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Original Research Article

Shock Wave Lithotripsy for Ureteric Stones: Success Predictors Based on CT-Scan Parameters

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Abstract:

Background: For the treatment of nephrolithiasis, shock wave lithotripsy has established itself as a successful, secure, and genuinely least invasive approach. The procedure's success can be impacted by a number of technical aspects as well as the patient's choice. The purpose of this study was to pinpoint the NCCT parameters that would indicate if shock wave lithotripsy (SWL) would be effective in treating ureteral stones.

Methods: The study included 102 patients who received SWL for ureteral stones identified by non-contrasted computed tomography between September 2019 and November 2022 at the Department of Urology, NMCH, Sasaram, Bihar. Remaining stones >4 mm were considered the failure. Age, gender, BMI, stone size, position, skin-to-stone distance (SSD), presence of Double J stent (JJ stent), and presence of secondary symptoms (hydronephrosis, renal enlargement, perinephric fat stranding, and tissue rim sign) were also evaluated.

Results: Stone size and stone density were strongly linked with the result of SWL in 102 patients with a success rate of 61.8%. While secondary symptoms such as tissue rim sign, perinephric fat stranding, and hydronephrosis, as well as SSD, JJ, and SSD, were minor. According to multivariate analysis, the two independent parameters influencing the outcome of SWL were stone size and stone density.

Conclusions: The study showed that in individuals with upper ureteral stones, stone size and density are important and independent determinants of prognosis. SSD and impaction indicators must still be assessed, though.

Keywords: Outcome, Shock Wave Lithotripsy, Ureteral Stones.

Introduction

Commencing with the start of its clinical use in the early 1980s [1]. As a reliable, efficient, and noninvasive therapeutic option for renal and ureteral calculi, shock wave lithotripsy (SWL) has gained widespread use [2].

The optimal course of treatment must be determined by the stone's radiographic examination. The recognized standard diagnostic imaging modality for urinary stone illness is non-contrast computed tomography (NCCT) [3]. The success of SWL has been predicted by a number of variables [4]. The stone's size, placement, density (Hounsfield unit and density), and presence of JJ are all variables that could be related to the patient (skin to stone distance, or SSD), or to the stone itself. On a CT scan, other signals are evaluated, such as the existence or absence of hydronephrosis, renal enlargement, perinephric fat stranding, and tissue rim sign [5]. By lowering the number of pointless therapy sessions, the identification of these characteristics in a clinical context will boost efficacy and lower costs [5].

Material and Methods

This study included 102 patients who underwent SWL with solitary and radio-opaque ureteric stone of size 5 mm to 20 mm at Department of Urology, Narayana Medical College and Hospital, Sasaram, Bihar from September 2019 to November 2022.

Patients with incomplete data, missed follow up, active UTI, bleeding tendency and elevated serum creatinine were excluded in this study. Age, sex, weight, height, body mass index (BMI), skin-to-stone distance (SSD), Hounsfield unit (HU), the existence of JJ, and the presence of secondary symptoms (hydronephrosis, renal enlargement, perinephric fat stranding, and tissue rim sign) were also evaluated. Each patient's BMI was calculated by dividing their weight in kilos by their height in square meters. The distances at 0°, 45°, and 90°

were used to measure the SSD on NCCT. The SSD is determined by the average of the three. Utilizing a 5-mm collimation width from the level of the pubic symphysis to the top of the kidneys, the HU for each stone was calculated. The analysis covered three areas of interest. The HU for that stone was the three regions' combined HU. The presence or absence of perinephric fat stranding, tissue rim sign, and hydronephrosis were considered secondary indications. The ocular identification of the dilated renal pelvicalyceal system served to distinguish hydronephrosis. Adipose tissue stranding around the kidney is known as perinephric fat stranding. The observation of the annular soft tissue created by an edematous ureteral wall surrounding the stones was known as the tissue rim sign. Using the Dornier lithotripter SII, SWL sessions were produced.

Under fluoroscopy, fragmentation took place. At each session, adults received 3000 shocks and children received 1200 shocks at a rate of 80 shocks per minute with localization occurring every 500 shocks. Two weeks following the initial session, plain KUB performed an examination on all patients to determine whether stones had broken down and whether additional sessions were necessary. A second SWL session was considered for fragments that were 4mm or larger. Three months following the final appointment, simple KUB assessed all patients to see whether they were still stone-free. Clearance, defined as the full elimination of the ureteral calculus, was captured on a plain film two weeks following the final SWL session. Clinically inconsequential residual fragments (CIRF) are defined as pieces smaller than 4 mm, and patients with CIRF are then treated conservatively.

To find clinical and radiologic characteristics linked to treatment outcomes, the data were evaluated. To evaluate the relationship between the various determinants and outcomes, univariate analysis was performed. Then, to find the independent determinants of treatment outcome, the significantly associated variables were put to the test with multivariate logistic regression analysis. Statistics were judged significant at $p \leq 0.05$ values.

