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Optimal Shock Wave Frequency and Energy, Important Factors for Renal Stone Fragmentation in ESWL: A Prospective Randomized Trial

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ABSTRACT

Background: Kidney stones are crystalline structures with high prevalence rate across the globe. Different treatment method are used to treat renal stones among which extracorporeal shock wave lithotripsy (ESWL) shows promising results for stone free rate among non-invasive treatment modalities. Different factors govern effectiveness of lithotripsy among which shock wave frequency and energy had always been in debate as they have direct effect on responsiveness of ESWL. **Objective:** Comparison of different energy and shock wave frequency levels in terms of effectiveness in stone fragmentation. **Study Design:** Prospective randomized study. **Settings:** Department of Urology, DHQ Hospital/Faisalabad Medical University, Faisalabad Pakistan. **Duration:** April 2018 to September 2020 (2.5 Years). **Methods:** 120 patients enrolled using non probable consecutive sampling according to inclusion and exclusion criteria. Patients subjected to four sessions of ESWL using electromagnetic lithotripter and stones observed for fragmentation. Patients divided into four groups i.e. A, B, C and D depending upon frequency and energy of shock waves applied. (Group-A: Frequency 60 shocks/min Energy 50)(Group B: Frequency 90 shocks/min Energy 50)(Group C: Frequency 60 shocks/min Energy 65)(Group D: Frequency 90 shocks/min Energy 65). Each group further divided into subgroups 1 and 2 according to age as subgroup I patients having age 15-35 years and subgroup II having age 36-55 years. Statistical analysis done and $P < 0.05$ was taken as statistically significant. **Results:** 120 patients enrolled from age 15-55 years with mean age 37.191 ± 11.09. Results showed that response of ESWL is statistically significant when frequency is low however both energy levels have equal response for effectiveness. **Conclusion:** We conclude that ESWL is an effective treatment method for renal stones when frequency of shock waves is less and combining it with low levels of energy shows with promising stone fragmentation rate with minimal side effects.

Keywords: *Renal stone, extra corporeal shock wave lithotripsy, electromagnetic lithotripter.*

INTRODUCTION

Renal stones, compound crystalline structures formed in renal pelvicalyceal system. These stones are formed by various mechanism including precipitation of super saturated solutes, obstruction leading to stasis, change in pH, either by infection or by urine pH change brought by different renal pathologies like RTA, or by reduction in urinary excretion of certain agents collectively termed as urinary stone inhibitors.[1]

There is vast variety of renal stones in terms of chemical composition including calcium oxalate dihydrate, calcium oxalate monohydrate, calcium carbonate, calcium phosphate, cysteine, magnesium ammonium phosphate, xanthine, uric acid, drug stones and matrix stones.[1] This diversity of composition imparts certain characters to stones including radio density, hardness, response to dissolution therapy and effectiveness to extra corporal shock wave lithotripsy (ESWL). Treatment of urinary stones has observed a wide scale and angled change in last 5 decades and inclusion of techniques like ESWL has benefitted patients of renal stones by achieving disease free status without surgery,[2] without hospital stay and without impacting on quality of life of patients.[3,4,5]

ESWL is a noval technique in which shock waves are used to break stones by various mechanisms including spall fracture, shear stress, cavitation, super focusing fatigue.[6,7,8] ESWL promises good stone free rate as indicated by figure that success rate range from 60% to 99%.[9,10] There are certain factors which rule for effective stone fragmentation using ESWL these factors include patient related dynamics, stone dynamics, lithotripter dynamics and lithotripsy dynamics.[10]

Each of such factors carry their own importance without any debate and doubt but lithotripsy dynamics is the most important and still a debatable factor among clinicians doing lithotripsy. Among lithotripsy related factors, appropriate shock wave energy and frequency has been matter under discussion and trial for last 10-20 years as both of these factors have been found to have effect on stone fragmentation in previous studies and much of debate focused for frequency of 60-120 shock per minute and energy of 50-90 but still no census has been made for optimal level of frequency and energy which can effectively fragment renal stones. So, this study was initiated with intent to solve mystery and compare different energy and frequency levels in terms of their effectiveness in stone fragmentation.

OBJECTIVE

Comparison of different energy and shock wave frequency levels in terms of effectiveness in stone fragmentation

METHODS

The Prospective randomized study was conducted at the Department of Urology, DHQ Hospital/Faisalabad Medical University, Faisalabad Pakistan between April 2018 to September 2020 (2.5 Years).

120 patients enrolled using non probable consecutive sampling technique.

Patients of either gender, aged from 15-55 years presenting with renal stones of either laterality in size range between 1-2 cm located in renal pelvis, upper calyx, middle and lower calyx (lower calyx with favorable anatomy) were included in the study.

Age less than 15 or more than 55 years, active infection and hematuria, patients with diagnosed chronic kidney disease, pregnancy, distal urinary tract obstruction, previous history of surgery or ESWL, previously diagnosed patients with abdominal aortic aneurysm, patients with BMI more than 30 kg/m^2, patients with musculoskeletal abnormalities of supine and para spinal region, congenital anomalies of kidney like ectopic kidney, fused or horseshoe kidney were excluded from the study.

Patients enrolled according to inclusion and exclusion criteria after evaluation of patients using ultrasonography, intravenous urography/contrast Computerized Tomography on outdoor basis in Department of Urology, DHQ Hospital, Faisalabad/Faisalabad Medical University, Faisalabad. Patients subjected to four sessions of ESWL using electromagnetic lithotripter and stones observed for fragmentation. Patients divided into four groups i.e. A, B, C and D as follows, depending upon frequency and energy of shock waves applied.

