nous avons trouvé une amélioration statistiquement significative dans le modèle de desintégration des lithiases quand la fenêtre d'accouplement a été changée. Le taux de complications, de clairance et les mesures d'auxiliaire étaient comparables dans tous les sous-groupes. **Conclusion:** Changer la fenêtre d'application des ondes de choc améliore le modèle de desintégration avec un nombre d'ondes de choc bas, baisse le nombre de sessions et le besoin en doses supplémentaires d'analgésique quand ESWL est indiquée pour des lithiases pyéliques de plus de 1,5 cm.

All correspondence to be sent to:

Ahmed Mohamed Abdel Moniem, M.D.; Urology Department; Assiut University Hospital; Assiut 71516 Egypt
E-mail: drahmed_2002@yahoo.com