Results

The study comprised 102 patients with ureteric stones. The failure rate was 38.2%, and the success rate was 61.8%. Age (table 1) and sex (table 2) were not statistically significant on a univariate analysis. In the success and failure groups, the mean stone size was, respectively, 9.3±2.2 mm and 11.2±2.2 mm ($p < 0.001$) (table 1). With statistical significance ($p < 0.001$), the mean density of the successful group was 855±219 while that of the unsuccessful group was 1039±267 (table 2). The secondary symptoms (hydronephrosis, perinephric fat stranding, and tissue rim sign), the SSD (table 1), the JJ stent (table 2), and the SSD were all statistically insignificant. According to multivariate analysis, stone size and density were both independent determinants for the success of SWL (statistically significant, p values for size and density were 0.002 and 0.003, respectively) (table 3).

Table 1: Univariate analysis of the factors in success and failure groups

	Failed		Success		
	Mean	**SD**	**Mean**	**SD**	**P value**
Age	41	14	37	12	0.105
BMI	27.4	5.8	27.9	6	0.691
Size(mm)	11.2	2.2	9.3	2.2	<0.001
Mean SSD	10.1	0.9	10.1	0.8	0.830
Density	1039	267	855	219	<0.001

SSD= skin to stone distance, SD= standard deviation

Table 2: Univariate analysis of the factors in success and failure groups

		Failed		Success		
		Count	**%**	**Count**	**%**	**P value**
Sex	Female	9	39.1	14	60.9	0.920
	Male	30	38.0	49	62.0	
JJ stent	Yes	9	23.07	14	22.22	0.920
HN	Yes	30	67.9	47	74.6	0.791
Tissue rim sign	Yes	9	23.07	20	31.7	0.346
Perinephric stranding	Yes	4	10.2	3	4.7	0.423

HN= hydronephrosis

Table 3: Multivariate analysis

					95% CI for OR	
	B	**S.E.**	**p value**	**OR**	**Lower**	**Upper**
Size(mm)	0.366	0.116	0.002	1.4	1.1	1.8
Density	0.003	0.001	0.003	1.0	1.0	1.0

B=Regression coefficients, SE=Standard error of the coefficient, OR=Odds Ratio, 95% CI for OR = 95% confidence interval for the = Odds Ratio. P-value≤0.05 is considered significant

Discussion

Upper ureteric stone removal with shock wave lithotripsy has been shown to be simple, safe, non-invasive, and effective. It has recently been determined that NCCT can be used to predict the outcomes of SWL treatment, which are assessed using a variety of metrics, including stone size, skin to stone distance, and stone density. The ability to predict stone fragility has been tested for a variety of radiological techniques and factors [6]. We enrolled 102 participants in our study who underwent SWL. 39 (38.2%) patients failed, while 63 (61.8%) patients succeeded.

Goel et al. analyzed 110 individuals and split them into two groups based on the size of the stones: group (A) consisted of 84 patients (76%) and group (B) consisted of 26 patients (24%). In groups a (success) and B (failure), the mean stone size was 8.1 mm and 11.3 mm, respectively. He came to the conclusion that the size of the stone was a significant predictor of SWL performance (p<0.001). Both univariate and multivariate analyses revealed that the bigger stone size was an independent predictor of SWL failure [5].

According to the findings of Naoya et al. [7], the size of the stone was a substantial and independent predictor of the effectiveness of SWL in patients with a single proximal ureteral stone. 70% (223/319 patients) of the patients were stone-free overall. The patients were sorted into two groups, success and failure. Each group's mean and standard deviation were respectively 9± 0.2 mm and 11±0.3 mm (p <0.001).They discovered that the failure rate rose with the size of the stone. 160 patients with a single ureteral stone that was between 5 and 15 mm in size were included in Ozgur et al. study and underwent SWL. He separated the patients into two groups, success 110 (68.2%) and failure 50 (31.8%).

Each group median stone size was 9 mm, whereas the other was 10 mm (p=0.349). They found that stone size was not a sole determinant of SWL success, which may account for the limited range of stone dimensions. 102 patients were separated into success and failure groups for our study. The average stone size for each group was 9.3± 2.2 mm and 11±2.2 mm, respectively, with stones ranging in size from 6 mm to 17 mm. When compared to patients in the failure group, the success group patients' stones had a clinically significant smaller mean stone size (p<0.001).

Yusuke et al. [9] analyzed 464 patients with ureteral stones who underwent SWL; according to the density of the stone, 324 (69.8%) patients were in the success group and 140 (30.2%) patients were in the failure group. The mean HU for the success and failure groups was, respectively, 978.5 and 1280.5 HU. Factors affecting CT attenuation value showed significant differences (p=0.01). The success rate was seen to rise with HU below 1000. Goel et al. [5] separated 110 patients into success group (84, or 76%) and failure group (26, or 24%). The patients were then split into A (<750 HU), B (750-1000 HU), and C (>1000 HU) of each success and failure group based on HU. HU with a (p = 0.06) was not statistically significant, but HU was consistently low in the successful group (85 % of success patients had HU <1000).