Group-A: Frequency 60 shocks/min Energy 50 Group B: Frequency 90 shocks/min Energy 50

Group C: Frequency 60 shocks/min Energy 65 Group D: Frequency 90 shocks/min Energy 65

Each group further divided into subgroups 1 and 2 according to age as subgroup 1 patients having age 15-35 years and subgroup 2 having age 36-55 years.

Data obtained, analyzed and stratified in terms of age and gender. Descriptive analysis done and described in terms of mean values and percentages. Continuous variables analysis was done using chi square test and unpaired t test whereas categorical variables analyzed using Fisher Exact Test. $P < 0.05$ was taken as statistically significant. Statistical analysis done using SPSS version 23.

RESULTS

120 patients enrolled from age 15-55 years with mean age 37.191 $\pm$ 11.09. Patients stratified into groups and gender distribution done (Table No. 1)

Table 1: Gender and group distribution

Gender	G-A1	G-A2	G-B1	G-B2	G-C1	G-C2	G-D1	G-D2	Total
Male	7	13	8	7	6	8	3	5	57
Female	3	7	11	4	10	6	9	13	63
Total	10	20	19	11	16	14	12	18	120
Grand Total	30		30		30		30		

Patients evaluated for effectiveness/response in group A, b, C and D (Table No. 2, 3, 4 and 5 respectively).

Table 2: Response effect in group A

Gender	G-A1			G-A2			Total		
	Total	Effect	*P*	Total	Effect	*P*	Total	Effect	*P*
Male	7	6	0.001	13	10	0.000	20	16	0.000
Female	3	3	0.000	7	5	0.008	10	8	0.000
Total	10	9	0.000	20	15	0.000	30	24	0.000

Table 3: Response effect in group B

Gender	G-B1			G-B2			Total		
	Total	Effect	*P*	Total	Effect	*P*	Total	Effect	*P*
Male	8	3	0.08	7	2	0.172	15	5	0.019
Female	11	2	0.167	4	1	0.391	15	3	0.082
Total	19	5	0.021	11	3	0.082	30	8	0.003

Table 4: Response effect in group C

Gender	G-C1			G-C2			Total		
	Total	Effect	*P*	Total	Effect	*P*	Total	Effect	*P*
Male	6	4	0.025	8	7	0.000	14	11	0.000
Female	10	9	0.000	6	6	0.000	16	15	0.000
Total	16	13	0.000	14	13	0.000	30	26	0.000

Table 5: Response effect in group D

Gender	G-D1			G-D2			Total		
	Total	Effect	*P*	Total	Effect	*P*	Total	Effect	*P*
Male	3	2	0.184	5	3	0.070	8	5	0.011
Female	9	6	0.004	13	9	0.000	22	15	0.000
Total	12	8	0.001	18	12	0.000	30	20	0.000

Results showed that response of ESWL is statistically significant when frequency is low however both energy levels have equal response for effectiveness, making low frequency coupled with low energy ideal combination for lithotripsy in terms of effectiveness yet having minimal complications.

DISCUSSION

Renal stones, a very common urological ailment,[11,12] has got diverse option for treatment ranging from conservative treatment to ESWL, minimally invasive surgery to open surgical procedures and advance procedures assisted by laparoscopy and robot assisted surgeries. Each treatment modality has various success rates and among them ESWL is still a treatment of choice depending upon size and dynamics related to stone[13]. ESWL offers a promising success rates as shown from figures of different studies conducted in past, ranging from 60 up to 99 % success rates has been observed for stone treatment using ESWL.[10] Among many factors governing success of ESWL, most important ones are related to shock wave frequency and energy[14,15] because the principle for ESWL to cause fragmentation is that mechanical as well as dynamic forces generated by ESWL shock waves should be able to penetrate the stone and disrupt the cohesive forces of stone by the mechanisms of cavitation, shear stress, spall fracture and fatigue[16] and according to Zeman *et al*, cavitation increases by increasing shock wave frequency.[17] On other hand increasing shock wave frequency has been found to be associated with increased renal damage and reduced frequency causes less renal damage.[18,19] Yilmaz *et al* concluded in a study conducted on 170 patients that the efficacy of lithotripsy session in terms of fragmentation relied on the interval between shock waves and found that when the shock wave interval was short, the success rate of lithotripsy decreased.[20] In another study, Pace *et al* concluded that treatment using ESWL at a slow rate had got better results in terms of stone fragmentation and stone free rate as compared to fast rate.[21,22] These results corresponds to our results showing promising efficacy of ESWL for low frequency as compared to high frequency of shock waves. Shock waves optimal level of energy has always been in debated that what should be optimal level of energy which on one hand should increase efficacy of ESWL,[23] and on other hand should be associated with less degree of renal damage as previously conducted studies, both in vitro and in vivo, showed that optimal energy of shock waves is an important factor for efficacy as well as degree of renal parenchymal damage determination. Our study shows that response rate decreased with increasing frequency, especially in patients in age greater than 35 years. However, efficacy remained comparable in either groups of patients for energy of shock waves.

CONCLUSION

Based upon results of the study, we conclude that ESWL is an effective treatment method for renal stones when frequency of shock waves is less and better results in terms of fragmentation can be achieved at even low levels of energy if low frequency of shock waves is used sand thus adverse effects to renal parenchyma associated with higher energy and higher frequency can be avoided with promising stone fragmentation rate.

LIMITATIONS

This is a single center study.

SUGGESTIONS / RECOMMENDATIONS

Study should be conducted in multiple centers using larger sample size.

CONFLICT OF INTEREST / DISCLOSURE

There is no conflict of interest to disclose.

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