Müllhaupt et al. [10] separated their 104 patients into success 52 (50%) and failure 52 (50%) groups for the purposes of their study. The mean HU value for the successful group was 956.7, whereas the failure group's score was 944.6. (P = 0.373) The mean attenuation value was an insignificant predictor of SWL success. He proposed that the cause was a tiny sample size and a limited HU range. In a trial of 50 patients who were administered a second generation electrohydraulic lithotripter, Pareek et al. [12] linked calculus density with clearance. They came to the conclusion that a mean calculus density of ≥900 HU or less was present in 36% of patients with residual calculi as opposed to a mean of 500 HU in 74% of patients who achieved clearance. In our study, we split 102 patients into two groups: the successful group (63 patients, or 62%) and the unsuccessful group (39 patients, or 38%). Each group was split into three groups based on HU: <700, 700–1000, and >1000. Each group's mean SD was 855±219 and 1039±267, respectively. With a significant independent predictor for the result of SWL, the density of the success group was lower than that of the failure group (p<0.001). 90% of patients with HU less than 1000 experienced success.

In an analysis of 464 patients with ureteral stones who had SWL, Yusuke et al. [9] found that 324 (69.8%) patients had successful outcomes while 140 (30.2%) patients had unsuccessful outcomes. They discovered that SSD was significantly (p<0.001) predictive of the outcome of SWL. Each group's average SSD was 9.6 cm or 9.9 cm, respectively. Goel et al. [5] observed that SSD was not a significant predictor of the outcome of SWL (P = 0.913) after splitting 110 patients into success group = 84 (76%) and failure group = 26 (24%) groups.

The mean for the success and failure groups, respectively, was 90.0 mm and 96.0 mm. Ozgur et al. [8] showed that SSD was unimportant for predicting the result of SWL. They included 160 patients with a single ureteral stone in their study and split them into success group (110 patients = 68%) and failure group (50 patients = 32%). In the success group, the mean SSD was 125±23 mm, while in the failure group, it was 126±26 mm (p = 0.754).

153 patients were split into two groups by Choi et al. [11]: group A had stones ≤10 mm, while group B had stones >10 mm. In groups A and B, the success rates were 90.2% and 68.6%, respectively. In terms of success and failure, the mean SD of each group's SSD was 102.4±12.88 mm, 110.8±5.66 mm, and 97.8±12.97 mm, 107.9±13.02 mm, respectively. SSD was a highly significant (P <0.05) predictor of SWL outcome. In our study, we split 102 patients into two groups: 63 patients in the success group (62%) and 39 patients in the failure group (38%). In our study, the SSD on SWL findings did not reach statistical significance (p > 0.05). In comparison to the failure group, which had a mean SSD of 10.1±0.9 cm, the success group's SSD was 10.1±0.8 cm. The limited range of SSD was to blame for this. Goel et al. [5] discovered that the existence of secondary alterations was statistically significant (P = 0.023) between success and failure groups in univariate and multivariate analysis based on secondary changes (hydronephrosis, perinephric fat stranding, and tissue rim sign). 27 patients had the modifications in the success group, whereas 57 people did not. In the failure group, 15 patients had the alterations while only 11 did not (5). 153 patients were split into two groups by Choi et al. [11]: group A, stone size ≤10 mm, and group B, stone size >10 mm.

All of the secondary indicators revealed statistically significant variations in SWL results (p <0.05). 99 individuals were examined by Boulay et al. [13], who retrospectively investigated the presence and severity of secondary obstruction symptoms. Treatment was unaffected by the presence and severity of secondary symptoms of blockage, which did not differ substantially between the two groups. A total of 102 participants from our study were split into success and failure groups. We discovered that the outcome of SWL and secondary modifications did not differ statistically significantly (P > 0.05). The tiny sample size could be the cause. Goel et al. [5] discovered that the presence of JJ between the success and failure groups was statistically negligible (P = 0.06) based on its presence. JJ was present in the success group in 5 patients (7.2%) but not in the failure group in 64 patients (92.8%) and in 8 patients (19.5%) but not in the 33 patients (80.5%) [5].

There were no significant differences for predicting SWL success, according to Müllhaupt et al. [10] (P = 0.825). There were 104 patients in total, and 28 of them had JJ stents. He split JJ patients into groups that were successful and unsuccessful. There were 13 patients in the failure group and 15 patients in the success group. According to Ghoneim et al. [14], just one session was given to seventeen patients (28.3%), including 7 (23.3%) of the stented group and 10 (33.3%) of the unstented group. 43 patients (71.7%), including 23 (76.7%) in the stented group and 20 (66.7%) in the unstented group, required more than one session. Although the group with stenting had a greater rate of re-treatment.

This difference was statistically negligible. El-Assmy et al. [15] showed that unstented patients had a greater success rate (91.4%) compared to stented patients (84.9%). This difference was negligible. 102 participants from our study were split into success and failure groups. JJ was present in 14 (22.22%) of the patients in the success group and in 9 (23.07%) of the patients in the failure group.

We discovered that there were no differences in the outcome of SWL between patients who had stenting and those who did not (P=0.920).

Conclusion

According to the study, patients with upper ureteral stones had significant and independent predictors of prognosis based on stone size and density. However, SSD and impaction indicators still need to be assessed.

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